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(54) Improvements in and relating to the incubation of samples

(57) The present invention relates to apparatus for incubating a plurality of samples, e.g. biological samples, and particularly as part of an analysis, e.g. radioimmunoassay or enzyme assay, of the samples.

The apparatus comprises an incubation station 9 comprising a plurality of containers 8 to which samples together with diluent and reagents are supplied. The containers 8 are arranged in rows 12*a* in two side-by-side columns 12*b* and are circulated in their rows along the columns and from the end of one column to the beginning of the other column. Sample removal means is provided either at a fixed location 16 as shown or movable relative to the incubator. Circulation of the containers in chamber 9 is controlled by a computer in dependance on the assay being performed and therefore the length of time of the incubation required for that sample so that each sample is placed in register with the sample removal means for removal thereof at the end of the required incubation period.

The station 9 may include a plurality of sections each similar to the station shown in Figure 1 but with the columns in communication so that rows of samples can be moved from the column of one section to the column of an adjacent section, to provide alternative paths for circulation of the samples.

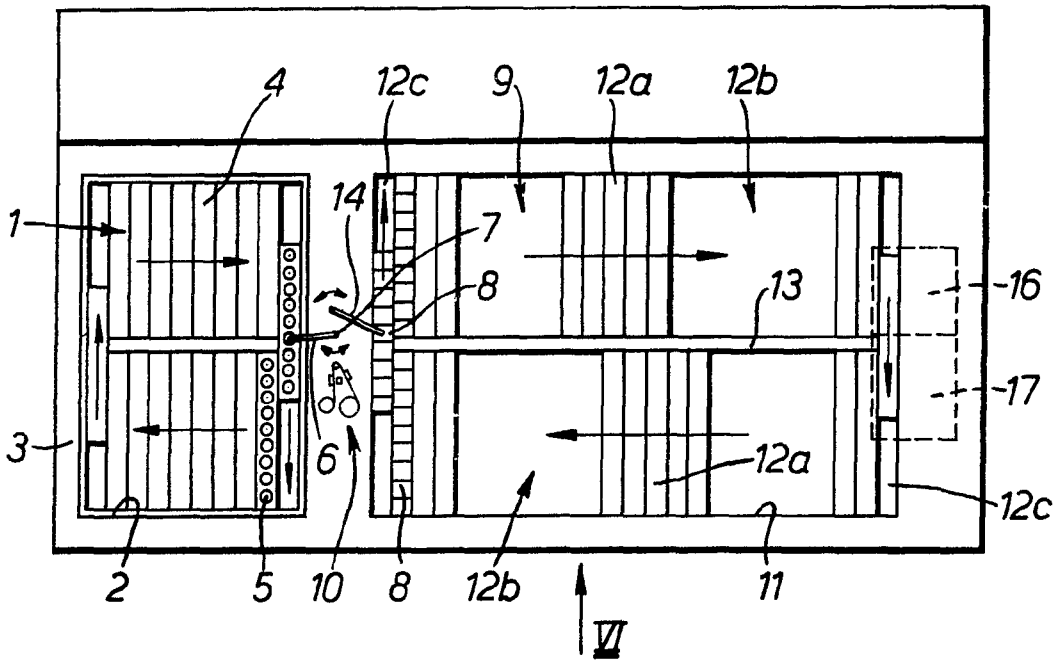

FIG. 1.

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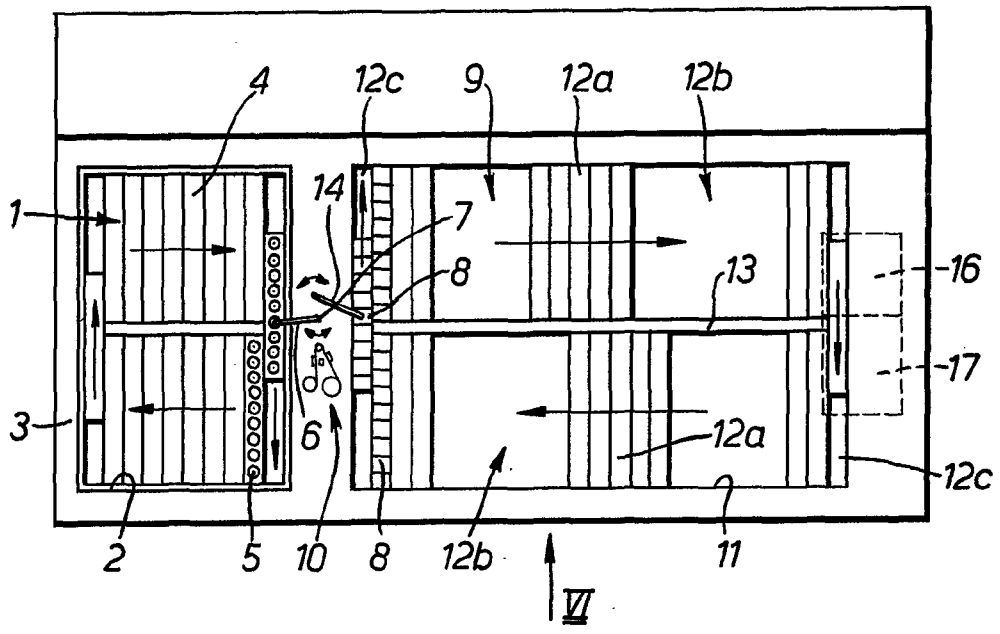
4
12c
9
12a
12b
1
14
7
8
13
16
17
3
6
12a
12c
2
5
10
8
12b
11
VI

FIG.1.

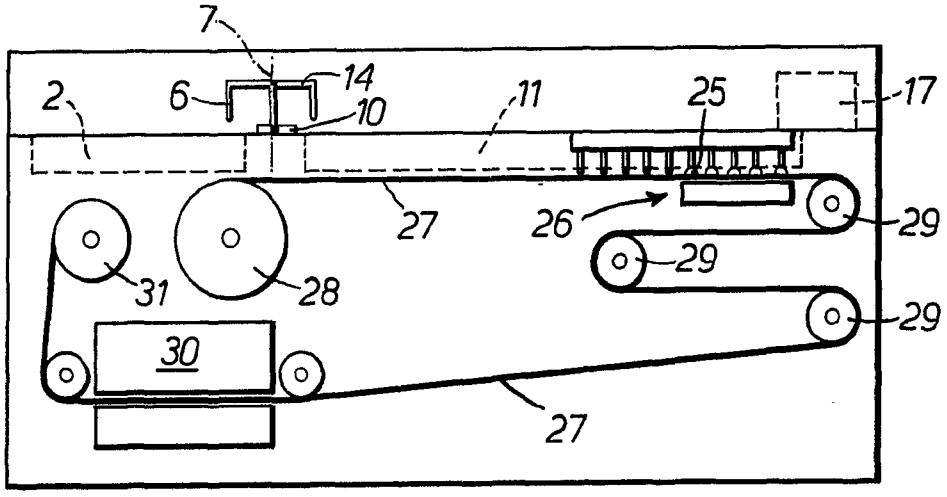
7
2
6
14
10
11
25
17
27
26
29
29
29
31
28
30
27

FIG.6.

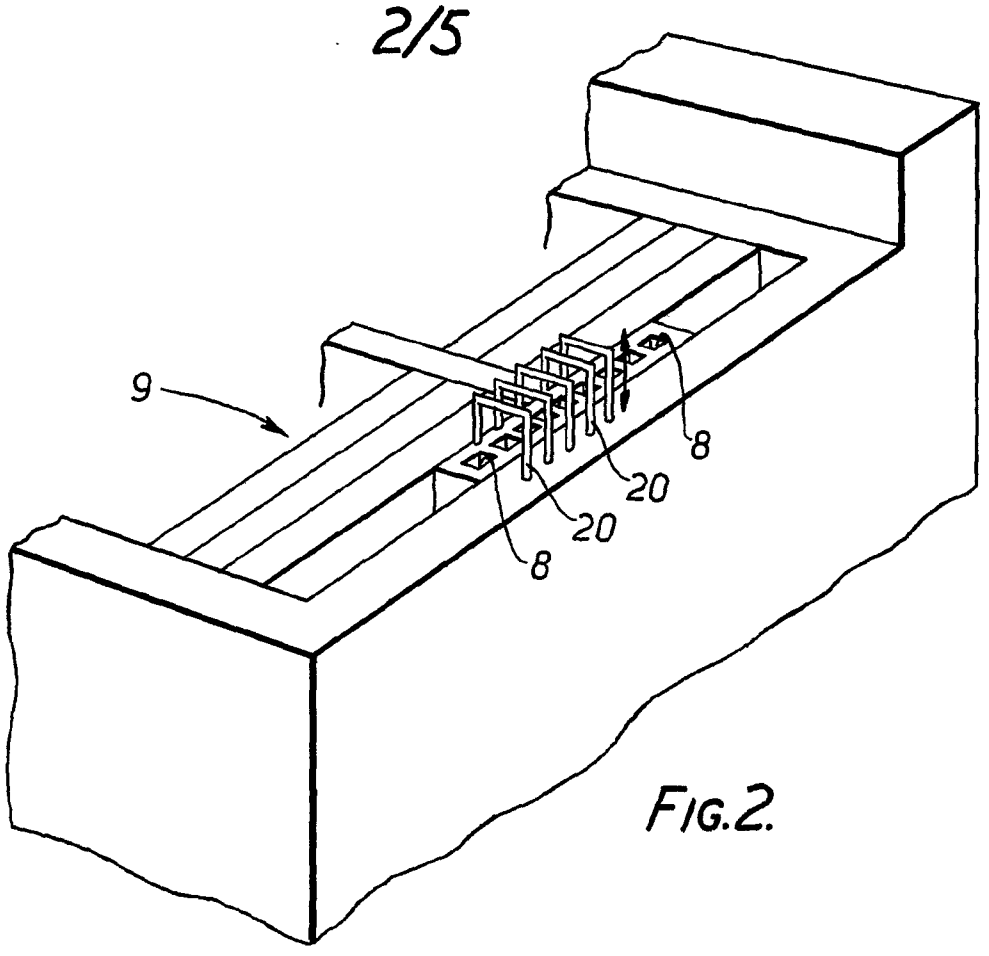

FIG.2.

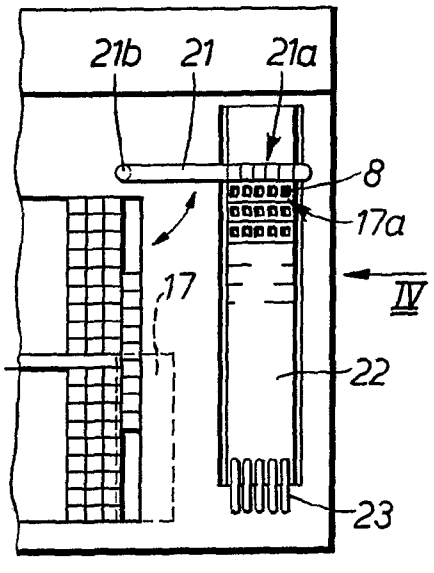

FIG.3.

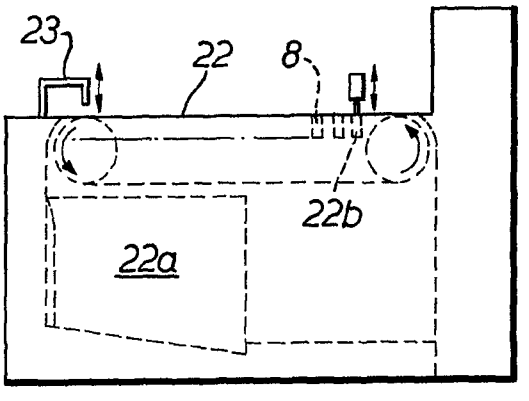

FIG.4.

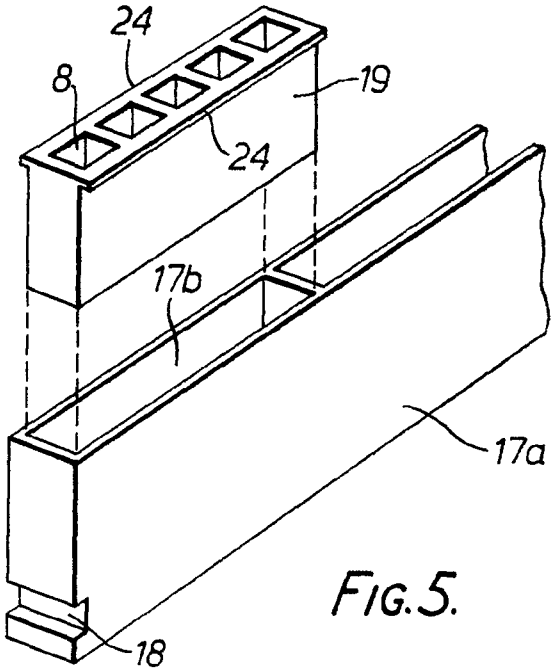
24
8
19
24
17b
17a
18

FIG.5.

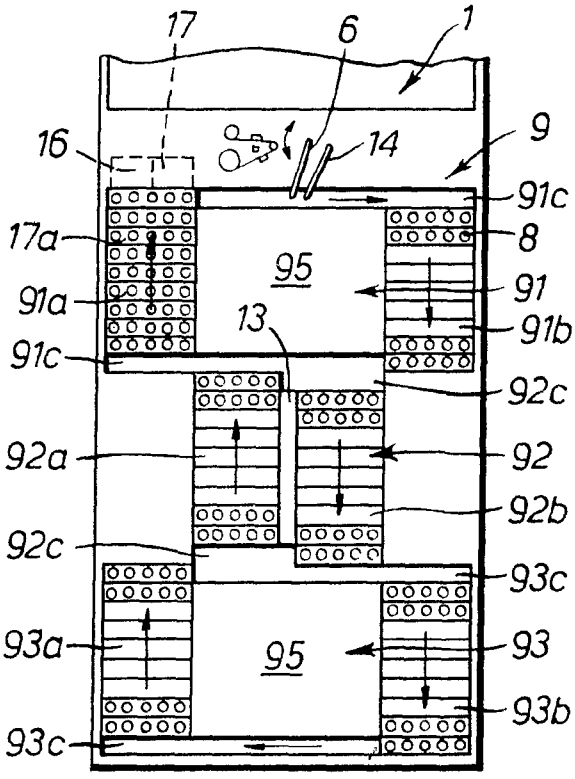
17
6
1
16
14
9
91c
17a
8
95
91
91a
13
91b
91c
92c
92a
92
92b
92c
93c
93a
95
93
93b
93c

FIG.7.

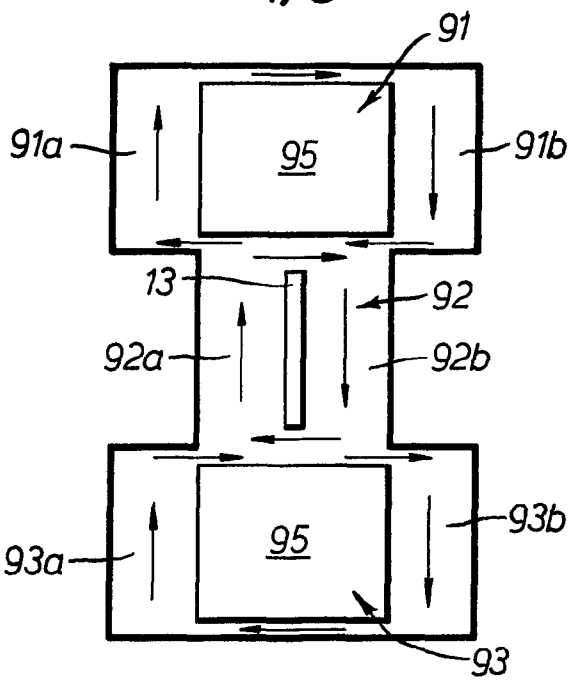
91
91a
95
91b
13
92
92a
92b
95
93b
93a
93

FIG.8.

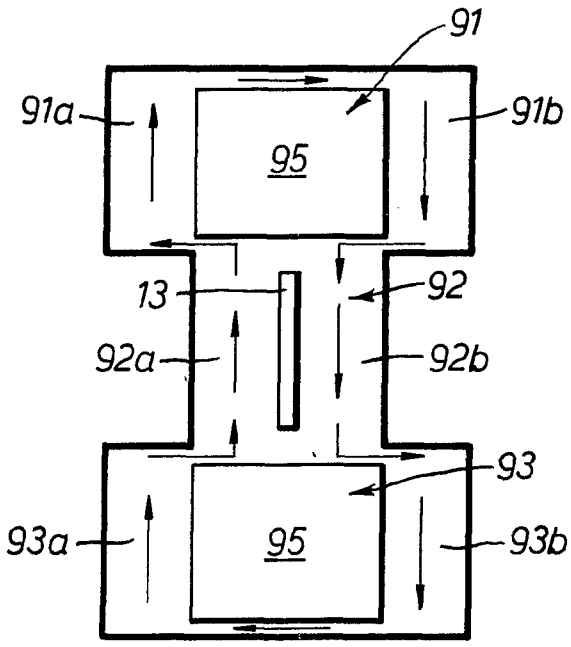
91
91a
95
91b
13
92
92a
92b
93
93a
95
93b

FIG.9.

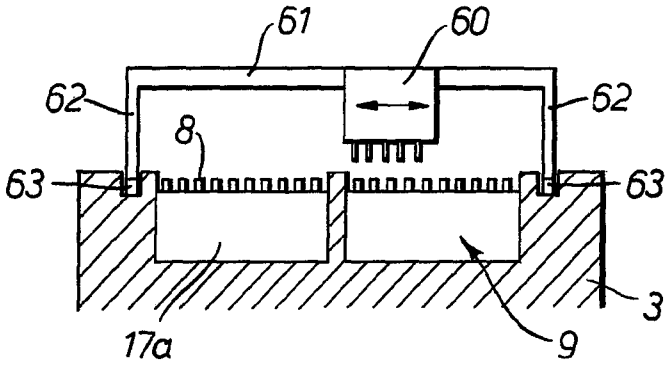

FIG. 10.

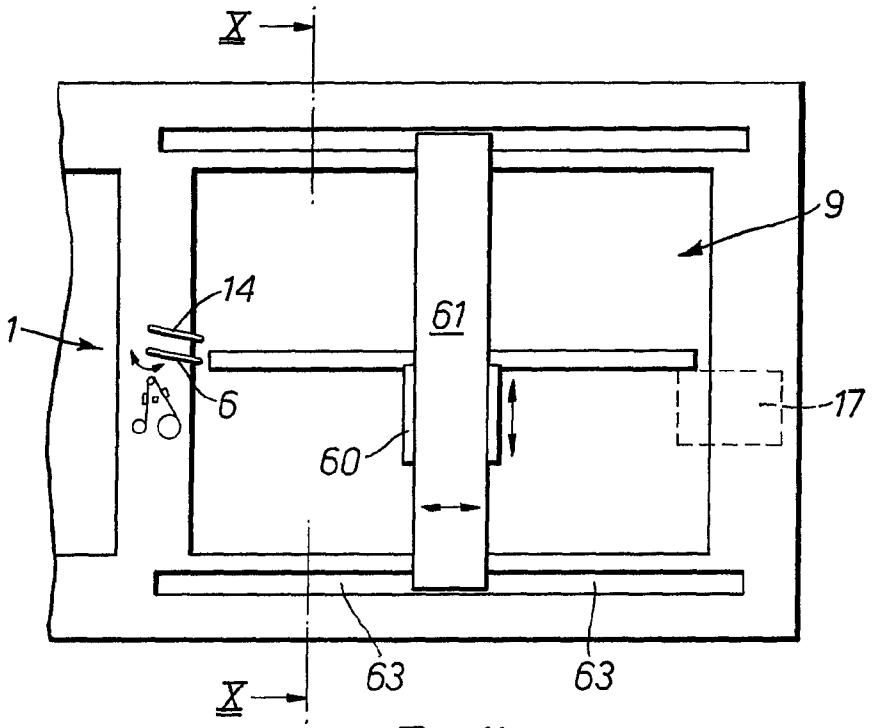

FIG. 11.

SPECIFICATION

Improvements in and relating to the incubation of samples

The present invention is concerned with improvements in the incubation of samples, e.g. biological samples, and particularly as part of an analysis of the samples.

Machines are known which automatically perform an analysis including incubation of a biological sample. However in these machines samples are processed sequentially throughout so that each sample must be subject to the same incubation time. Such a machine is described in U.S. patent No. 3784826. This limitation can be avoided by the use of a separate incubator in which samples are placed manually and then manually removed after the predetermined incubation period. Such an arrangement has however the disadvantage that the full analysis of the sample cannot be performed automatically, because of the interruption of the operation by manual incubation.

According to one aspect of the present invention, there is provided apparatus for incubating a plurality of samples in containers, the apparatus comprising an incubation chamber for receiving sample containers, means for controlling the temperature of the chamber, means for circulating containers through the chamber past sample input means and along a closed path, sample removal means, and control means operable to identify a specified container at the end of a predetermined length of time, to cause relative movement between the specified container and the sample removal means to bring the sample removal means and the specified container into register, and to operate the sample removal means to remove at least part of the sample from the chamber.

The sample removal means may be provided at a fixed location relative to the chamber, the containers then being circulated to bring the specified container into register with the sample removal means. Alternatively the sample removal means may be movable relative to the chamber and the apparatus includes means for moving the sample removal means to bring it into register with the specified container.

The sample removal means may withdraw the container with its sample from the incubation chamber or may withdraw part or all of a sample from a container. In the former case means are provided for inserting a new container in the space left by the removal of the filled container and in the latter case means may be provided for removing the used container and replacing it by a new container. The sample removal means may operate on a plurality of containers simultaneously.

The sample input means may comprise means for transferring a sample to a container in the chamber in register therewith, or may comprise means for transferring a sample already in a container into the chamber. The apparatus may include means for diluting a sample and means for adding one or more reagents to the sample, and the sample removal means may be connected directly or indirectly to means for detecting a characteristic or component of the sample or the part of the sample removed thereby. If the sample is subject to an assay, it may be necessary to filter the sample before the characteristic or component can be detected. Filtration may be effected after the sample has been removed from the container or the container may include two chambers separated by a filter, the sample for incubation being contained in one chamber. The sample removal means may then include means for applying a differential pressure to the container to cause the sample to pass through the filter and means for removing the filtered liquid from the other chamber of the container.

The chamber is preferably adapted to receive the sample containers in rows in at least one pair of side-by-side columns, the circulating means causing the rows of containers to move along the columns and at opposite ends of each column to move transversely from one column to the other column. The chamber may include a plurality of sections in each of which the containers are arranged in rows in a pair of side-by-side columns, circulating means being provided in respect of each section and means being provided to move one row of containers from one column of a section to a column of another section.

The control means may also be capable of checking that a container at the sample input means is empty and, if it is not empty, to cause circulation of the containers to bring an empty container to the sample input means and to then cause operation of the sample input means.

The control means may also include provision whereby if a sample is due for removal from the incubation chamber within a predetermined length of time, the sample input means is prevented from being operated until the particular sample has been removed from the incubation chamber.

The containers are preferably received in holders in the chamber to ensure maintenance of the sequences of containers in the chamber. Each holder may be adapted to receive a row of containers and may include a recess in respect of each container or a recess in respect of a plurality of the containers, which may be formed integrally with one another.

The present invention will be more fully understood from the following description of embodiments thereof, given by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 is a diagrammatic plan view of an embodiment of apparatus in accordance with the present invention;

Figure 2 is a perspective view of part of the apparatus of Figure 1 showing part thereof in detail;

Figure 3 is a plan view of the part of the apparatus shown in Figure 2 but showing a modification thereof;

Figure 4 is a view in the direction of the arrow IV in Figure 3;

Figure 5 shows a container holder and a group of sample containers for use in the apparatus of Figure 1;

Figure 6 is a view in the direction of the arrow VI in Figure 1;

Figure 7 is a diagrammatic plan view of a modification of the apparatus of Figure 1, showing the apparatus filled with sample containers;

Figures 8 and 9 are views similar to that of Figure 7 but showing the apparatus without sample containers;

Figure 10 is a diagrammatic section through a further modification of the apparatus of Figure 1, on the line X–X of Figure 11; and

Figure 11 is a diagrammatic plan view of the modification of Figure 10.

The apparatus shown in Figure 1 is designed to perform an analysis of a sample which includes taking a predetermined quantity of a specimen, if required diluting the sample by a predetermined amount, adding one or more reagents, incubating the reaction mixture and finally detecting a characteristic or product of the reaction of the reaction mixture. The apparatus is specifically designed for radio or enzyme immunoassay or enzyme assay protocols, but is, of course, applicable to other analyses which require incubation.

The apparatus comprises a first station 1 for receiving one or more specimens for analysis. The first station may comprise a recess in housing 3 for receiving a single container, e.g. a tube, containing the specimen, which container is introduced and removed manually. The recess is aligned with a probe 6 which is moved vertically downwardly to introduce its free end into the container aligned therewith, then moved vertically upwardly to withdraw the free end of the probe, pivoted about a vertical axis 7 and again moved vertically downwardly to introduce its free end into a container 8 in a second station 9. The probe 6 is connected to one or more pumps (not shown), for example as described in U.K. application No. 815/77, which are operable to withdraw a predetermined quantity of specimen from container 5 and supply that sample to the container 8. The pumps may also be connected to a supply of diluent for supplying, if or when required, a predetermined quantity of diluent to the container 8 with the sample. The diluent may alternatively be supplied by a separate diluent addition or diluting probe, if required. Advantageously the apparatus is designed to provide a serial dilution of the sample in a plurality of containers 8 in sequence in the second station. Accordingly when a diluted sample has been introduced into the first container 8, this container is moved from its position in alignment with the probe 6 and replaced by a second container 8 into which another diluted sample is introduced etc. Between each vertical movement into a container, the probe 6 is wiped by a mechanism 10 as described in U.K. specification No. 1451449 and between different specimens the probe is washed, also as described in U.K. specification No. 14515,449.

Alternatively the first station may include a conveyor for containers containing specimens and to which containers are supplied manually as samples are received for analysis. The conveyor is operated to move the containers past the probe 6. The conveyor may, for example, be an endless belt carrying means for receiving containers. Alternatively, as shown in Figure 1, the conveyor may cause the containers to move along a closed path. In Figure 1, the first station is provided by a recess 2 in a housing 3 for receiving a removable cassette 4 as described in U.K. specification No. 1451449 containing a plurality of containers 5 with specimens for analysis. The containers 5 in the cassette 4 are moved past the probe 6 by any suitable mechanism, for example as described in U.K. application No. 815/77, which is housed within the housing 3. In a modification the cassette 4 may be made a fixed part of the station.

The second station 9 is an incubation station and is provided by a recess 11 in housing 3, which recess is upwardly closed. In the recess 11 a plurality of the containers 8 are arranged in rows 12*a* in two side-by-side columns 12*b* which are separated by a central wall 13. The number of rows 12*a* of containers in the recess 11 is two less than the total capacity of the recess so that two spaces 12*c* can be provided at opposite ends of the columns, each space for receiving a row of containers from the other column. The wall 13 terminates short of the end walls of the recess to permit a row of containers to move from one column to the other. The containers 8 are circulated along a closed path around the recess 11, in the same way as containers circulate around the cassette as described in U.K. specification No. 1451449, i.e. by moving the rows 12*a* of containers along each column 12*b* in the direction of the arrows and then by moving the end rows at the opposite ends of the two columns transversely from the top of one column into the space 12*c* at the bottom of the other column. The drive for the containers may take any suitable form and may for example be as described in U.K.

application No. 815/77.

The probe 6 is of course arranged at a location past which all the containers move. As shown the probe 6 is arranged at one end of the array of containers in the second station so that each container will come into alignment with the probe 6 as the container passes from one column 12*b* to the other column. During operation of the input probe 6, the containers in the second station are moved intermittently to bring sequential containers into alignment with the probe 6.

One or more reagent addition probes 14 may, as shown, be arranged downstream of the input probe 6. If a single probe 14 is provided, it may be connected by a multi-position valve to a plurality of pumps each connected to a reagent supply. The reagent addition probe is pivotable between an inoperative position clear of the recess and an operative input position aligned with a container 8 and, when in its operative position, is movable vertically into the container.

At the other end of the array of containers, a sample removal device 16 for withdrawing a sample or part of a sample from a container 8 is provided, which device 16 includes or is associated with means 17 arranged downstream of device 16 for subsequently removing used containers and replacing them with new ones. The devices 16, 17 are shown diagrammatically in Figure 1 and will be described more fully hereafter.

In an alternative arrangement, the probe 14, any additional diluent addition probes and the devices 16, 17 may be arranged on the central wall 13 rather than on the housing 3 surrounding the recess 11.

The second station 9 is associated with heating or cooling means (not shown), which may be assisted by one or more fans, for controlling the temperature in the chamber to a predetermined level, e.g. up to 37°C or down to 4°C. The heating or cooling means are controlled by temperature detectors (not shown) arranged in the chamber. As previously mentioned, the recess 11 is upwardly closed and may for convenience be closed by a transparent lid hinged to the housing 3 to provide access to the chamber and a means of visually checking correct operation of the chamber. The lid is of course cut away at the location of the probe 6 and the device 17, at least, and is for simplicity not shown in Figure 1.

The sample removal means 16 may remove one sample at a time or may remove a plurality of samples simultaneously. For the latter, the drive to the containers 8 must be capable of moving the containers intermittently but by the length of a group, comprising the plurality, of containers. The drive means for moving the containers 8 in the second station is controlled by a computer (not shown) to which information concerning the samples introduced by probe 6 and the protocol for each sample is fed. The computer is programmed to identify each container and the protocol for that container. The various protocols capable of being effected by the machine may require different incubation times so that, while initially samples are introduced into the incubation station sequentially, they are not removed sequentially. When the incubation of a particular sample is complete and the sample is due for removal, the computer is programmed to cause continuous circulation of the containers to bring the particular container into alignment with the device 16 so that the sample can be removed. If there are no further samples which need removal within a predetermined length of time, the computer is programmed to then recommence operation of the input probe 6 and reagent probe 14. At the start of input of a sample into the incubation chamber, the computer is programmed to check that no other samples need to be removed within a predetermined period sufficient for input of the sample and its dilution and any addition of reagent. If a sample is due for removal within the preset time, operation of the probe 6 is disabled until the sample has been removed. When the machine has been in operation for some time, empty containers to be filled by the probe 6 will not appear in sequence. The computer is therefore programmed to identify the next empty container upstream of the probe 6 and to cause fast circulation of the containers in the station to bring that empty container to the probe 6.

Because of the continuous circulation of containers through the incubation chamber, it is possible to add reagent to a sample at an intermediate time during incubation, it merely being necessary to programme the computer to move the container to the reagent addition probe at the appropriate time and to cause operation of the pump associated with the probe.

For convenience, the containers 8 of each row in the incubation station are held in a holder 17*a*, Figure 5, which may for example be moulded of plastics material and may be similar to those used with the cassette 4. The holders are preferably arranged so that they cannot be easily removed from the station, to ensure that the sequence of containers is not disturbed, but can be removed for cleaning and maintenance of the apparatus. For example, the side walls of the recess 11 and the sides of the central wall 13 may be provided with a lip, which lips are engaged in recesses 18 at each end of each holder. Each holder 17*a* may have a plurality of pockets one for each individual container 8 of the row, which containers 8 may be made of glass or plastics. Alternatively, as shown in Figure 5, the containers 8 are in groups, each group 19 being made integral and the holder 17*a* is provided

with pockets 17*b* for each group. As shown in Figure 5, each row of containers in the second station comprises a plurality of groups of containers 8 and the holder 17*a* has a corresponding number of pockets 17*b*. However, it will be understood that there may be one group of containers per row. Where the containers are in groups, optionally the number of containers in each group is equal to the number of serial dilutions of a sample which require the same incubation time so that all the containers of a group are emptied at one and the same time.

Where the whole of a sample is to be removed from its container, the device 16 may, as shown in Figure 2, comprise one or more probes 20, each connected to a pump and vertically movable to introduce it into an aligned container 8. The probes 20 are connected to detection apparatus to be described.

In a modification, each container may comprise two chambers separated by a filter, the sample being initially placed in one of the two chambers. The device 16 comprises means for applying suction or pressure to one of the two chambers to cause the sample to flow from the one chamber through the filter to the other chamber, together with the probes 20 for removing the filtered liquid from the other chamber for detection.

Downstream of the probes 20, the device 17 (not shown in Figure 2) removes the or each emptied container and replaces it by a new one. The device 17 may comprise means for engaging an empty container removing it from the holder 17*a* and then depositing it in a discharge shoot or receptacle, and a magazine for new containers associated with means for feeding a new container into a vacated holder.

In an alternative, the removal of containers 8 may be associated with the operation of the probes 20. In this case, the containers are lifted up to the probes 20 by lifting means which engage a container or group of containers. To facilitate grasping of a group of containers, the group may be provided with a flange 24 (Figure 5) around or under which the lifting means engages. The probes 20 are stationary and, once the containers have been emptied, they are discarded by appropriate movement of the lifting means.

Alternatively the samples may be removed from the incubation station while still in their containers. A device for effecting this is shown in Figures 3 and 4 and comprises an arm 21 having means 21*a* at its free end for engaging a group of containers, e.g. by their flange 24. The arm 21 is pivotable about a vertical axis 21*b* between a position in which it engages one or a group of containers at the end of the incubation station and a position, as shown in Figure 3, in which it deposits the container or containers on an endless conveyor 22.

The conveyor 22, shown diagrammatically in Figures 3 and 4, is maintained at the temperature of the incubation station and may be provided with pockets 22*b* for receiving containers 8. The conveyor 22 is moved intermittently to bring the containers 8 on the conveyor to sample removal probes 23 at one end of the conveyor. As with the probes 20, where the containers 8 include filters, the probes 23 may be associated with means for applying suction or pressure to the containers to effect filtration in the containers. The emptied containers drop out of the conveyor 22 as it moves on to its lower run into a receptacle 22*a*. Again means 17 (Figure 3) are provided for replacing the removed containers by new containers. The device 17 may be associated with a checking device for ensuring that, downstream of the device 17, each holder is filled with containers.

The probes 20 and 23 are connected to apparatus for analysing a characteristic of each removed sample or part of a sample, which characteristic, and therefore the apparatus, depends on the analysis performed. Where filtration is not performed in the container, for radio and enzyme immunoassay and enzyme assay, the detection includes the step of filtration of the removed sample and, for radioimmunoassay, detection of the radioactivity of the filtrate or that part of the sample remaining on the filter, and, for enzyme immunoassay and enzyme assay, the addition of a reagent producing a colour change in the filtered liquid, the intensity of which is detected.

For radioimmunoassay and where the sample is to be filtered after its removal from the incubation station, the detection apparatus may be as described in U.K. specification No. 1451449 and can be mounted on the front of the casing 3, as shown in Figure 6. The probes 20 or 23 are connected to inverted cups 25 of a filtration unit 26 using filter tape 27 as described in U.K. specification No. 1451449, which is fed from a supply spool 28. Downstream of the filtration unit 26, the tape is dried as it passes around rollers 29 and is then led immediately to a radioactivity detector 30. The used tape is finally wound on a spool 31.

The detection apparatus is also linked with the computer controlling the incubation station and to an output device which provides a full report on each sample tested. The output device may produce the report in the form of a paper or magnetic tape which is then translated by a suitable printer and converted into printed reports.

In a preferred embodiment the above described incubation station contains from 800 to 2,000 containers 8 which are arranged in rows of between 12 and 24 containers, each row comprising groups of multiple containers, e.g. three groups of five or six containers or

four groups of five containers. It will be appreciated that the arrangement and number of containers in the incubation station will depend on the required throughput of the machine and the type of analysis to be performed by the machine.

Where prolonged incubation is required for some samples, provision may be made for removing those samples from the incubation station 9 to a separate incubator for further incubation. Such samples may be removed manually. For example a section of a lateral wall defining the recess 11 may be detachable or hinged to the housing 3 to provide access to the containers in their holders. The containers in their holders are removed laterally and replaced by new containers and holders. Alternatively, where samples are removed from the incubation station by the means shown in Figures 3 and 4, the arm 21 may be arranged to remove a group of containers and deposited it either on the conveyor 22 or on a means for transferring the group of containers to another incubation station.

Alternatively, as shown in Figures 7 to 9, the incubation station 9 may include two or more sections, each similar to the station of Figure 1, and in which containers can be circulated in a closed path, the sections being in communication so that containers can be passed automatically from one section to the other. As shown in Figures 7 to 9, the incubation station includes three sections, 91, 92 and 93. In each section, the containers 8 in holders 17*a* are arranged in two columns 91*a*, 91*b*, 92*a*, 92*b* and 93*a*, 93*b* and spaces 91*c*, 92*c* and 93*c* can be provided at opposite ends of the columns. The central section 92 has a central wall 13 similar to the wall of the station of Figure 1 whereas, for convenience, the corresponding walls 95 of the end sections 91 and 92 are substantially wider and indeed have a width equal to the width of the central section 92.

In one mode of operation, shown in Figure 8, containers in the three sections are circulated along the respective columns and from one end of a column of a section to the other column of the same section. In other words, the three sections operate independently as though they were three independent circulatory systems.

In an alternative mode of operation the containers in one column, e.g. column 91*b* of section 91 are circulated into the corresponding column 92*b* of section 92 and from there into column 93*b* of section 93. From column 93*b*, the containers are circulated to column 93*a* and from there to columns 92*a*, 91*a* and back to 91*b*. In other words, the sections operate together. In a variation of this circulation mode, two sections may operate together, with the third section operating independently. For example, containers in column 92*b* may be circulated direct to column 92*a* so that sections 91 and 92 operate together and section 93 is operated separately.

The drive to the station may comprise individual drives for the three sections 91, 92 and 93, similar to the drive for the incubation station of Figure 1 but operated synchronously, together with intermittently operated pushers for moving containers from one section to another, when required. Clearly the drive to these pushers is synchronised with the drive for the individual sections.

The sample input probe 6 and reagent addition probes 14 may be provided at any convenient point past which all containers can be moved. As shown these probes are provided at the outer end of section 91 and may be mounted on the housing surrounding the station or on the wall 95.

The multi-section incubation station described above provides the possibility of distinguishing between samples requiring short incubation time and samples requiring a long incubation time and designating the section including the sample input means, e.g. section 91, as a short incubation section through which samples with short incubation times circulate. The containers of samples requiring longer incubation times are then passed out of section 91 into section 92 or section 93, until the end of the incubation period. At least one sample removing means, either for removing the whole or a part of a sample or for removing a container including its sample, as described above, is provided on section 91. A second sample removing means may, if desired, be provided on one of the two sections 92 or 93 so that the longer incubation samples can be removed without requiring their return to section 91.

The above described incubator is controlled by computer as previously described and is associated with the ancillary equipment described above.

In the foregoing apparatus, sample removal is effected at a fixed point in relation to the circulating sample containers. This imposes the requirement on the apparatus that at the end of the incubation period of a sample, the container with that sample must be moved to the sample removal point. In another embodiment shown in Figures 10 and 11, this limitation is removed by providing the sample removal means on a body 60 which is mounted for movement above part or all of the incubation station. As shown the body 60 is mounted on a beam 61, e.g. by rollers running on a flange on the beam. The beam 61 extends across the full width of the station 9 and is supported on legs 62 which run along tracks 63 on the housing 3. Drive means are provided for moving the body 60 along the beam 61 and for moving the beam 61 on its leg 62 along the tracks 63. The sample removal means itself provided on the body 60 may take any of the forms described above

and is connected to suitable detection apparatus, also as described above. The station 9 includes all the ancillary equipment necessary, as described above, and particularly includes means 17 for removing emptied containers (if not removed by the sample removing means) and for replacing removed containers with new containers.

In a modification, the body 60 may be mounted on a cantilever arm extending over the apparatus, the arm being angularly or linearly movable above the station and the body 16 may be movable along the arm, if required.

In the above described apparatus, samples are supplied to the incubation station by probe 6, which transfers the sample from a container in station 1 to a container in station 2. In a modification, station 1 may be provided with containers containing predetermined quantities of specimens and probe 6 may be replaced by a container transfer device which transfers a container with its sample from station 1 to station 2. The container transfer device may transfer a plurality of containers simultaneously. With such an arrangement it is necessary to provide station 2 with container holders 17*a* providing spaces to which containers from station 1 are supplied. With this arrangement, the means in device 17 for supplying new containers to station 2 are omitted. The samples transferred to station 2 may be prediluted or may be diluted in station 2 using a probe similar to probe 6. The control means for the apparatus include means for checking that there is a space at the sample input means for the container and, if the space is already occupied by a container, for causing circulation of the containers to bring an empty space to the sample input means, before permitting operation of the sample input means.

It will be appreciated that containers with samples may alternatively be placed manually in station 2.

CLAIMS

1. Apparatus for incubating a plurality of samples in containers, the apparatus comprising an incubation chamber for receiving sample containers, means for controlling the temperature of the chamber, means for circulating containers through the chamber past sample input means and along a closed path, sample removal means, and control means operable to identify a specified container at the end of a predetermined length of time, to cause relative movement between the specified container and the sample removal means to bring the sample removal means and the specified container into register, and to operate the sample removal means to remove at least part of the sample from the chamber.

2. Apparatus as claimed in claim 1, wherein said sample removal means is arranged in a location fixed relative to the chamber and the control means is operable to cause the circulation means to cause circulation of the containers until the specified container is in register with the sample removal means.

3. Apparatus for incubating a plurality of samples in containers, the apparatus comprising an incubation chamber for receiving sample containers, means for controlling the temperature of the chamber, means for circulating containers through the chamber past sample input means and sample removal means along a closed path, and control means operable to identify a specified container at the end of a predetermined length of time, to operate the circulating means to cause circulation of the containers until the specified container has moved into register with the sample removal means, and to operate the sample removal means to remove at least part of the sample from the chamber.

4. Apparatus as claimed in claim 1, wherein the sample removal means is movable relative to the chamber, the control means being operable to move the sample removal means into register with the specified container.

5. Apparatus as claimed in any one of the preceding claims, wherein the incubation chamber is adapted to receive the containers arranged in rows in at least one pair of side-by-side columns and the circulating means is arranged to cause the rows of containers to move in opposite directions along the columns and then from the end of one column to the corresponding end of the other column.

6. Apparatus as claimed in claim 5, wherein the incubation chamber is adapted to receive containers in only one pair of columns and the containers are circulated by operation of the circulating means in a predetermined order through the chamber.

7. Apparatus as claimed in claim 5, wherein the incubation chamber comprises a plurality of sections each arranged to receive containers in rows in a pair of side-by-side columns, the sections being in communication to permit movement of containers from one section to another, and the circuiting means comprises means in respect of each section for causing the rows of containers in a respective pair of columns to move in opposite directions along the columns and then from the end of one column to the corresponding end of the other column of the pair, and means for causing a row of containers from the end of one column of one section to move to the end of a column of another section.

8. Apparatus as claimed in any one of claims 5 to 7, including container holders, each holder being adapted to receive a row of containers.

9. Apparatus as claimed in claim 8, wherein each holder comprises a plurality of

recesses each for receiving a single container.

10. Apparatus as claimed in claim 8, wherein each holder comprises at least one recess for receiving a plurality of containers.

11. Apparatus as claimed in any one of the preceding claims, wherein the sample removal means comprises at least one probe connected to pump means operable to withdraw liquid, the probe being adapted for insertion in a container to remove the contents thereof.

12. Apparatus as claimed in claim 11, wherein the sample removal means comprises a plurality of probes each connected to pump means and operable to remove a plurality of sample simultaneously from their containers.

13. Apparatus as claimed in either claim 11 or claim 12, wherein the or each probe is connected to means for detecting a characteristic or component of the sample or part thereof removed thereby.

14. Apparatus as claimed in any one of claims 11 to 13, wherein the or each probe is movable from a position above the level of the containers in the chamber to a position within a container.

15. Apparatus as claimed in any one of claims 11 to 13, wherein the or each probe is positioned above the level of the containers in the chamber and the sample removal means comprises lifting means for lifting a container in respect of the or each probe from the chamber to insert the or the respective probe therein.

16. Apparatus as claimed in any one of claims 11 to 15, for use with containers including two chambers separated by a filter, one of the chambers receiving the sample for incubation, wherein the sample removal means includes means for applying a differential pressure to a container to cause the sample to pass through the filter, the probe being arranged to be inserted into the other chamber of the container to remove the filtered liquid therefrom.

17. Apparatus as claimed in any one of claims 11 to 16, including means for removing a container from the chamber from which the sample has been removed and means for replacing the container with a new container.

18. Apparatus as claimed in any one of claims 1 to 10, wherein the sample removal means comprises means for removing a container with its sample from the chamber, and means being provided for inserting a new container in place of the removed container.

19. Apparatus as claimed in claim 18, including conveying means for receiving a container from the sample removal means and for conveying the container to other sample removal means for removing at least part of the sample from the container.

20. Apparatus as claimed in claim 19, wherein the other sample removal means comprises at least one probe connected to pump means, the probe being adapted for insertion in the container to remove the contents thereof.

21. Apparatus as claimed in claim 20, wherein the probe is connected to means for detecting a characteristic or component of the sample or part thereof removed thereby.

22. Apparatus as claimed in any one of the preceding claims including reagent addition means and/or diluent addition means for introducing a reagent and/or diluent into a container in the chamber, the circulating means causing containers to be circulated through the chamber past the reagent addition means and/or diluent addition means.

23. Apparatus as claimed in any one of the preceding claims, wherein the sample input means comprise means for taking up a predetermined volume of a sample and means for introducing at least part of that sample into a container in the chamber.

24. Apparatus as claimed in any one of claims 1 to 22, wherein the sample input means comprise means for transferring a container with the sample therein into the chamber.

25. Apparatus as claimed in claim 23, wherein the control means include means for checking that a container at the sample input means is empty and, if it is not empty, for causing circulation of the containers to bring an empty container to the sample input means.

26. Apparatus as claimed in claim 24, wherein the control means include means for checking that there is a space at the sample input means for the container to be transferred thereby and, if there is no space, for causing circulation of the containers to bring a space to the sample input means.

27. Apparatus as claimed in any one of the preceding claims, wherein the control means include means for preventing operation of said sample input means if a sample is due for removal from the chamber within a predetermined length of time.

28. Apparatus for incubating a plurality of samples in containers substantially as herein described with reference to Figures 1 to 6 of the accompanying drawings.

29. Apparatus for incubating a plurality of samples in containers substantially as herein described with reference to Figures 7 to 9 of the accompanying drawings.

30. Apparatus for incubating a plurality of samples in containers substantially as herein described with reference to Figures 10 and 11 of the accompanying drawings.

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