

July 15, 1958

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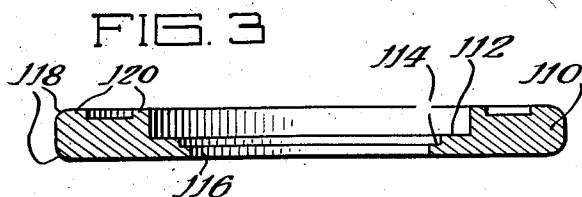
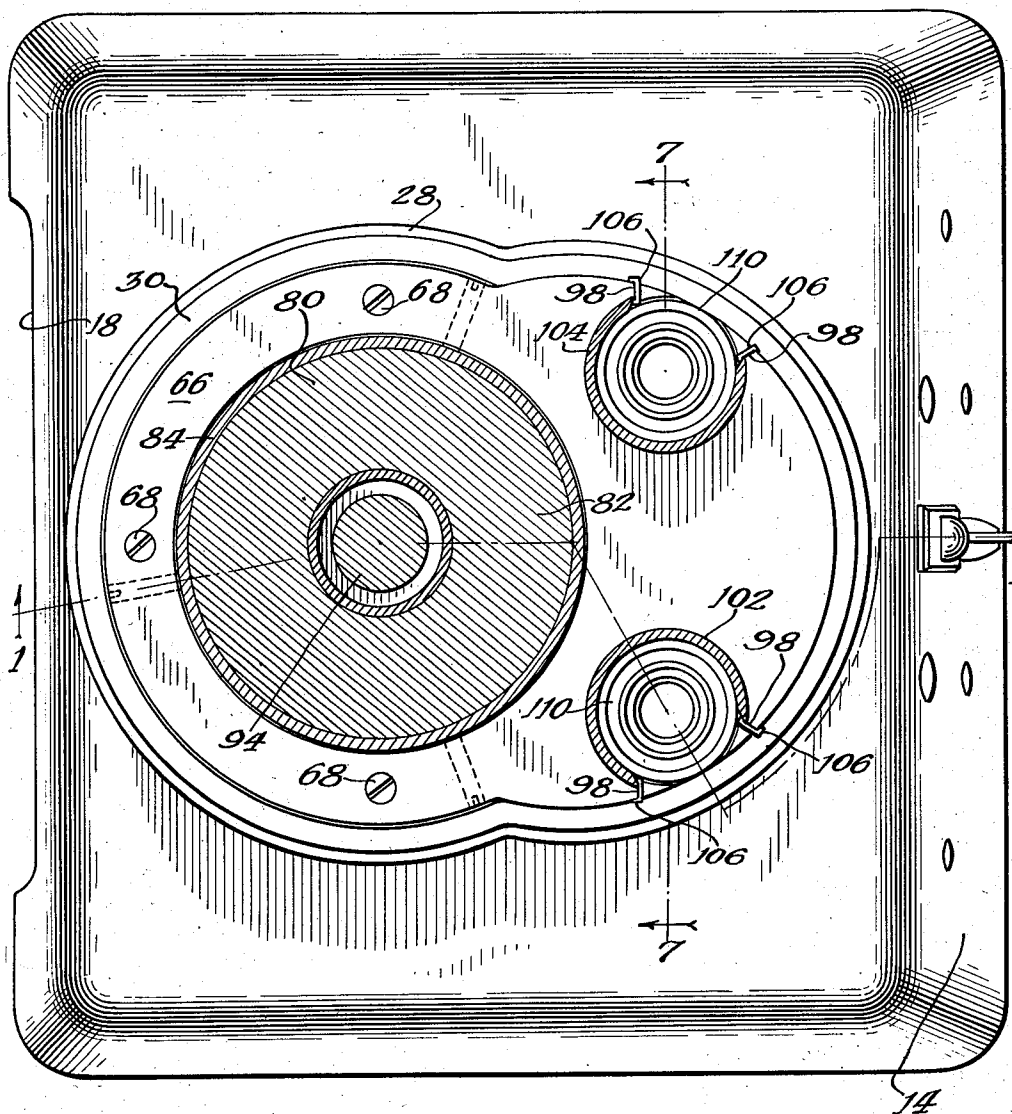
2,843,753

AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVE SAMPLES

Filed Jan. 21, 1954

6 Sheets-Sheet 2

FIG. 2



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FIG. 4

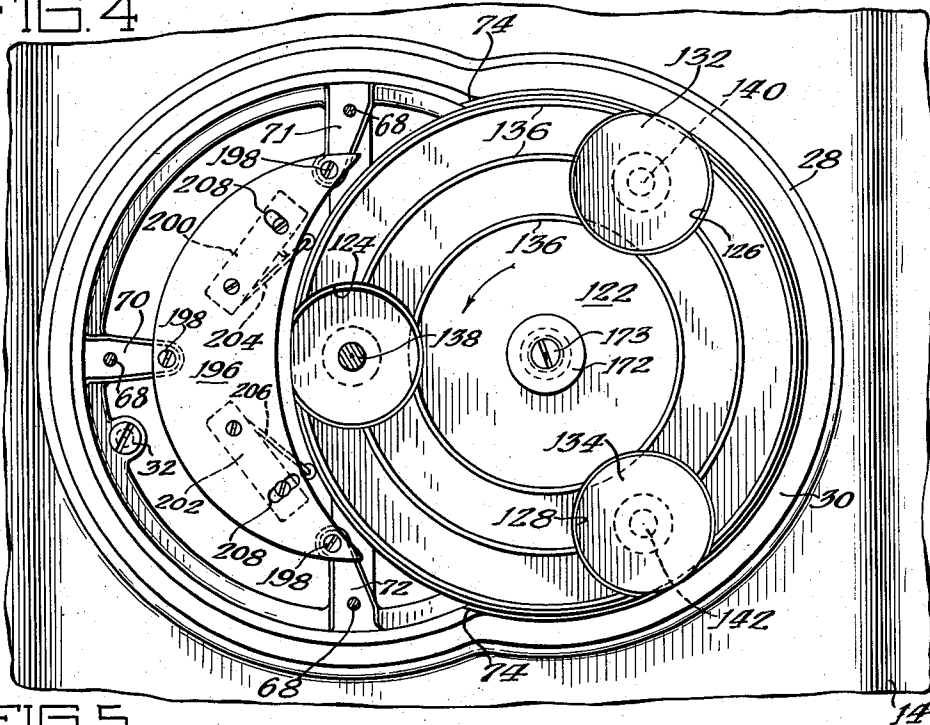
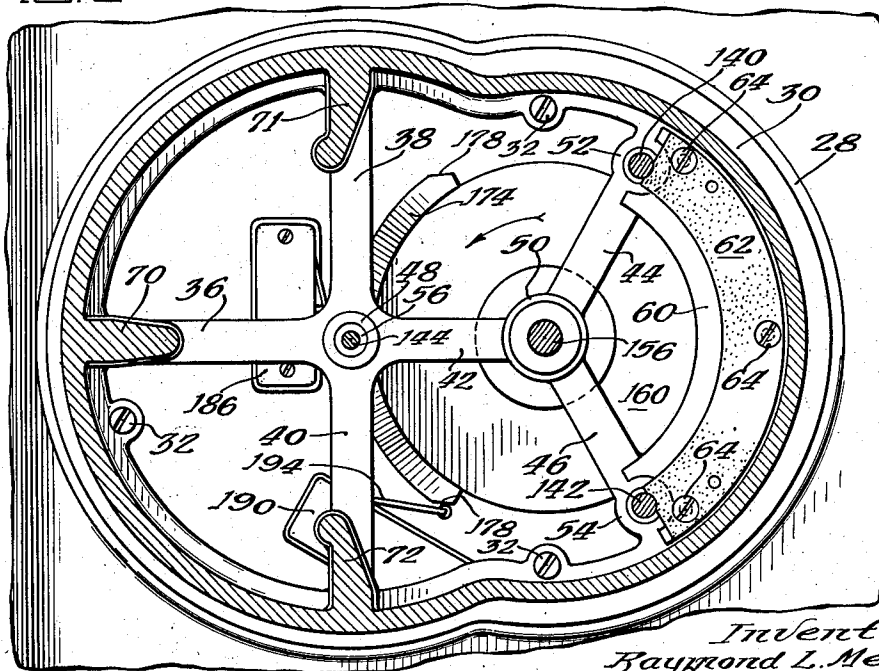


FIG. 5



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FIG. 6

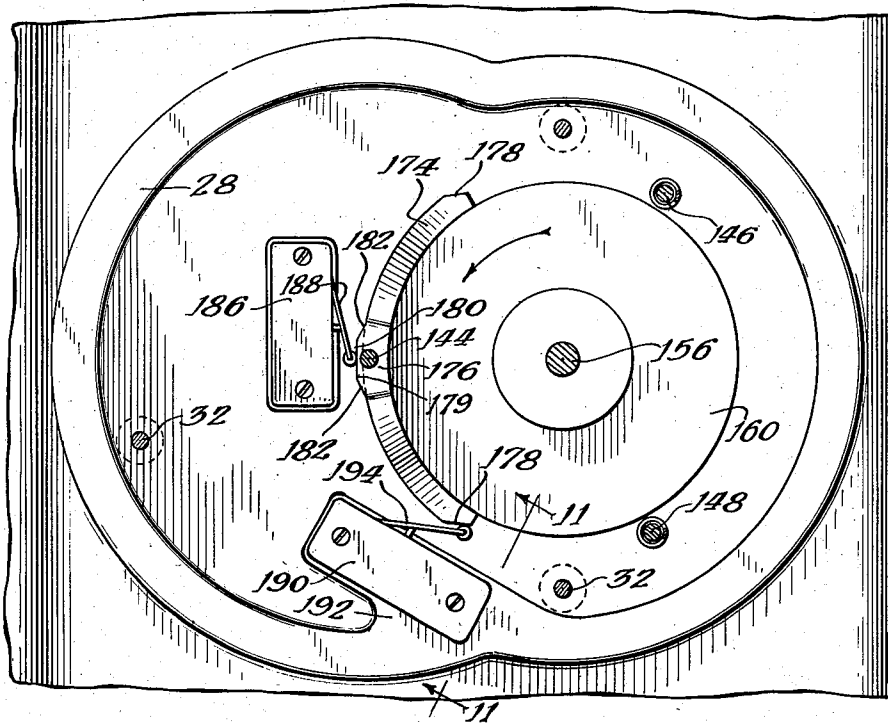
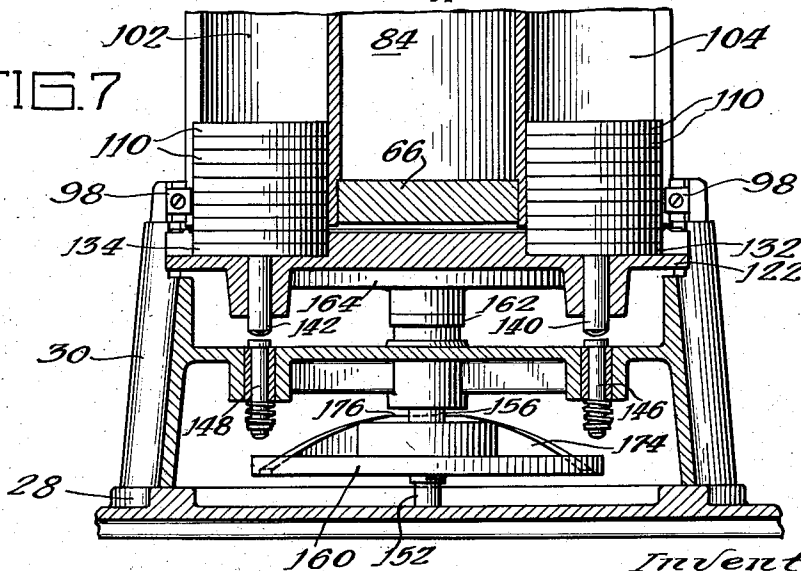


FIG. 7

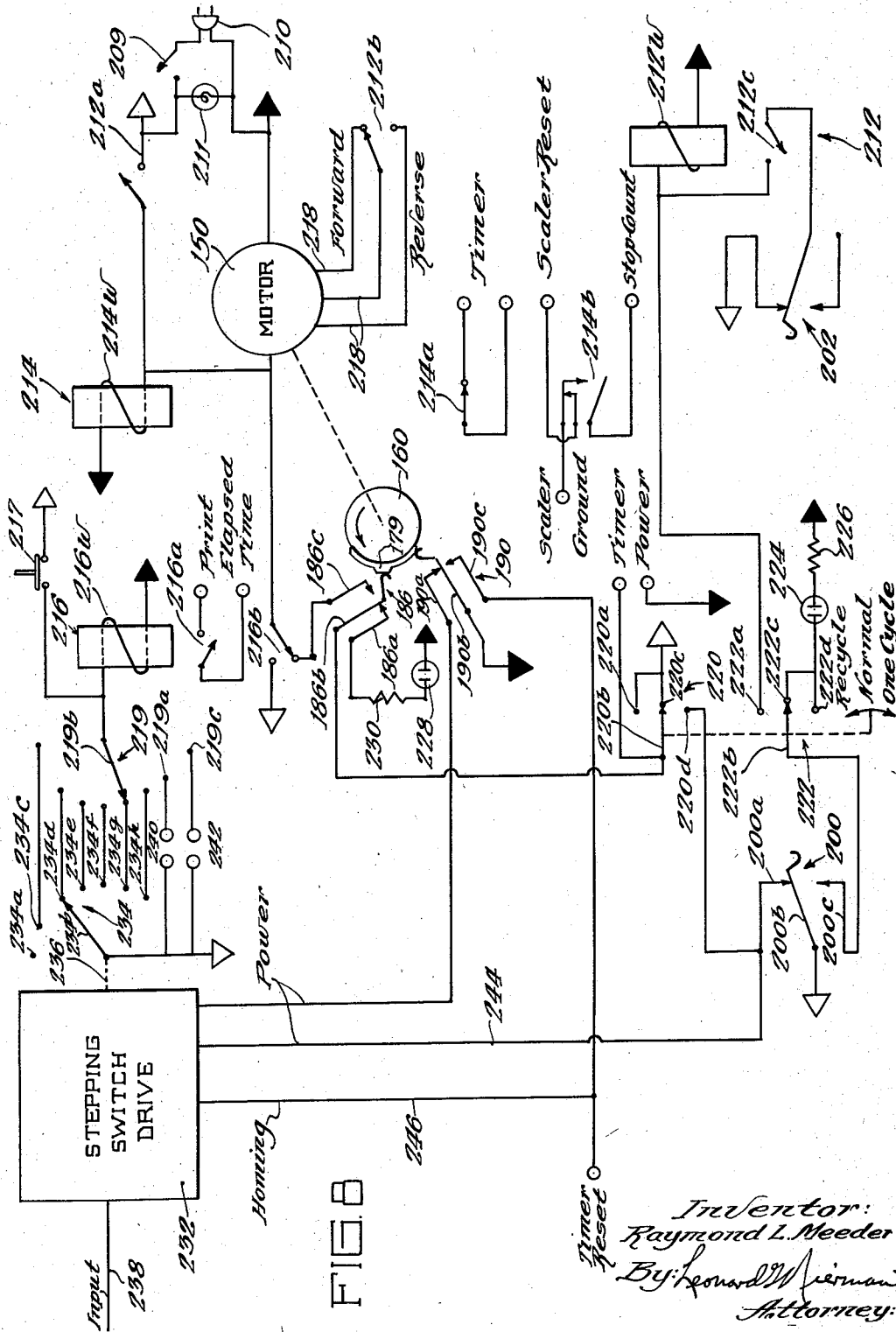


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AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVE SAMPLES

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FIG. 10

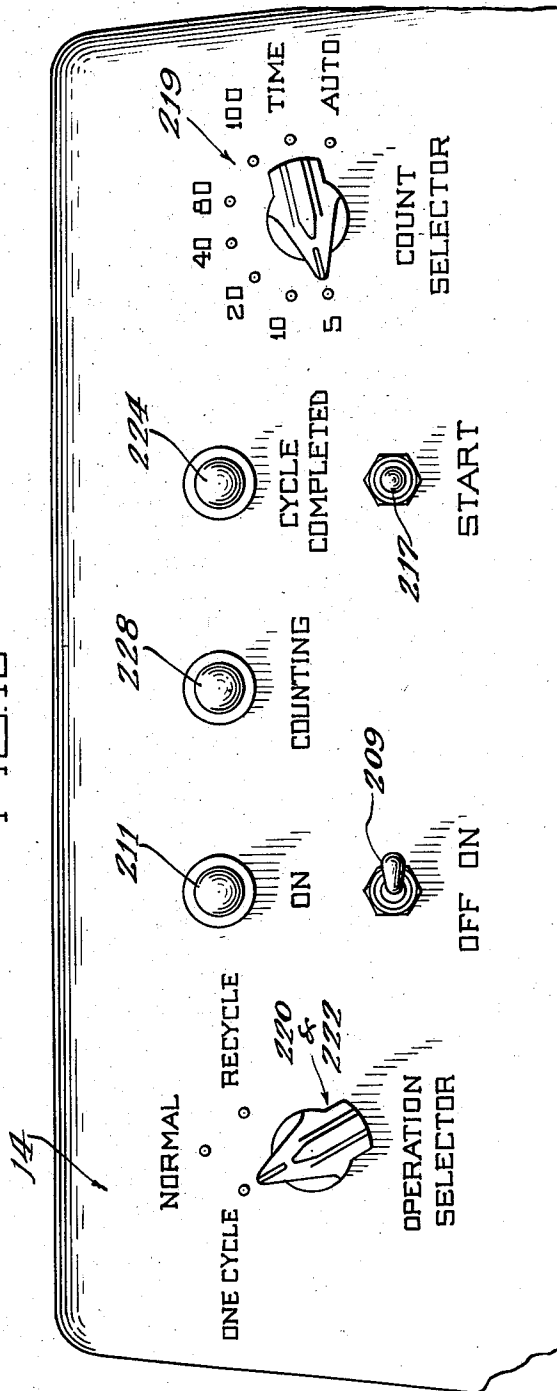


FIG. 9

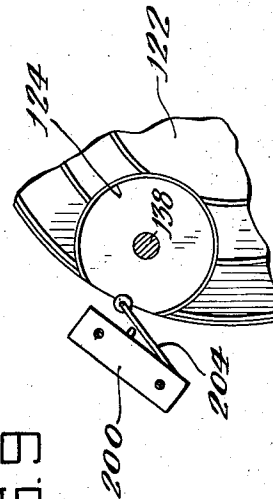
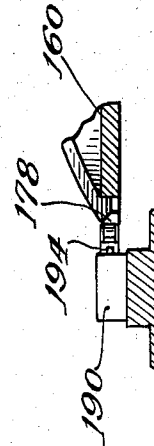


FIG. 11



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2,843,753

AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVE SAMPLES

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Application January 21, 1954, Serial No. 405,309

21 Claims. (Cl. 250—106)

This invention relates to devices for the measurement of the radioactivity of radioactive materials, and more specifically to an automatic sample changer for making successive measurements of the radioactivity of a large number of samples.

It is common, in laboratories and other installations wherein work is done with radioactive materials, as, for example, in biological, medical, radiochemical, and similar laboratories, to make successive measurements on large numbers of radioactive samples or specimens. Up until a relatively short time ago, it was universal practice for the technicians or scientific or medical personnel performing these measurements to manually place each radioactive sample or specimen to be counted in a location suitably adjacent to the radiation detection device being employed, and then to manually remove each sample upon termination of the desired counting interval, the interval being determined by the reaching of a predetermined count or the expiration of a predetermined time. More recently there have been devised automatic sample changers, in which there are inserted a large number of samples, suitable mechanism being provided to successively expose the samples to the radiation detector employed, such automatic sample changers having facilities for connection to suitable counting, timing and recording apparatus, so that each sample is automatically exposed to the radiation counter for a predetermined time (in which case the number of counts obtained from each sample during the constant interval is recorded on the recording apparatus), or until a predetermined count is obtained from each sample (in which case the quantity recorded is the amount of time required for each sample to give the predetermined count).

The automatic sample changers heretofore designed and made available are subject to a number of objections which have greatly limited the use of such automatic sample changers. For one thing, the automatic sample changers heretofore devised have been extremely complex from the mechanical standpoint, thus making the cost of constructing such a sample changer and of maintaining the mechanism extremely high. Additionally, the automatic sample changers heretofore devised have been extremely bulky, requiring large areas of desk or table space.

Further, the relatively numerous and complex manual operations involved in loading and unloading batches of samples into and from the prior sample changers have been sufficiently time-consuming to considerably reduce the time-saving advantages to be obtained in employing an automatic sample changer instead of using ordinary manual manipulation of samples.

The present invention provides an automatic sample changer for radioactive samples which is not subject to these objections. The automatic sample changer of the present invention is both simple and compact. The manual operations required, both in loading and unloading the changer, and in obtaining the radioactivity data, are minimized. The constructional simplicity substan-

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tially reduces the difficulties and expense of servicing. Further advantages of the invention, and objects accomplished by the invention, will be apparent from the single embodiment of the invention which is illustrated in the appended drawing and described below.

In the drawing:

Figure 1 is an offset vertical sectional view of an automatic sample changer for radioactive samples embodying the invention, the section being taken along the line 1—1 of Figure 2;

Figure 2 is a horizontal sectional view taken along the line 2—2 of Figure 1;

Figure 3 is a transverse sectional view of a sample holder or adapter designed for use with the sample changer;

Figure 4 is a horizontal sectional view taken along the line 4—4 of Figure 1 in the direction indicated by arrows;

Figure 5 is a similar sectional view taken along the line 5—5 of Figure 1 in the direction indicated by arrows;

Figure 6 is a horizontal sectional view taken along the line 6—6 of Figure 1 in the direction indicated by arrows;

Figure 7 is a fragmentary vertical sectional view taken along the line 7—7 of Figure 2 in the direction indicated by arrows;

Figure 8 is a schematic electrical diagram of a control circuit constituting the electrical portion of the sample changer, and illustrating the interrelation between the electrical and mechanical components thereof;

Figures 9 and 11 are fragmentary detail views; and

Figure 10 illustrates the control panel of the device.

In describing the embodiment of the invention illustrated, understanding of the invention and of its essential teachings will be facilitated by separating the descriptions of the component assemblies which form the device by appropriate headings. Thus there will first be described the stationary assembly comprising a radiation shield, first and second magazines each adapted to receive a plurality of sample holders, and means for supporting the shield and the magazines in mutually spaced relation. There will then be described the carriage assembly upon which sample holders are moved from one to another of the above stationary members, and thereafter the drive assembly which actuates the carriage assembly and its component parts to move the samples in the desired fashion. Finally, there will be described the electrical system which acts to control and cycle the drive assembly, and also to synchronize and interlock the operation of the sample changer with timing, counting, and recording equipment to which the sample changer may be connected.

The stationary assembly

The lower housing 12, which supports the device on a table or bench upon which it is placed, is a generally rectangular open-bottom base provided with a sloping front panel 14 appropriately apertured to permit the mounting thereon of the electrical controls and indicators generally designated by the numeral 16, and later to be described in connection with the electrical system. An opening or cut-out 18 in the rear surface of the bottom housing 12 permits access for making electrical connections to an aluminum chassis 20 of L-shaped cross section which is mounted within the lower housing 12. (It will be understood that the relays and other electrical circuit components later to be described, but illustrated only in the electrical schematic diagram of Figure 8, are mounted on the chassis 20 in a conventional manner, being omitted from the mechanical portion of the drawing for purposes of clarity.) Rubber feet 22 are secured by screws 24 to internal ribs 26 cast integrally with the lower housing 12.

Resting on top of the lower housing 12 on a ridge 28 formed thereon is an upper housing 30, secured to the lower housing 12 by bolts 32. The upper housing 30 consists generally of a substantially oval rim 34, the lower edge of which rests on the ridge 28, and a network of interconnected ribs or webs 36, 38, 40, 42, 44, and 46, which are formed integrally with, and constitute the support for, apertured bosses 48, 50, 52 and 54. These bosses are so spaced that the apertured boss 50 lies at the center of a circle upon the circumference of which lie the bosses 48, 52, and 54, disposed at 120 degree intervals. Force-fitted into each of the bosses 48, 52 and 54 is an oil-impregnated sleeve bearing 56, and a similar bearing 58 is provided in the aperture of boss 50. An additional rib or web 60 extends along an arc of the aforementioned circle, connecting the bosses 52 and 54, and a flat plate 62 of similar curved shape is bolted to the arc-shaped rib or web 60 by bolts 64. The plate 62 is preferably of a bearing material such as oil-impregnated bronze and is notched at its ends to conform to the circular shape of the apertures in the bosses.

Resting atop the upper edge of the upper housing 30 is a thick mounting plate 66 of the same general outline as the upper housing 30. The mounting plate 66 is bolted at 68 to support ribs or lugs 70, 71, and 72, which are cast integrally with the upper part of the upper housing 30, and extend inwardly from the rim 34 flush with the upper edge thereof. The ribs of lugs 70, 71 and 72 are all on the rearward portion of the upper housing 30. The front portion of the upper edge of the housing 30 is cut away, the upper edge being offset at 74 to permit passage of a carriage, later to be described, between the front portion of the upper edge of the housing 30 and the mounting plate 66. Thus the mounting plate 66 is rested upon, and secured to, the upper housing 30 only in the rearward portion thereof, the forward portion of the mounting plate 66 being cantilevered.

In the rearward portion of the mounting plate 66 is a large bore 76 having its center above the rearward boss 48 in the upper housing 30, and having an upwardly facing rabbet or shoulder 78. Seated on the shoulder 78 is the lower edge or mouth portion of an open-ended radiation shield 80. The shield 80 consists in general of a thick sleeve 82 of lead encased in a steel jacket 84. To the upper end of the cylindrical shield is affixed a mounting ring 86 by means of which there is mounted thereon a radiation detection assembly including a housing 88 snugly fitting into the aperture in the shield. A socket 90 is provided in the bottom of the housing 88 and a cable 92 is connected through the housing 88 (which may contain a preamplifier) to the socket 90. In the drawing there is illustrated a radiation detector 94, which may be, for example, a Geiger-Muller tube or a scintillation counter, provided with a suitable plug inserted in the socket 90. The shield and detector assembly are not illustrated in further detail in the drawing, since they in themselves constitute no part of the present invention.

In the forward portion of the mounting plate 66, centered above the bosses 52 and 54, are bores or apertures 96. The circular bores 96 are so located in the mounting plate 66 that they are at the edge of the plate 66 and thus form interruptions in that edge. The "neck" openings which are thus formed between the bores 96 and the outer edge of the mounting plate 66 are flattened off at 98 to permit the attachment of clips hereinafter to be described. Seated in the bores 96 are the lower ends or mouth portions of long tubes of transparent plastic which are employed as loading and unloading magazines, as will be more completely set forth hereinafter. The tubes or magazines 102 and 104 have the circumferential portion thereof corresponding to the opening between the flattened surfaces 98 of the "neck" entries to the bores 96 cut away to form slots for access to the interior. Spring clips 106, screwed to the "neck" portion 98, secure the tubular magazines 102 and 104 against rotation in the

bores 96. Security of positioning of the magazines 102 and 104 is further assured by screws 108 securing the magazines to the mounting plate 66, and by rabbeting of the lower ends of the magazines.

In Figure 3 is shown a cross sectional view of a sample holder or adapter 110, which is designed for use in the device. The adapter, which is preferably made of aluminum, is essentially a disc or wafer having centrally thereof a plurality of shoulders 112 and 114 of diminishing diameter. These shoulders 112 and 114 are designed to receive and support sample pans of the type conventionally used in specimen counting. The bottom of the holder 110 is apertured at 116 to permit ready removal of a sample pan from the holder or adapter 110. The provision of shoulders of different diameters permits use of the holders 110 with a plurality of sample pan sizes, and a substantially larger number of shoulder diameters may be provided if desired. The edges of the holders 110 are rounded at 118 to facilitate insertion of a holder at the bottom of a stack of similar holders, as hereinafter to be described. Ridges 120 are formed in the top of the holder in order to minimize friction as a holder is slid into or from the bottom of a stack, while at the same time preventing jamming which may occur if only a single lip or ridge is employed. The holders 110 are of a diameter to slide freely, but without excessive play, in the tubes or magazines 102 and 104.

As will more fully appear below, the magazine 102 is employed as a receiving magazine, and the magazine 104 as a dispensing magazine. In operating the device, the samples to be counted are inserted in holders 110. The holders 110 are then stacked in the dispensing magazine 104. When the device is then placed in operation, successive samples are moved beneath the shield 80, inserted into the shield so that the detector 94 measures the radioactivity, lowered out of the shield, and moved to the bottom of the magazine 102, wherein they are received in the reverse of their original order. The structure of the magazines 102 and 104 not only simplifies the operations of loading and unloading the device, but also permits ready access to the samples for such purposes as making substitutions or changes in order. The means for withdrawing the successive sample holders from the dispensing magazine and inserting them into the shield and for withdrawing them from the shield and inserting them into the receiving magazine will be described below.

The carriage assembly

Beneath the mounting plate 66, which supports the magazines 102 and 104 and the shield 80 as described above, is a circular carriage plate 122, which is rotatably mounted with its center directly above the boss 50 (the manner of mounting to be more fully described hereinafter) and has circular recesses in its upper surface at 124, 126 and 128. These circular recesses are equally spaced and are of essentially the same diameter as the bottom openings in the shield 80 and the magazines 102 and 104, i. e., of a diameter to receive freely sample holders 110. The circular recesses intersect the periphery of the carriage 122 and thus form interruptions in the upper portion of the edge of the carriage. Reciprocal in the respective recesses 124, 126 and 128, and normally resting on the bottom thereof, are elevating discs 130, 132, and 134, of essentially the same diameter as the sample holders. The thickness of the discs 130, 132 and 134 is so related to the depth of the recesses 124, 126 and 128 that when the disc is resting on the bottom of the respective recess, the upper surface of the sample holder 110 within the recess lies substantially flush with the surface of the carriage. In this manner a sample holder 110 within one of the recesses may be slid under or out from a stack of similar holders in the receiving magazine 102 or dispensing magazine 104 by rotation of the carriage 122. The upper surface of the carriage 122 is provided with concentric ribs or ridges 136 upon which stacks of sample

holders within the magazines ride or float as the carriage is rotated from one position in which there is a recess beneath each of the magazines and the shield and the next such rotational position. Depending from the centers of the respective discs 130, 132 and 134, through guide apertures provided through the carriage 122 at the centers of the recesses 124, 126 and 128, are integral tappet pins 138, 140 and 142. It will be seen that each disc and tappet pin constitutes elevating means in each recess to raise a sample holder above the surface of the carriage. When a sample holder 110 is within one of the recesses and is moved under one of the magazines, and the tappet pin is then elevated to make the disc flush with the surface of the carriage, and the carriage is then again moved, the sample holder which was previously in the recess will remain in the magazine and become the bottom-most sample holder in that magazine.

The drive assembly

Extending through the respective sleeve bearings 56 in the bosses 48, 52, and 54 are tappet or lifter pins 144, 146 and 148 having heads of sufficient size to prevent their falling through the bearings. The pin 144 which is beneath the aperture in the shield 80 is substantially longer than the pins 146 and 148, which are beneath the receiving and dispensing magazines.

Mounted on the chassis 20 is a motor 150 having an upwardly extending shaft 152. The shaft 152 is coupled by a bayonet connection 154 to a spindle 156, which is externally threaded at 158, a cam wheel 160 being threaded on the spindle 156 and locked in position by a locknut 161. The spindle is formed with a flange 162 which rests on the end of sleeve bearing 58. Fitted over the upper end of the spindle 156 and supported by the flange 162 is an apertured friction plate 164. Around the upper end of the spindle 156 is a tubular bearing 166. The carriage plate 122 has a central aperture fitted over the tubular bearing 166, the under surface of the carriage plate 122 thus resting on the upper surface of the friction plate 164. The upper surface of the carriage plate 122 is centrally recessed at 168. Within this recess is a spring 170 which is compressed between the bottom of the recess 168 and a retaining washer 172 by a screw 173 which is threaded into the upper end of the spindle 156.

It will be seen that the pressure exerted by the spring 170 creates a frictional engagement between the carriage 122 and the friction plate 164 and also between the friction plate 164 and the flange 162 on the spindle 156. The restoring force of the spring 170 is so chosen that the carriage 122, when loaded with sample holders in its recesses, is easily rotated by rotation of the spindle 156. However, when, as appears below, the carriage is locked in position, the spindle 156 may continue to rotate without undue wear on the parts. Thus it may be seen that the carriage 122 will normally be driven by the spindle 156, which is rigidly coupled to the motor 150, but the locking of the carriage in any given position, as by a fixed stop, permits the spindle, and the cam 160, to continue to rotate during the running of the motor 150.

The cam 160 is essentially a wheel having on the circumference thereof a camming lobe or rim 174 extending through an arc of approximately 120 degrees. The cam lobe is of maximum thickness or height at the center thereof, where it is essentially flat on top over an arc of approximately 20 degrees, as shown at 176. On either side of the highest portion 176, the rim or lobe 174 is tapered downwardly through a 50 degree arc. It is this surface which raises and drops the tappet or lifter pins 144, 146 and 148 in the manner hereinafter described. Additionally, on the outer or peripheral surface of the lobe 174 there are provided radial tapers 178 at each end of the lobe, and a central radial projection 179 which is flat in a small central region of the periphery, as indicated at 180, tapering radially to the radius of the bulk of the lobe 174, as shown at 182, within the 20

degree arc of the vertically flat portion 176. The bottom of the radial projection 179 is cut away at 181. The purpose and operation of the radial camming surfaces on the cam wheel 160 will be described below in connection with the electrical system.

The aggregate slope or pitch of the cam lobe 174 between the flat central portion 176 and the tapered ends is such that when the central elevated portion 176 supports either of the lifter pins 146 or 148, the lifter pin is elevated to an extent sufficient to raise the tappet pin 138, 140 or 142 which is thereabove to the level where the upper surface of the disc 130, 132 or 134 is substantially flush with the upper surface of the carriage. The lifter pin 144 is, as stated above, substantially longer than the lifter pins 146 and 148. Thus when the rotational position of the cam 160 is such that the elevated portion 176 supports the pin 144, the disc 130, 132 or 134 which is then above the cam surface 176 is elevated substantially above the surface of the carriage into the shield 80.

The manner of cooperation of the drive assembly with the carriage assembly to produce the manipulation of the samples described above in connection with the stationary assembly will now be readily understood. Each sample-changing operation is commenced in the cam position wherein the flat portion 176 at the apex of the cam lobe 174 supports the lifter pin 144, so that a sample 110 is supported well within the radiation shield 80. It will be understood that since the entire construction of the carriage 122 is symmetrical about its axis of rotation, the recesses 124, 126, and 128 and their associated moving parts being identical, the manner of operation is the same irrespective of which of the recesses is positioned beneath the shield 80 at the commencement of operation. However, for ease of explanation, the succeeding description of a change cycle will be based on the starting position as shown in the drawings, i. e., with the recess 124 beneath the shield 80.

The motor 150 drives the spindle 156 in a counter-clockwise direction (as viewed from the top). As the cam 160 commences to rotate with the spindle 156, the carriage 122 remains stationary due to the fact that the lower end of the tappet pin 142 is positioned against the end of the plate 62, which thus serves as a stop member in the portion of the rotational path of the depending tappet pins adjacent to the receiving magazine 102, locking the carriage 122 against rotation. Thus as the cam 160 commences to rotate, the only motion in the carriage plate assembly is the lowering of the sample 110 from the shield 80 to the point where the upper surface of the sample holder 110 is substantially flush with the upper surface of the carriage 122. Slightly after the point where this motion is complete, the forward end of the cam lobe 174 commences to elevate the lifter pin 148, which latter motion continues until the camming surface 176 supports the lifter pin 148, at which point the upper surface of the disc 134 is substantially flush with the upper surface of the carriage 122. Thus the sample holder within the recess 128 (remaining there from the previous change operation) is elevated into the receiving magazine 102, at the bottom of the stack deposited there by previous sample-changing operations. At the same time the lower end of the tappet pin 142 is elevated sufficiently to be disengaged from the end of the plate 62, so that the carriage plate 122 is unlocked. Thus for the next one third of a revolution of the cam 160, the carriage plate 122 rotates with the cam, the recess 124 thus being brought around to the point beneath the receiving magazine 102. At the same time the sample holder which was at the bottom of the stack in dispensing magazine 104 in the recess 126 slides out from beneath that stack and is placed beneath the opening in the shield 80. Meanwhile, the bottom end of the tappet 142 is supported on the top surface of the plate 62, so that the sample holder which was

previously supported on the disc 134 is left behind in the receiving magazine 102, supported in floating fashion by the ribs 136 on the carriage 122. During this one-third of a revolution of the cam 160, the lifter pin 148 is lowered to its normal position, and the lifter pin 146 is elevated. The continued elevation of the disc 134 permits it to slide in at the bottom of the stack of sample holders in the dispensing magazine 104. At this point the carriage 122 is again locked in position because the next tappet pin 138 is now engaged by the end of the plate 62. As the final one-third of a revolution of the cam 160 commences, the carriage 122 remains stationary, the disc 134 is lowered into the recess 128, and the sample holder previously at the bottom of the stack in the dispensing magazine 104 is thus positioned in the recess 128. Thereupon the new sample holder which was removed from the bottom of the stack in the dispensing magazine 104 by the motion of the carriage 122 during the second one-third of a revolution of the cam 160 is finally elevated by the cam lobe 174 into the shield 80, to have its radioactivity measured by the detector 94. By the means hereinafter to be described in connection with the electrical system, the motor 150 is inactivated at this point, and remains inactivated until the counting operation is completed, at which time the next change operation occurs in an identical manner.

It will be observed that with the structure described, the cyclical manipulation of the samples is completely reversible by merely reversing the direction of rotation of the spindle 156. As will be shown in connection with the electrical system, this fact is utilized to automatically restack all of the sample holders in the dispensing magazine 104 after the counting of the last sample in a batch and to then again restore the original cycle, so that the same group of samples may be recounted any desired number of times without the necessity of manipulation by an operator. It will also be seen that the insertion of the sample-holder into the shield in the manner described permits bringing the sample closely adjacent to the detector without increasing the exposure of the detector to external radiations through the opening in the shield through which the sample is inserted.

The electrical system

Mounted on a boss 184 on the upper surface of the lower housing 12 is a snap-action switch 186 having extending therefrom a lever 188 adapted to actuate the switch when struck by the radial projection portion 179 of the cam lobe 174. The switch 186 is so positioned as to be actuated when the cam wheel 160 is in the position wherein the lifter pin 144 is resting on the upper cam surface 176. A similar switch 190 is mounted on a boss 192 one-sixth of a revolution counter-clockwise from the switch 186. The boss 192 is lower than the boss 184 so that as the cam rotates, the radial projection 179 clears the lever 194 because of the cutaway of the radial projection 179 at 181. Thus the arrangement of the switches 186 and 190 is such that the switch 186 is actuated only by the radial projection at 179, while the switch 190 is actuated during essentially the entire first one-third of a revolution of the cam 160 from its original position as described above.

A crescent-shaped plate 196 is secured to the upper surface of the inner ends of the ribs or lugs 70, 71 and 72, by screws 198, and snap action switches 200 and 202 are secured to the underside of the plate 196, with levers 204 and 206 having roller ends normally resting on the upper portion of the periphery of the carriage plate 122. The switches 200 and 202 are positioned somewhat clockwise and counter-clockwise, respectively, of the aperture in the shield 80, and are adjusted in position by means of slots 208 in the plate 196 so as to sense the absence of a sample holder from a recess 124, 126 or 128 proceeding therepast. The levers 204 and

206 ride, as stated above, at the upper portion of the edge of the carriage plate 122. When sample holders are present in the recesses in the carriage plate, the switching positions of the switches 200 and 202 are not affected as the carriage rotates. However, if and when an empty recess appears opposite one of the levers 204 or 206, the respective switch 200 or 202 is actuated as shown in Figure 9.

Referring now to the schematic electrical diagram of Figure 8, it will be seen that the electrical system is adapted to be connected to a conventional single-phase power outlet by a power plug 210, the two sides of the power line being indicated in the drawing by shaded and unshaded triangles, and being hereinafter referred to for convenience as the "black" and "white" side of the power line, and being provided with a power switch 209 and pilot light 211. The system utilizes a series of relays 212, 214 and 216, of which the actuating windings bear the same reference character with the latter "w," and the contacts bear the same number with the letters "a," "b," etc. In Figure 8, the contacts are shown in their normal positions (winding circuits open), and with the contacts of each relay in vertical alignment with the schematically indicated core thereof.

One terminal of the motor 150 is permanently connected to the black side of the line and the other terminal of the motor is connected to the white side of the line through a normally open set of contacts 212a of the relay 212. The winding 214w of the relay 214 is connected between the black side of the line and the white terminal of the motor 150. The white terminal of the motor is also connected to the white side of the line through the normally open stationary contact of a double-throw set of contacts 216b of the relay 216. In the normal or unenergized position of the contacts 216b, the white side of the motor 150 is connected to the normally closed stationary contact 186c of the switch 186, which is mounted as described above. Normally open contacts 216a of the relay 216 interconnect terminals or binding posts designated in the drawing "Print Elapsed Time," the function of which will hereinafter be pointed out.

The motor 150 is provided with control leads 218 in conventional reversible motor fashion, so that the connection of the common lead determines the direction of operation of the motor. The leads 218 are connected to the contacts 212b of the relay 212 in such a manner that the motor direction is forward (counter-clockwise in the drawings) when the winding 212w is unenergized, and reverse when the relay 212 is actuated. One side of the winding 212w is connected to the black side of the line and the other terminal of the winding 212w is connected to a normally open set of contacts 212c of the relay 212 which serve, when closed, to connect the white side of the winding 212w to the white side of the line through the normally open contacts of the switch 202 (illustrated as in the closed position in the drawing, the normal position of the switch 202 itself being the position assumed when it senses an empty recess, as described above). The relay 214 is provided with a normally closed set of contacts 214a, interconnecting binding posts for external connection designated "Timer." An additional set of contacts 216b of the relay 216 normally connects a binding post "Scaler Ground" to a binding post "Scaler Reset," actuation of the relay 214 connecting, in make-before-break fashion, a "Stop-Count" binding post to the "Scaler Ground" binding post. The winding 216w has one side connected to the black side of the power line and the other side to the white side of the power line through a normally open manual push switch 217, and also to the movable tap 219b of a manual tap switch 219, to be later described.

It will readily be understood by those skilled in the art that the binding posts described are designed to be connected to commercially available printing timers and

scalers. The timer to which the "Timer" binding posts are to be connected is of the type in which the timing operation is interrupted by the opening of a switch, which commonly disengages a clutch. The "Print Elapsed Time" terminals are of course to be connected to the same device, which prints the total elapsed time recorded by the timer each time that the contacts 216a are closed. Likewise, it will be understood that the scaler employed is of the type wherein the counting is stopped by the connection of the "Scaler Ground" terminal to the "Stop-Count" terminal, and the scaler is reset when the former terminal is connected to the "Scaler Reset" terminal. As stated above, these auxiliary devices are commercially available and do not in themselves constitute any part of the present invention, and are accordingly not illustrated in the drawing.

The movable contact 186b of the switch 186 is directly connected to the movable tap 220b of a three-position manually operated tap switch 220, which is ganged with a similar switch 222. The tap 220b is also connected to one of a pair of binding posts designated "Timer Power," the other of which binding posts is connected to the black side of the line. These posts are designed to supply and interrupt the power to the timer described above, and not illustrated. Two of the stationary contacts 220a and 220c of the switch 220 are connected to the white side of the power line. The third stationary contact 220d is connected to the normally open stationary contact 200a of the switch 200, the movable contact 200b thereof being connected to the white side of the line. The normally closed stationary contact 200c of the switch 200 is connected to the movable tap 222b of the switch 222. The stationary contact 222a of the switch 222, which is contacted in the same position of the ganged switches as the stationary contact 220a of the switch 220 (this position being designated "Recycle" in the drawing), is connected to the white side of the winding 212w. The stationary contacts 222c and 222d, which are connected to the movable tap 222b in the positions of the ganged switches designated "Normal" and "One Cycle" are connected to the black side of the line through a neon glow lamp 224 and resistor 226. The normally open stationary contact 186a of the switch 186 is connected to the black side of the power line through a glow lamp 228 and resistor 230. The switch 190 has the movable contact 190b connected to the black side of the power line.

The cycling or timing stimulus for operation of the device is shown schematically in the upper left hand portion of the illustration of Figure 8. There is therein shown in block form a stepping switch drive 232, together with a stepping switch 234 which is driven by the drive 232 as indicated by the dotted line 236. The drive 232 and switch 234 constitute a commercially available unit of the type manufactured by a number of manufacturers of telephone relays, the drive 232 operating in response to pulses at the input 238 to advance the movable contact 234b each time an input pulse is received. It will be understood that the stationary contacts 234a through 234h shown in the drawing constitute only a small portion of the stationary contacts present in such a stepping switch, the unused stepping switch contacts not being illustrated in order to simplify the drawing. In a specific construction which has been employed, the movable contact or rotor 234b, which "homes" or "zeroes" at the contact 234a, progresses to contact 234c after five input pulses, 234d after ten input pulses, 234e after twenty input pulses, 234f after forty input pulses, 234g after eighty input pulses, and 234h after one hundred input pulses. The stationary contacts 234c through 234h are connected with respectively corresponding stationary contacts of the manual tap switch 219. The movable contact 234b of the stepping switch is connected to the white side of the power line. It will thus be seen that upon the occurrence of a number of input pulses to the stepping switch drive which is determined by the setting

of the manual switch 219, the tap 219b will be connected to the white side of the power line through the switch 234.

Additional stationary contacts 219a and 219c are provided on the switch 219. These latter contacts are each connected to one member of a pair of binding posts 240 and 242, the opposite members of the pairs being connected directly to the white side of the power line. Thus it will be seen that provision is made for inserting alternative timing or cycling stimuli in place of the stepping switch 234. For example, an ordinary repeating interval timer switch may be connected to the binding post 240, and a switch controlled by a predetermined count scaler may be connected to the binding post 242, as hereinafter set forth.

The power for the stepping switch drive 232 is supplied from power leads 244, one of which is connected to the normally closed stationary contact 190a of the switch 190, and the other of which is connected to the contact 200a, hereinbefore described. The "homing" or "zeroing" connection 246 which resets the stepping switch 234 (a facility provided in commercially available stepping switches) is connected to the normally open stationary contact 190c of the switch 190, and also to a binding post designated "Timer Reset."

Overall operation

The components and connections of the electrical system having thus been described, the manner of operation thereof, and the manner of cooperation with the mechanical system previously described to form a unitary automatic sample changer, will readily be understood. Since the exact mode of operation may be varied to a considerable extent at the discretion of the operator, by setting of the controls on the front panel of the device, as illustrated in Figure 10, it is convenient for purposes of clarity to first describe the complete operation in connection with one setting of the controls, and thereafter to describe the variants which the operator may change by making other settings of the controls. In Figure 10, the various switch levers and indicator lights are designated by reference characters corresponding to those of the schematic circuit diagram of Figure 8. The mode of operation will first be described with the switches 220 and 222 in the "Recycle" position and the switch 219 set to one of the numerical count positions corresponding to a number of advancements of the stepping switch 234.

The operator first loads any desired number of sample holders 110, containing samples to be counted, into the dispensing magazine 104. In the illustrated embodiment up to 50 samples may be so loaded into the device in one batch. Thereupon the automatic operation is instituted by pressing of the "Start" switch 217. The closing of the switch 217 actuates the relay 216. The resultant closing of the contacts 216a will cause the printing timer attached to the binding posts "Print Elapsed Time" to print the elapsed time, which will in this case be zero. The motor is actuated in the forward (counter-clockwise) direction by the closing of the connection at 216b to the white side of the power line. The push switch 217 need only be held down until the cam projection 179 progresses through the small angle required to permit the switch 186 to return to its normal position, at which point the deenergizing of the relay winding 216w does not stop the motor 150, because the normally open stationary contact of the contact set 216b is now itself connected to the white side of the power line through the switches 186 and 220. At the same time as the switch 186 is thus permitted to return to its normal position, the switch 190 is actuated to disconnect the power from the stepping switch drive and to "home" the stepping switch by connecting the "homing" line 246 to the black side of the power line.

The relay 214 is energized whenever the motor 150 is running. Thus as the motor starts, the timer is deactivated or declutched by the action of the contacts 214a,

At the same time the scaler, whose output pulses are coupled to the input 238 of the stepping switch drive 232, is inactivated by connection of the "Stop-Count" binding post to the "Scaler Ground" binding post by operation of the contacts 214b, thus effectively inactivating the detector 94. At the end of the first 1/3 of a revolution of the cam, the switch 190 returns to its normal position, supplying power to the stepping switch drive 232. However, for the balance of the revolution of the cam, the stepping switch drive 232 is not activated, because the input 238 is inactivated by the continued connection of the "Stop-Count" post which inactivates the scaler connected to the input. During this first revolution of the cam, the first sample is introduced into the shield in the manner described above. Then the cam projection 179 again actuates the switch 186, the motor 150 is stopped, and the relay 214 is inactivated, thus starting the timer. At the same time the scaler is reset by the operation of the contacts 214b and activated for a counting operation.

The mechanical assembly remains in this condition until a predetermined number of counts is registered by the detector 94 within the shield 80. This predetermined number of counts will be equal to the product of the scaling factor of the scaler employed with the illustrated equipment and the preset number of pulses received by the stepping switch drive as determined by the position of the tap switch 219. Thus, with a scaler having a scaling factor of 64, and a setting of 20 on the switch 219, the system will operate in this condition until 1280 counts have been received by the scaler. Thereupon the relay 216 will be energized by the resultant connection of the tap 219b to the white side of the power line through the switch 234. At this point the printing timer (not illustrated) will be actuated to print the elapsed time by the contacts 216a and the motor will again start. At this point the stepping switch and the timer are again reset to zero by the action of the switch 190. The first sample is removed from the shield in the manner described above and stored in the receiving magazine, and the succeeding sample is removed from the dispensing magazine and inserted in the shield. This cycle continues until all of the samples originally placed in the dispensing magazine are measured, the printing timer thus producing a record of the time required to reach the predetermined count for each sample.

After the counting of the last (top) sample of the stack originally placed in the dispensing magazine is completed, the same operation starts, but is interrupted when the switch 200 senses that there is no sample holder in the recess which is about to proceed to the point beneath the shield. At this point, the switch 200 returns to its normal (unactuated) position, disconnecting the power from the stepping switch drive 232 and energizing the winding 212w of the relay 212. The relay contacts 212a then continuously energize the motor 150 and the relay 214, and the contacts 212b reverse the direction of operation of the motor 150.

As the carriage 122 commences to rotate in the reverse direction (clockwise in the drawing), the switch 200 is again actuated to open the connection of the fixed contact 200c and the movable contact 200b. However, this does not inactivate the relay winding 212w because a normally open contact 212c of the relay 212 acts as a holding contact as long as the switch 202 is closed. The motor 150 thus continues to rotate in the reverse direction. It will be noted that the continued operation of the motor 150 is not interrupted by the opening and closing of the switch 186 in this portion of the operation because the motor is continuously activated by the relay contacts 212a. Likewise, the relay 214 is continuously activated to inactivate the timer and the scaler. As seen above, the reverse rotation of the motor 150 acts to restore the sample holders to the dispensing maga-

zine in their original order and this restacking operation is independent of the actuating stimulus which determines the time that a sample holder remains in the shield during the forward operation (in this case the predetermined count stimulus described above).

The reloading of the sample holders into the dispensing magazine continues until the last sample holder has been removed from the receiving magazine. As the next recess in the carriage plate progresses past the switch 202, the latter senses the absence of a sample holder, and opens the connection of the winding 212w, thus returning the contacts of the relay 212 to their normal position. At this point the motor 150 again reverses to assume its original forward direction, and all of the samples are counted a second time in the same manner as described above. In this manner the apparatus will continue to count the radioactivity of the batch of samples repeatedly until it is shut off by the operator. As is well known, the continued recounting of the samples is desirable in many cases, particularly where measurements are being made for the purpose of making radioactive decay curves on a large number of samples.

The above description of the overall operation assumes the position of the controls wherein the ganged switches 220 and 222 are in the "Recycle" position, and the selector switch 219 is set so that each sample holder (during the forward portion of the cycle) is maintained in the radiation shield until a predetermined count is reached. In the "Normal" position of the ganged switches, the counting of the samples after the loading thereof into the dispensing magazine occurs in the same manner as above described. However, in this position of the controls, the switch 200 does not operate to reverse the direction of the motor. Now the sensing by the switch 200 of an empty recess merely serves to flash the indicator light 224, which bears on the panel the legend "Cycle Completed." The rest of the apparatus continues to operate in the same manner as previously, the motor 150 continuing to operate in the forward direction, moving a new (but empty) recess beneath the shield each time the predetermined count is reached. However, the predetermined count which now constitutes the timing stimulus for determining the duration of each counting and resetting cycle is the background count which penetrates the radiation shield (or has been deposited therein by contamination). There is thus produced not only a record of the samples counted, but also a record of the intensity of the background, which continues until the operator intervenes. It is to be noted that if it is so desired, the background count may also be recorded by merely omitting a radioactive sample from one or more of the sample holders, thus producing a background count recording during the counting of the stack of samples in any position of the controls.

In the "One Cycle" position of the ganged switches, the operation is similar to that in the "Normal" position, except that when the switch 200 senses the absence of a sample from a recess in the carriage plate after the last sample has been counted, the motor is inactivated, since in this position of the ganged switches the connection of the motor 150 to the white side of the line is through the switch 200. Thus in the "One Cycle" position, the entire mechanism stops after the last sample has been counted, and the "Cycle Completed" lamp 224 is illuminated.

The effect of the position of the switch 219, designated the "Count Selector," will be readily apparent. In the first six positions of the switch, the timing stimulus is provided by the predetermined count mechanism including the stepping switch above described. When the rotor 219b is set to contact the stationary contact 219a (the position designated "Time" in Figure 10), the timing cycle which determines the intervals at which samples are changed is fixed by a repeating interval timer connected to the binding posts 240. In this case, of course, the de-

vice is used with a printing register which records the number of counts received during each timing intervals, rather than the time consumed to reach a predetermined count, as in the previous type of operation.

The binding posts 242 are connected in the same manner as the binding posts 240, the position of the switch 219 in which the former binding posts are used being designated "Auto" on the panel of Figure 10. This connection and switch position are designed for the use of an "automatic scaler," i. e., a scaler itself containing a predetermined count mechanism, thus rendering unnecessary the employment of the stepping switch 234 and its associated drive 232 for predetermined count operation.

There is herein described merely a single embodiment of the invention. Upon examination of the drawing and description above, persons skilled in the art will readily adapt the structures and operating principles described to other automatic sample changers which, despite differences in appearance and details of construction, nevertheless embody the essential teachings of the present invention. It is accordingly to be understood that the scope of the monopoly conferred by the patent laws shall be determined not from any details of construction herein shown or described, but solely from the claims which are hereto appended.

What is claimed is:

1. In an automatic sample changer for radioactive samples, a housing, a carriage rotatably mounted on the housing and having at least three recesses equally spaced and circularly disposed about the axis of the carriage, dispensing and receiving magazines and a radiation shield having mouth portions, means for mounting the magazines and the shield in relative positions corresponding to the relative positions of three of the recesses, the mouth portions facing and being closely adjacent to the rotational path of the recesses, a sample holder support in each recess having a depending portion extending through the carriage and adapted to be reciprocated to raise a sample holder within the recess beyond the surface of the carriage and to lower a sample holder in the recess to a level substantially flush with the carriage surface, a stop member mounted on the housing in the portion of the rotational path of said depending portions adjacent to the receiving magazine, a motor, a friction coupling between the motor and the carriage adapted to rotate the carriage except when one of the depending portions engages the stop member, and a rotatable cam coupled to the motor and having a camming surface successively driving the depending portions of the sample holder supports in such three recesses to raise the successive support members, whereby in each rotation of the cam a sample holder within the shield is lowered into a recess in the carriage, a sample holder within a recess in the carriage is raised into the receiving magazine, a sample holder in a recess is brought opposite the receiving magazine, a recess in the carriage is brought beneath the dispensing magazine, a recess containing a sample holder is moved beneath the shield, a recess receives a sample holder from the dispensing magazine and a sample holder in a recess is raised into the shield.

2. The sample changer of claim 1 wherein the stop member extends between positions adjacent to the two magazines, and comprises a plate having opposite ends adapted to engage said depending portions and having a flat surface between said ends adapted to support the depending portions as they pass thereover, and there are provided means for reversing the motor, whereby each sample holder support member is maintained in an elevated position as it passes between magazines in either direction, so that a sample holder is deposited in one magazine from each successive recess and another sample holder is received from the other magazine in each successive recess, and the cycle may be reversed by reversal of the motor.

3. In an automatic sample changer for radioactive

samples, a housing, a rotatable carriage journaled on the housing and having at least three recesses equally spaced and circularly disposed about the axis of the carriage, dispensing and receiving magazines and a radiation shield having mouth portions, means for mounting the magazines and the shield in a relative position corresponding to the relative position of three of the recesses, the mouth portions facing and being closely adjacent to the rotational path of the recesses, a sample holder support member in each recess adapted to be reciprocated to raise a sample holder within the recess beyond the surface of the carriage and to lower a sample holder in the recess to a level substantially flush with the carriage surface, means to rotate the carriage so that each recess passes from the shield to one magazine, thence to the other magazine and then again to the shield, and means to elevate each support member when it is opposite said one magazine and to retract the support member when it is opposite said other magazine, so that successive sample holders are removed from the mouth of said other magazine, brought opposite the mouth of the shield, and then inserted and retained in the mouth of the first magazine.

4. In an automatic sample changer for radioactive samples, a rotatable carriage plate having at least three recesses in the upper surface thereof, equally spaced from the axis of rotation and circumferentially spaced at equal intervals, open-bottom substantially tubular vertical dispensing and receiving magazines adapted to receive stacks of sample holders, and an open-bottom radiation shield, means for supporting the magazines and the shield closely above the carriage plate in the same relative spacing with respect to the axis of rotation of the carriage plate as three of said recesses, so that the recesses successively pass beneath the magazines and the shield, a sample holder support member in each recess, a motor, and cycling means coupled to the motor to lower the sample holder support member beneath the shield to withdraw a sample holder thereon from the shield, elevate the support member in the recess beneath the receiving magazine to insert a sample holder into the magazine, rotate the carriage plate through an angle corresponding to the spacing between recesses to bring an empty recess beneath the dispensing magazine, and raise the sample holder support in the recess beneath the shield to insert a new sample holder therein, whereby a sample holder is withdrawn from the shield and inserted in the receiving magazine while its successor is withdrawn from the dispensing magazine and inserted into the shield.

5. The sample changer of claim 4 wherein there are provided means responsive to the emptying of the first magazine to reverse the cycle of operation and means responsive to the emptying of the second magazine to restore the original cycle of operation.

6. The sample changer of claim 5 wherein there are provided means for inactivating the cycling means at the end of each of said original cycles thereof for a period responsive to an actuating stimulus, and means disabling the inactivating means during the reverse cycles.

7. In an automatic sample changer for radioactive samples, a rotatable carriage plate having at least three recesses in the upper surface thereof, equally spaced from the axis of rotation and circumferentially spaced at equal angular intervals, open-bottom substantially tubular vertical dispensing and receiving magazines adapted to receive stacks of sample holders, and an open-bottom radiation shield, means for supporting the magazines and the shield closely above the carriage plate in the same relative spacing with respect to the axis of rotation of the carriage plate as three of said recesses, so that the recesses successively pass beneath the magazines and the shield, a sample holder support member in the bottom of each recess having a depending portion extending downwardly through, and reciprocable in, the plate, so that a sample holder in the recess may be raised and lowered by raising and lowering of said depending portion, and means

for cyclically raising and lowering said support members and for rotating said carriage plate to withdraw successive sample holders from the bottom of the dispensing magazine and insert them into the shield and thereafter to withdraw them from the shield and insert them into the receiving magazine.

8. An automatic sample changer for radioactive samples comprising a horizontally rotatable flat-surfaced carriage having, equally spaced from the axis of rotation thereof, and circumferentially spaced at equal angular intervals, at least three substantially identical upwardly facing recesses of a depth to receive a sample holder, vertical open-bottom dispensing and receiving magazines each adapted to receive a stack of sample holders, an open-bottom shield adapted to hold a radiation counter, means to support the open bottoms of the magazines and the shield in circumferentially spaced relation at corresponding angular intervals above and closely adjacent to the rotational path of the recesses, elevating means in each recess to raise a sample holder above the surface of the carriage, means to activate and deactivate the elevating means to raise and lower a sample holder in each recess when the recess is beneath the shield, and to raise a sample holder as the recess passes beneath the receiving magazine and means to rotate the carriage to successively position the recesses under the magazines and the shield, whereby successive sample holders are removed from a stack of sample holders in the dispensing magazine, inserted into and removed from the shield, and then loaded into the bottom of the receiving magazine.

9. An automatic sample changer for radioactive samples comprising a rotatable flat-surfaced carriage having equally spaced from the axis of rotation thereof a plurality of circumferentially spaced substantially identical recesses of a depth to receive a sample holder, dispensing and receiving open-ended magazines each adapted to receive a stack of sample holders, an open-ended shield adapted to hold a radiation counter, means to support the open ends of the magazines and the shield in circumferentially spaced relation facing and closely adjacent to the rotational path of the recesses, elevating means in each recess to raise a sample holder above the surface of the carriage, means to activate and deactivate the elevating means to raise and lower a sample holder in each recess when the recess is positioned at the open end of the shield, and to raise a sample holder as the recess passes the receiving magazine, and means to rotate the carriage to successively position the recesses at the ends of the magazines and the shield, whereby successive sample holders are removed from a stack of sample holders in the dispensing magazine, inserted into and removed from the shield, and then loaded into the end of the receiving magazine.

10. An automatic sample changer for radioactive samples comprising a flat-surfaced carriage having in the flat surface thereof a recess of a depth to receive a sample holder, dispensing and receiving vertical open-ended magazines each adapted to hold a stack of sample holders, an open-ended shield adapted to hold a radiation counter, means to support the open ends of the dispensing magazine, the shield and the receiving magazine in spaced relation facing and closely adjacent to the flat carriage, means for moving the carriage in the plane of the flat surface to successively and repeatedly position the recess at the end of the dispensing magazine, the shield, and the receiving magazine, elevating means to raise a sample holder in the recess above the surface of the carriage, means to activate and deactivate the elevating means to raise and lower a sample holder in the recess when the recess is positioned at the open end of the shield, and to raise a sample holder as the recess passes the receiving magazine, whereby successive sample holders are removed from a stack of sample holders in the dispensing magazine, inserted into and removed from the shield, and then loaded into and retained in the end of the receiving magazine.

11. An automatic sample changer for radioactive samples comprising a horizontally rotatable flat-surfaced carriage having in the flat surface thereof an upwardly facing recess of a depth to receive a sample holder, an open-bottom magazine elongated vertical adapted to receive a stack of sample holders, an open-bottom shield adapted to hold a radiation counter, means to support the open bottoms of the magazine and the shield in circumferentially spaced relation above and closely adjacent to the rotational path of the recess, means for rotating the carriage to successively position the recess under the magazine and the shield, elevating means to raise a sample holder in the recess above the surface of the carriage, means coupled to the elevating means to activate and deactivate the elevating means to raise and lower a sample holder in the recess when the recess is beneath the shield, and means to remove a sample holder from the recess during its motion from the end of the shield to the end of the magazine, whereby successive sample holders are removed from a stack of sample holders in the magazine, and then inserted into and thereafter removed from the shield.

12. An automatic sample changer for radioactive samples comprising a shield adapted to receive a radiation counter, a magazine adapted to receive a plurality of stacked sample holders, means for supporting said shield and said magazine in mutually spaced relation, means adapted to be connected to an activating stimulus for withdrawing successive sample holders from the magazine and inserting them into the shield for a time responsive to the activating stimulus, means independent of the actuating stimulus for restacking the sample holders in the magazine in their original order, and means for again withdrawing successive sample holders from the magazine and inserting them into the shield for a time responsive to the actuating stimulus, whereby the samples are repeatedly counted in successive order.

13. An automatic sample changer for radioactive samples comprising a shield adapted to receive a radiation counter, dispensing and receiving magazines each adapted to receive a plurality of sample holders in successive order, means for supporting said shield and said magazines in mutually spaced relation, means adapted to be connected to an actuating stimulus for withdrawing successive sample holders from the dispensing magazine and inserting them into the shield and for withdrawing them from the shield after a time responsive to the actuating stimulus and inserting them into the receiving magazine, means responsive to the emptying of the dispensing magazine for withdrawing successive sample holders from the receiving magazine and inserting them into the dispensing magazine to restore the sample holders to said dispensing magazine in their original order, and means responsive to the emptying of the receiving magazine to again initiate the original cycle of operation, whereby the samples are repeatedly counted in successive order.

14. The sample changer of claim 13 wherein the means to restore the sample holders to the dispensing magazine are independent of said actuating stimulus.

15. An automatic sample changer for radioactive samples comprising a shield adapted to contain a radiation counter, dispensing and receiving magazines each adapted to receive a plurality of sample holders in successive order, means for supporting said shield and said magazines in mutually spaced relation, means adapted to be connected to an actuating stimulus for withdrawing successive sample holders from the dispensing magazine and inserting them into the shield and for withdrawing them from the shield after a time responsive to the actuating stimulus and inserting them into the receiving magazine, and means independent of the actuating stimulus responsive to the emptying of the dispensing magazine for withdrawing successive sample holders from the receiving magazine and inserting them in the dispensing magazine to restore the sample holders to the dispensing magazine in their original order.

16. An automatic sample changer for radioactive samples comprising a radiation shield adapted to contain a radiation counter, dispensing and receiving magazines each adapted to hold a plurality of sample holders, means for supporting said shield and said magazines in mutually spaced relation, and means adapted to be connected to an actuating stimulus for withdrawing successive sample holders from the dispensing magazine and inserting them into the shield and for withdrawing them from the shield after a time responsive to the actuating stimulus and inserting them into the receiving magazine, said withdrawing and inserting means comprising a sample-retaining member and means for moving the sample-retaining member in a circular path, the supporting means supporting the shield and the magazines in spaced relation on the circular path.

17. An automatic sample changer for radioactive samples comprising a rotatable carriage having at least three sample-carriers circularly disposed and spaced at equal angles about the axis of the carriage, substantially tubular dispensing and receiving magazines adapted to receive a plurality of stacked samples in successive order and a radiation detector holder, said magazines and detector holder having mouth portions, means for mounting the magazines and the detector holder in fixed positions in relation to each other corresponding to the relative positions of three sample-carriers, the mouth portions facing and being closely adjacent to the rotational path of the sample-carriers, and cycling means coupled to the carriage and to the sample-carriers including means to rotate the carriage in each cycle through an angle corresponding to the angle between adjacent sample-carriers, means operative in each cycle to insert a sample from the dispensing magazine into the sample-carrier adjacent thereto, means operative in each cycle to insert a sample into the receiving magazine from the sample-carrier adjacent thereto, and switching means operative in each cycle and adapted to activate and inactivate a radiation detector in the holder.

18. An automatic sample changer for radioactive samples comprising a rotatable carriage having a plurality of sample-carriers circularly disposed about the axis of the carriage, substantially tubular dispensing and receiving magazines adapted to receive a plurality of stacked samples in successive order and a radiation detector holder, said magazines and detector holder having mouth portions, means for mounting the magazines and the detector holder with their mouth portions facing and closely adjacent to the rotational path of the sample-carriers, motion-cycling means coupled to the carriage and to the sample-carriers including means to rotate the carriage in each cycle through an angle corresponding to the angle between two of the sample-carriers, means operative in each cycle to insert a sample from the dispensing magazine into a sample-carrier adjacent thereto, means operative in each cycle to stop a sample-carrier opposite the mouth portion of the detector holder, means operative in each cycle to insert a sample into the receiving magazine from a sample-carrier adjacent thereto, and means for retaining samples in the magazines during rotation of the carriage.

19. An automatic sample changer for radioactive samples comprising a carriage rotatable about a vertical axis and having at least three sample-carriers circularly disposed and spaced at equal angles about the axis of the carriage, elongated vertical dispensing and receiving magazines adapted to receive a plurality of samples in successive order and a radiation detector holder having downwardly facing mouth portions closely adjacent to the rotational path of the sample-carriers in relative positions

corresponding to the relative positions of three sample-carriers, motion-cycling means coupled to the carriage and to the sample-carriers including means to rotate the carriage in each cycle through an angle corresponding to the angle between adjacent sample-carriers, means operative in each cycle to lift a sample into the receiving magazine from the sample-carrier adjacent thereto, and switching means coupled to the motion-cycling means and operative in each cycle and adapted to be coupled to a control circuit and to a radiation detector in the holder.

20. In an automatic sample changer for radioactive samples comprising a radiation shield adapted to contain a radiation counter and means for inserting successive sample holders into said shield, the improved construction wherein there are provided first and second elongated substantially tubular magazines spaced from the radiation shield on opposite sides thereof, and adapted to receive a plurality of stacked sample holders in successive order and each having an open mouth, a sample carrier, drive means coupled to the carrier for moving the carrier along a closed path from the mouth of the first magazine past the shield and then past the mouth of the second magazine, and then again past the mouth of the first magazine, and actuating means coupled to the carrier for moving a sample in the carrier toward the mouth of the second magazine and away from the mouth of the first magazine as the carrier passes the mouths of the respective magazines, whereby the sample holders in one magazine may be successively received by the carrier member, carried to the shield, and thereafter deposited in the other magazine.

21. In an automatic sample changer for radioactive samples comprising a radiation shield adapted to contain a radiation counter and means for inserting successive sample holders into said shield, the improved construction wherein there are provided first and second elongated substantially tubular magazines spaced from the radiation shield on opposite sides thereof, and adapted to receive a plurality of stacked sample holders in successive order and each having a mouth portion, a sample carrier, drive means coupled to the carrier for moving the carrier along a closed path from the mouth of the first magazine past the shield and then past the mouth of the second magazine, and then again past the mouth of the first magazine, actuating means coupled to the carrier for moving a sample in the carrier toward the mouth of the second magazine and away from the mouth of the first magazine as the carrier passes the mouths of the respective magazines, and means for reversing the action of the actuating means to move samples in the carrier toward the mouth of the first magazine and away from the mouth of the second magazine as the carrier passes the mouths of the respective magazines whereby the sample holders in one magazine may be successively received by the carrier, carried to the shield, deposited in the other magazine, and thereafter restacked in the first magazine in their original order.

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