



- (51) **International Patent Classification:**
E21B 47/00 (2012.01) E02D 1/00 (2006.01)
E21B 49/02 (2006.01)
- (21) **International Application Number:**
PCT/US2014/038157
- (22) **International Filing Date:**
15 May 2014 (15.05.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/823,700 15 May 2013 (15.05.2013) US
- (71) **Applicant: M-I L.L.C.** [US/US]; 5950 North Course Drive, Houston, Texas 77072 (US).
- (72) **Inventors: ZAMORA, Mario;** 18314 Spellbrook Drive, Houston, Texas 77084 (US). **BARANOWSKI, Marian;** 5951 Lattimer Dr., Houston, Texas 77035 (US). **ROY, Sanjit;** 5950 North Course Drive, Houston, Texas 77072 (US).
- (74) **Agents: TRAN, Andrea E.** et al.; 10001 Richmond Avenue, IP Administration Center of Excellence, Room 4720, Houston, Texas 77042 (US).
- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, 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).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** INTERACTIVE MUD ENGINEERING SIMULATION

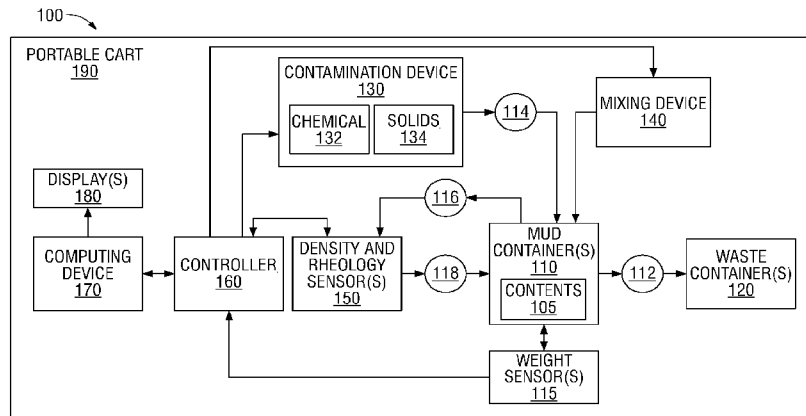


FIG. 1

(57) **Abstract:** A system disclosed includes a receiving container to receive contents including at least one of a drilling fluid and a contaminant. The system also includes a sensing device configured to receive at least one of a weight, a density and a rheologic property of the contents. The system may further include a controller configured to determine at least one measurement associated with the at least one of the weight, the density, and the rheologic property of the contents. Further, the system may include a computing device in communication with the controller, wherein the computing device executes an instruction to determine a performance parameter based on the at least one measurement.

WO 2014/186554 A1

INTERACTIVE MUD ENGINEERING SIMULATION

BACKGROUND

[0001] This application claims the benefit of U.S. Provisional Application No. 61/823,700 filed on May 15, 2013, which is incorporated by reference herein in its entirety.

[0002] The present disclosure contemplates that time spent in a training lab is considered by many to be among the most practical and enjoyable part of any training. For example, in drilling environments, mud engineering schools conducted for training fluids engineers, clients, and suppliers are extremely useful. Especially thought-provoking is the challenge to detect and properly correct for unknown contaminants injected into a mud sample by an administrator or instructor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The foregoing and other features of the present disclosure will become more fully apparent from the following description, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings.

[0004] FIG. 1 is a schematic representation of an example interactive mud engineering simulator;

[0005] FIG. 2 is a schematic representation of another example interactive mud engineering simulator in accordance with embodiments of the present disclosure;

[0006] FIG. 3 is a perspective view of the example interactive mud engineering simulator of FIG. 2;

[0007] FIGS. 4 and 5 are front views of the example interactive mud engineering simulator of FIG. 2;

[0008] FIGS. 6 and 7 are rear views of the example interactive mud engineering simulator of FIG. 2;

[0009] FIGS. 8 and 9 are right side views of the example interactive mud engineering simulator of FIG. 2;

[0010] FIGS. 10 and 11 are left side views of the example interactive mud engineering simulator of FIG. 2;

[0011] FIG. 12 is a schematic representation of yet another example interactive mud engineering simulator;

[0012] FIGS. 13 and 14 are example screenshots of another example interactive mud engineering simulator;

[0013] FIG. 15 is a perspective view of an example density and rheology sensor of an example interactive mud engineering simulator;

[0014] FIG. 16 is a top view of example contamination devices of an example interactive mud engineering simulator; and

[0015] FIG. 17 is a perspective view of an example mud container and example mixing device of an example interactive mud engineering simulator; all arranged in accordance with at least some of the embodiments disclosed in the present disclosure.

SUMMARY

[0016] One aspect of the present disclosure provides a system including a receiving container to receive contents including at least one of a drilling fluid and a contaminant. The system also includes a sensing device configured to receive at least one of a weight, a density and a rheologic property of the contents. The system further includes a controller configured to determine at least one measurement associated with the at least one of the weight, the density, and the rheologic property of the contents. Further, the system includes a computing device in communication with the controller, wherein the computing device executes an instruction to determine a performance parameter based on the at least one measurement.

[0017] Another aspect of the present disclosure provides a method including determining, by a computing device, a performance parameter based on at least one of a weight of contents of a receiving container, a density of the contents of the receiving container, and a rheologic property of the contents of the receiving container. The method further includes receiving, by the computing device, an instruction to alter a drilling parameter associated with the contents of the receiving container based on the performance parameter, and controlling a controller to alter at least one of the drilling parameter and the contents of the receiving container. The method further includes calculating, by the computing device, an updated performance parameter based on an updated weight of the contents of the receiving container, an updated density of the contents of the receiving container, and an updated rheologic property of the contents of the receiving container.

DETAILED DESCRIPTION

[0018] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described herein are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, may be arranged, substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and make part of this disclosure.

[0019] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, components, and/or groups, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0020] When an element is referred to as being "on," "engaged to," "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0021] This disclosure is generally drawn to systems, devices, apparatus, and/or methods related to simulating drilling site environments. Specifically, the disclosed systems, devices, apparatus, and/or methods relate to simulating drilling site environments with actual real world drilling fluids and contaminants, allowing users to learn and test mud engineering skills in a simulated environment. As used herein, drilling fluids and/or muds may also refer generally to oilfield fluids such as completion fluids, workout fluids, and the like.

[0022] Example simulators in accordance with at least some embodiments of the present disclosure may combine high-fidelity drilling simulation and actual drilling fluids under real-time control by humans-in-the-loop (HITL). This may be a highly effective training technique that promotes total immersion into a complex process requiring high levels of technical, cognitive, and relationship skills.

[0023] FIG. 1 is a schematic representation of an example interactive mud engineering simulator 100, in accordance with at least some embodiments of the present disclosure. Interactive mud engineering simulator 100 may include a receiving container 110 (i.e., simulated mud pit, mud container), a weight sensor 115, a waste

container 120 (i.e., simulated waste pit), a contamination device 130, a mixing device 140, a sensing device 150, a controller 160, a computing device 170, and/or display(s) 180. Interactive mud engineering simulator 100 may be portable, such as being integrated with or installed on a portable cart 190.

[0024] Receiving container 110 may simulate a mud pit that is typically present in real world drilling environments. In some examples, receiving container 110 may be a 3-6 gallon container for receiving contents 105 including drilling fluid (i.e., mud), contaminants, and/or other components. Receiving container 110 may be coupled to waste container 120 via hoses and/or pumps 112.

[0025] Weight sensor 115 (e.g., scale) may measure the weight of contents 105 of receiving container 110. Weight sensor 115 may also determine the volume of contents 105 in receiving container 110.

[0026] Waste container 120 may simulate a waste pit that is typically present in real world drilling environments. In some examples, waste container 120 may be a 3-6 gallon container for receiving a portion of contents 105 of receiving container 110. In some examples, a portion of contents 105 of receiving container 110 may be automatically transferred from receiving container 110 into waste container 120 as a training exercise and/or as a penalty for improper or inappropriate actions by users of interactive mud engineering simulator 100. In this manner, interactive mud engineering simulator 100 may enable the users to react under time constraints similar to those encountered in a real world drilling environment.

[0027] Contamination device 130 may store and disperse contaminants 132, 134 into receiving container 110. Contamination device 130 may be coupled to receiving

container 110 via hoses and/or pumps 114. Contaminants may include chemical contaminants 132 (e.g., Na⁺, Ca⁺⁺ brines) and/or solids contaminants 134 (e.g., drill solids, cuttings, Rev Dust). Dispersement of solids contaminants 134 may be assisted via an auger within contamination device 130. Contaminants 132, 134 stored in contamination device 130 may include known contaminants that may be encountered in real world drilling environments. In some examples, exercises with chemical contaminants 132 may enable users to recognize the impact on drilling and mud, find the chemical contaminants 132, and treat contents 105 accordingly. In some examples, exercises with solids contaminants 134 may enable users to control one or more rheologic properties to minimize excessive equivalent circulating density (ECD).

[0028] Mixing device 140 may agitate and/or mix contents 105 in mud container 110. Mixing device 130 may mix contaminants 132, 134 from contamination device 130 into contents 105 of mud container 110. In some examples, mixing device 140 may include a dispersator, such as a 10,000-rpm dispersator, to ensure high shear levels for proper mixing of the contents 105 and additives (e.g., contaminants 132, 134).

[0029] Sensing device(s) 150 may determine the density and/or rheologic properties of contents 105. In some examples, sensing device(s) 150 may include an automated density and rheology system based on a Marsh funnel and laboratory balance. Other known density and/or rheologic property sensors 150 may also be utilized. In some examples, density and/or rheologic properties may be automatically measured, but this information may not be shared with the users during a training exercise. Sensing device(s) 150 may be housed in a sensing container separate from receiving container 110. Sensing device(s) 150 may be coupled to receiving container

110 via hoses and/or pumps 116, 118 to transfer a portion of contents 105 to sensing device(s) 150 from receiving container 110 and back, respectively.

[0030] Controller 160 may receive data from weight sensor 115 and/or sensing device(s) 150. Controller 160 may also control the operation of contamination device 130 and/or mixing device 140. Controller 160 may be programmed to automatically (i.e., without user input) control the operation of contamination device 130 and/or mixing device 140. In some examples, controller 160 may be manually operated (e.g., by users, by administrators) to control the operation of contamination device 130 and/or mixing device 140. Controller 160 may be configured to operate contamination device 130 and/or mixing device 140 on a scheduled basis, a periodic basis, a conditional basis, and/or on demand.

[0031] Controller 160 may also include control drilling parameters (e.g., pump speed, weight-on-bit, rotary speed, trip rate, brake) and alarms. Drilling parameters may be displayed and/or plotted on display 180 (e.g., graphical engineering monitoring screen). Controller 160 may also interact with computing device 170 to generate a graphical summary of the simulation.

[0032] Controller 160 may be in electrical communication with computing device 170 such that controller 160 alters the operation of contamination device 130 and/or mixing device 140 based, at least in part, on instructions from computing device 170.

[0033] Computing device 170 may be in electrical communication with controller 160 and display(s) 180. Software may be stored on the computing device 170 to interface with controller 160. Computing device 170 may be executing one or more software applications to monitor and control interactive mud engineering simulator 100,

and/or simulate and predict how a real world drilling environment would operate based on user input, drilling parameters, performance parameters, and simulated environment, among other factors. In some examples, computing device 170 may include a laptop computer executing a version of M-I SWACO®'s PressPro RT® (PPRT) real-time hydraulics software and/or a version of NAVIGATOR® interactive 3D visualization of a drilling wellbore. In some examples, computing device 170 may output information to display(s) 180. For example, computing device 170 may project on display(s) 180 a real-time hydraulics software interface, measuring and predicting values of interactive mud engineering simulator 100, a NAVIGATOR® interactive 3D visualization. Engineering models may be stored on computing device 170 to predict drilling performance. During simulation, computing device 170 may also output sound effects to simulate sounds that may be present in real-world drilling environments.

[0034] During and after simulations, NAVIGATOR® and PPRT may monitor, predict, and/or display many drilling parameters, performance parameters, and/or other information, including, for example:

Controls: flow rate, weight of blend (WOB), rotary speed, trip rate

Meters: rate of penetration (ROP), pump pressure

Charts: flow and drilling parameters, ROP and block position, PVT, PWD

Schematics: block position, well + casing program

Other: drilling and documentation (may be customizable)

[0035] Example pumps 112, 114, 116, 118 may include peristaltic pumps for transferring contents 105 and/or contaminants 132, 134 through interactive mud

engineering simulator 100. In some examples, other known pumps may be utilized to effectuate such transfer.

[0036] Some examples may simulate conditions and activities that can occur on an active drilling site. A team of users can be challenged over a several-hour period to continually respond to conditions and issues encountered while drilling a predefined interval in a well. Users may measure, monitor, diagnose, and treat physical and chemical properties of the drilling fluid to maximize drilling performance, mitigate drilling problems, and achieve optimum fluid performance and costs. Users may physically control drilling parameters, including WOB, revolutions per minute (RPM), ROP, connections, and tripping depending on well conditions. PPRT may simulate drilling conditions and may display a simulated rendering of the wellbore during the exercise. Chemical contaminants covertly injected on demand by the software may warrant proper diagnosis and treatment with additives or the like.

[0037] Inability to maintain proper mud density may result in wellbore collapse or lost circulation, the latter of which will instruct the software to discharge mud into the waste container and request the students to mix new volume. Improper balance among drilling parameters and mud properties for given conditions may result in problems related to hole cleaning, barite sag, stuck pipe and others. Overall performance may be based on performance indicators including footage drilled, drilling problems encountered, and costs of additives.

[0038] In some examples, during a simulation exercise, a team of users may control drilling parameter(s) and independently analyze, pilot test, and/or treat water-based mud as if they were on location at a real-world drilling environment.

[0039] Some simulation processes may run autonomously in the background (i.e., automatically, without user input), while others are manually controlled by the users. The PPRT software may use input values from these processes to conduct and display real-time predictions of downhole conditions.

[0040] Inappropriate actions and responses from the users may result in penalties, including lost circulation which may automatically transfer some or all contents 105 from mud container 110 into waste container 120, and may subject the team to react under time constraints similar to those encountered in the field. Additional realism may be provided by low-gravity solids 134 (e.g., Rev Dust) added proportionately during drilling phases. Chemical contaminants 132 may be incorporated at random and/or on demand when entering certain simulated underground formations. The users may be asked to determine the type of contaminant and treat the contents 105 appropriately in a timely manner.

[0041] In some examples, maintaining a focus on exercise objectives, for example, may work when using a “standard” set up with a few variations to inject a bit of uncertainty. This may make it possible to compare performances, evaluate skills and competencies, and identify issues among several teams of users.

[0042] In some examples, simulated footage amount drilled during a given time frame may be a very good metric for evaluation performance, maximized by optimizing operations and minimizing lost-time incidents. The cost to build and maintain the simulated drilling environment during the training exercise may also serve as a performance indicator.

[0043] Some example interactive mud engineering simulation exercises may be team efforts where ultimate success depends on how well teams organize, plan, interact, measure and interpret data, and respond to changing simulated conditions. Prior to the start of a training exercise, teams may be given time to prepare, determine responsibilities, and develop contingencies based on a detailed well plan. The users also use this time to become familiar with the equipment and process, and to mix the base contents (i.e., base mud system).

[0044] Group dynamics may be maximized if users are selected from different industry sectors (e.g., operators, drilling contractors, suppliers, companies) with varied experience and expertise levels. A 6-person team of users, for example, may function in various roles, including a company man, a driller, a procurer, a roustabout, and mud physical and chemical properties testers.

[0045] In some examples, the team may determine an appropriate balance among drilling and mud parameters to maximize drilling performance without exceeding the boundaries defined by the simulated well conditions. For example, density, hydraulics, hole cleaning, wellbore stability, equivalent static density (ESD), and ECD may be of particular interest.

[0046] The PPRT software may monitor, model, predict, and visualize the downhole environment as if it were a real well. Thus, any errors by the team involving measurements, mud treatment, or drilling parameters may be recognized and properly dealt with. The environment is such that teams feel much of the same time constraints and pressures as would be encountered in the field during difficult situations.

[0047] An example simulation exercise may be broken down into a preparation period, an execution period, and an evaluation period.

[0048] During a preparation period, users may study a well plan and mud program. Users may also familiarize themselves with the system, equipment, and overall exercise, and mix the base contents 105 (i.e., base mud). Users may also establish group responsibilities and dynamics.

[0049] During an execution period, users may drill interval, balance drilling and mud parameters for optimum performance, and/or respond to drilling environment and uncertainties. Users may also review and print performance screens and/or reports. Further, users may conduct review, including overall performance, group interactions, and lessons learned, for example. Users may also quantify their performance, including footage drilled and total mud cost, for example.

[0050] FIG. 2 is a detailed schematic representation of another example interactive mud engineering simulator 200, in accordance with at least some embodiments of the present disclosure. FIG. 2 includes a more detailed example of FIG. 1, in that specific devices are identified. For example, FIG. 2 includes a dispersator for a mixing device, Rev Dust for solids contaminants, and an M-I SWACO® driller's console for a controller.

[0051] FIG. 3 is a perspective view of an example interactive mud engineering simulator 300, in accordance with some embodiments of the present disclosure. For example, displays 380, controller 360, and contamination device 330 are shown installed on a portable cart 390. Displays 380 are displaying a NAVIGATOR®

interactive 3D visualization of a drilling wellbore on an upper screen and PPRT real-time hydraulics software on a lower screen.

[0052] FIGS. 4 and 5 are front views of an example interactive mud engineering simulator 400, 500, in accordance with at least some embodiments of the present disclosure. FIG. 4 and FIG. 5 may depict the same interactive mud engineering simulator. FIG. 4 depicts interactive mud engineering simulator 400 with concealment shades (not shown) opened. FIG. 5 depicts interactive mud engineering simulator 500 with concealment shades 595 closed. As shown in FIGS. 4 and 5, example interactive mud engineering simulators 400, 500 may include displays 480, 580, mixing device 440, 540, controller 460, 560, and computing device 470, 570 installed on portable cart 490, 590, respectively. Displays 480, 580 are displaying a NAVIGATOR® interactive 3D visualization of a drilling wellbore on an upper screen and PPRT real-time hydraulics software on a lower screen.

[0053] FIGS. 6 and 7 are rear views of an example interactive mud engineering simulator 600, 700, in accordance with at least some embodiments of the present disclosure. FIG. 6 and FIG. 7 depict the same interactive mud engineering simulator. FIG. 6 depicts interactive mud engineering simulator 600 with concealment shades (not shown) opened. FIG. 7 depicts interactive mud engineering simulator 700 with concealment shades 795 closed. As shown in FIGS 6 and 7, example interactive mud engineering simulators 600, 700 may include displays 680, 780, mixing device 640, 740, contamination device 630, mud container 610, container including sensing device(s) 650, and/or pumps 612, 614 installed on portable cart 690, 790, respectively.

[0054] FIGS. 8 and 9 are right side views of an example interactive mud engineering simulator 800, 900, in accordance with at least some embodiments of the present disclosure. FIG. 8 and FIG. 9 may depict the same interactive mud engineering simulator. FIG. 8 depicts interactive mud engineering simulator 800 with concealment shades (not shown) opened. FIG. 9 depicts interactive mud engineering simulator 900 with concealment shades 995 closed. As shown in FIGS 8 and 9, example interactive mud engineering simulators 800, 900 may include displays 880, 980, controller 860, 960, computing device 870, 970, mixing device 840, 940, contamination device 830, 930, mud container 810, waste container 820, and/or container including sensing device(s) 850, installed on portable cart 890, 990, respectively.

[0055] FIGS. 10 and 11 are right side views of an example interactive mud engineering simulator 1000, 1100, in accordance with at least some embodiments of the present disclosure. FIG. 10 and FIG. 11 may depict the same interactive mud engineering simulator. FIG. 10 depicts interactive mud engineering simulator 1000 with concealment shades (not shown) opened. FIG. 11 depicts interactive mud engineering simulator 1100 with concealment shades 1195 closed. As shown in FIGS 10 and 11, example interactive mud engineering simulators 1000, 1100 may include displays 1080, 1180, controller 1060, 1160, computing device 1070, 1170, mixing device 1040, 1140, contamination device 1030, 1130, pumps 1012, 1014, 1016, 1018, and/or container including sensing device(s) 1050, installed on portable cart 1090, 1190, respectively.

[0056] FIG. 12 is another detailed schematic representation of yet another example interactive mud engineering simulator, in accordance with at least some

embodiments of the present disclosure. This example includes specific components and model numbers for use in some embodiments.

[0057] FIGS. 13 and 14 are example screenshots of another example interactive mud engineering simulator, in accordance with at least some embodiments of the present disclosure. FIG. 13 shows an example screenshot of a NAVIGATOR® interactive 3D visualization of a drilling wellbore, while FIG. 14 shows an example screenshot of PPRT real-time hydraulics software. These are example screenshots that may be viewed by users during a training exercise.

[0058] FIGS. 15-17 depict various components of example interactive mud engineering simulators, in accordance with at least some embodiments of the present disclosure.

[0059] FIG. 15 is a perspective view of an example density and rheology sensor 1550 of an example interactive mud engineering simulator.

[0060] FIG. 16 is a top view of example contamination device 1630 of an example interactive mud engineering simulator. Contamination device 1630 includes chemical contaminants 1632 and solids contaminants 1634 that may be dispersed via pump(s) 1614.

[0061] FIG. 17 is a perspective view of an example mud container 1710 and example mixing device 1740 of an example interactive mud engineering simulator. Contents 1705 of mud container 1710 may be mixed and/or agitated by mixing device 1740.

[0062] In some examples, computing device may include a controller and/or a computer, the computer including a processing unit, a system memory and a system

bus. The system bus may couple system components including, but not limited to, the system memory to the processing unit. The processing unit may be any of various commercially available processors. Dual microprocessors and other multi-processor architectures may also be employed as the processing unit.

[0063] The system bus may be any of several types of bus structure that may further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory includes read only memory (ROM) and random access memory (RAM). A basic input/output system (BIOS) may be stored in a non-volatile memory such as ROM, EPROM, EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer, such as during start-up. The RAM may also include a high-speed RAM such as static RAM for caching data.

[0064] The computing device may further include an internal hard disk drive (HDD) (e.g., EIDE, SATA), which may also be configured for external use in a suitable chassis (not shown), a magnetic floppy disk drive (FDD), (e.g., to read from or write to a removable diskette) and an optical disk drive, (e.g., reading a CD-ROM disk or, to read from or write to other high capacity optical media such as the DVD). The hard disk drive, magnetic disk drive and optical disk drive may be connected to the system bus by a hard disk drive interface, a magnetic disk drive interface and an optical drive interface, respectively. The interface for external drive implementations includes at least one or both of Universal Serial Bus (USB) and IEEE 1394 interface technologies.

[0065] The drives and associated computer-readable media (e.g., machine-readable media) may provide nonvolatile storage of data, data structures, computer-

executable instructions, and the like. For the computer, the drives and media may accommodate the storage of any data in a suitable digital format. Although the description of computer-readable media above may refer to a HDD, a removable magnetic diskette, and/or a removable optical media such as a CD or DVD, it should be appreciated by those skilled in the art that other types of media which are readable by a computing device or computer, such as zip drives, magnetic cassettes, flash memory cards, cartridges, and the like, may also be used in the operating environment, and further, that any such media may contain computer-executable instructions for performing the methods of an example system, such as the interactive mud engineering simulator disclosed herein.

[0066] A number of program modules may be stored in the drives and RAM, including an operating system, one or more application programs, other program modules and program data. All or portions of the operating system, applications, modules, and/or data may also be cached in the RAM. It is appreciated that an example system may be implemented with various commercially available operating systems or combinations of operating systems.

[0067] A user may enter commands and information into the computing device through one or more wired/wireless input devices, e.g., a keyboard and a pointing device, such as a mouse. Other input devices (not shown) may include a microphone, an IR remote control, a joystick, a game pad, a stylus pen, touch screen, or the like. These and other input devices are often coupled to the processing unit through an input device interface that is coupled to the system bus, but may be connected by other

interfaces, such as a parallel port, an IEEE 1394 serial port, a game port, a USB port, an IR interface, etc.

[0068] A monitor or other type of display device may also be coupled to the system bus via an interface, such as a video adapter. In addition to the monitor, a computing device typically includes other peripheral output devices (not shown), such as speakers, printers, etc.

[0069] The computing device may operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s). The remote computer(s) may be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically includes many or all of the elements described relative to the computer, although, for purposes of brevity, only a memory storage device is illustrated. The logical connections depicted include wired/wireless connectivity to a local area network (LAN) and/or larger networks, e.g., a wide area network (WAN). Such LAN and WAN networking environments are commonplace in offices, and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which may connect to a global communication network, e.g., the Internet.

[0070] When used in a LAN networking environment, the computer may be connected to the local network through a wired and/or wireless communication network interface or adapter. The adaptor may facilitate wired or wireless communication to the LAN, which may also include a wireless access point disposed thereon for communicating with the wireless adaptor.

[0071] When used in a WAN networking environment, the computer may include a modem, or is connected to a communications server on the WAN, or has other means for establishing communications over the WAN, such as by way of the Internet. The modem, which may be internal or external and a wired or wireless device, may be coupled to the system bus via the serial port interface. In a networked environment, program modules depicted relative to the computer, or portions thereof, may be stored in the remote memory/storage device. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers may be used.

[0072] The computer may be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This includes at least Wi-Fi and Bluetooth[®] wireless technologies. Thus, the communication may be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

[0073] Wi-Fi, or Wireless Fidelity, allows connection to the Internet virtually without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE 802.11 (a, b, g, n, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network may be used to connect computers to each other, to the

Internet, and to wired networks (which use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, at an 11 Mbps (802.11a) or 54 Mbps (802.11b) data rate, for example, or with products that contain both bands (dual band), so the networks may provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

[0074] Systems and methods disclosed herein may provide for a unitized, active learning system for training in areas of mud and/or drilling fluid engineering, as well as evaluating competency of operators in such areas. To this end, disclosed systems and methods may be utilized in a laboratory setting to simulate conditions which may occur on an active drilling site. Physical and chemical properties of drilling fluid may be measured, monitored, and/or diagnosed to maximize drilling performance, mitigate drilling problems, and achieve optimum fluid performance and costs.

[0075] Although the preceding description has been described herein with reference to particular means, materials, and embodiments, it is not intended to be limited to the particulars disclosed herein; rather, it extends to all functionally equivalent structures, methods, and uses, such as are within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A system comprising:

a receiving container to receive contents including at least one of a drilling fluid and a contaminant;

a sensing device configured to receive at least one of a weight, a density and a rheologic property of the contents;

a controller configured to determine at least one measurement associated with the at least one of the weight, the density, and the rheologic property of the contents;

and

a computing device in communication with the controller, wherein the computing device executes an instruction to determine a performance parameter based on the at least one measurement.

2. The system of claim 1 further comprising:

a display in communication with the computing device, wherein the display generates a rendering associated with at least one of the performance parameter, the weight, the density, and the rheologic property of the contents.

3. The system of claim 1, wherein the computing device controls the controller.

4. The system of claim 3, wherein the computing device controls the controller in response to an external event.
5. The system of claim 4, wherein the external event comprises at least one of:
 - an increase in a volume of the contents in the receiving container;
 - a removal of a portion of the contents from the receiving container; and
 - a transfer of the portion of the contents from the receiving container to a waste container.
6. The system of claim 1 further comprising at least one of:
 - a contamination device configured to disperse the contaminant within the receiving container;
 - a mixing device configured to mix the contents in the receiving container; and
 - a weight sensor configured to determine the weight of the contents.
7. The system of claim 1, wherein the controller is configured to perform at least one of:
 - causing the contamination device to disperse the contaminant;
 - causing the mixing device to mix the contents in the receiving container;
 - receiving the weight from the weight sensor; and
 - receiving at least one measurement associated with at least one of the weight, the density, and the rheologic property of the contents.

8. The system of claim 1, further comprising at least one pump configured to transfer the contents between at least one of:
- the contamination device and the receiving container;
 - the receiving container and a waste container; and
 - the receiving container and the sensing device.
9. The system of claim 1, wherein the at least one contaminant comprises at least one of a chemical contaminant and a solid contaminant.
10. A method comprising:
- determining, by a computing device, a performance parameter based on at least one of a weight of contents of a receiving container, a density of the contents of the receiving container, and a rheologic property of the contents of the receiving container;
 - receiving, by the computing device, an instruction to alter a drilling parameter associated with the contents of the receiving container based on the performance parameter;
 - controlling a controller to alter at least one of the drilling parameter and the contents of the receiving container; and
 - calculating, by the computing device, an updated performance parameter based on an updated weight of the contents of the receiving container, an updated density of the contents of the receiving container, and an updated rheologic property of the contents of the receiving container.

11. The method of claim 10 comprising:

displaying, by a computing device, a rendering associated with at least one of the performance parameter, the weight, the density, the rheologic property, and a drilling parameter associated with the contents of the receiving container.

12. The method of claim 10 further comprising:

sensing at least one of a weight, a density, and a rheologic property of the contents of the receiving container; and

determining at least one measurement associated with the at least one of the weight, the density, and the rheologic property of the contents of the receiving container.

13. The method of claim 10, wherein controlling a controller to alter at least one of the drilling parameter and the contents of the receiving container is in response to at least one of:

an increase in a volume of contents in the receiving container;

a removal of a portion of the contents from the receiving container; and

a transfer of the portion of the contents from the receiving container to a waste container.

14. The method of claim 13 further comprising:

transferring, by a pump, contents between the receiving container and the waste container.

15. The method of claim 10, wherein the controller causes a contaminant to be dispersed within the receiving container.
16. The method of claim 10, wherein the controller causes the mixing of the contents in the receiving container.
17. The method of claim 10, wherein the controller receives the weight of contents of the receiving container.
18. The method of claim 10, wherein the controller receives at least one measurement associated with at least one of the weight, the density, and the rheologic property of the contents of the receiving container.
19. The method of claim 10 further comprising:
transferring, by a pump, contents between the receiving container and a sensing device.
20. The method of claim 10, wherein the drilling parameter comprises at least one of a pump speed, a weight-on-bit, a rotary speed, a trip rate, and a brake.

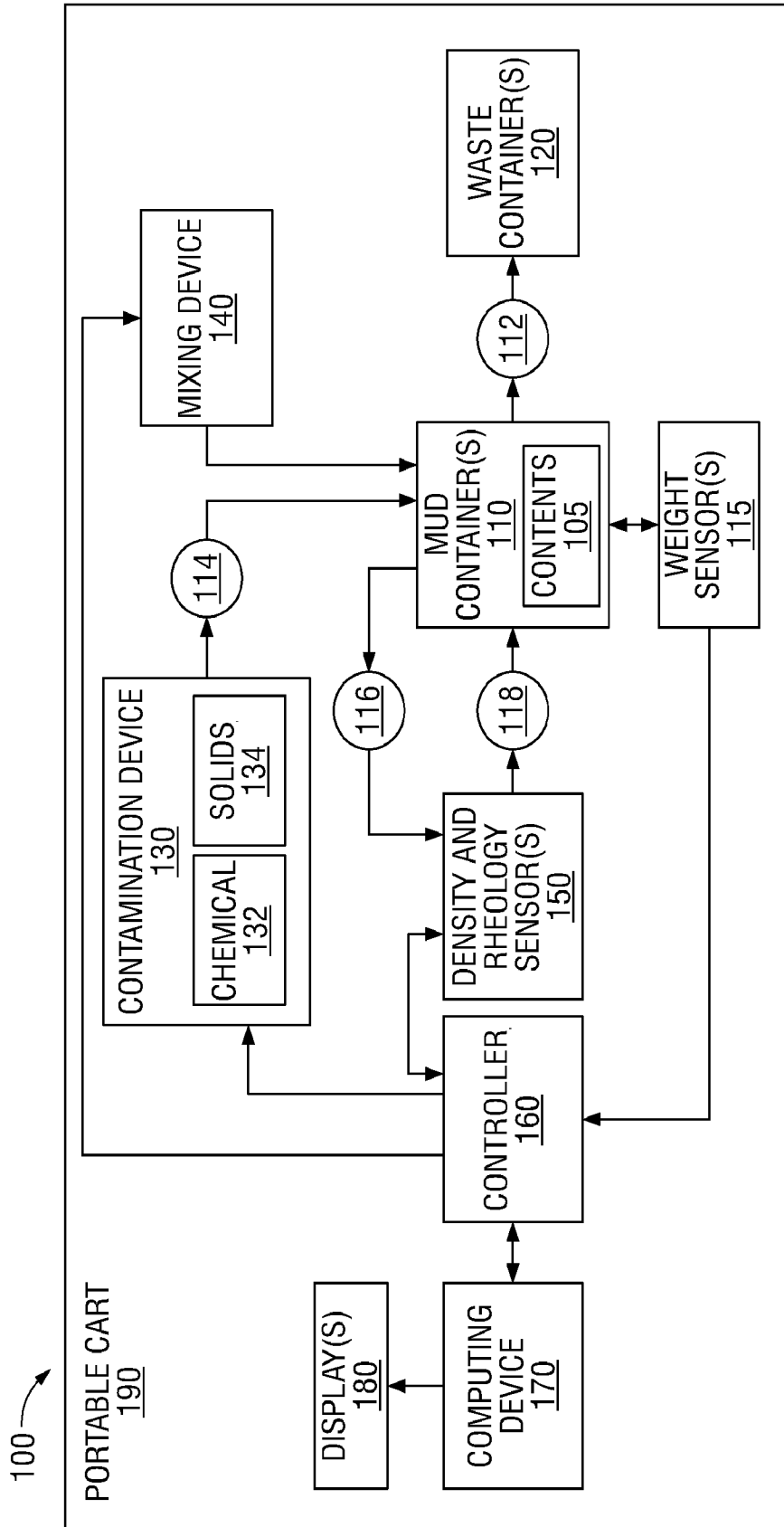


FIG. 1

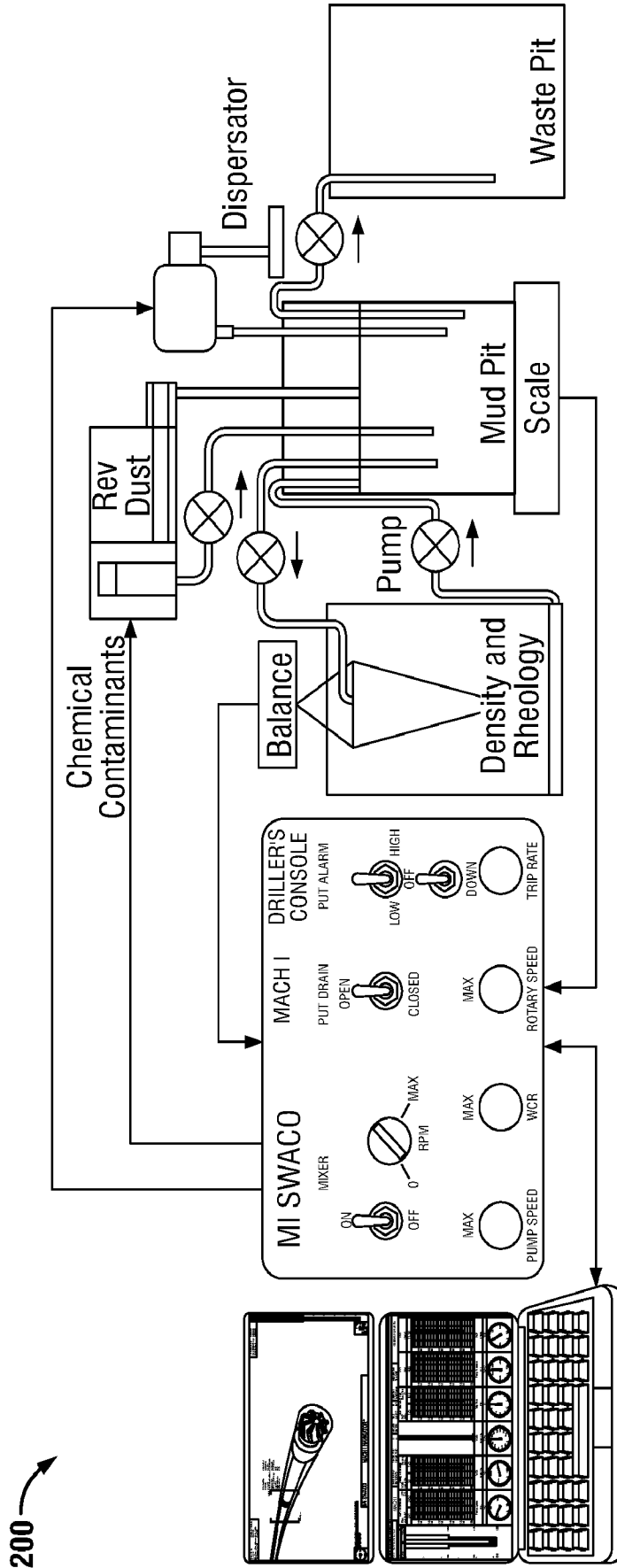


FIG. 2

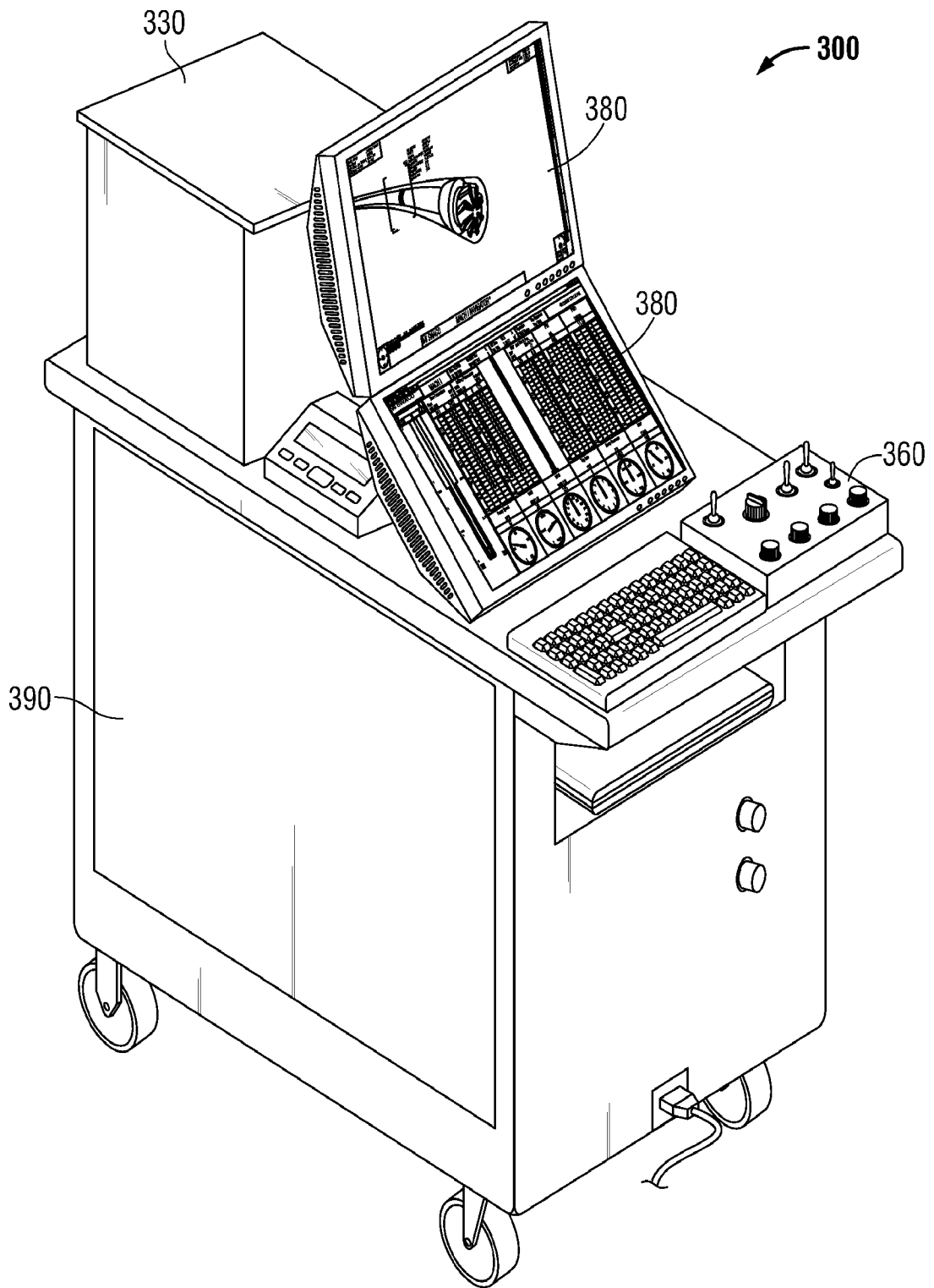


FIG. 3

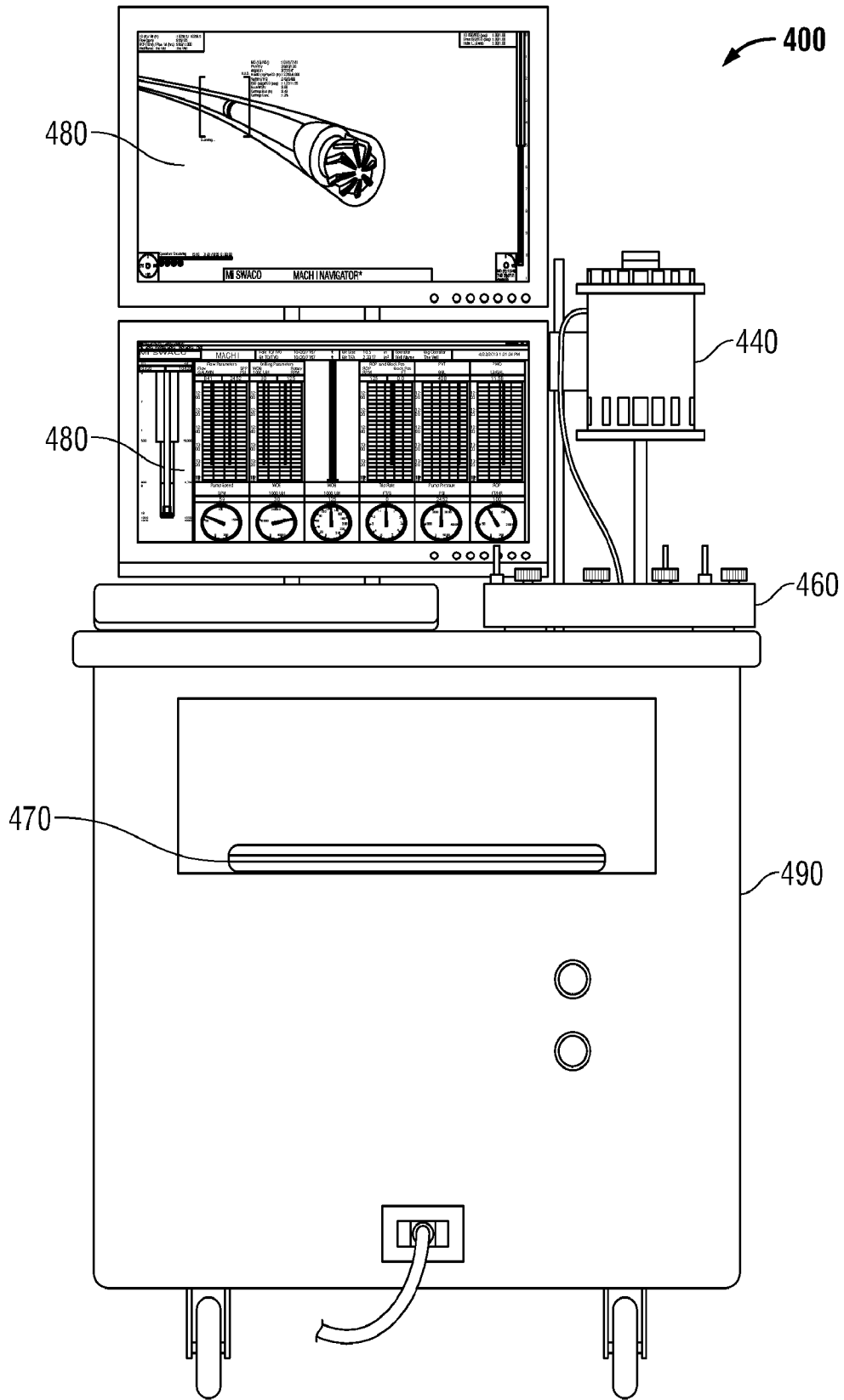


FIG. 4

5/17

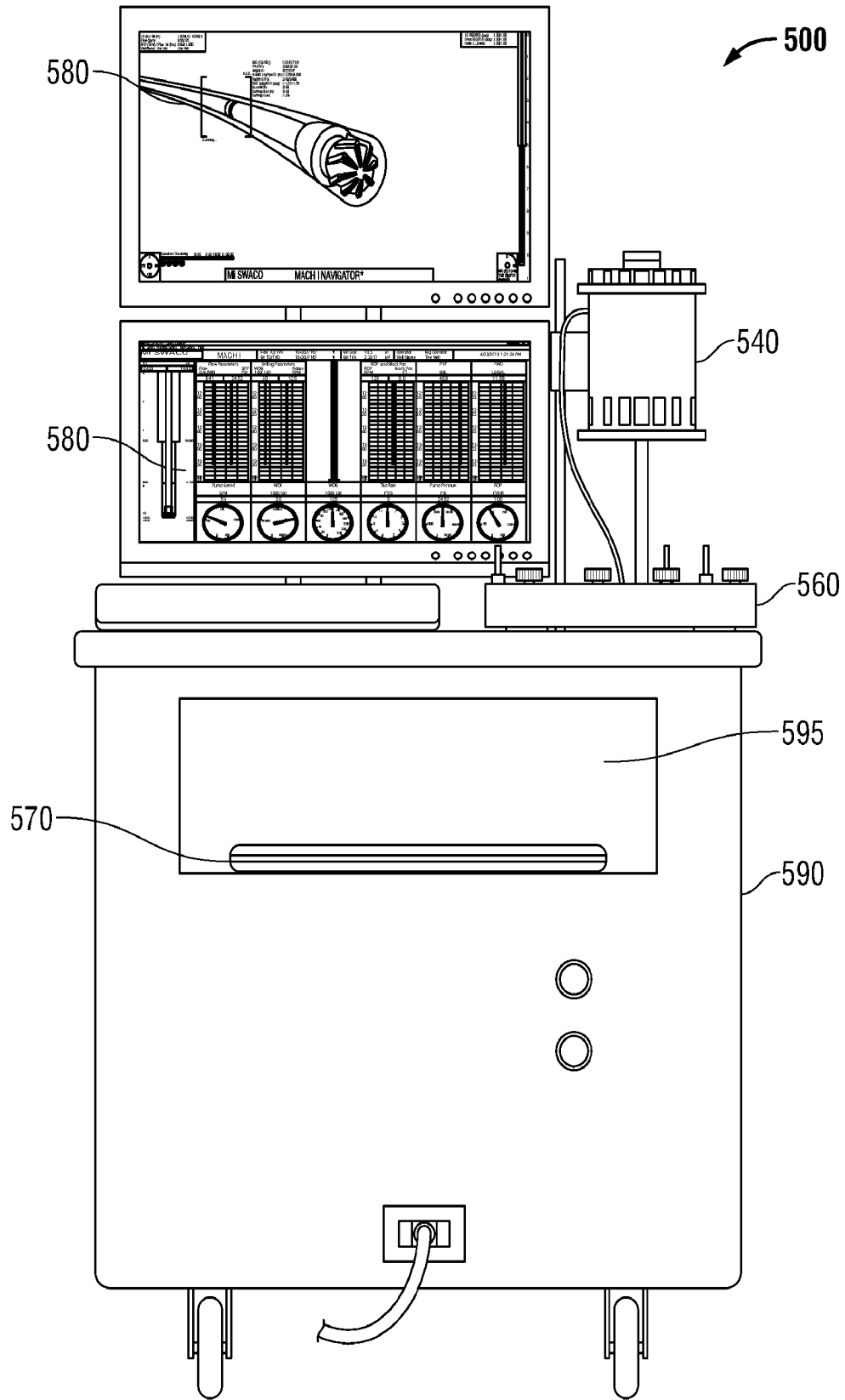


FIG. 5

6/17

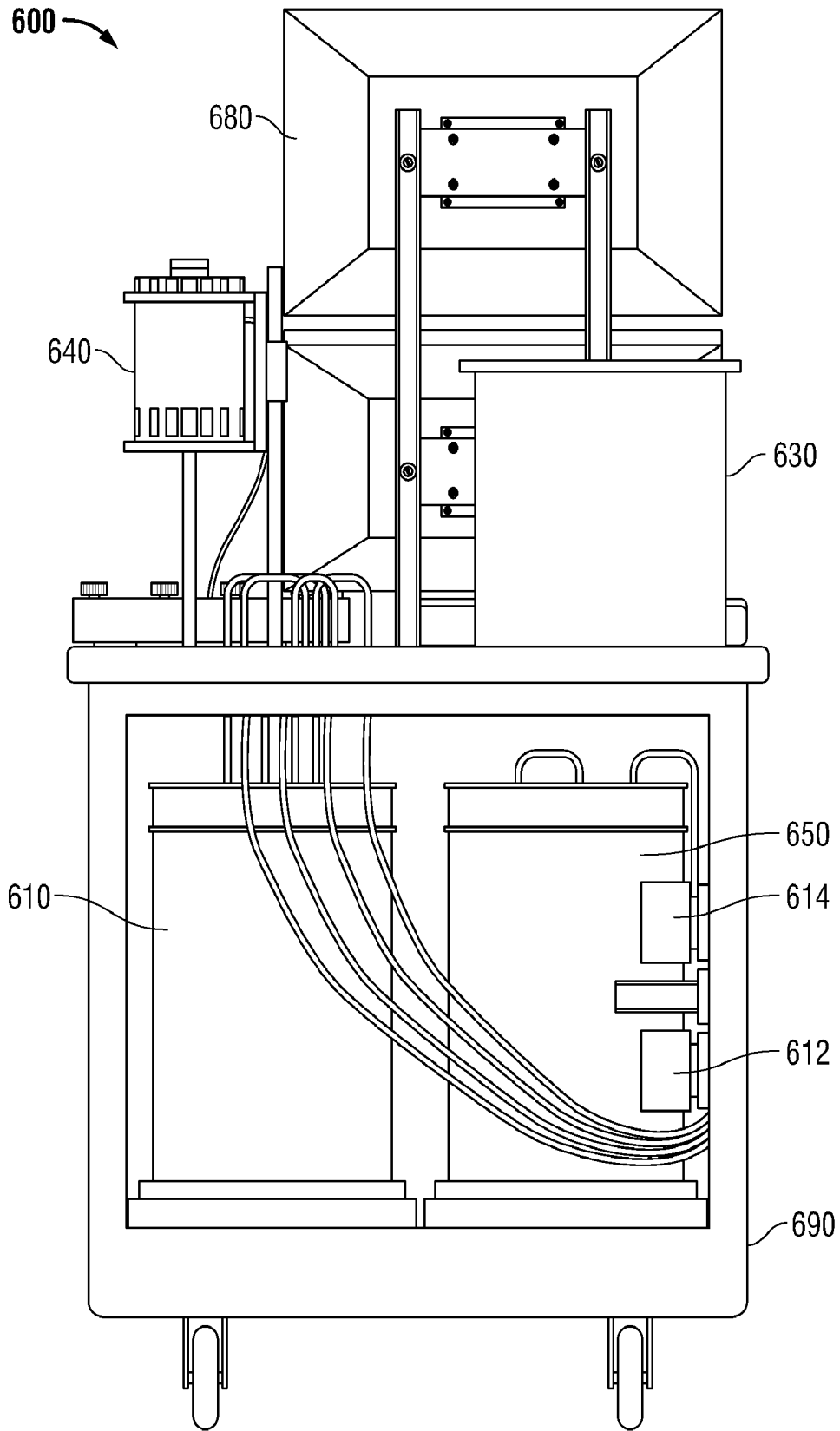


FIG. 6

7/17

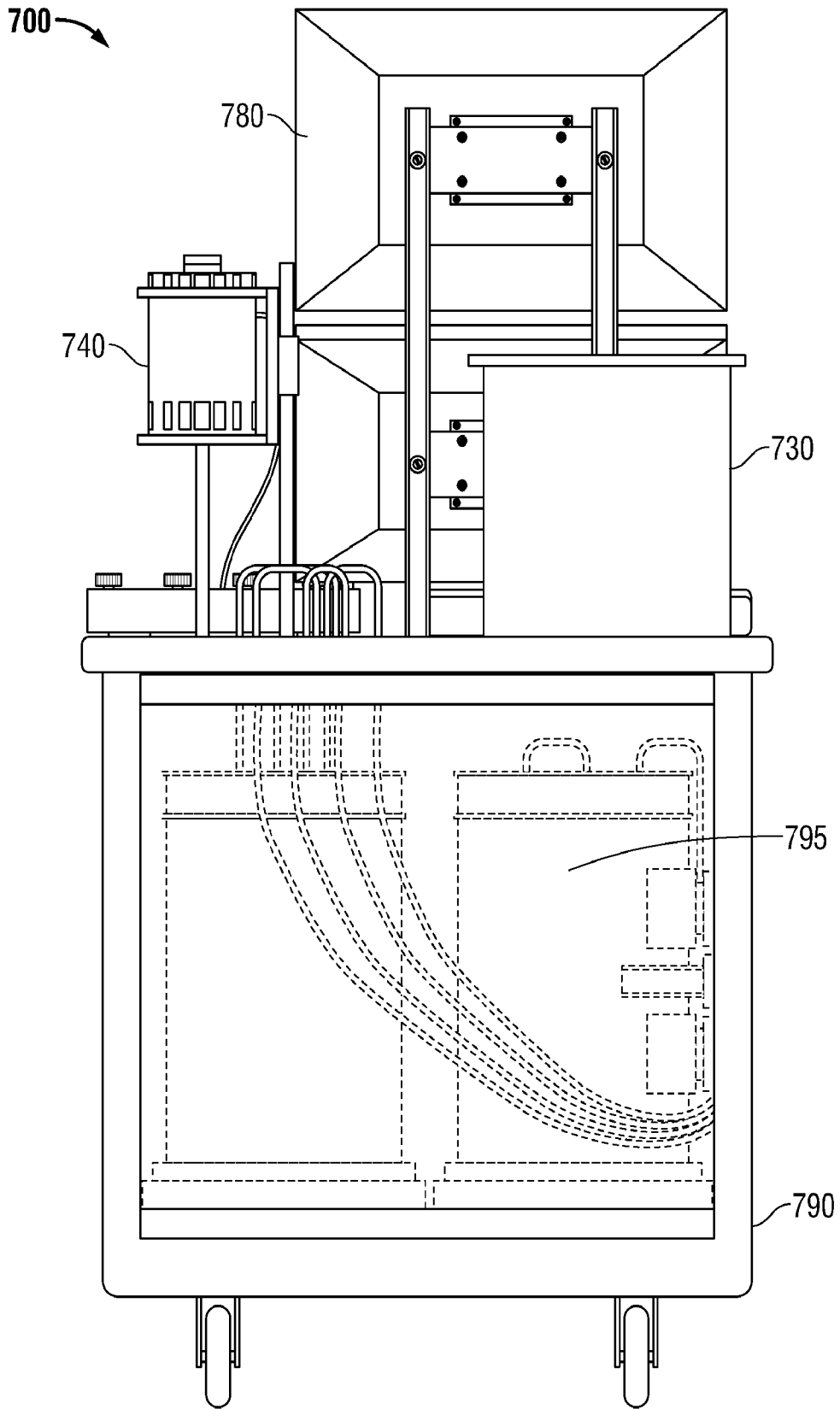


FIG. 7

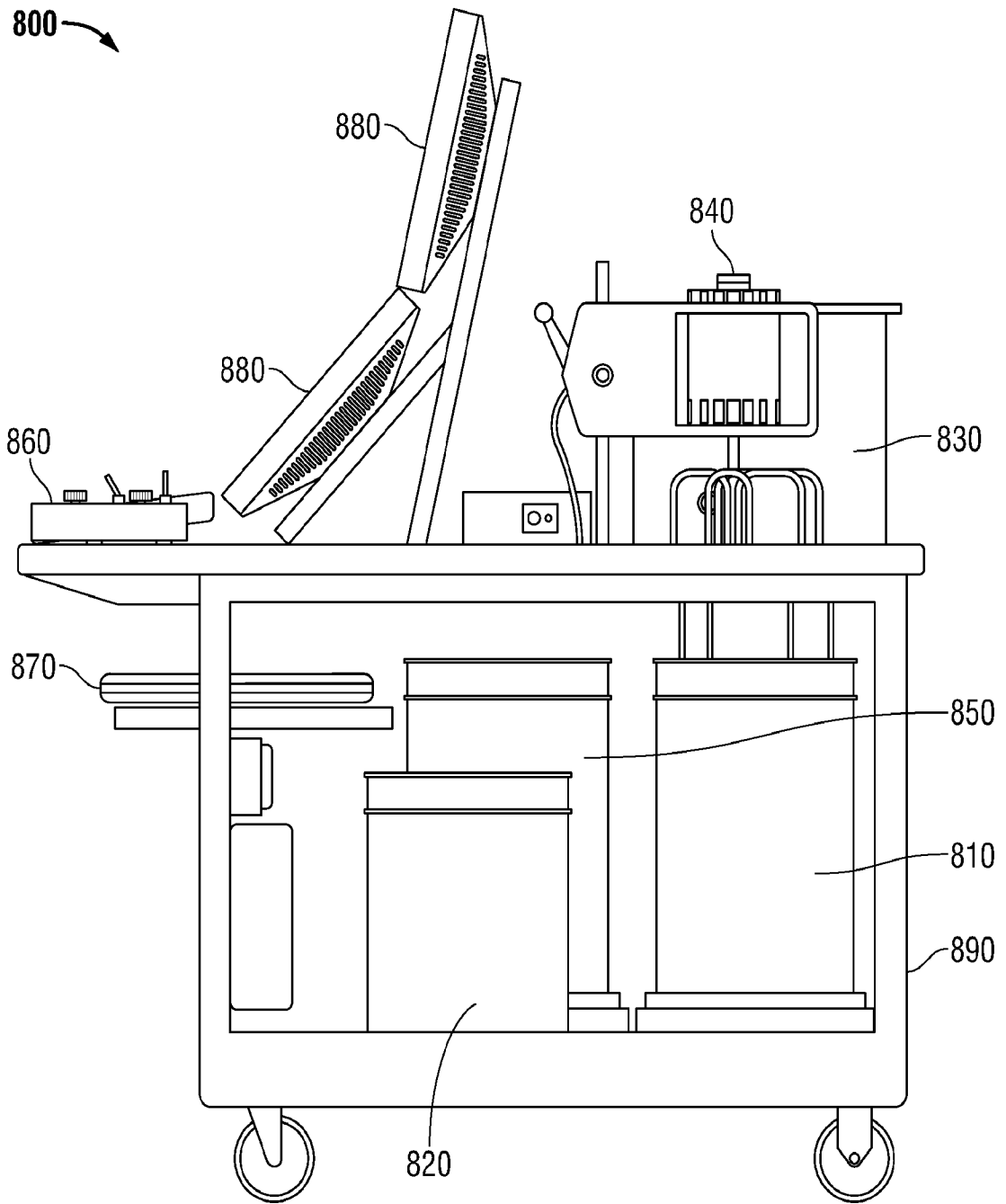


FIG. 8

9/17

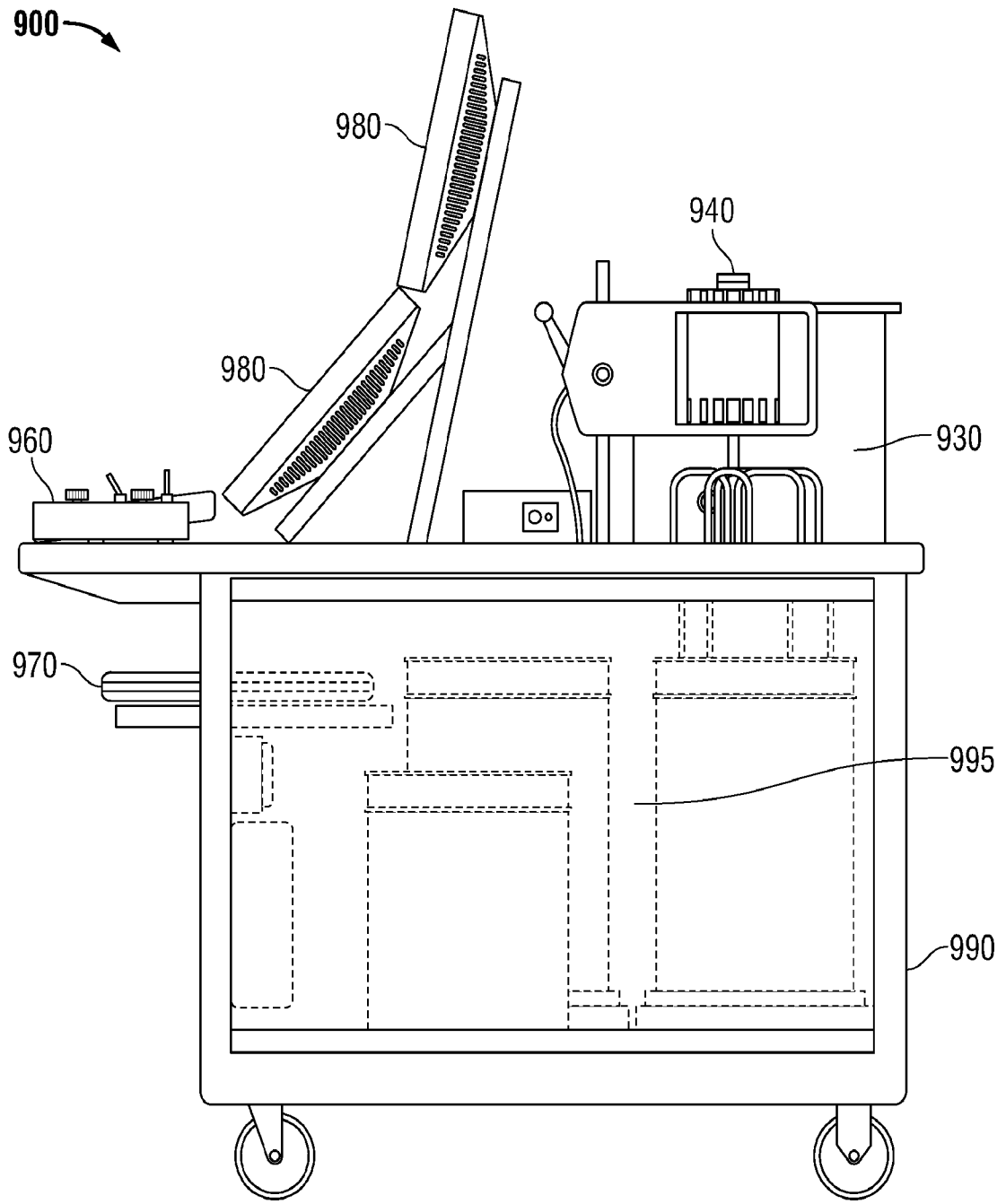


FIG. 9

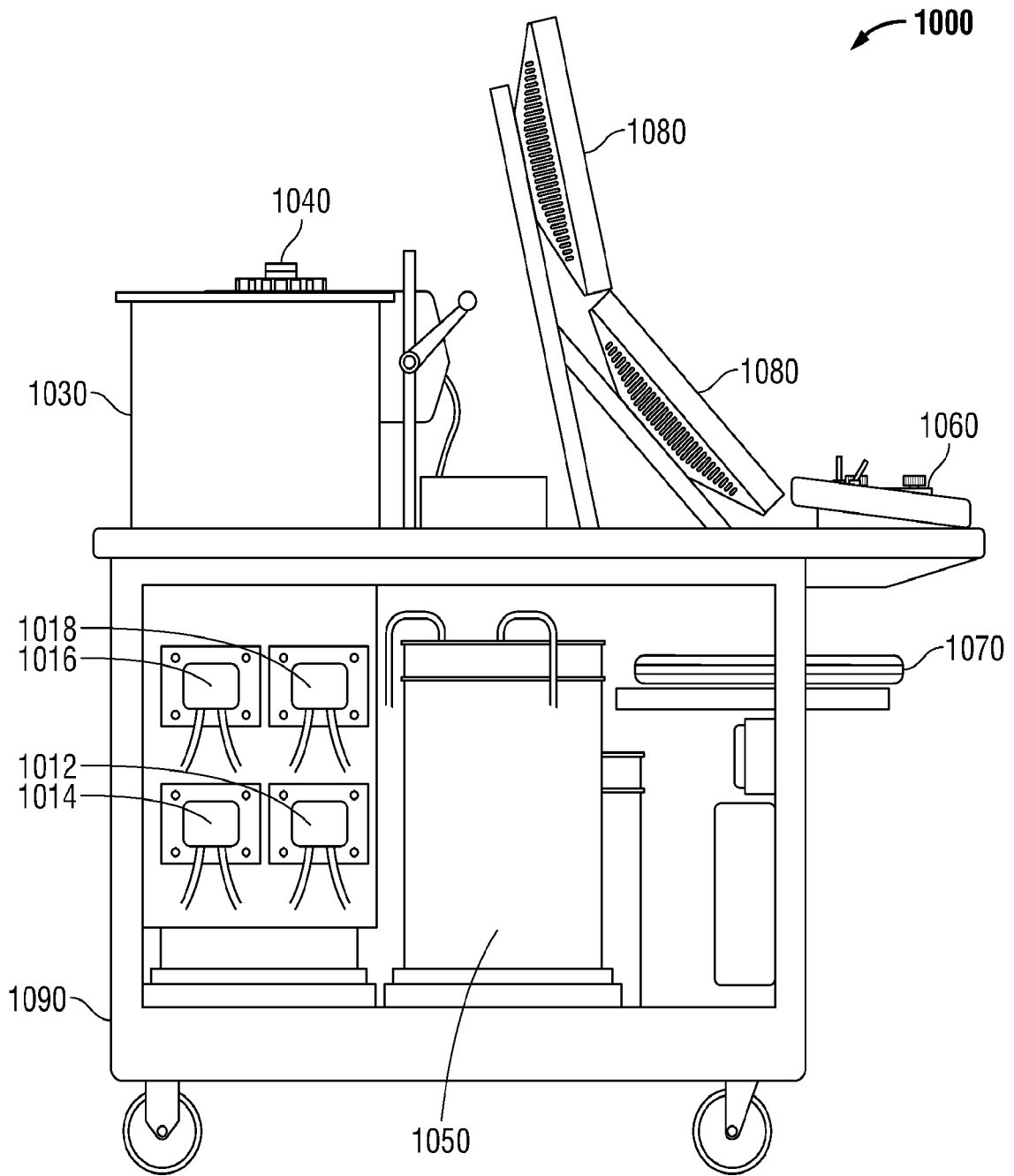


FIG. 10

11/17

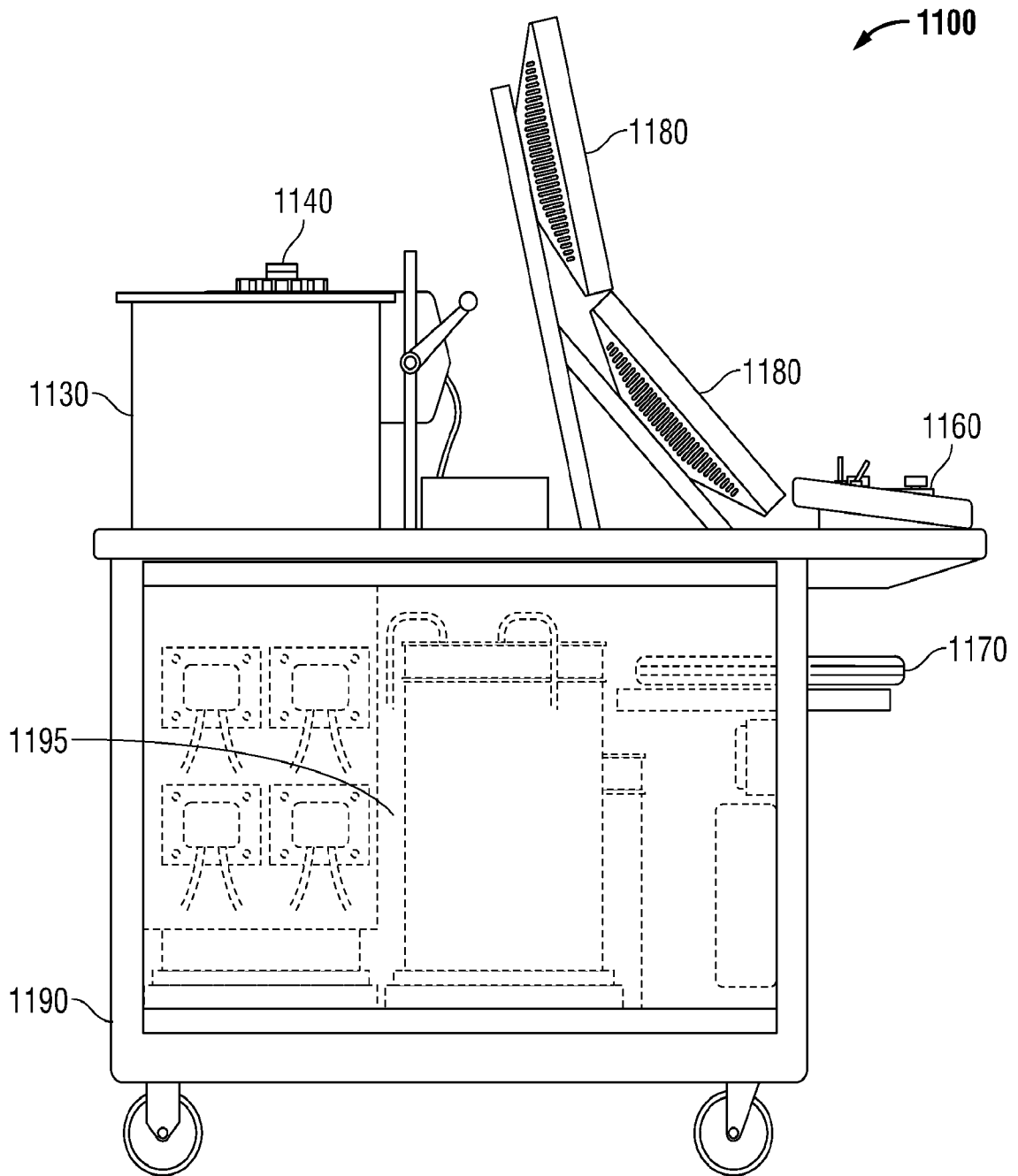


FIG. 11

12/17

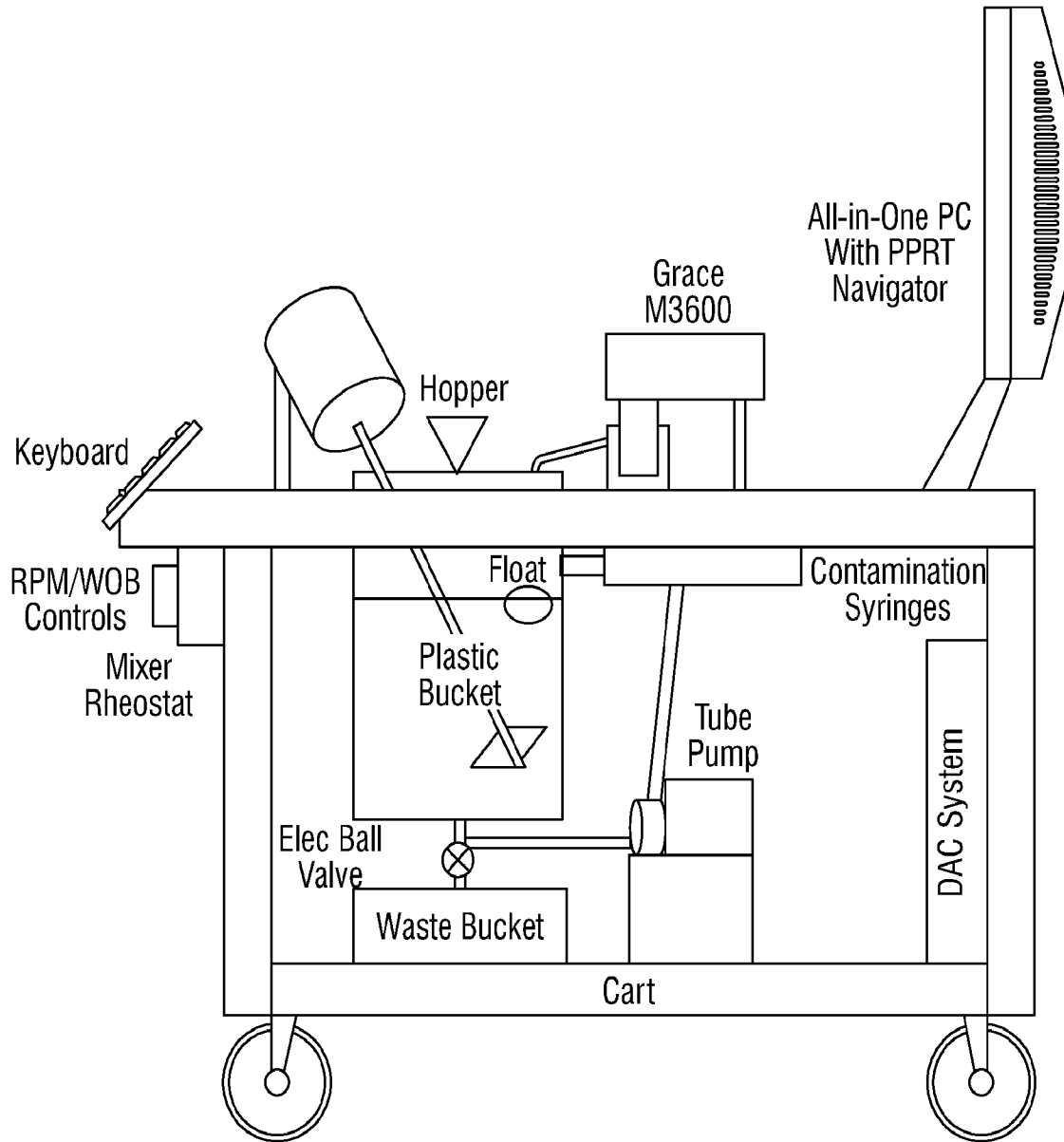


FIG. 12

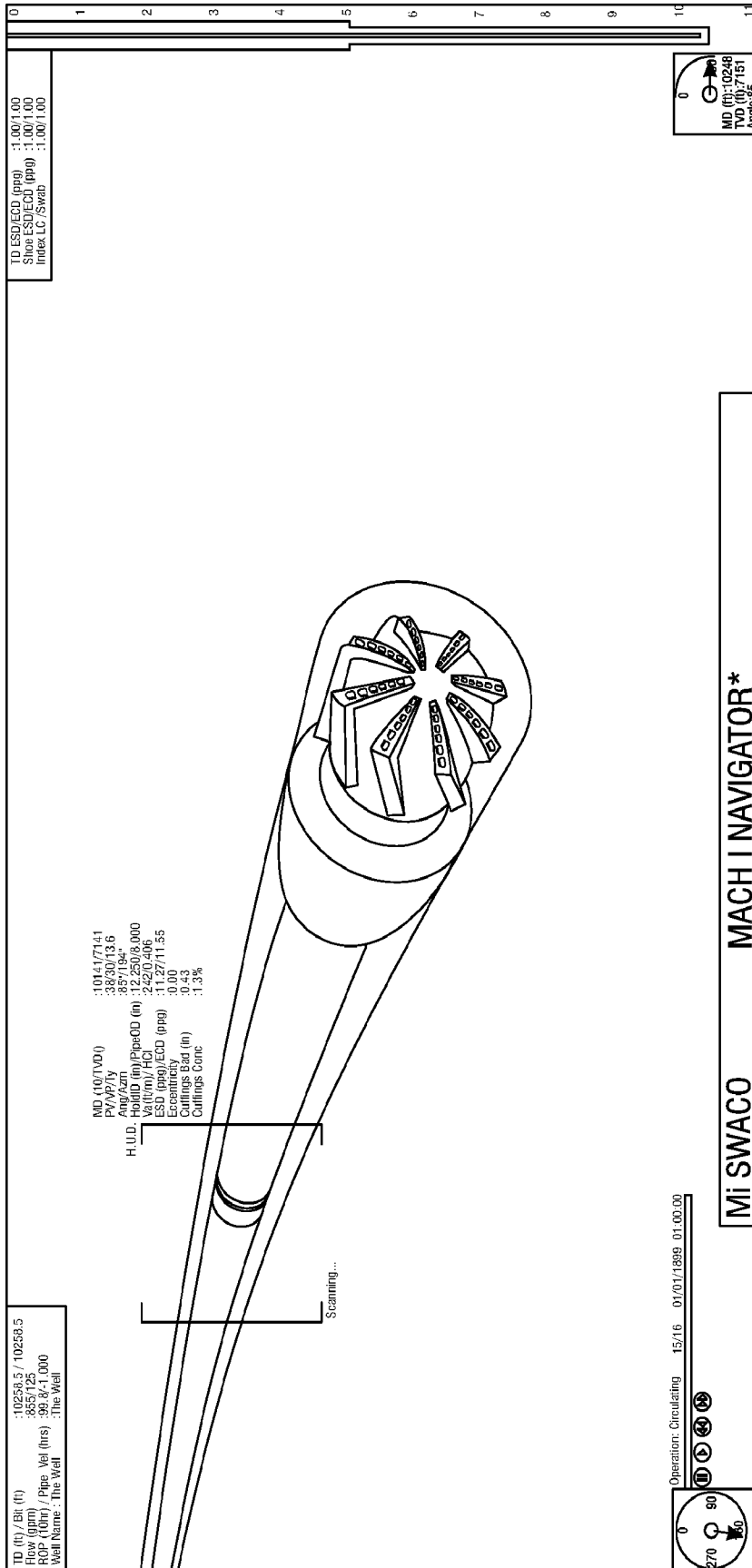


FIG. 13

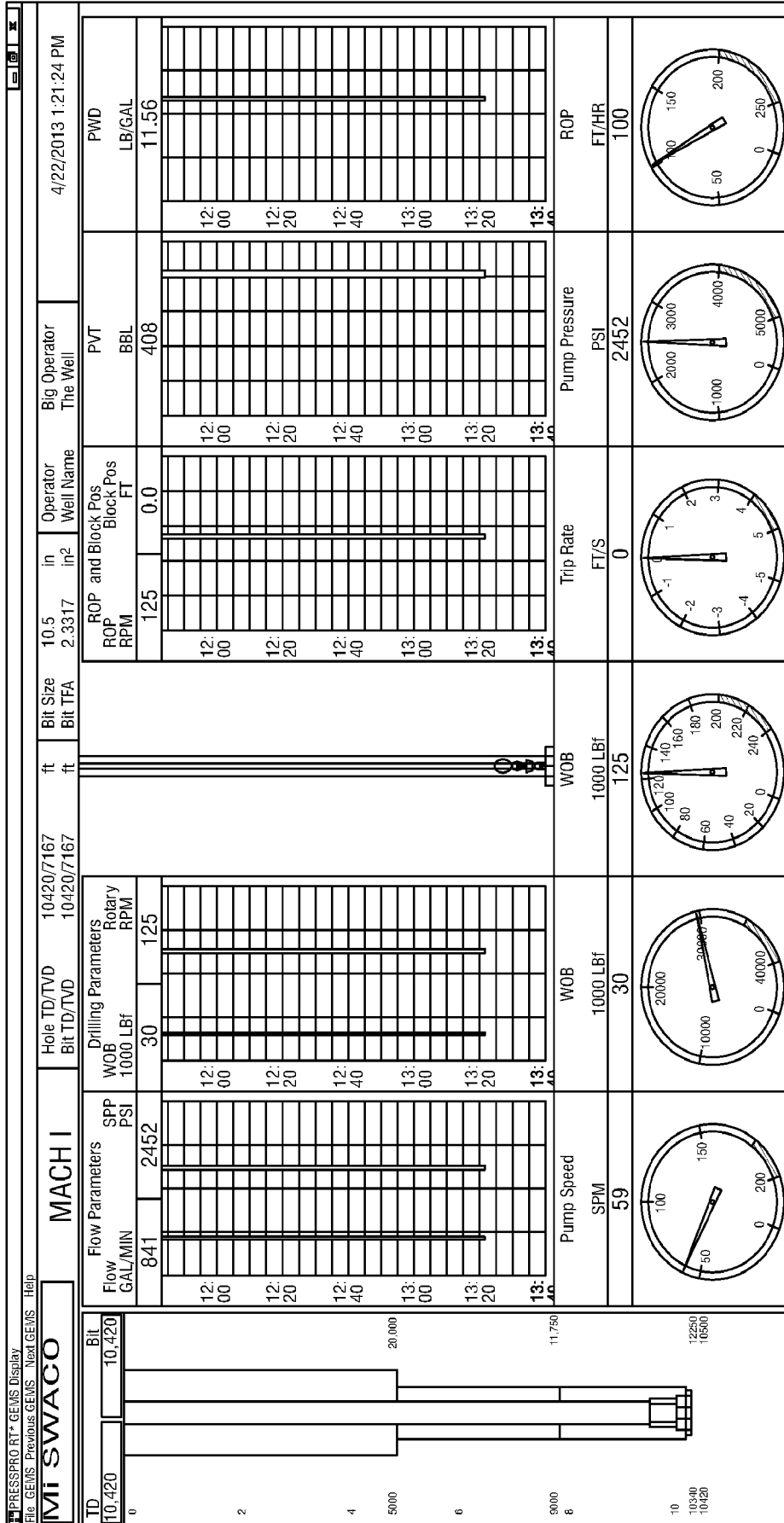
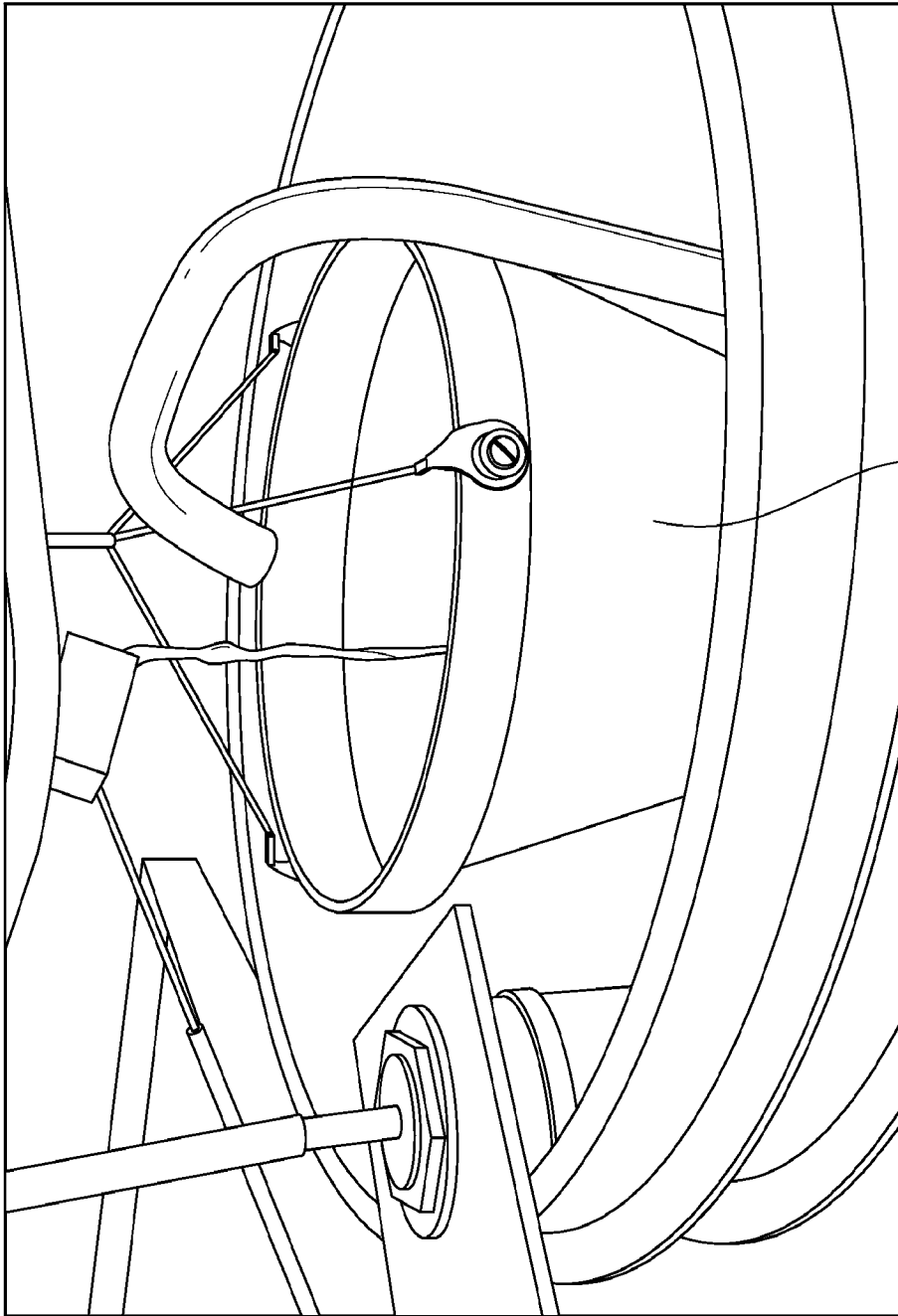


FIG. 14



1550

FIG. 15

16/17

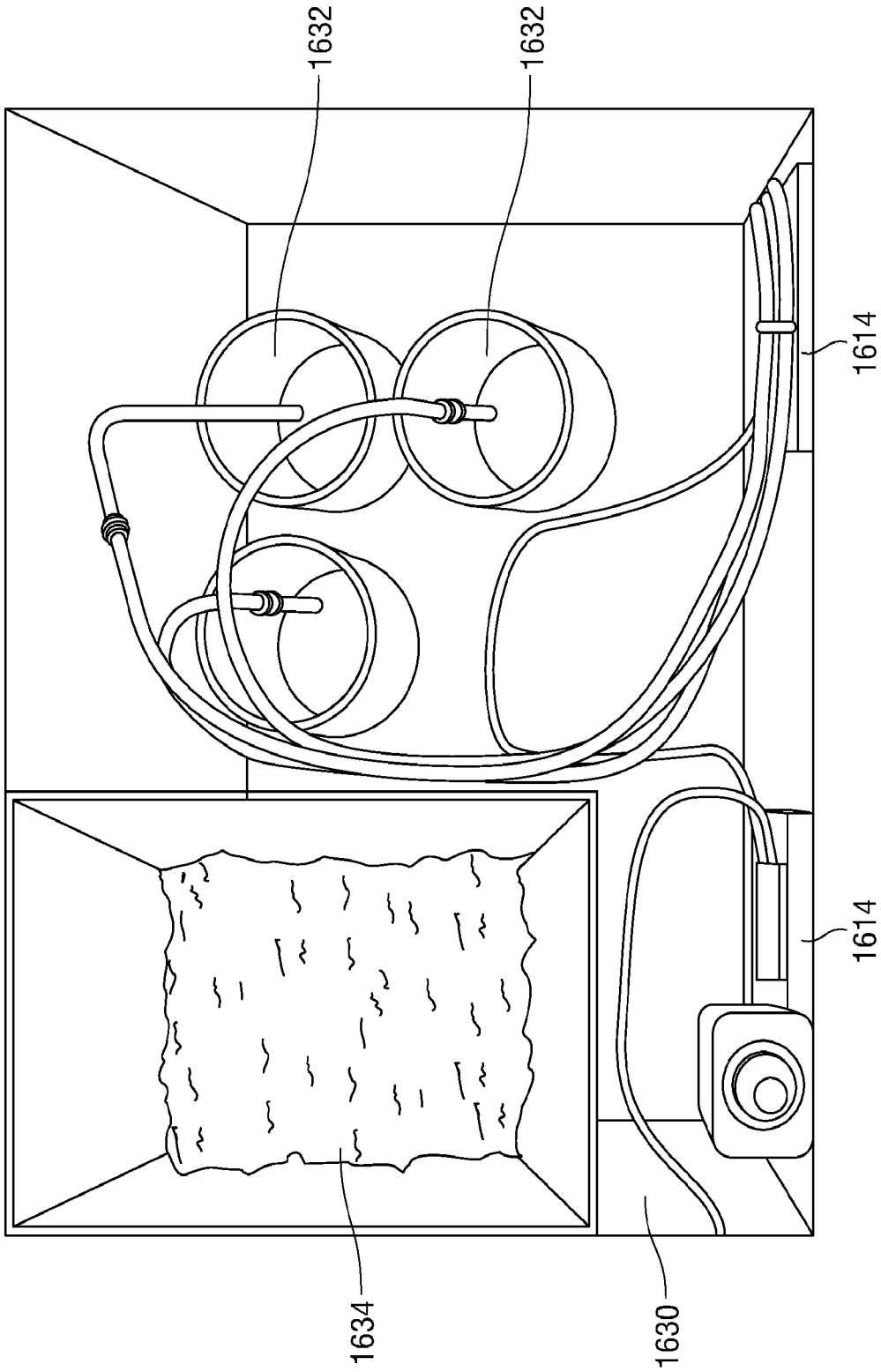


FIG. 16

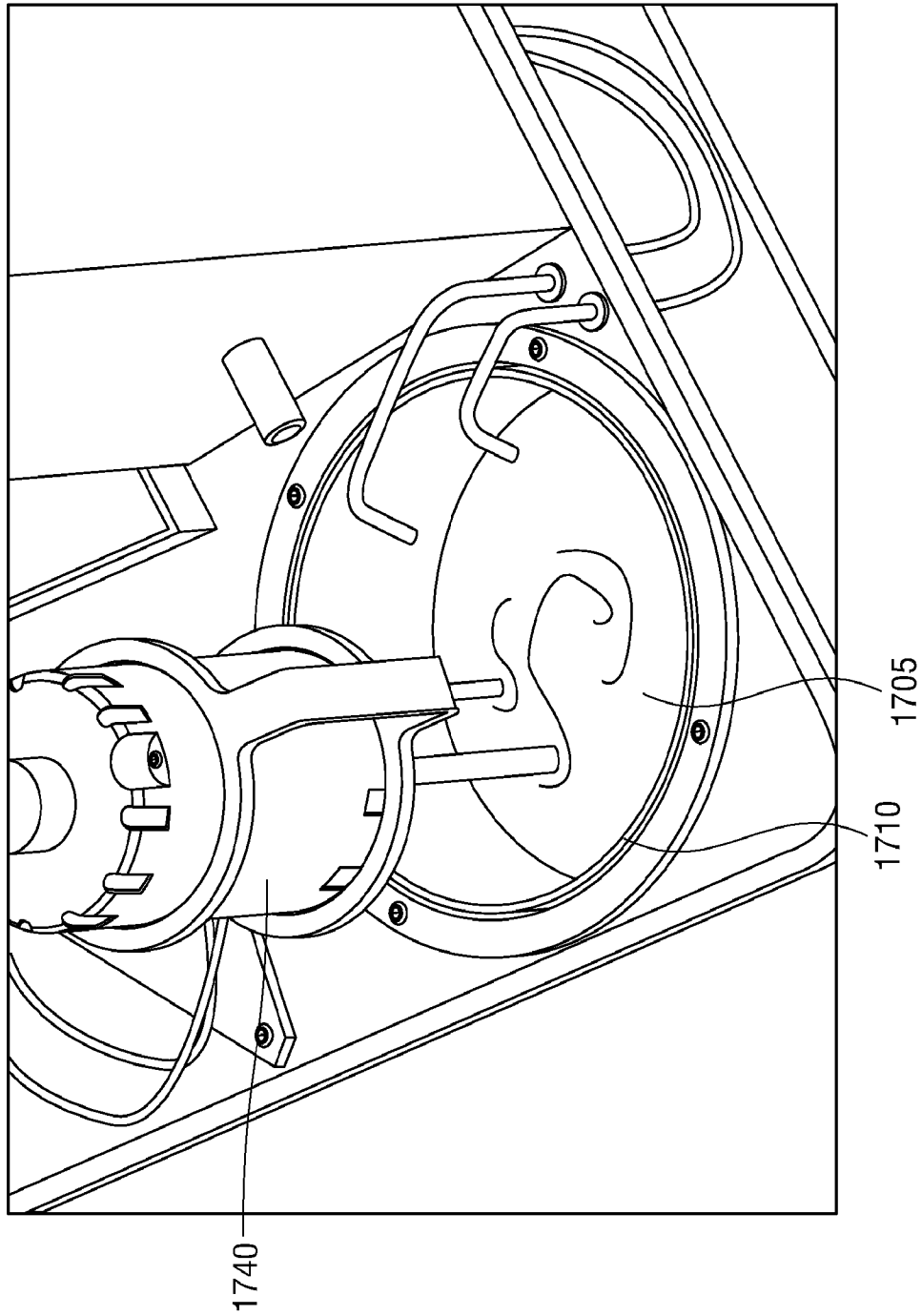


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/038157**A. CLASSIFICATION OF SUBJECT MATTER****E21B 47/00(2006.01)i, E21B 49/02(2006.01)i, E02D 1/00(2006.01)i**

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)

E21B 47/00; E21B 7/00; G01N 11/00; E21B 21/00; E21B 21/01; E21B 44/00; E21B 21/06; E21B 49/02; E02D 1/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: receiving container, sensing device, controller, computing device, contamination device, and mixing device

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007-045925 A1 (VARCO I/P, INC. et al.) 26 April 2007 See abstract, page 9, line 14 - page 11, line 21, and figure 1.	1-5, 7-8, 10-14 , 17-20
Y		6, 9, 15-16
Y	US 2002-0108786 A1 (ROWDEN, MICHAEL V.) 15 August 2002 See abstract, paragraphs [0045]-[0048], and figure 4.	6, 9, 15-16
A	US 2007-0186625 A1 (ROGERS et al.) 16 August 2007 See abstract, paragraphs [0034]-[0037], and figure 5.	1-20
A	US 2009-0194330 A1 (GRAY, KENNETH E.) 06 August 2009 See abstract, paragraphs [0043]-[0047], and figures 2A-3.	1-20
A	US 2012-0024602 A1 (LARSON, THOMAS ROBERT) 02 February 2012 See abstract, paragraphs [0034]-[0039], and figure 3.	1-20

 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

15 September 2014 (15.09.2014)

Date of mailing of the international search report

15 September 2014 (15.09.2014)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

LEE, Jong Kyung

Telephone No. +82-42-481-3360



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/038157

Patent document cited in search report	Publication date	Patent family member(s)	Publication date		
WO 2007-045925 A1	26/04/2007	AU 2006-305652 A1	26/04/2007		
		CA 2624751 A1	26/04/2007		
		CA 2624751 C	13/12/2011		
		EP 1937934 A1	02/07/2008		
		US 2007-0084639 A1	19/04/2007		
		US 2007-0087927 A1	19/04/2007		
		US 7540837 B2	02/06/2009		
		US 7540838 B2	02/06/2009		
		US 2002-0108786 A1	15/08/2002	BR 0115051 A	30/12/2003
CA 2427327 A1	10/05/2002				
CA 2427327 C	08/04/2008				
GB 0310469 D0	11/06/2003				
GB 2386916 A	01/10/2003				
GB 2386916 B	23/03/2005				
NO 20031919 A	27/06/2003				
NO 20031919 D0	29/04/2003				
NO 325074 B1	28/01/2008				
US 6739408 B2	25/05/2004				
WO 02-36929 A1	10/05/2002				
US 2007-0186625 A1	16/08/2007			AR 056009 A1	12/09/2007
				AT 497570 T	15/02/2011
				CA 2616188 A1	08/02/2007
		CA 2616188 C	22/11/2011		
		DE 602006019968 D1	17/03/2011		
		DK 1910642 T3	23/05/2011		
		EA 017330 B1	30/11/2012		
		EA 200800483 A1	30/06/2008		
		EP 1910642 A1	16/04/2008		
		EP 1910642 B1	02/02/2011		
		EP 2292891 A2	09/03/2011		
		MX 2008001139 A	13/03/2008		
		NO 20081060 A	29/04/2008		
		US 2007-0022802 A1	01/02/2007		
		US 2007-0197851 A1	23/08/2007		
		US 7721594 B2	25/05/2010		
		US 7721595 B2	25/05/2010		
		US 7721596 B2	25/05/2010		
		WO 2007-016389 A1	08/02/2007		
US 2009-0194330 A1	06/08/2009	US 7908034 B2	15/03/2011		
		WO 2007-005822 A2	11/01/2007		
		WO 2007-005822 A3	16/08/2007		
US 2012-0024602 A1	02/02/2012	CA 2805715 A1	02/02/2012		
		EP 2598710 A2	05/06/2013		
		US 8469116 B2	25/06/2013		
		WO 2012-015574 A2	02/02/2012		

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/038157

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		WO 2012-015574 A3	19/04/2012