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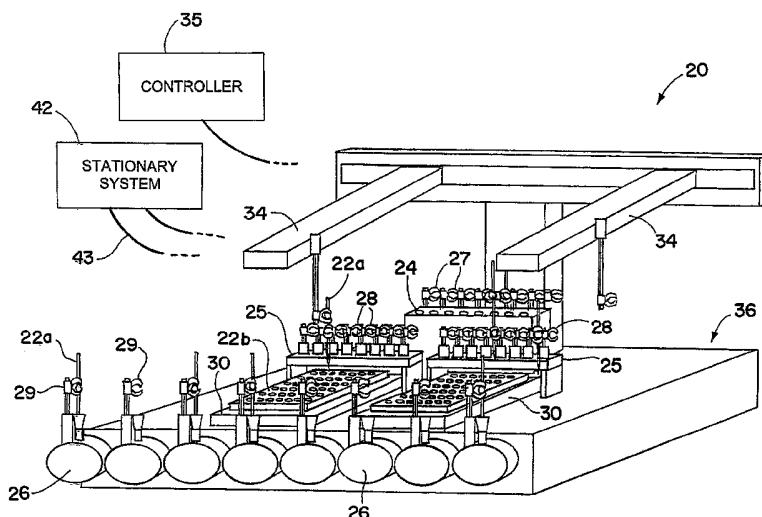
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(54) Title: ROBOTIC HANDLING SYSTEM AND METHOD WITH INDEPENDENTLY OPERABLE DETACHABLE TOOLS



(57) Abstract: An analytical system and method that enables more efficient transport of movable devices (22) among stations (24, 25, 26). According to one aspect of the invention, the system and method permit operational timesharing of a transport mechanism (34) for the movable devices. According to another aspect of the invention, control of the transport mechanism is effected on an event-driven basis. The invention has particular application to an adaptive, motion and fluids system for automating the sample handling/management process associated with analytical processes and especially bioanalytical processes such as introducing samples into LC and HPLC systems.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ROBOTIC HANDLING SYSTEM AND METHOD WITH INDEPENDENTLY OPERABLE DETACHABLE TOOLS

Related Applications

This application claims the benefit of U.S. Provisional Application No.
5 60/579,370 entitled "Indiprobe" and filed June 14, 2004, and U.S. Provisional
Application No. 60/685,833 entitled "Event Driven Laboratory Sample Transport
Paradigm" and filed May 31, 2005, both of which are hereby incorporated by
reference in their entireties.

Field of the Invention

10 The invention herein described relates generally to robotic handling
systems and methods, particularly for analytical applications, more particularly
for liquid sample analytical systems, and still more particularly for bioanalytical
applications.

Background

15 Sample handling robots of various configurations are known in the
biotechnology industry. A common feature of such systems is the use of a
robotic or other motion control device to either move a fluid aspirating/-
20 dispensing syringe (herein generally referred to as a sampling probe) about a
deck of vessels or other deck components like wash stations, reagent troughs,
injection valves, etc., or to move the vessels and/or other deck components
relative to a stationary sampling probe. Among the more sophisticated systems,
plural sampling probes are ganged together for common movement by a sample
25 handler. These systems generally fall into two different categories.

In a first category, the sampling probes are attached to a single holding
bracket affixed to a transport member, commonly referred to as a gantry. All of
the sampling probes travel together as a unit. While such systems are easy to
design, build and implement, a disadvantage is that all of the ganged probes
30 must travel in the X, Y and Z axes together. Even if only one of the probes
needs to draw a sample from a vessel at a sampling station, for example, all of

the probes will be immersed in their respective vessels at a sampling station. This increases the risk of sample and/or probe contamination and carryover.

In a second category, the systems are designed to allow independent Z axis motion for each sampling probe. That is, each probe can travel toward and
5 away from the deck independently of the other probes. This allows one or more of the probes to be immersed in their respective vessels while the remainder remain suspended above their respective vessels at a sampling station.

In both cases, the probes must be simultaneously positioned in relation to the various work stations, such as a wash station, sampling station, injection
10 station, etc. In the various automated sample transport implementations known in the art, the transport functionality is completely deterministic both spatially and temporally.

In addition, the transport functionality is either schedule or operation-table driven. Before execution, the system control software would be made aware of
15 the number and types of transportable devices, the number and types of objects on which the devices must operate, and the specific workflow for each object. The system also would be instructed, or calculates via a deterministic set of algorithms, where each transportable device must be within the workflow relative to the others (temporally and spatially) and the exact sequence of operations
20 from start to finish.

This paradigm works sufficiently well when overall processing throughput is not a concern and also when there are only a couple transportable devices each of which remains dedicated to a given operation for its duration. In typical cases, the system assumes the workflow of one of the objects and sees it
25 through to the end before attending to the workflow of another object or a new workflow for the same object. All remaining objects are processed in sequence.

The problem becomes more complex when overall throughput is of concern or when several transportable devices must be administered during execution, especially when individual unit operation time frames are not
30 balanced throughout the workflow.

The prior art systems also are not able to handle failure situations very well. For example, if a transportable device breaks down, the entire schedule

must be recalculated and retransmitted to the system. Typically, major assumptions must be made to accommodate the modified labor deployment and in most cases, system operation gets suspended to wait for a user to reestablish the new schedule. In a worst case scenario, the system has to shut itself down
5 and wait for repair.

Summary of the Invention

The present invention provides a system and method that enables more efficient transport of transportable devices, herein also referred generally
10 referred to as movable devices. A system and method according to one aspect of the invention permits operational timesharing of a transport mechanism or multiple transport mechanisms for the movable devices. According to another aspect of the invention, control of a transport mechanism is effected on an event-driven basis. The principles of the invention have particular application to
15 an adaptive, synchronized motion and fluids system for automating the sample handling process associated with analytical processes and especially bioanalytical processes such as introducing samples into liquid chromatography (LC), high performance liquid chromatography (HPLC) systems, etc.

Accordingly, the invention provides an analytical system and method
20 wherein a plurality of movable devices are used in performing one or more operations at one or more stations. The stations have associated therewith one or more receivers for receiving one or more of the movable devices so that a prescribed operation can be commenced at the respective station. A transport mechanism transports the movable devices from station to station, and a
25 controller directs the transport mechanism to leave at least one of the movable devices with the receiver(s) in a first one of the stations thereby to free the transport mechanism for transport of at least one other movable device between stations while the movable device or devices left at the first station are used to perform a prescribed operation at the first station.

30 The movable devices may also be transported between clusters of stations throughout a lab-wide or corporate-wide set of clusters each containing

a logical grouping of stations for performing specific operations within each given cluster.

According to another aspect of the invention, an analytical system and method are characterized by a plurality of movable devices for use in performing
5 one or more operations in an analytical procedure, a plurality of stations each having associated therewith one or more receivers for receiving one or more of the movable devices so that a prescribed operation can be commenced at the respective station, one or more transport mechanisms for transporting the movable devices from station to station, and a controller for directing a transport
10 mechanism to retrieve one or more of the movable devices from a station in response to a request corresponding to completion of the prescribed operation by a movable device or devices at such station.

In various embodiments, the movable devices may include one or more sampling probes for aspirating and/or dispensing an agent. At least some of the
15 sampling probes may be connected electrically and/or fluidically to a stationary system by a tether for receiving and/or dispensing fluids and/or for communicating with the system controller or other system components.

In other embodiments, the sampling probes may be self-contained thereby eliminating the need for a tether and thus reducing the complexity of
20 coordinating the flow of the sampling probes through the system. An untethered self-contained sampling probe typically would include a plunger and a motive device for moving the plunger in response to a command signal. The command signal may be effected wirelessly between the sampling probe and a stationary system component, and/or by other suitable means.

25 For some applications, the receivers may assist the movable device in performing a prescribed task at the station. In particular, one or more of the receivers may include a positioning device for moving the movable device in relation to the station, such as moving or rotating the movable device in relation to one or more movement axes of the station.

30 Transport mechanisms typically will include a robotic device such as a robotic arm or other controllable means for effecting transport of the movable devices. Such transport may be effected individually or a ganged arrangement

of the movable devices may be moved simultaneously during a transport operation.

To facilitate system control, each movable device may be uniquely identified for independent operation by the controller.

5 The above-mentioned prescribed operation may include one or more of sample reformatting, sample injection, reagent addition or dilution. The stations may include a wash station, a processing station, or a station for supplying liquid reagents.

Each station may be provided with a signal generator to generate an
10 in-place signal indicating the arrival and positioning of a movable device at the station and particularly in a receiver at the station, after which movable device may be operated, manipulated or otherwise used at the station to perform a prescribed task or other operation. A task-complete signal may be generated when the movable device completes the task and communicated to the
15 controller for the transport mechanism which then directs a transport mechanism to retrieve the movable device and deliver it to a next station. Such transport request may be coordinated with other transport requests received from other stations.

The present invention also envisions a self-contained sampling probe
20 including a dedicated metering device for independent aspiration and/or dispensing of an agent, and control circuitry for receiving commands and controlling the metering device. The metering device generally comprises a syringe including a lumen, a plunger for drawing and/or dispensing a fluid into and/or from the lumen, and a motive device, such as an electric motor, for
25 moving the plunger. In addition, the sampling probe may include a power supply for powering the motor and associated control circuitry, or other means by which power is supplied to the syringe at a station.

Further features of the invention will become apparent from the following detailed description when considered in conjunction with the drawings.

30

Brief Description of the Drawings

In the annexed drawings,

Fig. 1 is a schematic illustration of an exemplary embodiment of an analytical system according to the invention;

Fig. 2 is an illustration of an exemplary self-contained sampling probe useful in the practice of the invention;

5 Fig. 3 is a diagrammatic illustration of a consolidated workflow model; and
Fig. 4 is a diagrammatic illustration of a distributed workflow model.

Detailed Description

Because the invention was conceived and developed as an adaptive,
10 synchronized motion and fluids system for automating the sample handling process associated with analytical processes and especially bioanalytical processes such as introducing samples into LC systems, HPLC systems, etc., it will be herein described chiefly in this context. However, the principles of the invention in their broader aspects can be adapted to other types of systems,
15 such as automotive production line systems and electronic assembly systems.

Referring now in detail to the drawings and initially to Fig. 1, an exemplary embodiment of an analytical system according to the invention is generally denoted by reference numeral 20. The system 20 comprises one or more movable devices 22 for use in the performance of one or more analytical
20 operations, which movable devices may be active devices, such as sampling probes 22a, and/or passive devices, such as trays 22b.

The system further comprises one or more stations which, as shown, may be arranged in groups. For example, the system 20 includes one or more wash stations 24, one or more aspirating stations 25 (two shown), and one or more
25 analysis stations 26. The stations 24, 25 and 26 have respectively associated therewith one or more receivers 27, 28 and 29 for receiving one or more of the movable devices 22a so that a prescribed operation can be commenced at the respective station. The stations 25 also are provided with a receiver 30 for the trays 22b.

30 The system further comprises one or more transport mechanisms 34 for transporting the movable devices 22 from station to station, and a controller 35 for directing the transport mechanism to leave at least one of the movable

devices with the receiver(s) in a first one of the stations thereby to free the transport mechanism for transport of at least one other movable device between stations while the movable device or devices left at the first station are used to perform a prescribed operation at the first station. Simply, the moveable devices
5 are transported to and among receivers via the transport mechanism. Once transported, the moveable devices are "released" to the receivers by the transport mechanism, thereby freeing the transport mechanism for transporting other moveable devices between the stations.

In the illustrated embodiment, the stations are arranged in relation to what
10 is commonly referred to a "deck" 36.

As a result of the foregoing arrangement, many operations can be executed in parallel, thereby increasing overall system efficiency and throughput relative to the prior art systems where the movable device remains attached to the transport mechanism for effecting an operation, whereupon such operations
15 according to the prior art could be performed only serially. The movable devices 22, and particularly the active movable devices 22a, can be positioned anywhere in the system without constraint on other movable devices, active or passive.

The transport mechanisms 34 can be, but are not limited to, robots, particularly robotic devices capable of three-dimensional translating (X, Y and Z
20 axis) and/or rotational movement; levitation devices; antigravity devices; automated slides or tracks; and stackers. The transport mechanisms can be equipped with a suitable holder for the movable device being transported. As will be appreciated, multiple transport mechanisms may be employed and independently operated to retrieve and transport the movable devices. In
25 addition, the movable devices may be transported by attending personnel, as in response to instructions provided by controller either audibly, visually and/or otherwise.

The movable devices 22 can be, but are not limited to, sample probes/syringes; reaction vessels; plate carriers; sample loops; and other active
30 or passive devices. An active movable device is one that is capable of performing an action, such as a syringe that can aspirate or dispense an agent. A passive movable device is one that does not perform an action but which can

receive or be subjected to an action, such as a vial containing a sample or a tray containing multiple samples. An otherwise passive movable device may become an active or intelligent movable device if it is equipped with logic circuitry for storing a workflow and communicating a need for a particular service
5 with the system controller or other system components.

The stations can be, but are not limited to, wash stations; aspirating and/or dispensing stations, sample reformatting stations; reagent addition stations; dilution stations; shaking stations; thermally and environmentally controlled stations; parking stations; plate handlers; centrifuges; and other
10 processing stations. At any given station multiple processes may be performed, as desired for a particular application. The stations may be equipped with positioning devices for positioning components relative to other components.

Moreover, the stations may be logically grouped in clusters, and the movable devices may be transported between clusters of stations throughout a
15 lab-wide or corporate-wide set of clusters. A cluster of stations may be configured, for example, as an autosampler system or a generic liquid handling system. A cluster of stations is one that is grouped for a particular purpose. Fig. 1 illustrates one such cluster of stations that functions as an autosampler system.

20 The receivers 27-30 at the respective stations can be, but are not limited to, grippers; holders; cradles; electrical and/or mechanical grid systems; manipulators; or other components. The receivers may physically articulate with the movable device delivered thereto and position it for proper operation.

As will be appreciated, the transport mechanism(s) 34 can be a low
25 precision device(s) inasmuch as any high precision positioning needed at a station can be obtained by the receiver or receivers which can include a high precision positioning and/or operationally capable device.

One or more of the receivers 27-30 may possess the ability to assist the movable component received thereby in the performance of a requisite task at
30 the respective station. For example, the receivers 27 at the wash station 24 may have the capability of raising and lowering a movable device, particularly a sampling probe 22a, into and out of a wash well or trough. Other receiver

actions may include not only up and down actuation but also rotation, precise servo driven multi-axis positioning, and others. For example, the receivers 30 for the stations 25 may include a high precision X and Y positioning device used for fine positioning of microplates under sampling probes 22a held in the
5 stations 25.

The analytical system 20 shown in Fig. 1 overcomes various drawbacks associated with prior art systems. Systems using prior art design concepts requiring physical attachment of the movable devices to the gantry during performance of a prescribed operation, would require as many transport devices
10 as there are probes to confer the spatial independence afforded by the system of Fig. 1. The system of Fig. 1 reduces the number of transport devices and complicated transport controls previously needed. The prior art systems also required the transport mechanism to be of high precision if high precision is needed at the station. The system of Fig. 1 allows lower cost low precision
15 transport devices to be used to transport the movable devices between work stations.

In some implementations of the present invention, the movable devices 22 may include one or more sampling probes (e.g. syringes or pipettes) for aspirating and/or dispensing an agent, sonicators, readers, detectors, or other
20 components. At least some of the sampling probes (or other movable devices) may be connected electrically and/or fluidically to stationary system components 42 by a tether or tethers 43 for receiving and/or dispensing fluids and/or for communicating with the system controller 35 or other system components. For example, a tether may be used to supply an agent, specifically a liquid agent, to
25 the probe for metered dispensing. A metering device may be employed at the stationary system or integrated into the probe, as desired for a particular application. The tethers typically would be flexible to allow for free transport of the probes from station to station. As will be appreciated, provision should be made to avoid entanglement of the tethers. This can be dealt with through
30 appropriate tether awareness and management routines included in the programming of the controller 35.

In other implementations of the present invention, the sampling probes may be self-contained thereby eliminating the need for a tether and thus reducing the complexity of coordinating the flow of the sampling probes through the system. An exemplary untethered self-contained sampling probe is denoted
5 by reference numeral 47 in Fig. 2. The probe 47 may include a dedicated metering device 48 for independent aspiration and/or dispensing of an agent, and control circuitry 49 for communicating with the overall system controller 35 (or components thereof) and for controlling the metering device. The metering device may include a syringe 52 including a syringe barrel 53 terminating at a
10 lumen 54, a plunger 56 movable in the barrel for drawing and/or dispensing a fluid into and/or from the barrel via the lumen, and a motive device 57, such as an electric motor, for moving the plunger via an appropriate gear train or other transmission components. In addition, the sampling probe 47 may include a power supply 59 for powering the motor and associated control circuitry, or other
15 means by which power is supplied to the syringe at a station. Command signals may be communicated wirelessly between the sampling probe and system controller (or components thereof), or by a make and break signal connection at point of placement (physical electrical contact or inductive), clip on control circuitry, and/or by other suitable means.

20 The probes may contain a time of day clock and may be used for timed reactions. For example, the probe may automatically draw up a plurality of solutions, mix them in its barrel, and hold them for a designated amount of time before expelling them. It may also automatically draw up a solution or solutions, wirelessly tell the controller 35 to inform the user to place the syringe in a
25 laboratory device or container separate from its current location (e.g. incubator or refrigerator), sit in the device or container for a designated amount of time, and wirelessly tell the controller to tell the user to remove it from the device or container so it can become part of the active system again.

The syringe barrel may also have a cross-port 60 allowing for fast
30 washing once the plunger is fully retracted.

An analytical system according to the invention, such as that described above, can be operated in an "event driven" mode. In addition to permitting

operational timesharing among all transportable devices associated with a given system, attention to each device can be provided on an as needed basis with the transportable device itself requesting service as an "event" in a system queue maintained by the controller. In this context, a system could consist of a
5 single instrument tasked with performing a prescribed set of functions but employing multiple transportable devices. Alternatively, the system could include a network of instruments (each employing multiple transportable devices) deployed as part of an enterprise-wide laboratory, facility or corporate automation entity.

10 Accordingly, active movable components may request service at the appropriate point within their current workflow and the system controller and/or other components of the system can respond to that request. This framework can be extended to include not only transport control but any servicing the active movable components on an event driven basis. For example, a system's
15 movable elements might share an electrical discharge device or a heating device whose services are requested on an as needed basis. The requests are non-deterministic in nature as they are issued in accordance with each movable component's workflow requirement for such service at such time that it is needed.

20 According to one particular paradigm, the controller (or dedicated components thereof such as a transport controller) need not know *a priori* or deterministically which movable devices will require transport at any given time. Instead, the movable devices can be configured to request service at the appropriate point within their current workflow and the transport mechanism
25 commanded in response to that request.

Fig. 3 depicts one implementation of this paradigm. A sample functional workflow manager 65 delivers general workflow requests to a system operation manager 66 such as "deliver x amount of samples a, b and c to injection ports d, e and f of analytical devices, respectively", and "wash each probe with y amount
30 of washing fluid between each injection". The system operation manager translates the general workflow request into a specific operational workflow for each movable device 67a-67n, such as a sampling probe. The system

operation manager then communicates with the movable devices (e.g. probes) telling them their respective workflows which may be implemented with the assistance of the receivers 68a-68n at respective stations. New workflows may be transmitted to the movable devices as they complete their current workflow
5 and request a new workflow. During operation, the movable devices, which also can be referred to as "active components", execute their workflow and generate system events whenever they need assistance performing an operation. Events can include but are not limited to transport requests to the transport manager 69 that controls the transport mechanism 70, turning equipment on and off,
10 time-of-day synchronization, operations to perform at remote locations, and others.

Fig. 4 depicts another implementation of the paradigm and uses the same reference numerals to denote components similar to those shown in Fig. 3. A sample functional workflow manager 65 delivers general workflow requests such
15 as "deliver x amount of samples a, b and c to injection ports d, e and f, respectively" and "wash each probe with y amount of washing fluid between each injection" to the system operation manager. The system operation manager 66 translates the general workflow request into a specific operational workflow for each movable device 67a-67n. It then communicates with the
20 receivers 68a-68n holding the movable devices and tells them how the movable devices should execute and where the movable devices need to go after they have completed their current task. Each receiver relays that information to the movable device it is holding. The movable device then executes the task and sends a transport request event signal to the system at the completion of the
25 task for transport to a next station. After the transport is complete, the movable device then may request a next set of instructions be passed to the receiver in which it is situated.

As may be desired, each movable device may be uniquely identifiable within its control logic to allow control transmissions to reach a specific device on
30 a "hub" via a "broadcast" transmission scheme.

In both implementations, the controller, or a transport manager 69 included as part of the overall controller, may maintain a queue of the pending

requests for transport. A movable device's request for transportation is placed in the queue as a result of a signal from a movable device signaling that it requires transportation. This allows the transportation device to move other moveable devices while other moveable devices are executing an operation. The system
5 is therefore flexible and can accommodate processes that require different lengths of time to complete. Even the failure of a particular set of steps or of a particular station need not stop other processes, at least those that do not require the malfunctioning moveable device or failed station. Attention to each device is provided on an as needed basis with the transportable device itself
10 requesting service as an "event" in the system queue. In the case of component failures, the system can work around the failed device(s) to complete the remaining operations. It can even remove the failed device(s) and recruit redundant, similar device(s) to circle back and complete the workflow of the failed element(s).

15 Although the invention has been shown and described with respect to a certain embodiment or embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described elements
20 (components, assemblies, devices, compositions, etc.), the terms (including a reference to a "means") used to describe such elements are intended to correspond, unless otherwise indicated, to any element which performs the specified function of the described element (i.e., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs
25 the function in the herein illustrated exemplary embodiment or embodiments of the invention. In addition, while a particular feature of the invention may have been described above with respect to only one or more of several illustrated embodiments, such feature may be combined with one or more other features of the other embodiments, as may be desired and advantageous for any given or
30 particular application.

CLAIMS

1. An analytical system comprising one or more movable devices (22) for use in performing one or more operations, a plurality of stations (24, 25, 26) each having associated therewith one or more receivers (27, 28, 29) for receiving one or more of the movable devices so that a prescribed operation can be commenced at the respective station, at least one transport mechanism (34) for transporting the movable devices from station to station, and a controller (35) for directing the transport mechanism to leave at least one of the movable devices with the receiver(s) in a first one of the stations thereby to free the transport mechanism for transport of at least one other movable device between stations while the movable device or devices left at the first station are used to perform a prescribed operation at the first station.
2. An analytical system according to claim 1, wherein the movable devices include one or more sampling probes (47) for aspirating and/or dispensing an agent.
3. An analytical system according to claim 2, comprising a stationary system component (42), and at least some of the sampling probes are connected to the stationary system by a tether (43).
4. An analytical system according to claim 3, wherein the stationary system component includes a supply of the agent.
5. An analytical system according to claim 3, wherein the stationary system component includes a metering device for metering an amount of the agent to be aspirated and/or dispensed by the sampling probe.
6. An analytical system according to claim 2, wherein the sampling probe is not tethered to any stationary component of the system.

7. An analytical system according to claim 6, wherein the sampling probe includes a plunger (56) and a motive device (57) for moving the plunger in response to a command signal.

5 8. An analytical system according to claim 1, including a communication link between the motive device and the controller.

9. An analytical system according to claim 8, wherein the communication link is effected via a tether (43) connecting the movable device
10 to a stationary system component (42).

10. An analytical system according to claim 8, wherein the communication link is effected wirelessly between the movable device and a stationary system component (42).

15 11. An analytical system according to claim 8, wherein the movable device and the controller identify the proper positioning of the movable device for proper operation.

20 12. An analytical system according to claim 8, wherein the movable device communicates with the controller when an operational fault is detected.

13. An analytical system according to claim 8, wherein the communication link is temporarily effected between the movable device and an interface associated with a receiver when the movable device is received by the
25 receiver.

14. An analytical system according to any preceding claim, wherein the receiver assists the movable device in performing a prescribed task at the
30 station.

15. An analytical system according to any preceding claim, wherein the receiver includes a positioning device for moving the movable device in relation to the station.

5 16. An analytical system according to any preceding claim, wherein the receiver is operable to move or rotate the movable device in relation to one or more movement axes of the station.

10 17. An analytical system according to any preceding claim, wherein the transport mechanism includes a robotic arm.

18. An analytical system according to any preceding claim, wherein the transport mechanism is controlled in response to requests corresponding to completion of the prescribed operation by a movable device or devices.

15 19. An analytical system according to any preceding claim, wherein each movable device or set of movable devices is uniquely identified for independent operation by the controller.

20 20. An analytical system according to any preceding claim, wherein the prescribed operation includes one or more of sample reformatting, sample injection, reagent addition or dilution.

25 21. A device for processing liquid biological specimens comprising a plurality of stations (24, 25, 26), at least one of which supports a liquid biological specimen; a syringe assembly (22; 47) for aspirating or dispensing a preselected volume of liquid; a transporter (34) adapted to releasably engage the syringe and to position the syringe at a selected one of the stations; and a controller (35) to direct the transporter from one station to another; and wherein the syringe is
30 operable independently of the location of the transporter.

22. A device according to claim 21, wherein the plurality of stations include a wash station, a processing station, or a station for supplying liquid reagents, or a station for accepting a supplied amount of liquid reagents.

5 23. A device according to claim 21, wherein each station includes a signal generator to generate an in-place signal indicating the arrival and positioning of a frame in the station, and the syringe is operated in response to the in-place signal.

10 24. A device according to claim 21, wherein a task-complete signal is generated when the syringe completes a task, and the controller includes a queue of task complete signals for processing.

15 25. An analytical system comprising a plurality of stations (24, 25, 26), a plurality of self-contained syringes (47) each including a dedicated metering device for independent aspiration and/or dispensing of an agent, and a transport mechanism (34) for transporting the movable devices from station to station.

20 26. An analytical system comprising a plurality of movable devices (22) for use in performing one or more operations in an analytical procedure, a plurality of stations (24, 25, 26) at which an analytical procedure is performed, a transport mechanism (34) for transporting the movable devices from station to station, and a controller (35) for directing the transport mechanism to retrieve one or more of the movable devices from a station in response to a request
25 corresponding to completion of the prescribed operation by a movable device or devices at such station.

27. A method comprising the steps of providing a plurality of movable devices (22) for performing one or more operations at respective stations (24,
30 25, 26) each having associated therewith a receiver (27, 28, 29) for receiving one or more of the movable devices so that a prescribed operation can be commenced at the respective station, and transporting the movable devices

from station to station, wherein the transporting step includes directing the transport mechanism (34) to leave at least one of the movable devices with the receiver in a first one of the stations thereby to free the transport mechanism for transport of at least one other movable device between stations while the
5 movable device or devices left at the first station are used to perform a prescribed operation at the first station.

28. A method according to claim 27, wherein the movable devices include one or more sampling probes (47) for aspirating and/or dispensing an
10 agent.

29. A method according to claim 28, at least some of the sampling probes are connected to a stationary system (42) by a tether (43) through which the agent is supplied to the sampling probe.
15

30. A method according to claim 27, wherein at least some of the sampling probes are not tethered to any stationary component of the system.

31. A method according to claim 30, wherein the sampling probe
20 includes a plunger (56) and a motive device (57) for moving the plunger in response to a command signal.

32. A method according to claim 27, wherein the movable devices communicate with a transport controller.
25

33. A method according to claim 27, wherein the transport mechanism is controlled in response to requests corresponding to completion of the prescribed operation by a movable device or devices.

34. A method according to claim 27, each movable device is uniquely
30 identified for independent control by a controller.

35. A method according to claim 27, wherein the prescribed operation includes one or more of sample reformatting, sample injection, reagent addition or dilution.

5 36. A method comprising the steps of using a plurality of movable devices (22) to perform one or more operations in an analytical procedure at respective stations (24, 25, 26), a transport mechanism (34) for transporting the movable devices from station to station, and a controller (35) for directing the transport mechanism to retrieve one or more of the movable devices from a
10 station in response to a request corresponding to completion of the prescribed operation by a movable device or devices at such station.

 37. A method by which movable devices can be shared among two or more clusters in similar or different configurations all of which contain stations
15 and receivers capable of interacting with and utilizing the movable devices.

 38. A method according to claim 37, wherein the movable device carries with it the set of operations it is to perform on the various clusters

20 39. A method according to claim 37, wherein the set of operations a movable device is to use on the several clusters is broadcast to the respective clusters via an enterprise wide control software package using a network or other functionally equivalent means.

25 40. An analytical system comprising one or more autonomous movable devices (22) for use in performing one or more operations in an analytical procedure, one or more stations (24, 25, 26) at which an analytical operation is performed, and one or more transport mechanisms (34) for transporting the movable devices from station to station, wherein at least one of
30 the autonomous movable devices is configured to receive and store a workflow including one or more operations to be performed by or on the movable device,

and further to execute their workflow and generate system events whenever movable device needs assistance performing an operation.

41. An analytical system according to claim 40, wherein a
5 communication link is effected wirelessly between the autonomous movable device and a stationary system component.

42. An analytical system according to claim 40, wherein a
communication link is temporarily effected between the autonomous movable
10 device and an interface associated with a receiver at a station when the autonomous movable device is received by the receiver.

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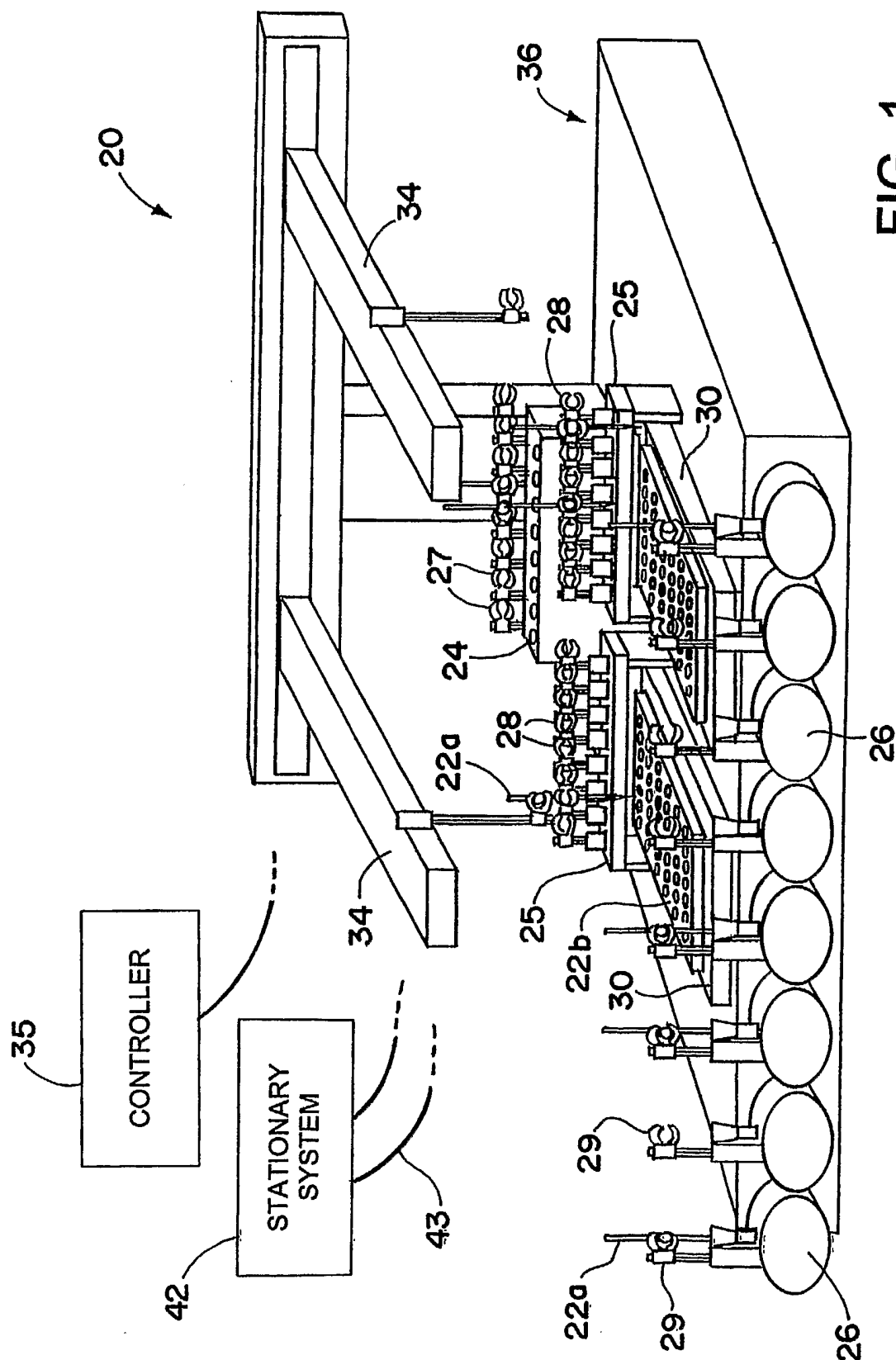


FIG. 1

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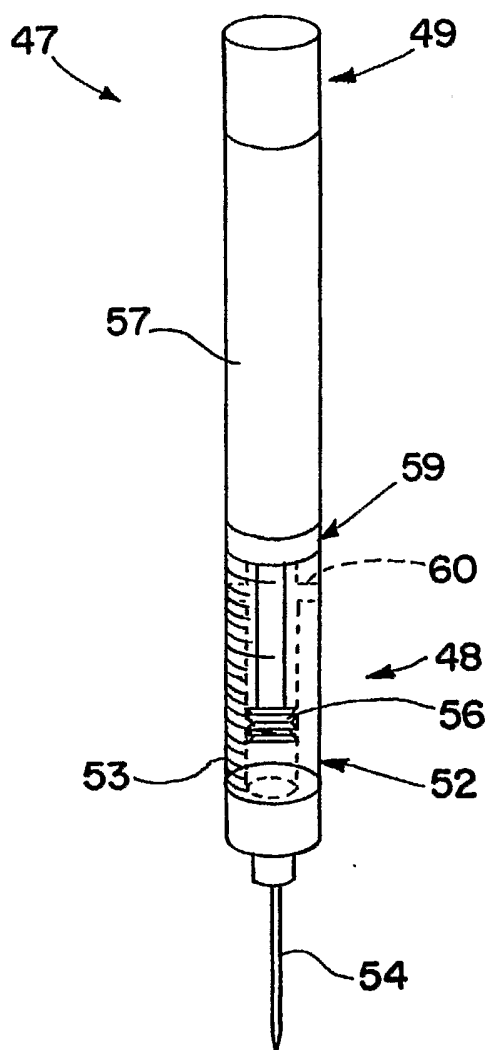
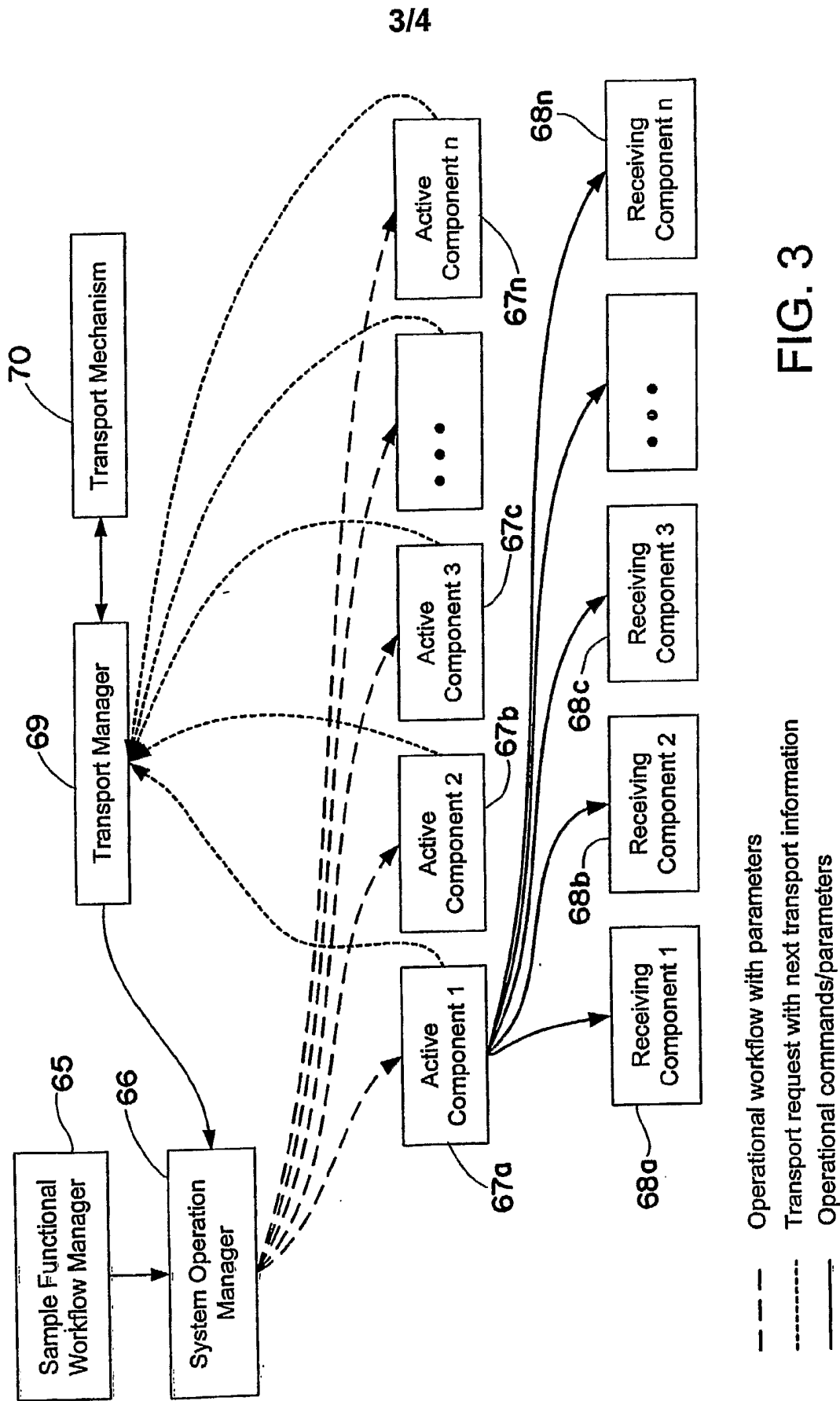


FIG. 2



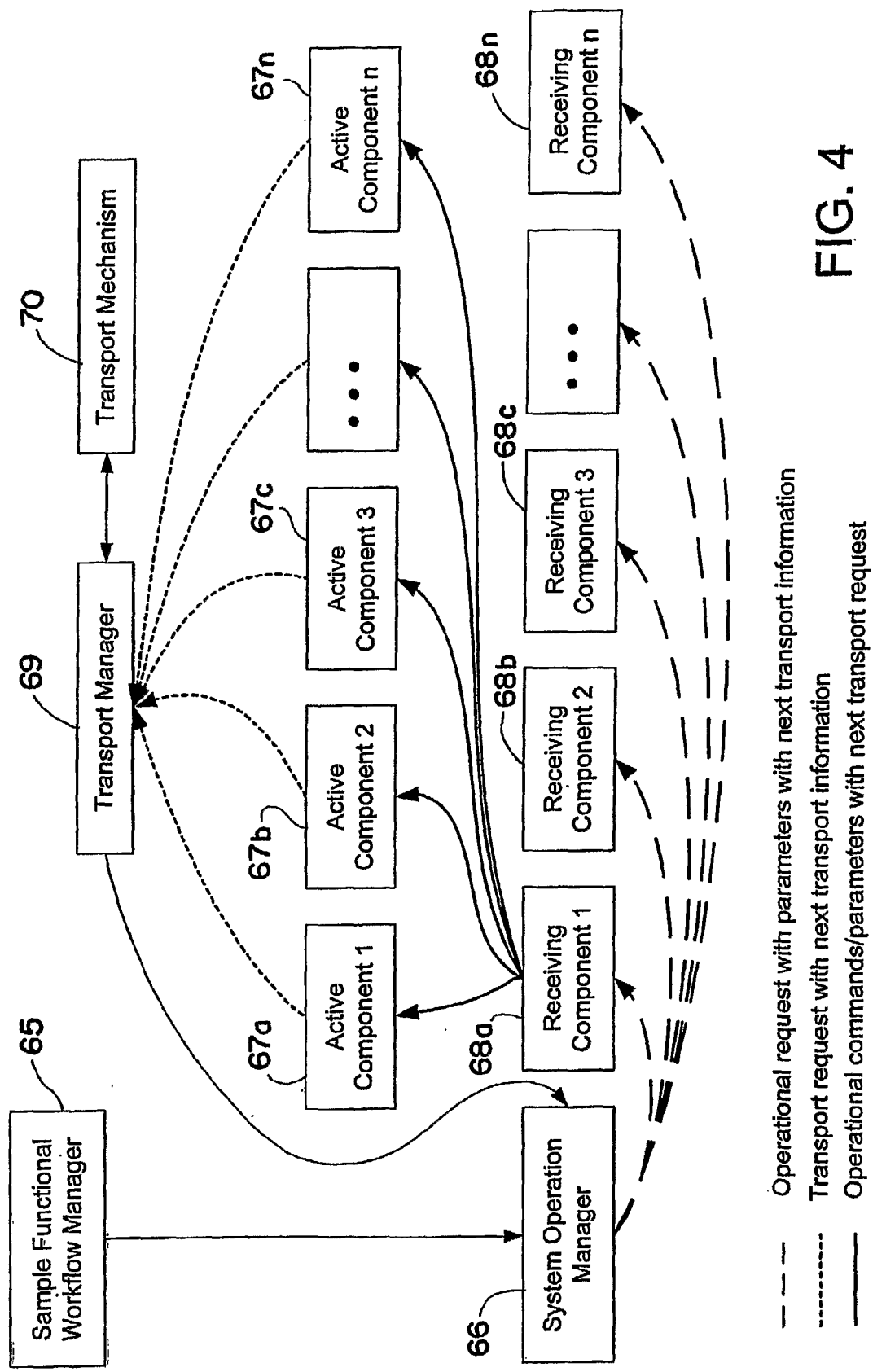


FIG. 4

INTERNATIONAL SEARCH REPORT

PCT/US2005/020732

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N35/00 G01N35/10

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

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

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

EPO-Internal, WPI Data, INSPEC, COMPENDEX, BIOSIS, EMBASE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/019845 A1 (BIENERT KLAUS ET AL) 6 September 2001 (2001-09-06) paragraph '0022! - paragraph '0042! figures 1a-7d	1-42
A	US 2004/022680 A1 (GUELLER ROLF ET AL) 5 February 2004 (2004-02-05) figures 1-10	1-42
A	US 5 897 837 A (MIZUNO ET AL) 27 April 1999 (1999-04-27) the whole document	1-42
A	DE 38 05 808 A1 (EUROPAEISCHES LABORATORIUM FUER MOLEKULARBIOLOGIE , 6900 HEIDELBERG, D) 7 September 1989 (1989-09-07) the whole document	1-42
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

15 September 2005

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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