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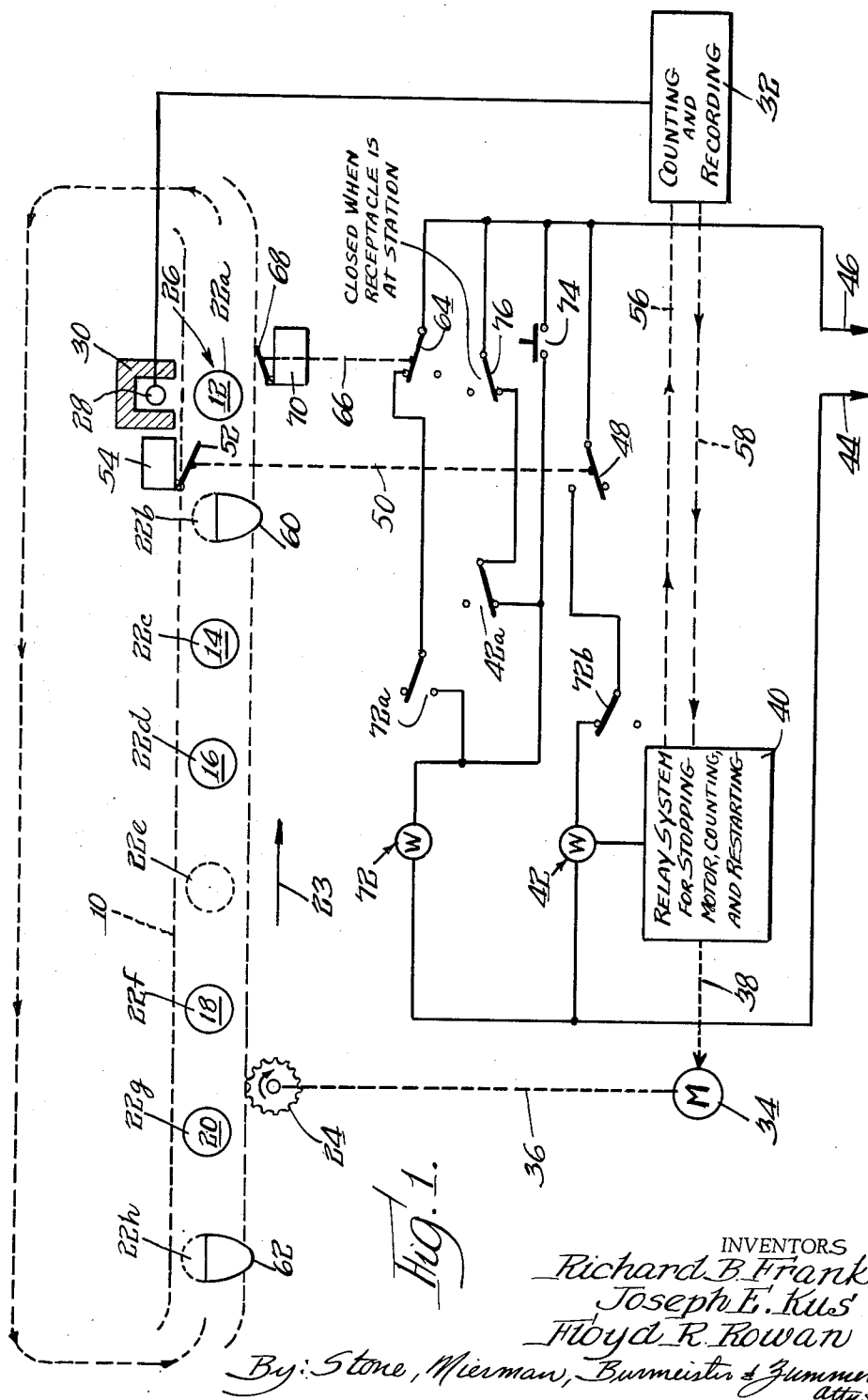
R. B. FRANK ET AL

3,246,156

AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVE SAMPLES

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Fig. 2.

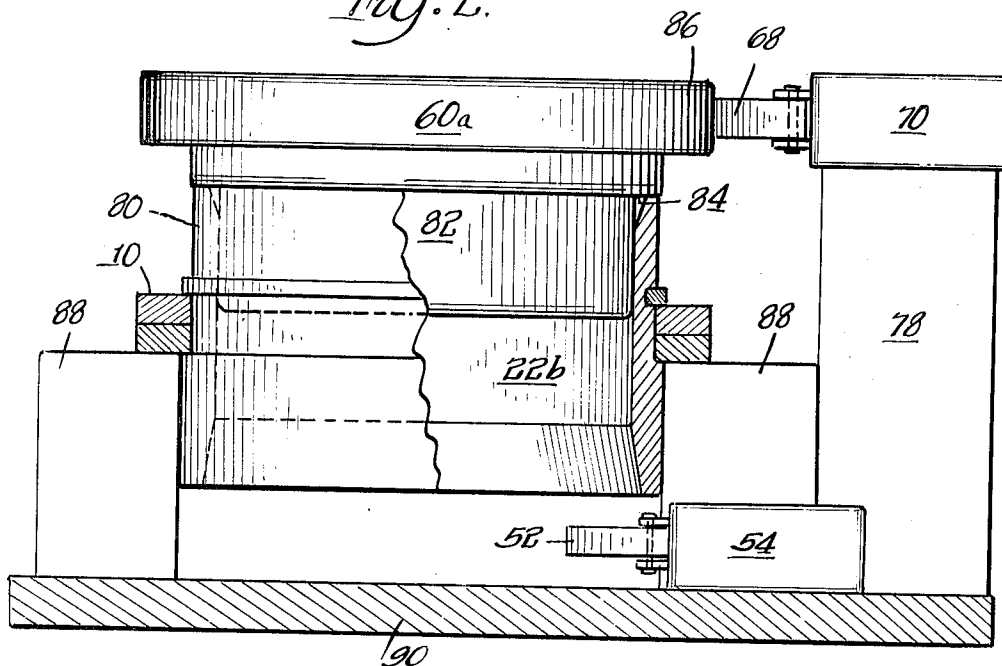
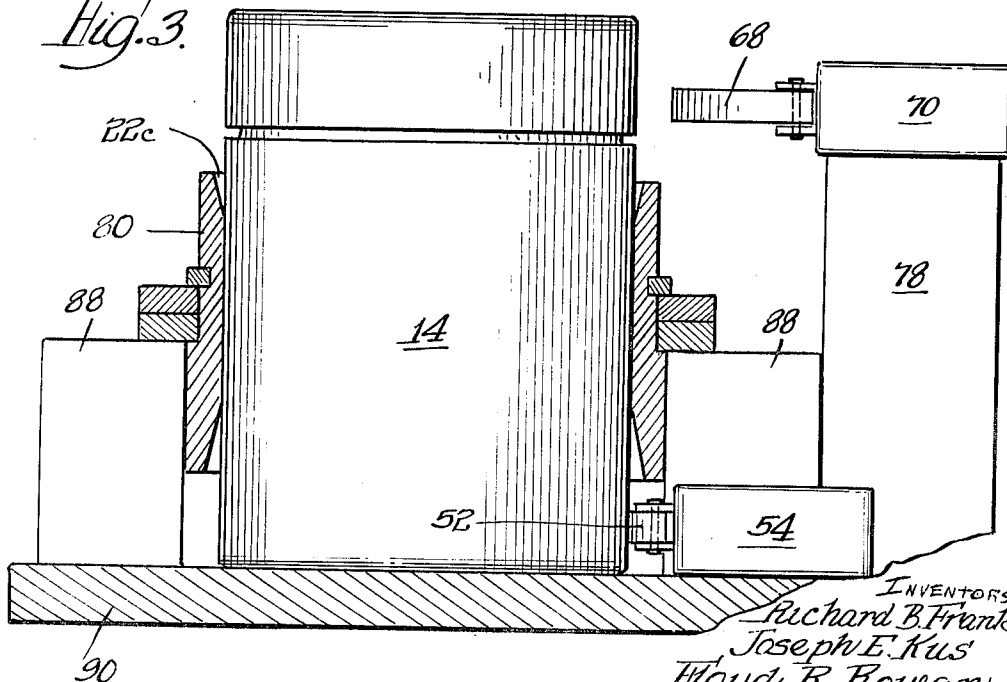


Fig. 3.



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AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVE SAMPLES

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This invention relates to radioactivity measurement devices, and more particularly to automatic devices for measuring and recording the radioactivity of large numbers of samples, such devices being generally known as automatic sample changing systems. The invention is of particular application to systems in which the samples are placed in receptacles on an endless conveyor which stops at a counting station for the measurement and recording of the activity of each sample which is to be measured.

One type of automatic system now in fairly common use is the liquid scintillation system, in which the receptacles for the cylindrical sample bottles normally employed constitute ring-shaped or tubular guides carried by a wheel, chain, etc., the bottles being loosely held in these rings and having their bottoms resting slidably on a table surface along which they are pushed by the wheel or chain conveyor, to bring successive samples to be counted to a counting station, at which point the conveyor stops, the sample is removed (normally by a ram or elevator removing the sample to a light-tight chamber for counting of the scintillations produced by the activity in a scintillating solution in which the sample has been dissolved in preparation for counting), its activity is measured and recorded, it is restored to the conveyor, and the latter is then again moved to bring a new sample to the station.

This type of system has found extremely wide usage in applications such as medical and biological research, where large numbers of samples must be counted. Because the equipment involved is both expensive and bulky, and because of the rapid increase in experimental utilizations found for such equipment in recent years, it is frequently impractical to use a separate system for each individual experiment or worker, and it is accordingly common to provide a large-capacity system for centralized use in a laboratory for various investigations or experiments being carried on at more or less the same time. Various types of experiments or investigations require successive measurements at substantially different intervals. It is inconvenient, and in some cases impractical, to remove the samples from the equipment after each time they are counted, particularly in view of the fact that the sample-holding and counting portion of the system are normally enclosed in a refrigerated region which is desirably at a set temperature during the making of measurements, so that it is in general desirable that access for the changing of samples and similar purposes either be very infrequent or, if frequent, restricted to very short times during which the refrigerated condition of the interior is not substantially changed.

The present invention flows from the recognition of the fact that the factors above have heretofore constituted a substantial limitation on the utility of such automatic sample-changers, and lies in the devising of a fully practical solution to the problem of selective operation of the apparatus for the counting of particular batches or groups of samples while permitting samples temporarily not under examination to remain in place on the conveyor but be by-passed for counting and recording.

Upon examination of the problem presented, a number of solutions present themselves as being apparently satisfactory, but are found to be impractical. For example, it has heretofore been known to provide camming pins

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signaling, as to each sample, whether it is one that is to be counted or one that is to be by-passed, the presence or absence of the pins being detected by one or more suitable switches. This represents a solution which is highly impractical, since the time and care required for the installation and removal of the camming pins each time alteration is made in the samples to be by-passed is virtually equal to that required for the removal of samples whose counting is not desired.

By the present invention, there is provided a very simple manner of providing for the counting of only particular desired groups of samples in the operation of the system, so that the samples to be counted, and those to be by-passed, can be easily selected and altered. In the present system, a single signaling member on the conveyor serves, by its presence or absence, to produce the counting or by-passing of an entire following group of samples, of any desired length. The end of the group, additionally, is signaled without the necessity of installation or removal of any second signaling means; since any particular experiment or investigation is in general found to require counting of all samples in any batch or group, the end of each group to be counted is signaled by the simple omission of a sample from the receptacle appearing after the last sample in the group to be counted.

By the present invention, accordingly, there is provided a flexibility of use heretofore unknown in such devices. For example, the conveyor may readily be divided up into segments allocated to various persons or experiments, with the division point represented by a sample receptacle in which no sample is placed, and which is followed by the successive receptacles bearing the samples to be counted (or by-passed) together as a group. With this arrangement, all that is necessary to start the counting and recording of the samples of that group is the installation of the single signaling member, and the entire group can be restored to the by-pass or storage condition by mere removal of this single signaling member.

The signaling member for installation on the conveyor in accordance with the present invention is extremely simple to use. It constitutes a plug which is inserted in the conveyor in a manner similar to the operation involved in inserting a sample, and similarly easily removed.

For understanding of the invention in greater detail, and in its most advantageous form, reference is made to the embodiment of the invention illustrated in the drawing, in which:

FIGURE 1 is a highly schematic view of a sample-changer system embodying the invention, showing both mechanical and electrical portions in highly diagrammatic and simplified form;

FIGURE 2 is a view in elevation showing in greater detail the manner in which a sensing switch initiating the counting of a group of samples is actuated by a signaling plug placed in a conveyor receptacle in place of a sample, while a sample-sensing switch is not actuated thereby; and

FIGURE 3 is a view generally similar to that of FIGURE 2 showing the manner in which a sample actuates the sample-sensing switch while not actuating the group switch.

The invention will readily be understood in its broader aspects from the highly schematic diagram of FIGURE 1. An endless conveyor 10, as there shown, carries sample bottles 12, 14, 16, 18 and 20. The conveyor 10 is, in the drawing, merely outlined in dotted lines, with a single dotted line showing in a conventionalized manner that the entire path is the closed path of an endless conveyor. In practice, it will of course be understood that the schematic showing may represent any type of endless conveyor, such as a wheel with peripheral apertures, or a serpentine chain provided with suitable sample recep-

tacles, a portion of which (representing the receptacle at the counting station later to be described and the seven receptacles following it) are indicated at 22a through 22h. As seen in the drawing, indicated by the dotting of the appropriate receptacles, no samples are present in the receptacles 22b, 22e, and 22h. The conveyor is driven in the direction indicated in the drawing by the arrow 23 by means of the drive 24, so that the receptacles pass any given point in alphabetical order as indicated by the letters following the numeral 22 in their respective designations.

As illustrated in the drawing the receptacle 22a is positioned at a counting station 26. In the highly diagrammatic illustration, the counting station is shown as a detector 28 and shield 30, this crude illustration being fully sufficient for understanding of the present invention, but it will be understood that in fact the greatest advantages of the invention are achieved in liquid scintillation counting systems, in which the sample is not actually counted in the simple manner shown, the stopping of the samples to be counted at the counting station being followed by removal of the sample from the conveyor to a light-tight region where it is exposed to a photomultiplier (preferably with an additional photomultiplier for discrimination against spurious counts by coincidence circuitry) and then returned to the conveyor receptacle after the counting and recording, after which the drive 24 recommences the motion of the conveyor.

The detector 28 is connected to counting and recording equipment 32, preferably of the type consisting of scalers following suitable amplification and pulse-height selection circuits and suitable print-out registering equipment showing on tape or in similar form each sample (receptacle) number and the appropriate counting data (in terms of time where predetermined count is used, or in terms of count where predetermined time is used).

The drive 24 is coupled to a motor 34, the coupling being indicated schematically by the dotted line 36. The motor 34 is controlled, as indicated by the dotted line 38, provided with arrows showing the direction of control, by a relay system 40 which stops the motor, initiates the counting operation (including the removal of the sample to the region where it is counted and its subsequent return to the conveyor) and restarts the motor 34 at the end of the counting operation.

The winding W of a relay 42 is employed in this relay system, being connected between power lines 44 and 46 by a switch 48 (an additional switching provision shown in series with the switch 48 being presently neglected by considering it as closed, its function being later described). As shown by a dotted coupling 50, the switch 48 is operated by the actuator 52 on the exterior of the switch housing 54. The switch 48 is normally open, but is closed to actuate the relay 42 when the actuator 52 is struck by a sample within a receptacle, but the switch is not actuated upon the passage of an empty receptacle.

As shown in the drawing, the sample-sensing switch 48 is actuated shortly before the sample actuating it reaches the counting station. The relay system 40 includes further relays interconnected with the relay 42 (not shown because not of relevance, and such systems being in any event well known) to keep the relay 42 actuated until after the conclusion of the counting cycle, even though the actuator 52 is released to reopen the switch 48 before actual commencement of the counting cycle.

As indicated by the dotted and arrowed control connection 56 and the reverse control connection 58, the relay system 40 controls the counting and recording equipment 32 as regards initiation of the operation thereof, while the relay system receives from the counting and recording equipment the information regarding the termination of the counting operation which is used to initiate the mechanical operations (if any) in returning the sample to the conveyor, marking the end of the counting cycle, at which point the conveyor again begins

to move. However, as will be seen from what has been said, a sample receptacle which contains no sample, such as 22b, 22e, or 22h, will not be sensed by the actuator 52, so that such a receptacle on the conveyor will be "by-passed," i.e., the empty receptacle will proceed past the counting station without stopping.

As thus far described, the system is of a general type now well-known, the by-passing of empty receptacles being by now conventional in commercial sample-changers, in substantially the manner thus far described. As previously indicated, it would of course be possible to alter this system in a variety of ways to by-pass samples, in addition to empty receptacles, for example by inserting appropriate pins at sample locations to drive the actuator 52, rather than having it driven by the samples themselves, or to supplement the switch 48 with another switch in series therewith but actuated oppositely and simultaneously by such pins, which would in this case operate as selectors for locations to be by-passed, rather than selectors of stations to be counted. However, as previously indicated, provisions of this type are impractical.

In the present construction, it will be seen that in place of samples, the receptacles 22b and 22h are provided with signaling actuators 60 and 62 which operate a switch 64, as shown by dotted coupling 66, by means of an actuator 68 on the switch housing 70. The actuator 68 is positioned to be actuated by the signaling or camming members when the receptacles in which they are placed have proceeded slightly beyond the counting station 26. The switch 64 is normally closed, being opened when so actuated, and is connected in series with the winding W of a relay 72 having latching contacts 72a in series with the switch 64, and having a normally closed set of contacts 72b in series with the relay winding 42 and the switch 48. The series combination of the switch 64 and the latching contacts 72a is shunted by a pushbutton switch 74.

Considering the portion of the structure thus far described, it will be seen that the manual pressing of the pushbutton switch 74 actuates the relay 72, thus closing the latching contacts 72a so that the relay 72 remains actuated until the switch 64 is opened by a signaling or camming member 60 or 62. While the relay 72 is actuated, the relay 42 is disabled by the contacts 72b, so that all samples will be by-passed until one of the signaling or camming members actuates the switch 64, at which point the relay 72 will be inactivated, so that the normal cycle of operation previously described will proceed from that point on, i.e., the next sample after the receptacle bearing the camming signal, and all subsequent samples, will be counted, the portion thus far described having no means for again restoring the by-passing of samples without again operating the pushbutton 74. The primary utility of this mode of operation is the convenience feature of ability to preset the commencement of counting operations in such a manner that the first sample that will be counted is one which is presently remote from the counting station, the insertion of the signaling cam or plug permitting full setting of the external manual controls and placing of the equipment in operation by means of the switch 74, with knowledge that all samples prior to the desired commencement of operation will be by-passed.

Shunting the two connection paths for the relay 72 previously described (and switched out by a switch, not shown, when the deferred conventional operation just mentioned is desired) is a third path consisting of the series combination of a switch 76 and the normally closed contacts 42a of the relay 42 (this set of contacts of course being auxiliary or additional to other sets of contacts of this relay within the system 40). The switch 76 is normally open, but closes each time that a receptacle passes the counting station 26. The mechanism for closing this switch is not shown in the drawing, many suitable mechanisms for this purpose being obvious, such as, for example, the provision of auxiliary actuators on the con-

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veyor, or, more simply, direct driving of the switch 76 by a suitable cam connected to the motor drive.

Consider now the effect of this third shunt branch in the connection of relay 72. As previously pointed out, the relay 72, when actuated, disables the relay 42, and thus the relay system 40 which stops the motor and produces the counting cycles. As just pointed out, the opening of the switch 64 by a signaling pin or plug (or other signaling attachment) disables the relay 72, thus restoring the operation of the relay 42 and the relay system 40, to "normal." It was earlier pointed out that the relay 42, once actuated by the switch 48 as a sample approaches the counting station, is held in latched condition by the system 40 until the end of the counting cycle. Accordingly, so long as the switch 48 senses samples in the receptacles, each time the switch 76 closes, it will find the normally closed contacts at 42a open. However, when the switch 76 closes with no sample in the receptacle at the counting station, the switch 48 will not have been operated, so that the contacts 42a will still be closed, and the relay 72 will accordingly again be actuated to recommence the by-passing of samples, until another signaling actuator 60, 62, etc., again actuates the switch 64. Thus with this last branch in the circuit, the system stops and counts each sample after the switch 64 is actuated, until there comes to the counting station a receptacle bearing no sample, at which point the by-pass operation is restored until another signaling member 60, 62, etc., actuates the switch 64 again.

Applying this to the elementary or rudimentary arrangement of samples shown in the drawing, it will be seen that the signaling member 60 will initiate the counting of samples 14 and 16, the empty receptacle 22e will be by-passed as in all modes of operation, and the samples 18 and 20 will also be by-passed, but the further signal cam or attachment 62 will again start the counting of the next group of samples, which will again cease when an empty receptacle is encountered.

It may be noted, as schematically indicated by the shaping of the cams 60 and 62 in FIGURE 1 so that they do not actuate the sample-sensing switch 48, that a single receptacle can, if no empty receptacle precedes it, serve the combined purpose of signaling the end of one group and the commencement of another. Where the system is used solely for the purpose of by-passing samples, this feature is not in general greatly important, but it will be seen that the group indication can also be used for other purposes, such as advancing of a print-out tape by a substantial amount for convenience in the appearance of groups on the tape, and the group mode of operation can accordingly be used for this purpose even where the conveyor contains no samples desired to be by-passed. Such purposes may readily be served, for example, by use of the presently unused "open" contact of the switch 64. Additionally, of course, where switching provision (not illustrated) is made for disabling of the "group" system to employ a conventional sequential operational mode, the receptacles bearing signaling members will be effectively empty as regards the conventional by-passing of empty receptacles.

FIGURES 2 and 3 show a more detailed construction of a particularly advantageous form of a part of the construction illustrated schematically in FIGURE 1. As shown in these figures, the housing 70 of the sensing switch for the "group signal" is mounted on a support 78. The conveyor 10 is of the type described in the copending application of Raymond L. Meeder and Joseph E. Kus, filed April 15, 1963, Serial No. 273,067, constituting in itself no portion of the present invention, and which issued as U.S. Patent No. 3,206,006. The sample receptacle is a thimble or ring 80, shown in FIGURE 3 with a sample bottle or vial 14 therein, and shown in FIGURE 2, in accordance with the present invention, with a group-signaling plug 60a having a stem 82 fitting into the ring or thimble 80, a lip 84 resting on its upper edge, and a rela-

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tively large flange 86 engaging the actuator 68 of the switch 70. The actuator 52 of the switch 54 is below the ring or thimble 80 and extends into the path subtended by the sample 14, the conveyor 10 being supported by slide blocks 88, and the sample 14 sliding on the top plate or table 90 of the apparatus. It will be seen that the actuators 68 and 52 of the respective switches are in the paths subtended transversely by the plug 60a and the sample bottle 14, but neither is in the subtended path of the object actuating the other, thus corresponding to the highly diagrammatic representation of the signaling members 60 and 62 of FIGURE 1.

It will be of course understood that the invention is not limited in its scope to the particular embodiment illustrated and described above, and that persons skilled in the art will readily make many modifications thereof, some obviously incorporating the teachings of the invention, and some seen to incorporate the teachings of the invention only after careful study. Accordingly, the scope of the invention should not be limited to the particular embodiment illustrated, but should be determined in terms of the structure described in the annexed claims, and equivalents thereof.

What is claimed is:

1. In an automatic sample changer for radioactive samples having

(a) a counting station, an endless conveyor with receptacles adapted to receive samples to be counted and to transport them repetitively through the path of the conveyor, means for driving the conveyor to move successive samples to the counting station, counting cycle programming means to stop the conveyor to position samples at the counting station and to measure and record the activity of each sample so stopped at the counting station, and means to restart the conveyor after each counting cycle, the improved construction having

(b) a first sensing means adjacent to the counting station for sensing the presence of a sample in each receptacle and for actuating the counting cycle programming means only when a sample is present,

(c) group selection members adapted to be placed at desired preselected locations on the conveyor,

(d) a second sensing means for sensing the presence of such a group selection member as it reaches a predetermined point in the path of the conveyor, and

(e) means including the second sensing means to inactivate the counting cycle programming means to by-pass the counting of all samples other than groups commencing at the positions corresponding to the preselected locations of the group selection members and to activate the counting cycle programming means to count the samples in said groups.

2. The sample changer of claim 1 wherein the group selection members are seated in the sample receptacles.

3. The sample changer of claim 2 wherein the group selection members are of different configuration from the samples, and the sensing means are electrical switches having operating members in the paths respectively subtended by the samples and the group selection members.

4. The sample changer of claim 2 wherein the group selection members are plugs having flanges resting on the edges of the receptacles.

5. In an automatic sample changer for radioactive samples having

(a) a counting station, an endless conveyor with receptacles adapted to receive samples to be counted and to transport them repetitively through the path of the conveyor, means for driving the conveyor to move successive samples to the counting station, counting cycle programming means to stop the conveyor to position samples at the counting station and to measure and record the activity of each sample so stopped at the counting station, and means to restart the conveyor after each counting cycle, the improved construction having

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- (b) a first electrical switch adjacent to the conveyor having an actuator member in the path subtended by samples in the receptacles,
 - (c) plug members seated in preselected receptacles and differing in transverse shape from the samples to have a portion of their subtended paths in transverse regions extending beyond the subtended paths of the samples,
 - (d) a second electrical switch adjacent to the conveyor having an actuator member in said portion of the subtended paths of the plug members and out of the subtended paths of the samples and
 - (e) means responsive to said switches to program the sample-counting in accordance with the preselected locations of the plug members.
6. The sample changer of claim 5 wherein the last programming means includes means responsive to the actuation of the second switch to repeatedly stop the conveyor and count all successive samples following the plug actuating the switch and means responsive to absence of actuation of the first switch in the passage of a receptacle to terminate the stopping and counting until the second switch is again actuated.
7. In an automatic sample changer for radioactive samples having
- (a) a counting station, an endless conveyor with receptacles adapted to receive samples to be counted and to transport them repetitively through the path of the conveyor, means for driving the conveyor to move successive samples to the counting station, counting cycle programming means to stop the conveyor to position samples at the counting station and to measure and record the activity of each sample so stopped at the counting station, and means to restart the conveyor after each counting cycle, the improved construction having
 - (b) means associated with the stopping means for the disablement thereof,
 - (c) a signaling member at a manually preselectable position on the conveyor,
 - (d) means responsive to the movement of the signaling member past the counting station to disable the disabling means to restore the operation of the stopping means, and
 - (e) means responsive to movement of a subsequent manually selectable position on the conveyor past the counting station to restore the operation of the disabling means to again disable the stopping means until another passage of a signaling member.
8. The sample changer of claim 7 having
- (f) said last means comprising means for sensing the first absence of a sample from a receptacle following the signaling member.

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- 9. The sample changer of claim 8 having
 - (g) the signaling member comprising a plug member insertable in a sample receptacle in substitution for a sample.
10. In an automatic sample-measuring device,
- (a) a housing having a measuring station,
 - (b) an endless conveyor having sample receptacles transporting samples repetitively through the path of the conveyor,
 - (c) selectively activated and inactivated measurement cycle control means for stopping the conveyor for measurement of successive samples at the measuring station and restarting the conveyor after each such measurement,
 - (d) manually settable actuating means to activate the measurement cycle control means at any selected conveyor position to initiate the measurement of a group of successive samples, and
 - (e) means to inactivate the measurement cycle control means at the end of the measurement of each such group until again similarly activated at the commencement of another such group.
11. The device of claim 10 including
- (f) means for sensing the absence of a sample from a receptacle, the inactivating means being responsive thereto.
12. The device of claim 10 having
- (f) the actuating means including signal members inserted in sample receptacles on the conveyor and sensing means on the housing responsive to the signal members and unresponsive to samples.
13. The device of claim 12 having
- (g) second sensing means on the housing responsive to empty receptacles, the inactivating means being responsive to said second sensing means, any sample group thus being selectively measured or bypassed by insertion or removal of a single signal member.
14. The device of claim 13 having
- (h) said second sensing means being responsive to a receptacle bearing a signal member in the same manner as an empty receptacle.

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