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(54) Title: ROBOTIC SYSTEM FOR SORTING SAMPLE TUBES

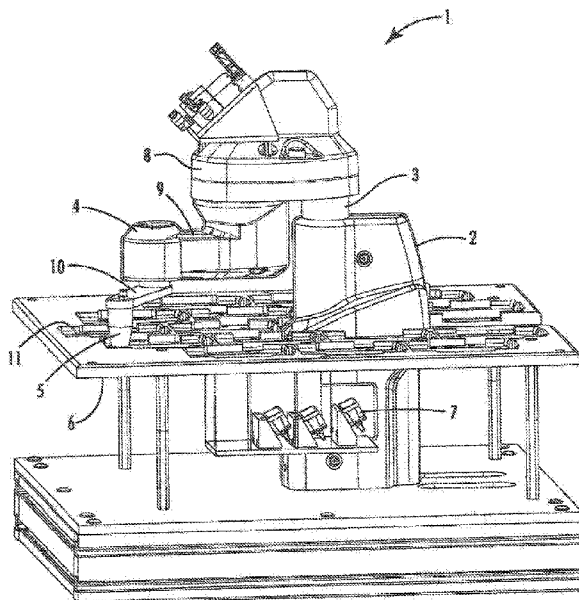


FIG 1

(57) Abstract: A device and method for sorting sample tubes, having a robotic assembly with a horizontal robotic arm which is configured to pivot around the base. The end of tooling arm is configured to pick up and hold a sample tube when a vacuum is applied and to deposit the sample tube into a designated slot in a tube rack when the vacuum is removed. The device includes a vacuum source to pull a vacuum through the tooling; an air source to expel air through the tooling; a horizontal stage underneath the robotic arm to hold a plurality of tube racks in a position; a vision system configured to record coded information on sample tubes and on the sides of tube racks in the device and to convey the coded information to a control system; and tube racks to store the sample tubes.





DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,  
LU, LV, MC, 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).

— *before the expiration of the time limit for amending the  
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amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/68337

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC(8) - B07C 5/00 (2017.01)  
 CPC - B01L 9/06, G01N 2035/0425, G01N 35/026

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)

See Search History Document

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

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y ----- A	US 8,703,492 B2 (Self et al.) 22 April 2014 (22.04.2014). Entire document, especially Fig 4, it 404 and platform underneath racks 412 Fig 5, it 504 and (col 6, ln 65 to col 7, ln 4 and ln 63-64; col 9, ln 6-12; col 16, ln 54 to 17 ln 17; col 17, ln 46-56; col 18, ln 11-64; col 19, ln 9-60; col 23, ln 40-48; col 24, ln 27-31; ln 7-9; col 37, ln 48-66; col 38, ln 6-10 and col 37, ln 66 to col 38, ln 3.	1-4, 9, 11,12,14, 17-19 and 34 ----- 10, 13, 15 and 16 ----- 5-8
Y	US 5,357,095 A (Weyrauch et al.) 18 October 1994 (18.10.1994) Entire document, especially col 8, ln 43-53	10, 13 and 15
Y ----- A	US 2008/0116338 A1 (Kalb) 22 May 2008 (22.05.2008) Entire document, especially Fig 2, it 22 and 38 and para [0026] Cl 16	16 ----- 5-8

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

12 July 2017

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/68337

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:  
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-19 and 34, directed to a device for sorting sample tubes

Group II: claims 20-33 directed to a method for sorting sample tubes.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special technical features:

---Continue on the first sheet---

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-19 and 34

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/68337

Continue from Box III

Group II requires a method for sorting tubes; further comprising wherein the control system moves the robotic arm to configure the end of arm tooling above the first location, wherein a vacuum is applied via the vacuum source, thereby providing a suction force through the end of arm tooling, wherein the sample tube is picked up from the first location and retained by the end of arm tooling via vacuum suction, wherein the control system moves the robotic arm to configure the end of arm tooling with the retained sample tube above the second location, wherein the vacuum is terminated and positive air pressure is applied through the end of arm tooling to expel the sample tube in the second location, and wherein the presence of the sample tube in the first location and/or second location is determined by reading of coded information on the sample tube by the vision system, not required by group I

Common technical features:

Groups I-II share the technical feature of a device for sorting sample tubes, comprising: a robotic assembly, comprising: a base that comprises a vertical lift shaft; a horizontal robotic arm comprising a proximal end and a distal end, wherein the proximal end of the robotic arm is configured to be lifted vertically by the lift shaft and is configured for pivotal movement around the base; and end of arm tooling at the distal end of the robotic arm that is configured to pick up and hold a sample tube when a vacuum is applied and to expel and deposit the sample tube into a designated slot in a tube rack when air is expelled through the tooling; a vacuum source that is fluidly connected to the end of arm tooling and configured to pull a vacuum through the tooling; an air source that is fluidly connected to the end of arm tooling and configured to expel air through the tooling; a horizontal stage underneath the robotic arm and configured to hold a plurality of tube racks in a position from which the end of arm tooling may pick up and deposit sample tubes; a vision system that is configured to record coded information on sample tubes and on the sides of tube racks in the device and to convey the coded information to a control system; and a control system that tracks coded information provided by the vision system, and that controls the robotic assembly to pick up a coded sample tube from a first location in a first tube rack and to deposit the sample tube in a second location in a second tube rack, wherein the first tube rack and the second tube rack are the same or different.

However, this shared technical feature does not provide a contribution over the prior art because these shared technical features are obvious over US 8,703,492 B2 to Self et al. (hereinafter 'Self'). As Self discloses a device for sorting sample tubes ('bottles' col 19, in 49-53 'The access arm 404 is programmed to remove each sample bottle 412 from the sample rack 201, place the bottle 412 in the barcode reader 218, remove the bottle 412 from the barcode reader 218 after a sample is taken') comprising: a robotic assembly, comprising: a base that comprises a vertical lift shaft (col 18, in 40-41 'Referring back to FIG. 4, an access arm 404 is pivotally and vertically mounted on a shuttle 406 that, in turn'); a horizontal robotic arm (Fig 4, it 404 arm) comprising a proximal end and a distal end (col 18, in 62-64 'At its distal end, the access arm 404 has a gripper 410 that is adapted to grasp and move sample bottles 412' implies proximal end), wherein the proximal end of the robotic arm is configured for pivotal movement around the base (col 18, in 40-42 'Referring back to FIG. 4, an access arm 404 is pivotally and vertically mounted on a shuttle 406 that, in turn, is adapted to move laterally along an access arm track 408 located above the sample racks 201'); and end of arm tooling at the distal end of the robotic arm that is configured to pick up and hold a sample tube ('bottles' col 18, in 62-65 'At its distal end, the access arm 404 has a gripper 410 that is adapted to grasp and move sample bottles 412 having various sizes. The gripper includes a contact surface that transmits force to the sample bottle to control its positioning and movement') when a vacuum is applied and to expel and deposit the sample tube into a designated slot in a tube rack when air is expelled through the tooling (col 19, in 22-37 'A suction cup gripper may be used as well ...A vacuum seal may be formed by evacuating air (using a pump or by pressing the suction cup against the workpiece) out of a chamber defined by the workpiece surface and the gripper surface... in addition, the volume of the chamber may be increased by applying a force that pulls the gripper surface, also resulting in partial vacuum. Once a partial vacuum is established, the workpiece is held against the gripper by atmospheric pressure. The workpiece may then be released by restoring ambient pressure within the chamber, which breaks the seal'); a vacuum source that is fluidly connected to the end of arm tooling and configured to pull a vacuum through the tooling (col 19, in 22-28 'A suction cup gripper may be used as well ...A vacuum seal may be formed by evacuating air (using a pump or by pressing the suction cup against the workpiece) out of a chamber defined by the workpiece surface and the gripper surface'); an air source that allows air to enter the vacuum gripper allowing release of the workpiece (col 18, in 33-35 'The workpiece may then be released by restoring ambient pressure within the chamber, which breaks the seal'); a horizontal stage underneath the robotic arm and configured to hold a plurality of tube racks in a position from which the end of arm tooling may pick up and deposit sample tubes (Fig 4, platform underneath racks 412),

a vision system (bar code reader) that is configured to record coded information on sample tubes and on the sides of tube racks in the device and to convey the coded information to a control system (col 19, in 49-53 'The access arm 404 is programmed to remove each sample bottle 412 from the sample rack 201, place the bottle 412 in the barcode reader 218, remove the bottle 412 from the barcode reader 218 after a sample is taken, and return the bottle 412 to the location on the rack 201 from which it was taken'); and a control system that tracks coded information provided by the vision system, and that controls the robotic assembly to pick up a coded sample tube from a first location in a first tube rack and to deposit the sample tube in a second location in a second tube rack, wherein the first tube rack and the second tube rack are the same (col 19, in 49-53 'The access arm 404 is programmed to remove each sample bottle 412 from the sample rack 201, place the bottle 412 in the barcode reader 218, remove the bottle 412 from the barcode reader 218 after a sample is taken, and return the bottle 412 to the location on the rack 201 from which it was taken'). Further, Self disclose raising the platforms (col 23, in 7-9 'Pneumatic linkages 622 are connected to platform 618, and adapted to raise the platform 618 at the pipetting station') and air to enter the vacuum gripper (col 18, in 33-35 'The workpiece may then be released by restoring ambient pressure within the chamber, which breaks the seal'). While Self does not disclose the robotic arm is configured to be lifted vertically by the lift shaft, it would have been obvious to one of ordinary skill in the art to utilize the pneumatic linkages used on the platforms to be configured to lift the robotic arm vertically by the lift shaft to provide added control in the movement of the robotic arm. Further, while Self does not specify an air source that is fluidly connected to the end of arm tooling and configured to expel air through the tooling, it would have been obvious to one of ordinary skill in the art to expel air through the gripper to provide finer control on the release of the vacuum grip as opposed to allowing ambient pressure to return to the chamber.

Groups I-II, therefore, lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature providing a contribution over the prior art.