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(54) Title: SAMPLE CUP FEEDING SYSTEM

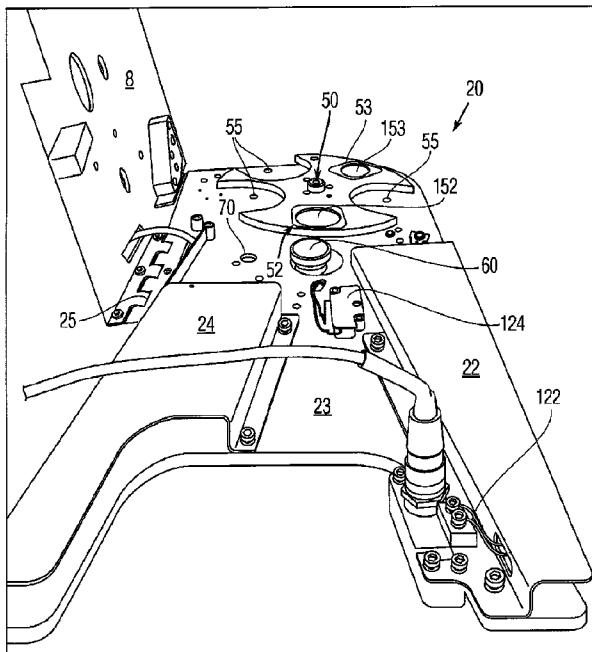


Fig. 3

(57) Abstract: A feeding system (2) for feeding disc-shaped objects such as sample cups (4) to an analyzer. The system (2) includes an infeed track (22) angled downward from horizontal and the outfeed track (24) angled downward, plus a reject chute. The disc feeding system (2.) uses two RFID readers/writers, one (32) a standalone desktop and a second (190) proximate the sample bay of the analyzer for more comprehensive track-and-trace capability. The information read from the cup (4) tag as it is scanned is also stored with the resultant spectra so that predictive processing is applied properly and without error. For post scan (after the sample scan is completed) the scan information itself may be written directly to the sample cup RFID tag including, reflection/transmission, characteristics, constituent results etc.

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**SAMPLE CUP FEEDING SYSTEM****CROSS-REFERENCE TO RELATED APPLICATION(S)**

The present application derives priority from U.S. Provisional Patent  
10 Application 62/302,430 filed 2 March 2016.

**BACKGROUND OF THE INVENTION**

## 1. Field of the invention

The present invention relates generally to feeder mechanisms for disc-shaped  
objects and, more particularly, to a feeder/conveyor mechanism for optical sampling  
15 cups.

## 2. Description of the Background

Many agricultural and food production operations rely on spectroscopic  
analysis to test materials with radiated energy, and there are many different variations  
of spectroscopic analyzers on the market today. Near-infrared (NIR) spectroscopy  
20 has greatly simplified and improved the speed of analysis for quality testing of grains,  
flours and beans. The use of near-infrared spectroscopy has led to higher sample  
throughput by replacing multiple time-consuming and complicated chemical  
techniques. Using NIR spectroscopy it is possible to non-destructively analyze  
inhomogeneous samples for moisture, protein, oil and many other parameters in less  
25 than one minute at all stages of production: grading, milling, oil extraction and final  
product quality verification. In most large scale operations such as grain processing,  
representative samples of the product are tested at predetermined intervals.  
Commercial grain analyzers suitable for this purpose in grain production operations  
are commercially-available. Of these, some grain analyzers are transmission-mode  
30 analyzers that test the whole grain. Others are reflectance-mode analyzers that  
typically test ground grain (though reflectance-mode analyzers are also suitable for

5 some whole grains, flour, feeds, forages etc.). Reflectance-mode grain analyzers and many other analyzers use "sample cups" to contain the test sample. An amount of grain is deposited into a disc-shaped sample cup which has one or more windows, and measurements of radiation transmitted through or reflected through the grain via the window(s) is analyzed. Traditional grain analysis systems require an operator to  
10 monitor the process line and to manually remove representative samples of grain from the process line for testing.

FIG. 1 is a front perspective view of a plurality of various (feed/forage) grain samples in individual marked envelopes 10, with corresponding marked adhesive labels 12 for attachment to sample cups prior to loading. The marking shown in FIG.  
15 1 is currently done by bagging the various grain samples in individual envelopes, marking the envelopes, filling individual sample cups with (product/grain from the envelopes, and marking the sample cups in accordance with the envelopes, all by hand. The process is tedious and error-prone. The sample cups are then hand fed into a grain analyzer one-by-one. The entire process suffers from the additional  
20 manpower needed to select, organize and catalogue representative samples, transport them to the grain analyzer and monitor the progress of grain analysis before manually returning the sample container and/or the sample to the product line to repeat the process. Few attempts have been made to automate the process.

United States Patent 5,087,423 to Ishibashi issued February 11, 1992 shows a  
25 modular analyzer in which sample cups are automatically transported and distributed via conveyer belts. Unfortunately, when it comes to auto-feeding disc-shaped objects into a precise position at finely-timed intervals, conveyer belts do not provide the measure of control necessary.

5           In addition, the accuracy of the conventional process of analyzing samples from a production line comprising grain or other agricultural or non-agricultural goods also suffers with greater variability in intervals between samples as they are taken from the production line. Ideally, for the best sample accuracy, a sample is removed from the process line and transferred immediately to a grain analyzer or  
10 other sampling device without delay, so that testing occurs as soon as possible after the sample is removed from the line. With grain, as with other types of agricultural goods and other selected products, defects occur in a non-random fashion due to differences in the way that batches of crops are grown, harvested, stored, etc. When samples from the production line are tested as soon as possible after being removed  
15 from the line, any samples that do not meet quality control standards may be noted as soon as possible and the batch(es) corresponding to same may be removed from production or otherwise corrected earlier in the process.

          Accordingly, what is needed is a feeder/conveyor for sample cups that allows a human operator to fill a plurality of sample cups with materials to be analyzed,  
20 easily label the sample cups with a machine-readable label, load those sample cups into a queue on the feeder/conveyor, the feeder/conveyor thereupon automating the infeed and outfeed of the queued sample cups into an analyzer on an as-needed basis so that samples are tested as soon as possible after being removed from the line, then ejected from the analyzer back onto a return queue on the feeder/conveyor for prompt  
25 disposition.

#### SUMMARY OF THE INVENTION

          Accordingly, it is an object of the present invention to provide an improved feeder for disc-shaped objects such as sample cups that employs inclined infeed and  
30 return tracks for efficiently and automatically forming infeed and outfeed queues, the

5 infeed and return tracks converging on a rotating carousel for transporting multiple disc elements such as sampling cups to the infeed of a grain analyzer for on-demand-processing.

It is another object of the invention to provide an improved feeder/conveyor that automatically queues and transports multiple disc elements along an infeed track  
10 and a return track for testing at the analyzer.

It is also an object of the present invention to provide such an improved disc feeding system with dual RFID readers/writers, one desktop and the other proximate the sample bay of the analyzer so that it can communicate with the sample the cup while it is in the scanning position, the combination giving a more comprehensive  
15 track-and-trace capability.

These and other features and benefits are achieved with an improved disc feeding system for disc-shaped objects such as sample cups and the like with both an infeed track for queuing a plurality of disc-shaped objects, and an outfeed track. The infeed track is angled downward from horizontal and the outfeed track is angled  
20 downward from horizontal opposite the infeed track, such that the infeed track and outfeed track converge toward a point. In addition, a reject chute drops disc-shaped objects directly downward. The infeed track, outfeed track and reject chute converge to a servo-drive carousel that is rotatable about a point, the servo-drive carousel comprising a disc defined by a plurality of U-shaped notches for receiving disc-  
25 shaped objects. There is a switchable gate proximate an end of the infeed track for gating disc-shaped objects into the carousel. The disc feeding system uses two RFID readers/writers, one standalone desktop and a second proximate the sample bay of the analyzer for more comprehensive track-and-trace capability. The desktop RFID reader/writer allows technicians to tag each sample cup with a label with a unique

5 sample number, type and other known information after the samples have been prepared in the lab, prior to its scan. A second RFID reader/writer is mounted proximate the carousel. The RFID read/write head (including coil) is attached remotely from the electronics on a pusher bar that is actually touching the sample cup while it is in the scan position to read and write to the RFID tags while at the

10 instrument. The pusher bar pushes the sample cups and/or calibration tiles into position relative to the scanning plane, thereby keeping them accurately positioned. Mounting a second RFID reader/writer with head directly on the pusher bar gives an accurate pre-scan read and an accurate post-scan write because the reader/writer head is actually touching the sample cup while it is in the scan position. For pre-scan, the

15 sample cup is placed in the feed carousel and the initially-stored data is transferred to the second RFID reader/writer and verified, thereby eliminating the risk of erroneous scan errors and ensuring sample traceability. The information read from the cup tag as it is scanned is also stored with the resultant spectra so that predictive processing is applied properly and without error. For post scan (after the sample scan is completed)

20 the scan information itself may be written directly to the sample cup RFID tag including reflection/transmission characteristics, constituent results etc. The information read from the cup tag in conjunction with the spectra and coordinated prediction of constituent values along with other information may be used at this point to eject the sample cup.

## 25 BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiment and certain modifications thereof, in which:

5           FIG. 1 is a front perspective view of a plurality of various grain samples in individual marked envelopes 10, with corresponding marked adhesive labels 12 for attachment to sample cups prior to loading.

          FIG. 2 is a perspective view of an embodiment of the improved disc feeder/conveyor system 2 according to the present invention.

10          FIG. 3 is a side perspective illustration of the open-hinged disc feeder/conveyor mechanism 20 of the present invention.

          FIG. 4 is a close-up side perspective illustration of the open-hinged disc feeder/conveyor mechanism 20 as in FIG. 3 showing the cup carousel 50.

          FIG. 5 is a close-up side perspective illustration of the cup carousel 50 of FIG. 4 (with a reference/baseline reflector 152 in place).

          FIG. 6 is a close-up side perspective illustration of the cup carousel 50 of FIGs. 4-5 with loaded sample cup 4.

          FIG. 7 is a close-up side perspective illustration of one of two floating calibration standards 152, 153. One calibration standard 152 is used for the baseline measurement and the other 153 can be used as a wavelength alignment standard to check the instruments wavelength and/or absorbance calibration. The use of the carousel 50 to revolve both calibration standards 152, 153 in the same sample plane as the sample cup, all seated in the cup carousel 50 of FIGs. 4-5 is a novel feature.

          FIG. 8 is an open-top illustration of the electronics assembly 100 for the disc feeder/conveyor mechanism 20 of the present invention.

          FIG. 9 is a close-up illustration of the electronics assembly 100 for the disc feeder/conveyor mechanism 20 of the present invention.

## 5            DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 is a perspective view of an embodiment of the improved disc feeder/conveyor system 2 according to the present invention. The disc feeder/conveyor system 2 is herein configured to feed and eject sample cups to/from a conventional scanning monochromator 8 of a type which generally includes an optical bench having a light source assembly 51, entrance optics, a slit/shutter assembly, and exit optics (not shown). In general operation of scanning monochromator 8 the light source assembly 51 emits a broad spectrum of radiation which is collected by the entrance optics, and projected onto a diffraction grating then through the exit slit/shutter assembly. The diffraction grating disperses light by diffracting different wavelengths at different angles, and a selected spectral component of the light emanates out through an exit aperture 63.

The present invention includes a sample cup infeed/outfeed queuing mechanism 20 configured for attachment to the scanning monochromator 8 such that the selected spectral component of the light emanating out through an exit aperture 63 passes directly into the sample cup infeed/outfeed queuing mechanism 20 of the present invention. The sample cup infeed/outfeed queuing mechanism 20 automatically loads one sample cup 4 from a multi-cup infeed track 22 onto an internal carousel (obscured) which is rotatably controlled to position the sample cup 4 at a prescribed distance from exit aperture 63. The selected spectral component of the light emanating out through exit aperture 63 is refracted off the sample in sample cup 4, back to a detector/detection system in monochromator 8 which measures the intensity of the diffusely reflected light from the sample, converting the light power to an electrical signal by which a quantitative analysis of any of a variety of characteristics of a sample, including constituent analysis, moisture content, taste,

5 texture, viscosity, etc. The high degree of automation and mechanical technique (pusher bar for example) ensures consistent sample presentation, more efficient sample pick-up and scanning, and more accurate scanning as a consequence.

In addition to the sample cup infeed/outfeed queuing mechanism 20, the disc feeder/conveyor system 2 includes a desktop RFID writer/reader 32 external to the  
10 sample cup infeed/outfeed queuing mechanism 20, plus an internal RFID writer/reader (not shown...to be described) internal to the sample cup infeed/outfeed queuing mechanism 20. The desktop RFID writer/reader 32 has a dock for indexing a sample cup 4 thereon during reading/writing, and a central controller 5.

The controller 5 includes a programmable controller and non-transitory  
15 storage memory housing the system control software that is programmed to detect and decode the RFID tags, and to synchronize operation of the disc feeder/conveyor system 2. The controller 5 may be any conventional computing device with display and user-input device, and may be the existing controller provided with the scanning monochromator 8.

20 The controller 5 software provides a graphical user interface to guide a user through the following steps: (1) collecting a sample to be tested and cataloging the specimen; (2) analyzing the specimen; and (3) reviewing and recording the test results; and (4) track-and-trace of each specimen. Collecting and cataloging a sample broadly includes storing batch and sample information (i.e. information related to the  
25 customer, product type, calibration that is to be used for predictive analysis etc.) in a collection facility database accessible by the controller 5 and assigning a unique indicia to each sample, filling a sample cup 4, labeling the sample cup 4 with a machine scannable label bearing the indicia, as well as information such as which calibration equation to use for predictive analysis once the sample is scanned, and

5 loading the sample cup 4 into the infeed track 22 and administering the test. One skilled in the art will readily understand that different users may prefer to store different data on the machine scannable label. Typically, the laboratory technician will want to write a bar code related to their customer(s) and a product code which may be used to direct the prediction engine to the appropriate calibration equation.

10 Optionally, that calibration equation or any other information as desired may be stored on the scannable label. Preferably, the machine scannable label is a radio frequency identification (RFID) tag, and toward that end the desktop RFID reader/writer 32 is connected by USB (Universal-Serial-Bus) connector to Controller 5. The RFID reader/writer 32 includes a rectangular housing with a flattop platform

15 defined by a slightly-recessed circular receptacle to index position of a sample cup 4 placed thereupon (as shown). Internally, the RFID reader/writer 32 includes a circuit board having a processor and a USB controller, and an antenna board stacked on the circuit board. The antenna board includes a toroidal antenna directly beneath the circle-receptacle for reading/writing an RFID code to an adhesive label as seen in

20 FIG. 1. This way, as each sample cup is filled and logged the controller 5 assigns a unique indicia along with product and processing information and guides the user to label the sample cup 4 by adhering an RFID label, writing the label with the assigned indicia using the RFID reader/writer 32, then loading the sample cup 4 into the infeed track 22 and administering the scan.

25 FIG. 3 is a side perspective illustration of the open-hinged disc feeder/conveyor mechanism 20 of the present invention. The disc feeder/conveyor mechanism 20 attaches to the face of the scanning monochromator 8 on lower-hinges to allow it to swing open downward for easy access. The disc feeder/conveyor mechanism 20 is constructed with a flat plate 23 that is cut to define the infeed and

5     outfeed tracks 22, 24, and plate 23 is mounted on hinges 25 to the monochromator 8.  
Tracks are screwed to the inside of plate 23 to define the ramped infeed and outfeed  
tracks 22, 24, and the motor drive and electronics are mounted on the opposite side of  
plate 23 and fully enclosed in a cover 125 as seen in FIG. 2.

FIG. 4 is a close-up of the cup carousel 50. A predetermined number (e.g.,  
10     five) sample cups 4 may be RFID-tagged and loaded onto the infeed track 22 at a  
given time. The infeed track 22 generally comprises a downwardly inclined open-  
topped chute equipped with a first sample cup sensor 122 at its upper end (see FIG. 3)  
and a second sample cup sensor 124 at its lower end. The illustrated sensors 122, 124  
are microswitches but one skilled in the art will understand that sensors 122, 124 may  
15     be Reed switches, paddle switches, proximity switches or other suitable switches, or  
hall-effect (magnetic) or photo-optic sensors. Sample cups 4 residing in the chute 22  
are detected by the first and second sensors 122, 124, indicating to the controller 5  
(e.g., indicating that there is a sample cup to load and/or that the unit is/is not  
full...this configuration indicates whether there are 0 cups, 1 cup or 5 cups).

20     Thus, if the first microswitch 122 is depressed the infeed track 22 is full, and if  
the second microswitch 124 is not depressed the infeed track 22 is empty. Loading  
may be automated (from a conveyor) or manual in which case the user is prompted to  
add specimen/sample cups 4 accordingly. One skilled in the art will understand that  
sample cups 4 may be automatically loaded onto the disc feeder/conveyor 2 by some  
25     external hopper assembly (not shown), which may or may not be under common  
control of controller 5 (the information from sensor 122 is used to decide whether or  
not to load another cup 4 into the upper infeed track 22). A servo-controlled gate 80  
is provided at the mouth of infeed track 22 to selectively admit sample cups 4 into the  
carousel 20 by rotating out of the way.

5           Similarly, the outfeed track 24 generally comprises a downwardly inclined open-topped chute, optionally equipped with microswitches at its upper and/or lower ends. Operation is similar for the outfeed track 24, where off-loading may be manual or automated.

          In addition to the infeed track 22 and outfeed track 24, the present device  
10 includes an ejection chute 26 for discarding sample cups 4 that present anomalous scan results. The ejection chute 26 leads directly downward.

          As seen in FIG. 5, the infeed and outfeed tracks 22, 24, as well as ejection chute 26 all converge to/from servo-controlled carousel 50. The carousel 50 is formed with three semi-circular recesses separated by three leaves. Floating calibration  
15 standards 52, 53 are carried within two of the three leaves. The floating calibration standards both comprise calibrated reference materials i.e. reflectance standards or wavelength/absorbance standards 152, 153 carried within a rectangular frame as shown, and slidable within a conforming window in the carousel 50. When  
20 measuring reflectance it is necessary to zero the instrument using light reflected from a stable reflectance tile/material which is generally fairly inactive in wavelength species, e.g., ceramic or spectralon). One standard 52 with tile 152 serves this purpose, while the other standard 53 and tile 153 is a wavelength alignment and/or  
check tool which could also be used to check for optical abnormalities including wavelength alignment, absorbance linearity, optical noise etc. It is then necessary to  
25 perform a mathematical correction based on these standards. All this is automated in the present invention. One skilled in the art should readily understand that additional calibration standards may be used is desired, each likewise slidable within a conforming window in the carousel 50.

5           In use of the carousel 20, a sample cup 4 is queued into the carousel 50 from  
infeed track 22 by turning the carousel 50 until the sample cup 4 falls into a U-shaped  
recess 55 defined between flanking leaves of the carousel 50 (three recesses 55 total,  
though carousel 50 may be scaled in diameter to accommodate more or fewer recesses  
55 and number of leaves to store more sample cups 4 without departing from the  
10   scope and spirit of the invention). The radius of curvature at the trough of each U-  
shaped recess 55 is on the order of approximately 1 inch, just larger than the sample  
cup 4. A sample cup need not be in the carousel 50 while it is placing and scanning  
the reference and/or references 152, 153. The carousel 50 is rotated to position the  
standards 152, 153 for scanning and completes two calibration scans using calibration  
15   standards 152, 153, then it loads and positions the sample cup 4 directly in front of the  
monochromator reflection aperture (see FIG. 2). The scan is completed.

Referring back to FIG. 5, in addition to the servo-controlled carousel 50, a  
servo-controlled spinner/indexing wheel 60 is offset from carousel 50.  
Spinner/indexing wheel 60 comprises a rotary wheel with rubber lip spaced at about a  
20   1" offset from carousel 20. Spinner/indexing wheel 60 serves two purposes. First, as  
seen in FIG. 6, it rotates each sample cup 4 while still in the scan position to allow  
taking of multiple scans at various orientations. The rotating sample cup 4 helps to  
eliminate problems associated with sample non-homogeneity. The sample cup 4  
rotation is controlled by controller 5, and may be user-programmed, for example, for  
25   ten scans taken at 36° intervals and averaged for each wavelength. Spinner/indexing  
wheel 60 also operates in conjunction with a detent post 70 to selectively direct  
sample cups 4 into the outfeed track 24 or ejection chute 26. Detent post 70 is  
solenoid driven, journaled into plate 23, and also operates under computer control or  
on-board control. Detent post 70 is energized to protrude slightly from the plate 23,

5 or is deenergized to sit flush with plate 23. When not energized and when carousel 50 is rotated downward or clockwise from FIG. 6, spinner/indexing wheel 60 along with gravity assists to unload the cup from the carousel 50 and push it into the outfeed track 24. When energized, detent post 70 protrudes and allows sample cups 4 to pass into the ejection chute 26.

10 Referring now to FIG. 7, one of the two floating calibration standards 52 is shown in the carousel 20 of FIGs. 3-6. The calibration standards 52, 53 are made to float so that when they are in scan position an underlying magnetic or gravity fed pusher bar 90 (seen beneath) pushes them into direct facing contact with the monochromator scan window, thereby eliminating tolerances. Indeed, pusher bar 90  
15 does this same thing with sample cups 4, which are likewise floating within U-shaped notches. This construct ensures more consistent and accurate scans both of calibration standards 52, 53 and sample cups 4. The pusher 90 is an offset weight hanging at the end of a pivoting arm. The offset bar of pusher 90 makes contact with the selected calibration standard 52, 53 or sample cup 4 to cause the desired force to  
20 act on them, thereby keeping them biased flatly against the scan window of the instrument.

FIG. 8 is an open-top illustration of the electronics assembly 100 for the disc feeder/conveyor mechanism 20 of the present invention, and FIG. 9 is a close-up illustration of the electronics assembly 100. With collective reference to FIGs. 8 and  
25 9, a cover plate 25 is suspended above the hinged plate 23 on support pylons 123, and a cover 125 (removed in these Figs.) encloses the foregoing. This provides protective clearance for mounting an electronic circuit board 200, as well as a first servo-motor 130 and reduction gear 132 for incremental rotation of the carousel 20, and a second rotary servo motor 160 for pivoting operation of the gate 80. As seen in FIG. 9 the

5 weighted pusher bar 90 is attached to a hinge outside inner plate 23 and protrudes forward through an aperture in the plate 23 to urge the selected calibration standard 52, 53 or sample cup 4 against the scan window of the instrument. A magnetic solenoid 150 drives the detent post 70. A servo 180 actuates the servo-controlled gate 80 provided at the mouth of infeed track 22 to selectively admit sample cups 4 into  
10 the carousel 20 by rotating out of the way.

The offset bar of pusher 90 is equipped with an embedded RFID reader/writer 190 (dotted lines) that makes close contact with the selected sample cup 4 to scan and write to RFID tags attached to the disc-shaped sample cups 4 seated in the carousel 50. The RFID reader/writer 190 is preferably a read/write head (pickup coil)  
15 attached remotely from the electronics, integral to the pusher bar 90 that is actually touching the sample cup while it is in the scan position to read and write to the RFID tags of sample cups 4 while at the instrument. This way, as the pusher bar 90 pushes the sample cups the reader/writer head 190 contacts the RFID tag directly. As stated above this second RFID reader/writer 190 pickup coil built into the pusher bar 90 is  
20 connected to RFID reader/writer electronics on circuit board 200, and the resulting functionality is essential to the track-and-trace abilities of the present system. Given that each sample cup in the carousel has a label with a unique sample number, type and other known information from the desktop reader/writer (FIG. 2, ref 32), this second local RFID reader/writer 190 (coil pickup in pusher bar 90) and associated  
25 electronics on circuit board 200 automatically reads the initially-stored data and verifies the proper sample cup 4. It also tells the controller 5 which calibration to use when predicting the constituent values etc. This eliminates the risk of operator error in loading the wrong sample cups. Also, when the instrument completes its sample

5 scan, the scan information itself may be written directly to the sample cup RFID tag including reflection/transmission characteristics, predicted constituent values etc.

It should now be apparent that the above-described system is a more efficient and less error-prone feeder/conveyor for sample cups or other disc-shaped objects that allow a human operator to prepare sample cups, scan them, and track the entire  
10 process quickly and efficiently on an as-needed basis. This helps to ensure that samples are tested as soon as possible after being removed from the line, then ejected from the analyzer back onto a return queue on the feeder/conveyor for prompt disposition.

Although described herein with reference to a process of feeding sample cups  
15 4 into a spectrum analyzer, it should be understood that the inventive device 2 may be used in any industrial, agricultural, or commercial process requiring the queued advancement of disc-like objects from one area to another with minimal electrical output and with the ability to gate said objects for optimal spacing thereof.

Having now fully set forth the preferred embodiments and certain  
20 modifications of the concept underlying the present invention, various other embodiments as well as certain variations and modifications of the embodiments herein shown and described will obviously occur to those skilled in the art upon becoming familiar with said underlying concept. It is to be understood, therefore, that the invention may be practiced otherwise than as  
25 specifically set forth in the appended claims.

## 5 STATEMENT OF INDUSTRIAL APPLICABILITY

There are numerous industrial applications that require the linear transfer of small disc-shaped objects along process lines, batch operations or product storage locations for quality control, testing, packaging, labeling, surface treatment, painting/coating, etc. This is particularly true for commercial grain analyzers which use disc-shaped sample cups that are hand-loaded into the grain analyzer individually. Despite attempts at automating the process, it has proved difficult to feed disc-shaped objects into a precise position at finely-timed intervals. There would be great industrial applicability in a disc feeder/conveyor that can be readily interfaced to a conventional grain analyzer or other device to queue sample cups and transfer them on-demand immediately into a grain analyzer without delay, so that testing occurs as soon as possible after the sample is loaded into the sample cup. The foregoing would allow a human operator to fill a plurality of sample cups with materials to be analyzed, load those sample cups into a queue on the feeder/conveyor, the feeder/conveyor thereupon automating the infeed of the queued sample cups into an analyzer on an as-needed basis so that samples are tested as soon as possible after being removed from the line. Also, sample cups can be ejected from the analyzer back onto a return queue on the feeder/conveyor for prompt disposition.

25

5 We claim:

1. A feeding mechanism for indexing sample cups at the exit aperture of a scanning monochromator, comprising:

a sample cup queuing mechanism configured for attachment to said scanning monochromator, said sample cup queuing mechanism further comprising,

10 an infeed track acutely-angled downward from horizontal toward a point facing said exit aperture for gravity-feeding a plurality of said sample cups thereto,

an outfeed track acutely-angled downward from horizontal away from said point for gravity-feeding a plurality of said sample cups therefrom,

15 whereby said infeed track and said outfeed track converge radially toward said point aperture; and

a carousel rotatable about said point, said carousel comprising a rotatable disc defined by a plurality of radially-spaced recesses, each of said plurality of recesses being configured to seat one of said sample cups.

20 2. The feeding mechanism according to claim 1, further comprising a switchable gate proximate an end of said infeed track for gating sample cups into said carousel.

3. The feeding mechanism according to claim 1, further comprising a spinner wheel proximate said carousel for spinning said sample cups when seated in one of said U-shaped notches.

25 4. The feeding mechanism according to claim 1, further comprising a reject chute.

5. The feeding mechanism according to claim 4, further comprising a solenoid post proximate said carousel, outfeed track and reject chute for diverting said disc-shaped objects away from said outfeed track into said reject chute.

- 5 6. The feeding mechanism according to claim 1, wherein said sample cup queuing mechanism is pivotally-attached to said scanning monochromator by hinges.
7. The feeding mechanism according to claim 1, wherein said infeed track has a first sensor for detecting when it is full of sample cups.
8. The feeding mechanism according to claim 7, wherein said infeed track has a  
10 second sensor for detecting when it is empty of sample cups.
9. The feeding mechanism according to claim 1, wherein said plurality of radially-spaced recesses all comprise semi-circular recesses.
10. The feeding mechanism according to claim 1, further comprising a first calibration standard seated in one of said radially-spaced recesses.
- 15 11. The feeding mechanism according to claim 10, further comprising a second calibration standard seated in another of said radially-spaced recesses.
12. The feeding mechanism according to claim 1, further comprising a pusher mechanism for keeping said sample cups pressed flatly against the monochromator.
13. The feeding mechanism according to claim 1, further comprising a first radio  
20 frequency identification (RFID) reader/writer external to said sample cup queuing mechanism.
14. The feeding mechanism according to claim 13, wherein said sample cup queuing mechanism comprises a second RFID reader/writer.
15. The feeding mechanism according to claim 1, wherein said carousel is servo-  
25 driven.
16. A feeding mechanism for indexing objects to an analyzer, comprising:  
an object queuing mechanism configured for attachment to said analyzer, said object queuing mechanism further comprising,

5                    an infeed track acutely-angled downward from horizontal toward a  
point proximate said analyzer for gravity-feeding a plurality of said objects  
thereto,  
                      an outfeed track acutely-angled downward from horizontal away from  
said point for gravity-feeding a plurality of said objects therefrom,  
10                    whereby said infeed track and said outfeed track converge radially  
toward said point; and  
                      a carousel rotatable about said point, said carousel comprising a disc defined  
by a plurality of radially-spaced recesses, each of said plurality of recesses being  
configured to seat one of said objects.

15    17.    The feeding mechanism according to claim 16, further comprising a  
switchable gate proximate an end of said infeed track for gating objects into said  
carousel.

18.    The feeding mechanism according to claim 16, further comprising a first radio  
frequency identification (RFID) reader/writer external to said object queuing  
20    mechanism.

19.    The feeding mechanism according to claim 18, wherein said object queuing  
mechanism comprises a second RFID reader/writer.

20.    A feeding mechanism for advancing a disc-shaped object, the device  
comprising:

25                    an infeed track for queuing a plurality of said disc-shaped objects, said infeed  
track being angled downward from horizontal;  
                      an outfeed track for queuing a plurality of said disc-shaped objects, said  
outfeed track being angled downward from horizontal opposite said infeed  
track, whereby said infeed track and said outfeed track converge;

5 a reject chute;

a servo-drive carousel rotatable about said point, said servo-drive carousel comprising a disc defined by a plurality of U-shaped notches for receiving said disc-shaped objects;

10 a switchable gate proximate an end of said infeed track for gating disc-shaped objects into said carousel; and

a spinner wheel proximate said carousel for spinning said disc-shaped objects when seated in one of said U-shaped notches; and

15 a solenoid post proximate said carousel, outfeed track and reject chute for diverting said disc-shaped objects away from said outfeed queue into said reject chute.

20

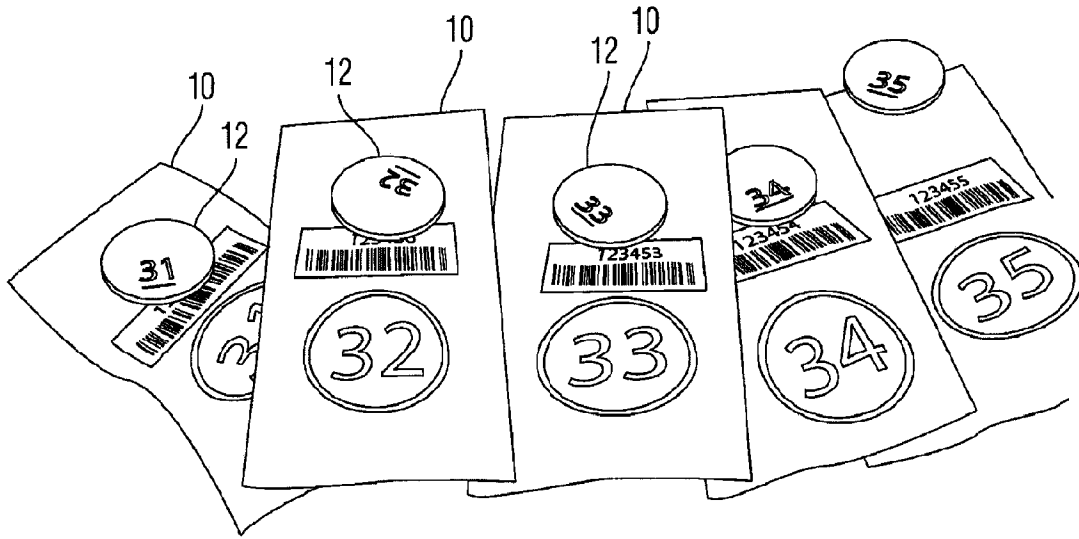


Fig. 1

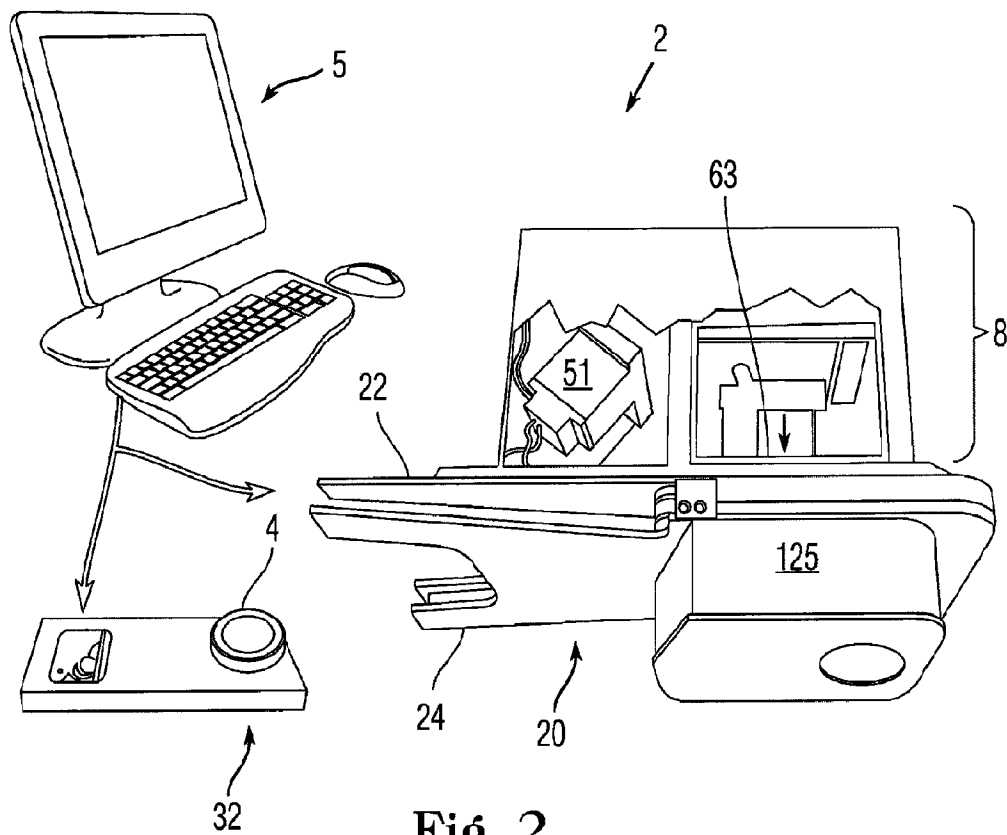


Fig. 2

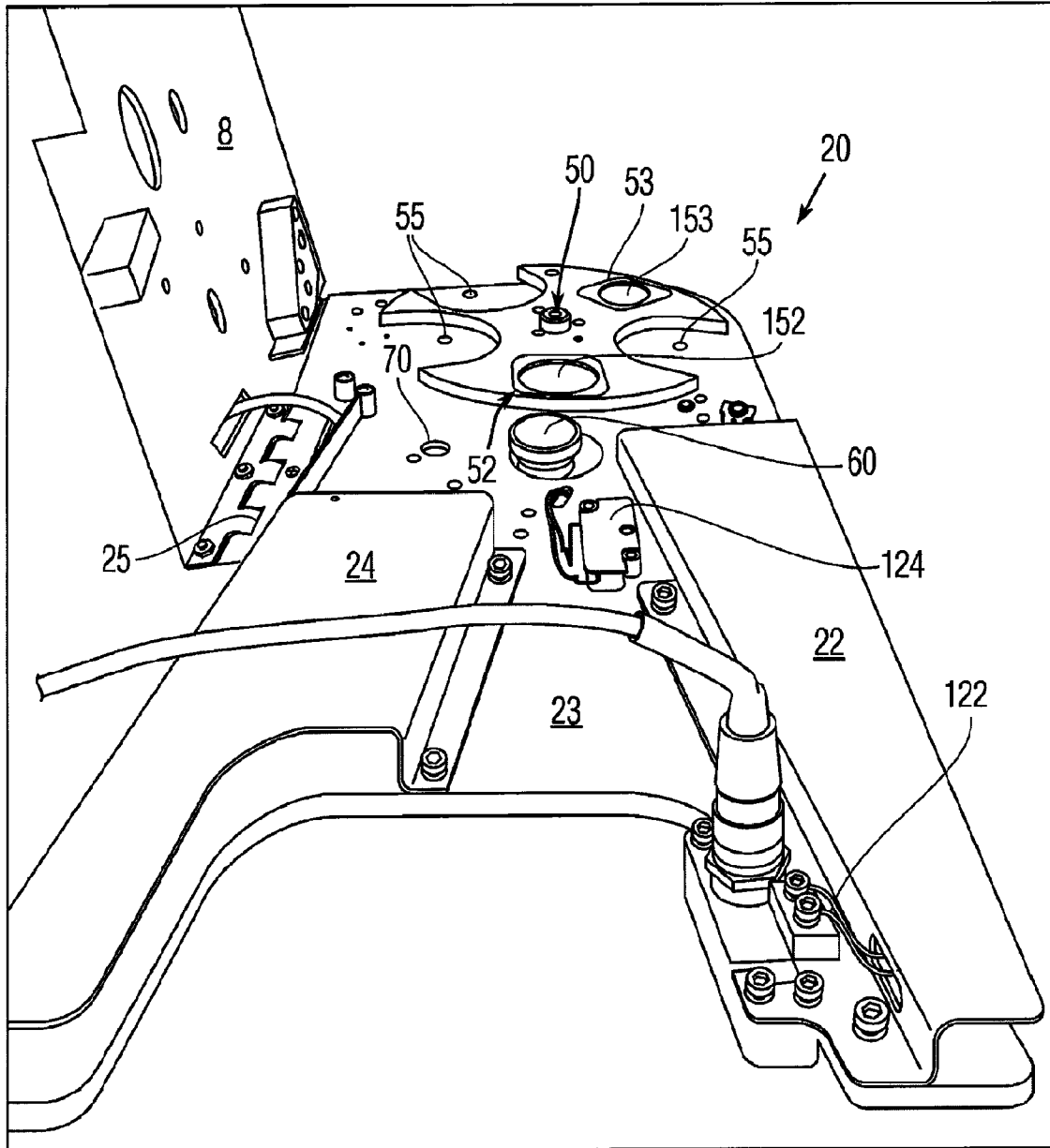


Fig. 3

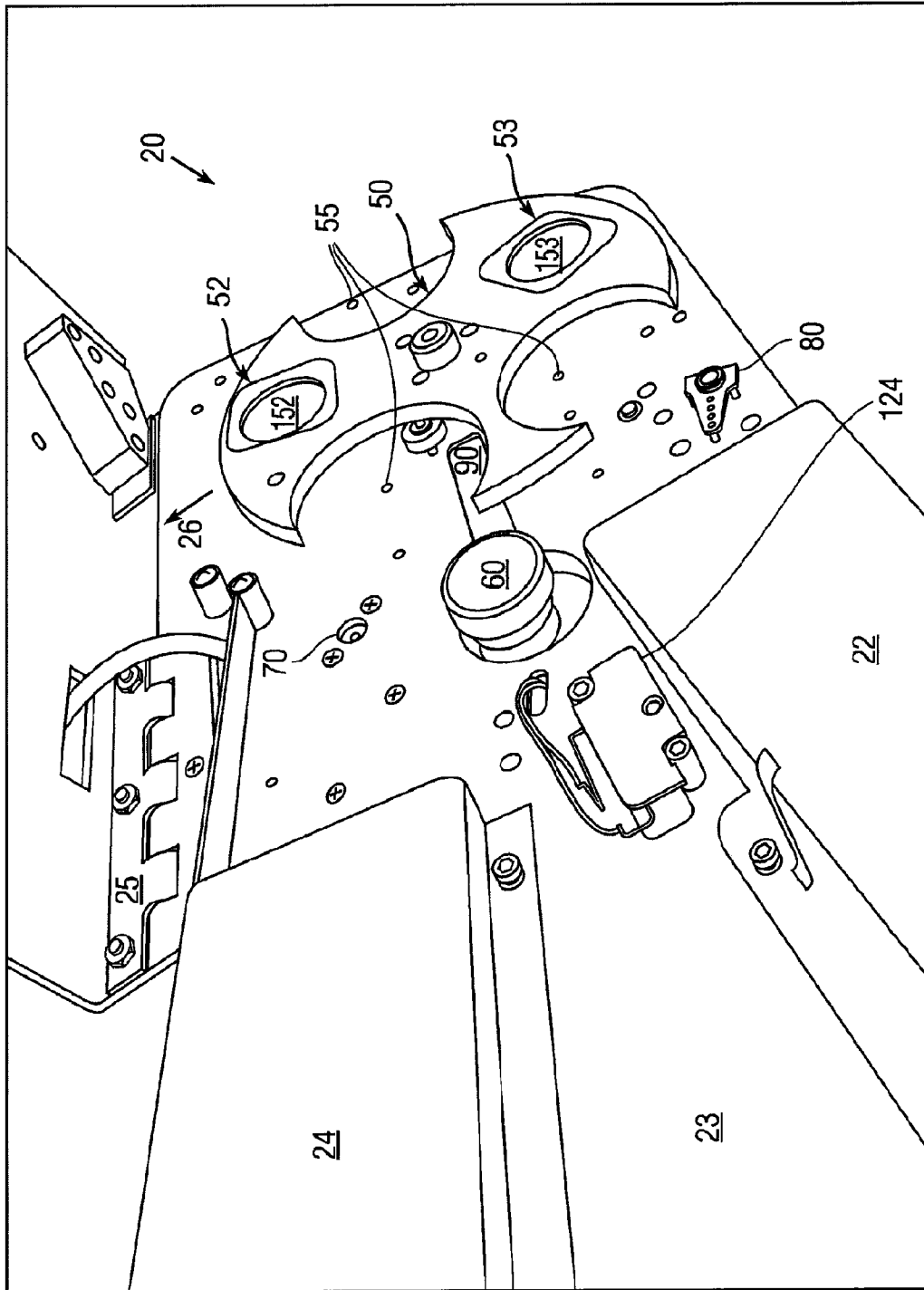


Fig. 4

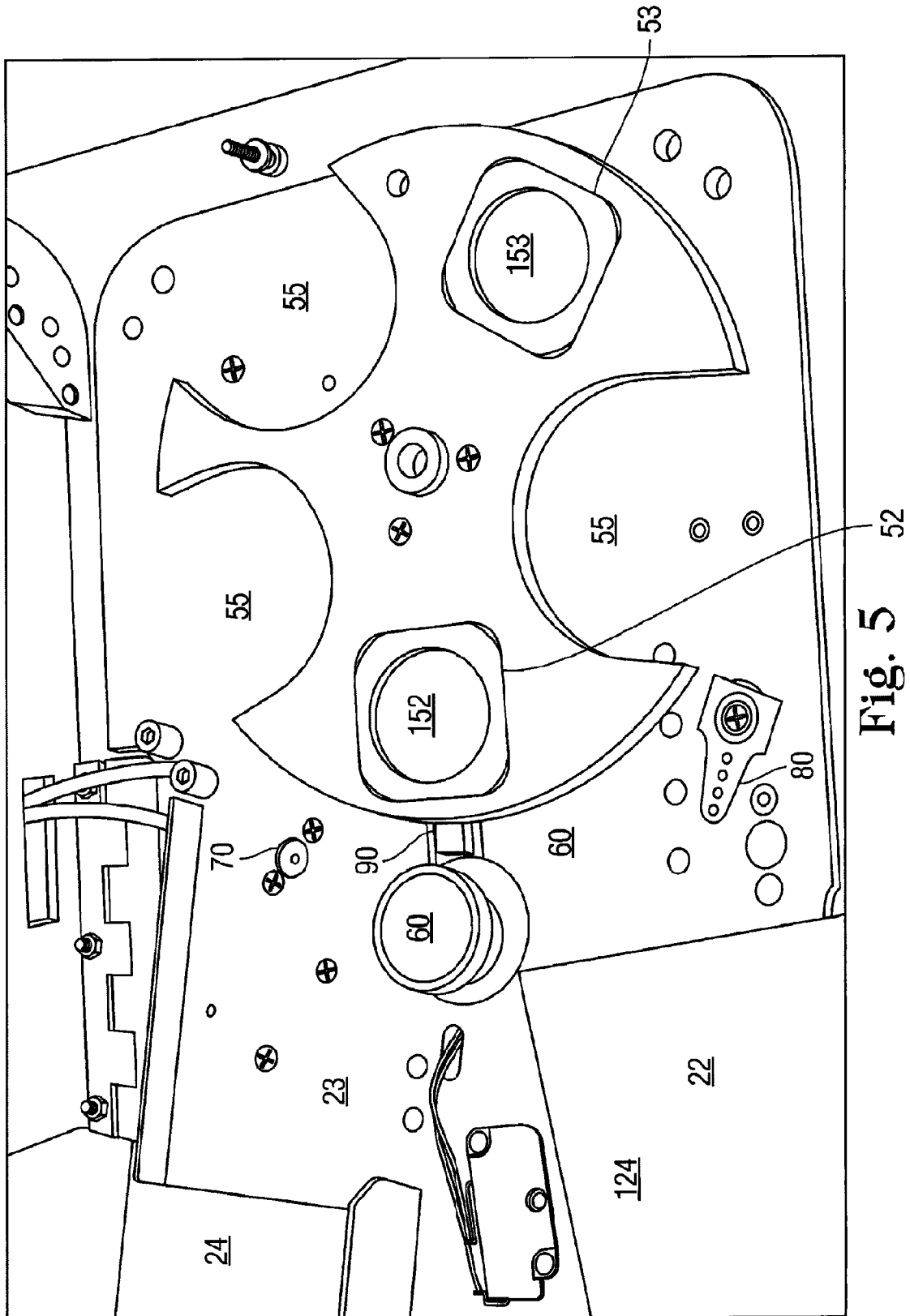


Fig. 5

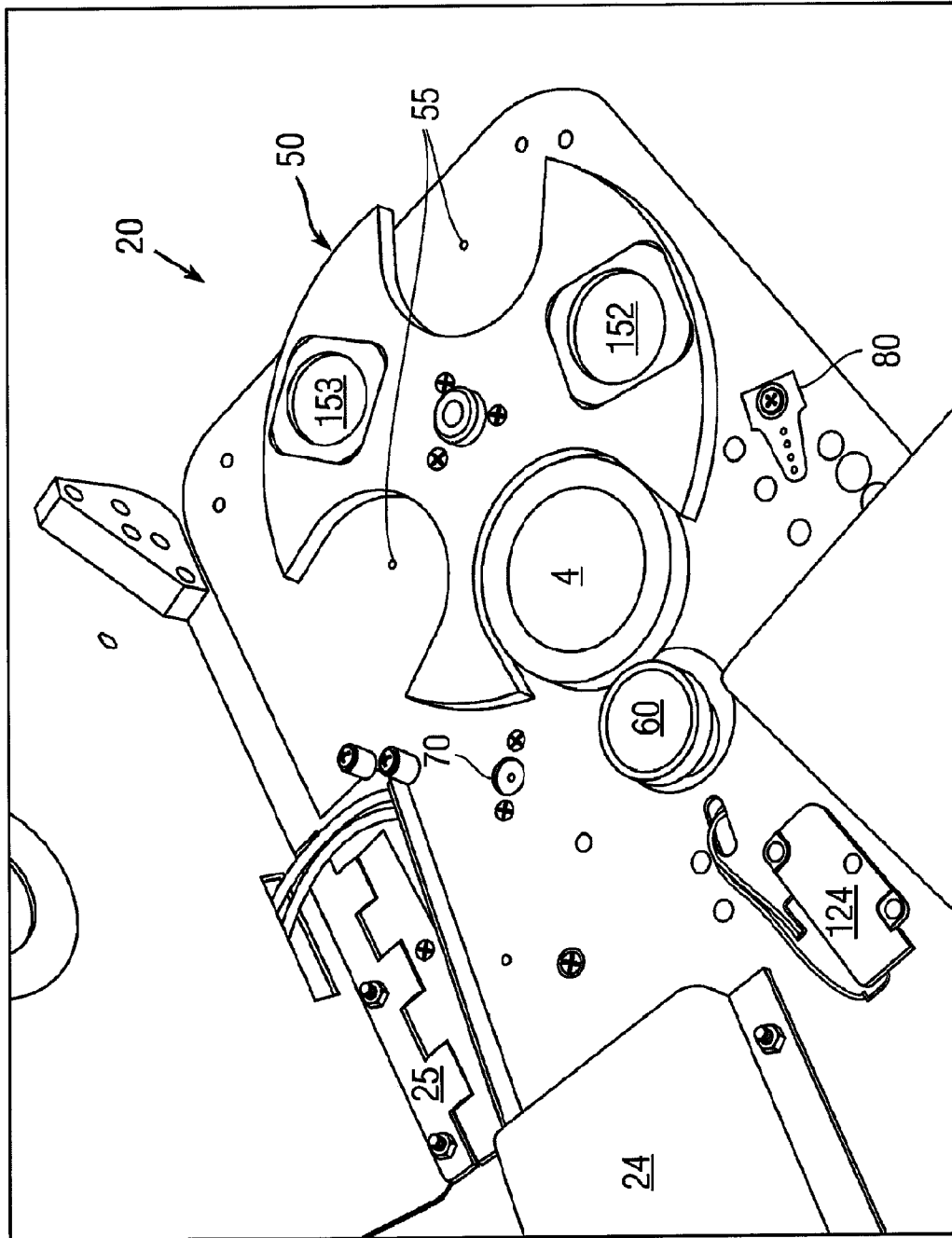


Fig. 6

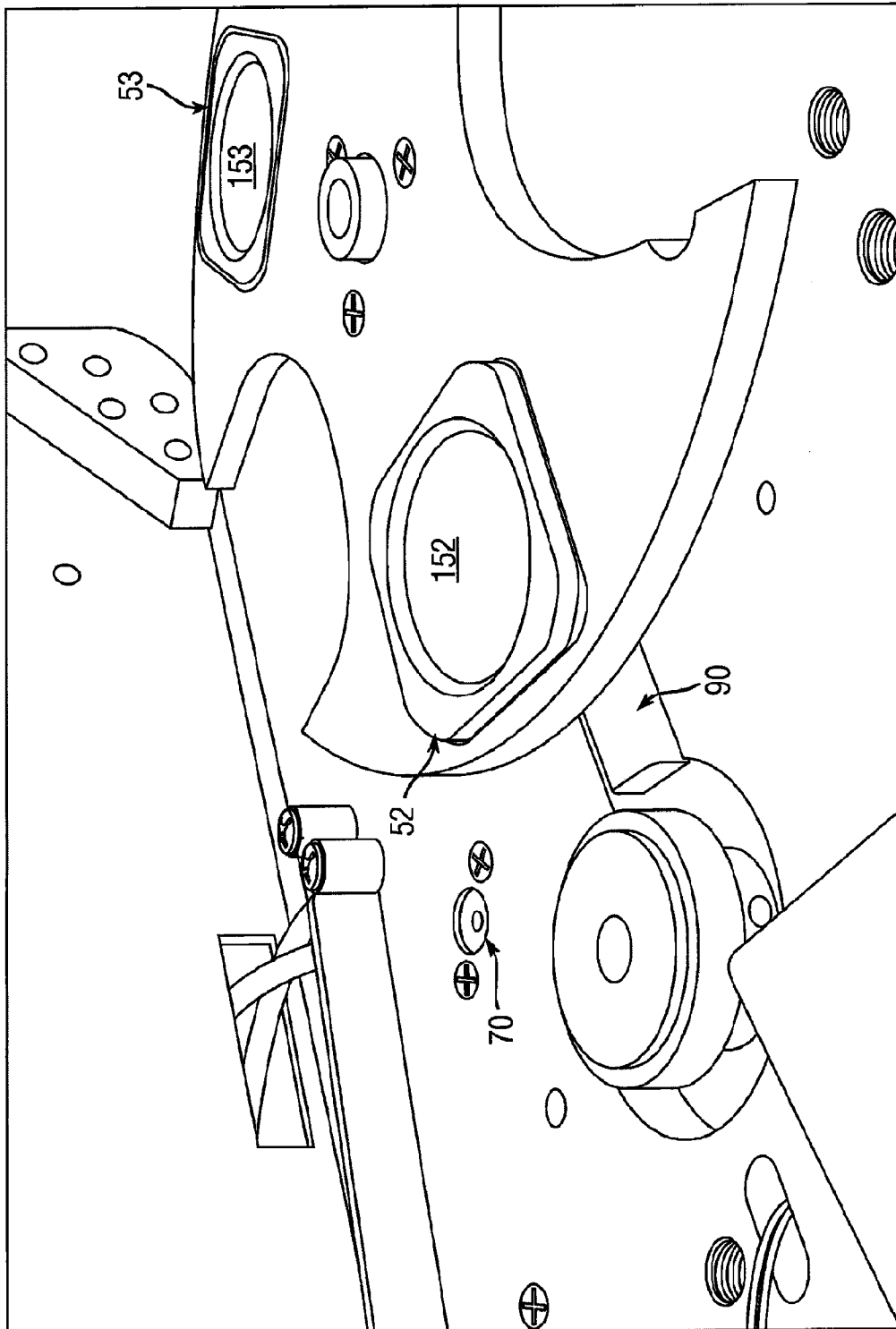


Fig. 7

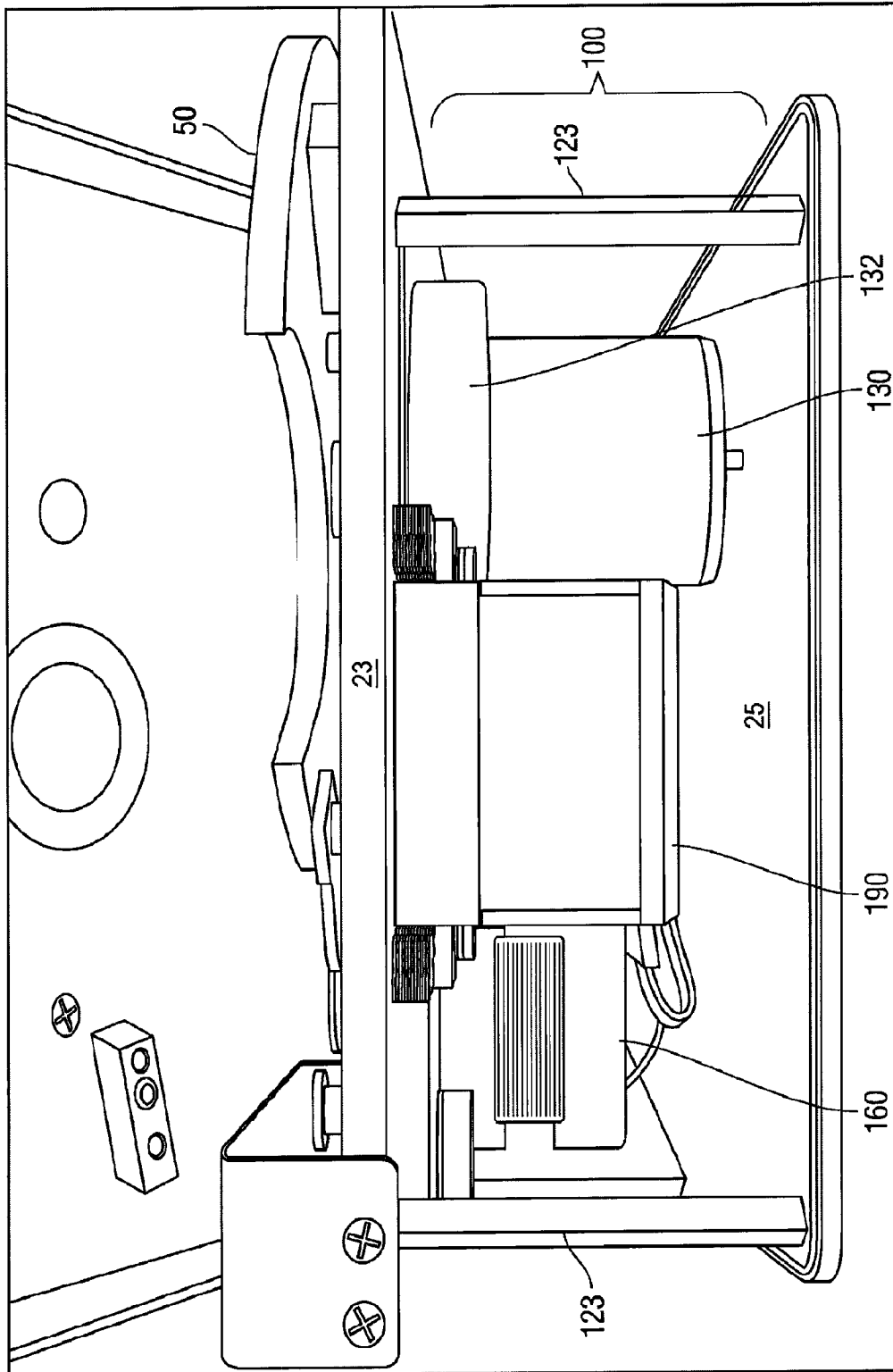


Fig. 8

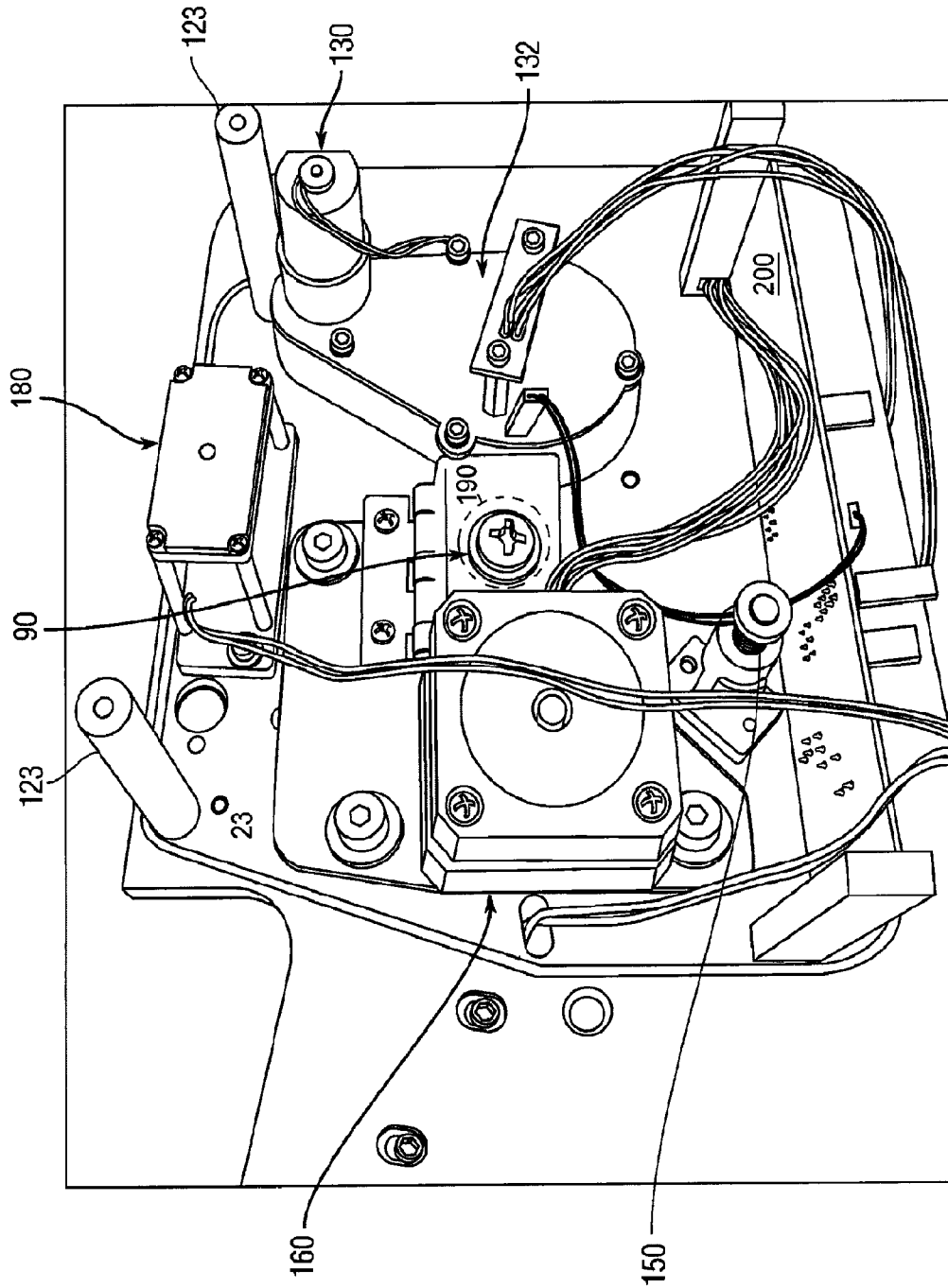


Fig. 9

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/20448

## A. CLASSIFICATION OF SUBJECT MATTER

IPC - G01N 21/13, 21/31, 21/63, 33/02, 33/10, 35/02, 35/04 (2017.01)  
 CPC - G01N 21/13, 21/31, 21/63, 33/02, 33/10, 35/02, 35/025, 35/04

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 See Search History document

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

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,575,978 A (CLARK, FL et al.) 19 November 1996; figures 3, 4A, 17, 56; column 13, lines 1-22; column 21, lines 1-40; column 37, lines 1-10; column 59, lines 30-63; column 61, lines 17-35; column 64, lines 4-8	1, 16, 20
A	US 2011/01125314 A1 (ROBINSON, RJ et al.) 26 May 2011; figures 1, 13-15, 25C; paragraphs [0073], [0080], [0082]-[0085], [0090]-[0091], [0127], [0154]	1, 16, 20
A	WO 2014/002955 A1 (KYOWA MEDEX CO LTD) 03 January 2014; figures 1-2, 6A-B; page 2, paragraph 6; page 5, paragraph 2; page 6, paragraph 2; page 7, paragraph 8; page 9, paragraph 5; page 10, paragraph 3; page 13, paragraphs 2-3	1, 16, 20
A	US 2005/0244972 A1 (HILSON, RO et al.) 03 November 2005; figure 1, 18; paragraphs [0049], [0069], [0080], [0102]-[0104], [0127]	1, 16, 20
A	EP 0 898 171 A1 (ABBOTT LABORATORIES) 24 February 1999; entire document	1-20
A	US 2015/0064802 A1 (SIEMENS HEALTHCARE DIAGNOSTICS INC) 05 March 2015; entire document	1-20
A	EP 0 502 638 B1 (BAYER CORPORATION) 31 May 2000; entire document	1-20
A	US 2002/00056669 A1 (PRATT, WC) 16 May 2002; entire document	1-20

 Further documents are listed in the continuation of Box C.

 See patent family annex.

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

21 April 2017 (21.04.2017)

Date of mailing of the international search report

26 MAY 2017

Name and mailing address of the ISA/

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