

Sept. 22, 1953

A. W. WANZER ET AL
APPARATUS FOR AUTOMATICALLY MAKING
BLOOD SUGAR SCREENING TESTS

2,653,083

Filed Dec. 6, 1951

5 Sheets-Sheet 1

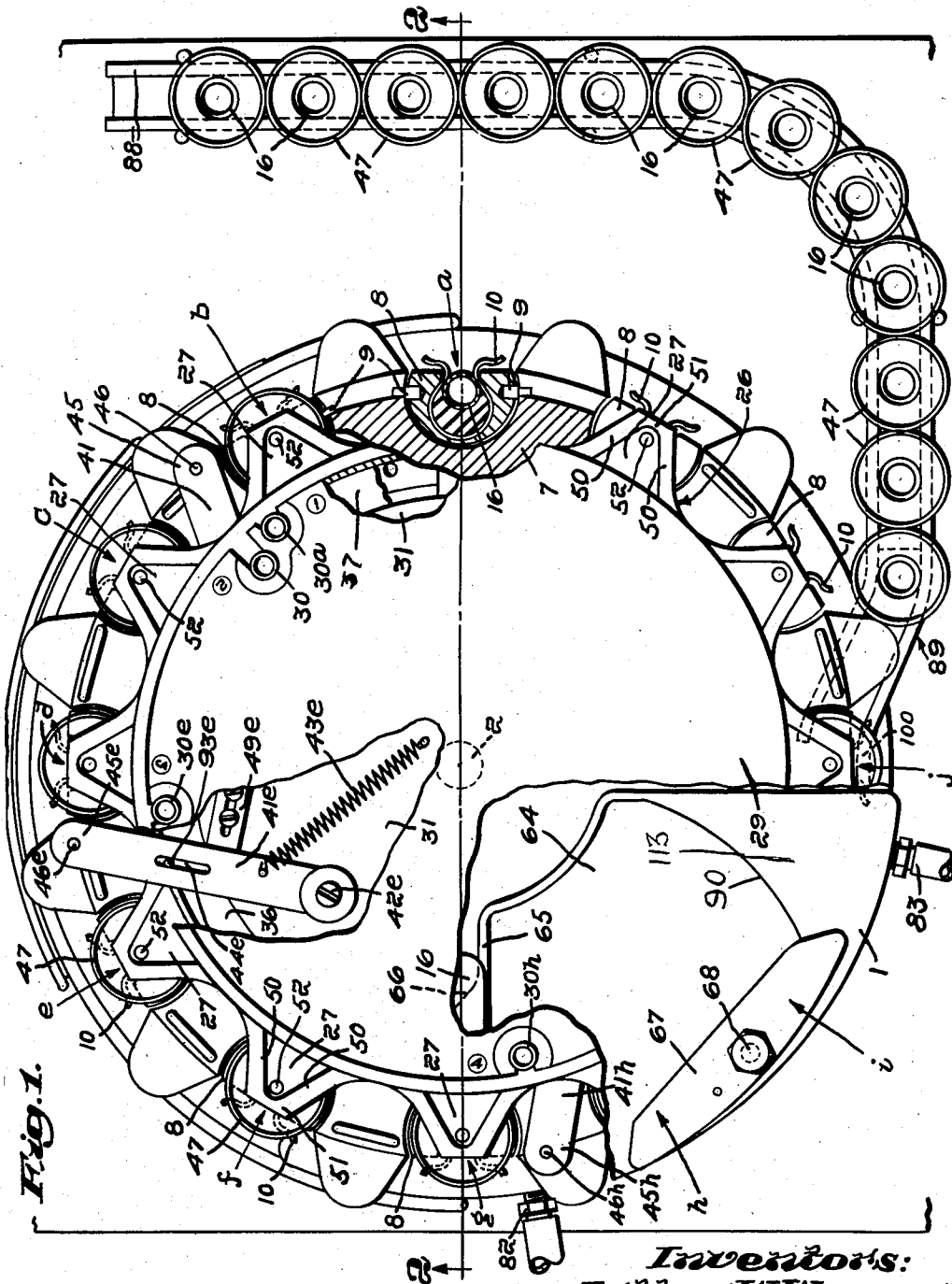


Fig. 1.

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5 Sheets-Sheet 2

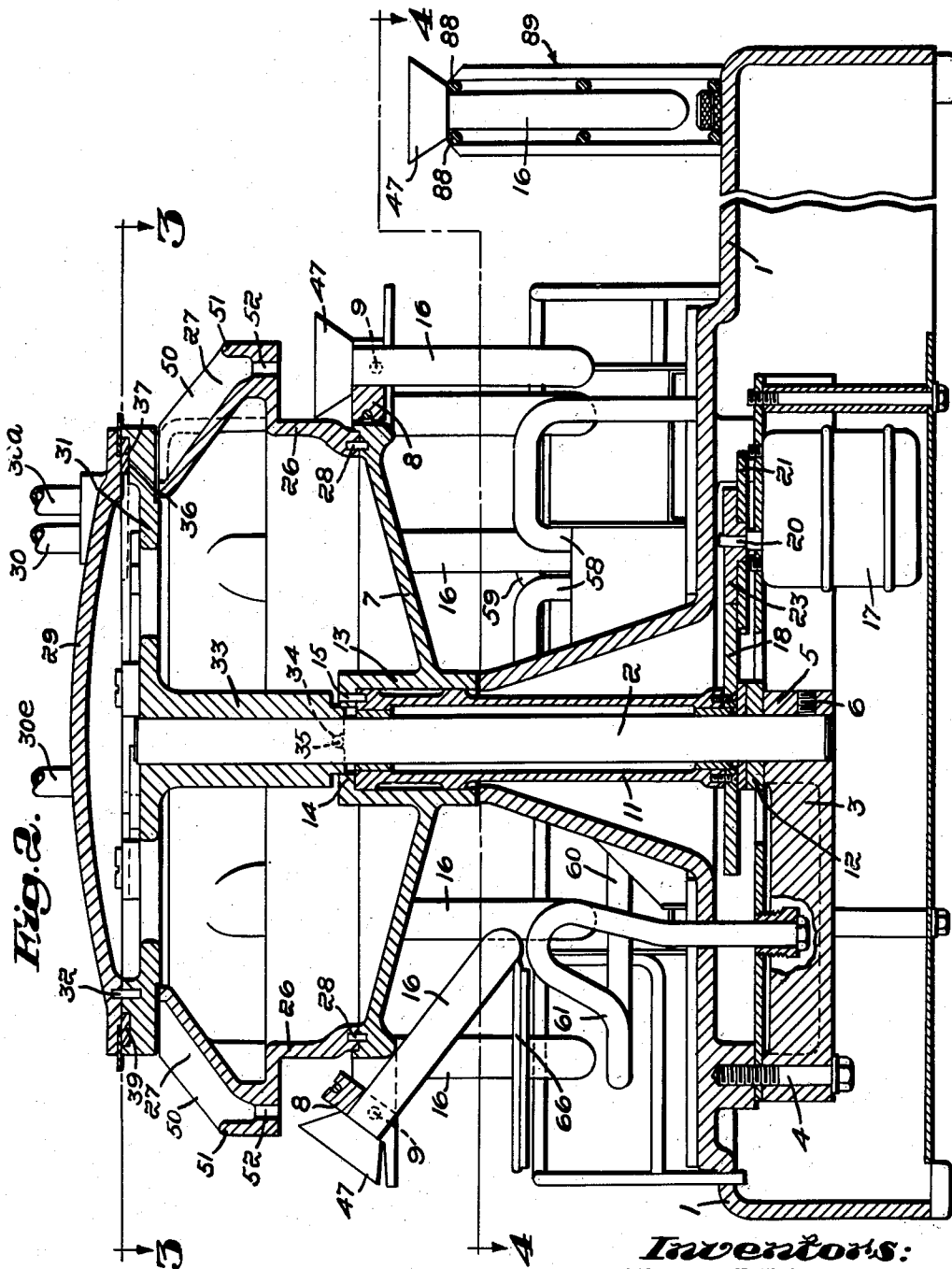


Fig. 2.

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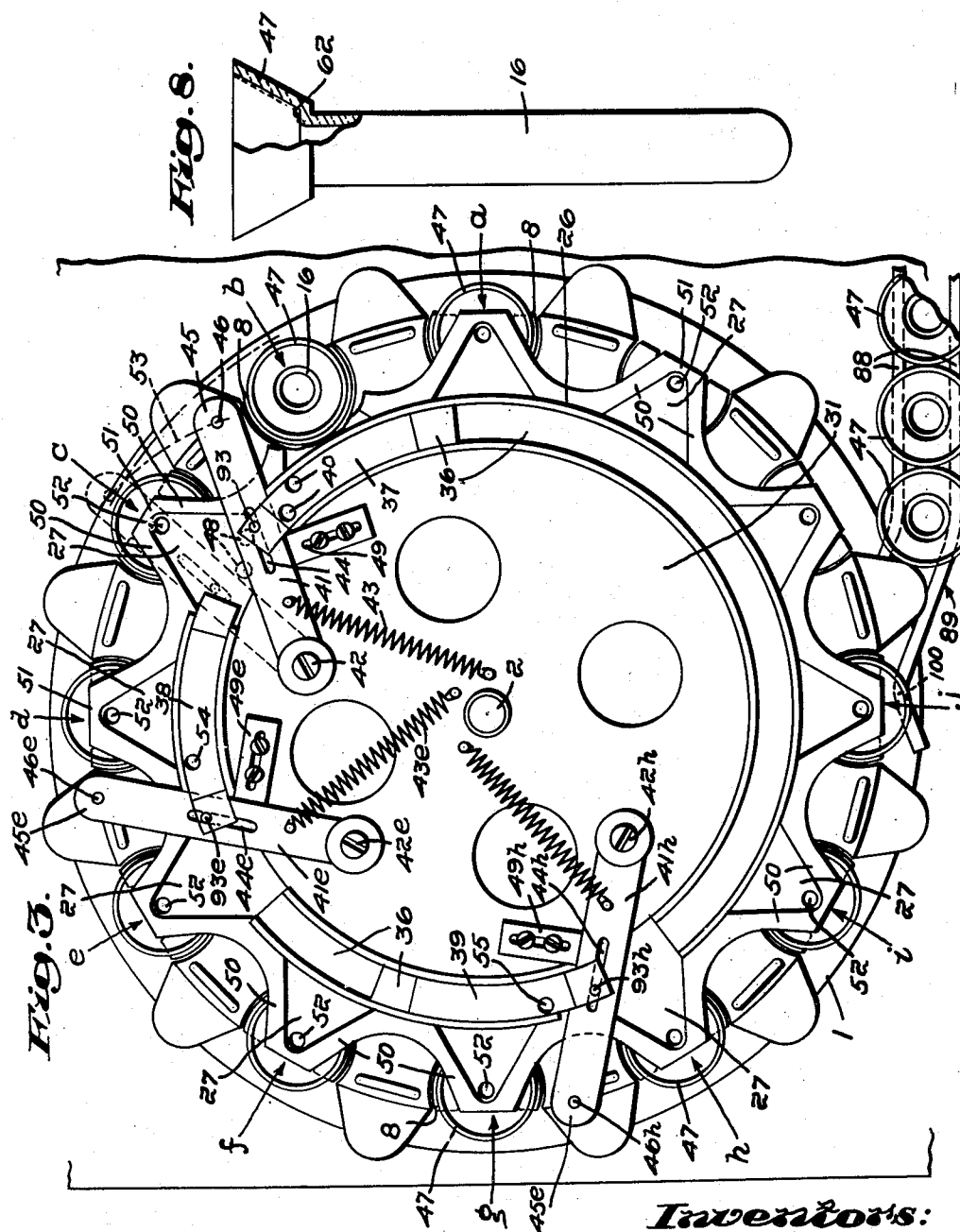
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5 Sheets-Sheet 3

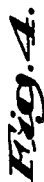


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5 Sheets-Sheet 4

5 Sheets-Sheet 4



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5 Sheets-Sheet 5

Fig. 5.

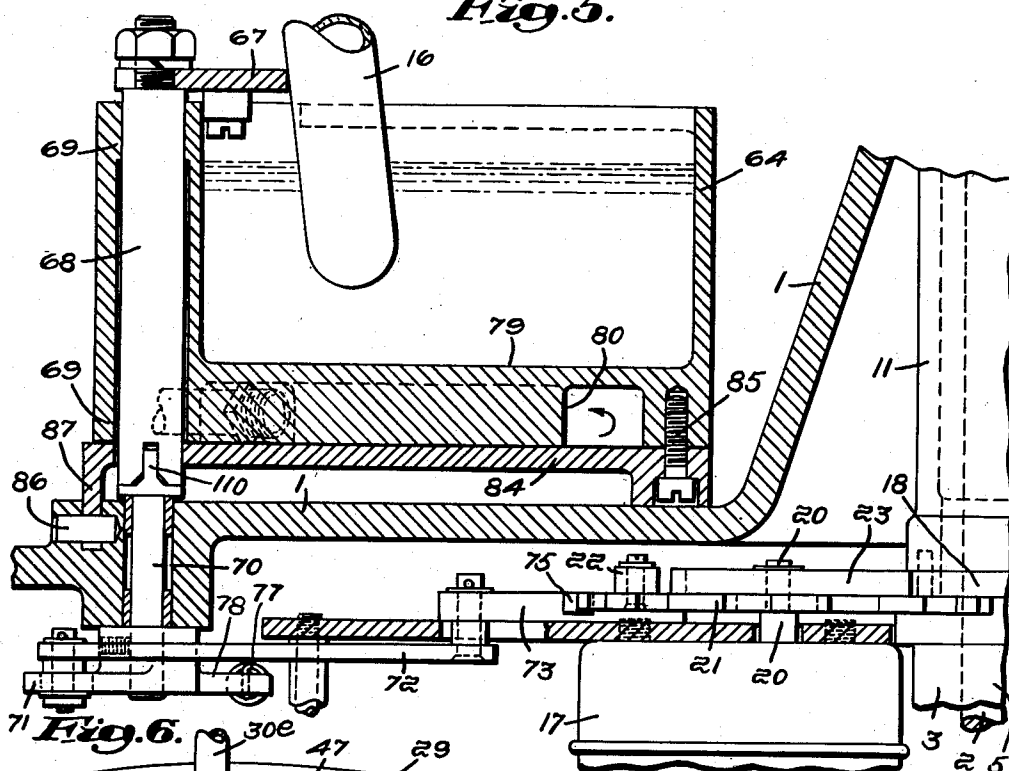


Fig. 6.

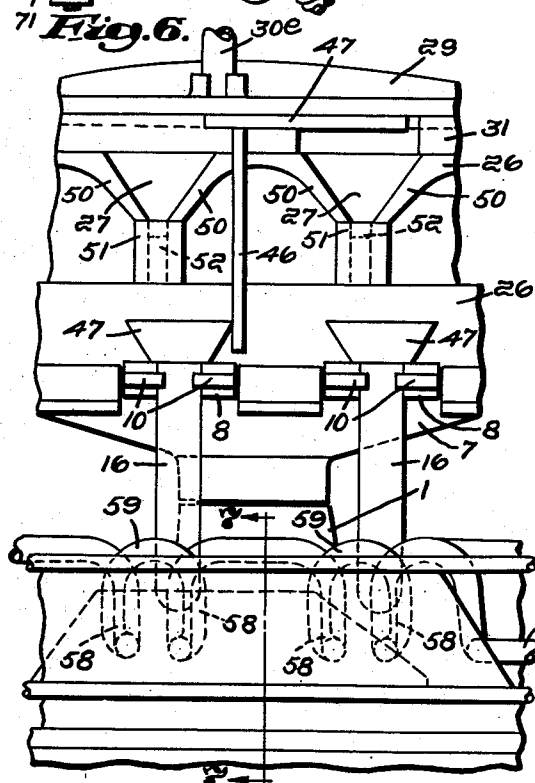
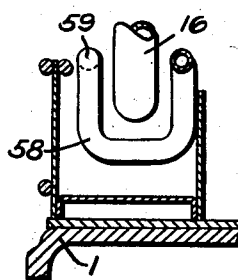


Fig. 7.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR AUTOMATICALLY MAKING
BLOOD SUGAR SCREENING TESTS

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7 Claims. (Cl. 23—253)

1

This invention relates to a portable chemical testing equipment capable of processing large numbers of samples in a minimum time.

While the device may be used for making various chemical tests, yet it has been especially designed for conducting blood sugar screening tests for the detection and diagnosis of diabetes.

The invention is in the nature of an improvement in the device illustrated in the Hewson Patent No. 2,560,107, dated July 10, 1951, which device includes a rotatable carrier or turntable supporting a plurality of test tubes containing the blood samples to be tested, means to rotate the test tubes with a step by step movement to carry said test tubes from one station to another and with a period of rest at each station, means to deposit a re-agent into each test tube at certain of said stations, and means to heat the tubes as they are moved forward in order to obtain the required chemical reaction.

The successful operation of a machine of the type shown in said Patent No. 2,560,107 depends to a considerable extent on the accuracy with which the re-agent tablets are delivered to the test tubes. One of the objects of the present invention is to insure a positive accuracy in this respect.

Another object of the invention is to provide an apparatus of the above character in which the various parts can be easily dissociated for inspection or repair.

Further objects of the invention are to provide various other improvements in an apparatus of this character which will be more fully hereinafter set forth.

In the drawings wherein is illustrated a selected embodiment of the invention,

Fig. 1 is a top plan view of an apparatus embodying the invention.

Fig. 2 is a vertical section on the line 2—2, Fig. 1.

Fig. 3 is a section on the line 3—3, Fig. 2.

Fig. 4 is a section on the line 4—4, Fig. 2.

Fig. 5 is an enlarged section on the line 5—5, Fig. 4.

Fig. 6 is a fragmentary side view illustrating the manner in which the gates are operated by the test tubes for delivering the re-agent tablets to the tubes.

Fig. 7 is a section on the line 7—7, Fig. 6.

Fig. 8 is a view of one of the test tubes.

The apparatus comprises a base member 1 which supports an upstanding stationary post 2 that forms an axis about which the rotary carrier or turntable rotates. This post is shown as

2

supported in a member 3 which in turn is secured to the base 1 by means of suitable screws 4. The member 3 has a hub portion 5 in which the lower end of the post 2 is received, said post being retained in position by the set screw 6.

The turntable comprises a tube-carrying member 7 which is provided at its periphery with a plurality of pivoted test tube holders 8, each holder being pivotally mounted to turn about a horizontal axis 9 and each having spring fingers 10 adapted to yieldingly embrace a test tube 16. The rotary member 7 is mounted on the upper end of a sleeve 11 which turns about the post 2 and is supported at its lower end by a suitable bearing 12. The member 7 is formed with a hub portion 13 which fits the upper end of the tube 11 and has at its upper end an inwardly directed flange 14 that rests on the top of the tube 11. The flange 14 of the hub 13 carries a pin 15 which fits into a socket formed in the upper end of the tube 11. The tube 11, and consequently the member 7, is given a step by step rotative movement with a period of rest at the end of each forward step, and in the construction shown each forward step turns the member 7 through a 30° arc, and hence there will be twelve forward steps in a complete rotation. This step by step movement carries each test tube 16 through different stations, at each of which the test tube is held stationary during the period of rest, and at certain of the stations a re-agent tablet will be delivered to each test tube while it is at rest at said station, as set forth in the above mentioned patent.

The means for giving the member 7 its step by step forward rotary movement comprise a motor 17 carried by the base 1 and connected to the sleeve 11 by means of a Geneva movement. The lower end of the tube 11 has secured thereto a disk 18 having a plurality of radial slots 19 in its periphery. The motor 17 has a power take-off shaft 20 on which is mounted a disk 21 having an eccentrically located pin 22 which at each rotation of the disk 21 enters one of the slots 19 and thus moves the disk 18 and the tube 11 forward one step, this being the familiar construction of a Geneva movement.

The shaft 20 also has a disk 23 fast thereon which is circular throughout most of its periphery but is provided with an indentation 24. The engagement of the circular periphery of the disk 23 with the concavely curved portions 25 of the periphery of the slotted disk 18 serves to hold the disk 18 and the tube 11 from rotation during the period of rest. The indentation 24 in the

disk 23 provides for the forward rotation of the disk 18 each time that the pin 21 enters and thus operates in one of the slots 19.

Detachably mounted on the tube carrying member 7 is a member 26 which is provided with a plurality of chutes 27, one for each tube holder 3, and by which the individual chemical tablets are accurately delivered into the test tube 16. This member 26 is connected to the tube carrying member 7 so as to rotate therewith by means of pins 28.

Surmounting the member 26 is a stationary top element comprising a cap member 29 which carries a plurality of tablet dispensing tubes 30, 30a, 30e, and 30h, from which the reagent tablets are dispensed at the proper time. The tablet dispensing tubes are all located at the same radial distance from the axis of rotation of the tube carrying member 7 but at less radial distance from said axis than the tube holders 3. Hence, the tube holders travel in a circle outside of the circle which includes the tablet dispensing tubes. The chutes 27 extend downwardly and outwardly in a radial direction and the upper inner end of each chute is situated to move in a circle directly underneath the tablet dispensers, while the outer delivery end of each chute travels in a circle directly over the tube holders 8. Said top element also comprises a lower member 31 which is provided with gates by which the reagent tablets are individually withdrawn from the tubes 30, 30a, 30e, and 30h and delivered to the chutes 27. The members 29 and 31 are detachably connected together by means of pins 32, the construction being such that the cap member can be readily lifted off from the member 31. Said member 31 is formed with a hub 33 which encircles the upper end of the post 2 and which is formed in its lower edge with a notch 34 in which is received a supporting pin 35 extending from the post 2. The pin and notch serve to hold the member 31, and consequently the member 29, from rotative movement, but as the hub 33 merely rests on the pin 35 the member 31 can be readily removed if it is necessary to do so for inspection or repair purposes.

For convenience the various stations at which the tube holders 8 remain at rest during each rotation of the rotary carrier are indicated in Figs. 1 and 3 at a, b, c, d, e, f, g, h, i, j.

At the station c two reagent tablets are delivered from the twin or two tube tablet dispenser 30, 30a to each tube 16 while it is at rest at said station. At the station e a single tablet is delivered from the tablet dispenser 30e to each tube, and also at the station h a single tablet is delivered from tablet dispenser 30h to each tube. For thus delivering these tablets the member 31 is provided in its upper surface with a circular groove 36 concentric with the post 2 in which groove operate three gate members 37, 38, and 39, each gate member being actuated to take a tablet from its dispensing tube 30 and deliver it into the corresponding chute 27 by the movement of each tube as it is stepped forward.

The gate 37 cooperates with the twin tube dispenser and it has two openings 40 there-through which have a position relative to each other similar to that of the twin tubes 30, 30a. The gate 37 is connected to a lever 41 pivoted at 42 and acted upon by a spring 43 which yieldingly holds it in its retracted position shown in Fig. 3 against a stop 49. The connection be-

tween the gate 37, which moves in the arc of a circle having the post 2 as its center, and the lever 41 is a pin and slot connection, said gate member having a pin 93 which extends into a slot 44 with which the lever 41 is provided. The outer end 45 of the lever 41 has a pin 46 depending therefrom which is of a length and is so positioned that as each test tube 16 approaches the station at which it is to receive the two tablets from the twin dispenser 30, 30a, the upper end 47 of the test tube engages the pin 46 and thereby swings the lever 41 from the full to the dotted line positions, Fig. 3.

When the gate 37 is in its retracted position the apertures 40 therein are in alinement with the twin tubes 30, 30a, and hence each aperture has received a re-agent tablet. When the test tube 16 moves forward into station c, the engagement of the upper end of said tube with the pin 46 moves the gate forward into the dotted line position, Fig. 3, thereby carrying the openings 40, each of which holds a re-agent tablet, into alinement with two openings 48 formed in the member 31, so that the tablets which are occupying the openings 40 in the gate will fall out of said openings and through the openings 48. At this time one of the chutes 27 has been brought beneath the openings 48 so that the tablets are deposited into said chute and from this chute they gravitate into the test tube 16 which is arriving at station c.

As the tablets are thus deposited into the chute 27 the test tube arriving at station c becomes disengaged from the pin 46 of the lever 41, which is then returned to its initial or retracted position by the spring 43, and as it reaches such retracted position with its openings 40 alined with the dispensing tubes 30, 30a, each aperture 40 becomes again loaded with a re-agent tablet. The retracting movement of the lever 41 is limited by a stop member 49.

The upper inner end of each chute 27, which travels in a path directly beneath the tablet dispensers as stated above, is relatively wide, and each chute has a progressively decreasing width from its upper end to its lower delivery end which is located directly over a tube holder 8. Each chute is provided with side walls 50 which converge toward the lower end, the lower ends of said walls being connected by an end wall 51. At its lower end the chute is provided with a discharge opening 52 through which the tablets deposited in the chute are delivered into the test tube 16.

Inasmuch as the member 26 which carries the chutes 27 is rotating with the member 7 which carries the tube holders, the delivery opening 52 of each chute will always be directly above the tube 16 carried by the corresponding tube holder, and hence any tablet which is deposited into the chute will, without fail, be delivered to the test tube.

The upper end of each chute is relatively wide, as stated above, and has sufficient width so that when any tube engages the depending pin 46 and the lever 41 is moved forward, the wide upper end of the chute will be brought underneath the openings 48 before the tablets are actually transferred from the gate 37 into said openings 48, and hence any tablet which is dispensed from either of the twin tube dispensers will, without fail, be delivered into the chute 27 and hence into the test tube.

The disengagement of each test tube with the pin 46 results from the fact that the swinging

5

movement of the lever 41 about its pivot 42 carries the pin 46 in an arc indicated by the dotted line 53 in Fig. 3, and by the time the tube which is acting on the pin 46 has reached the station *c* the arcuate movement of the pin 46 carries it outside of the path of movement of the tube 16, and thereby the lever 41 is released for its spring impelled return movement.

A similar mechanism is employed for actuating the gate 38 for delivery of a re-agent tablet to each tube 16 when it reaches station *e*, and also for actuating the gate 39 for delivering a re-agent tablet for each tube 16 when it reaches station *h*, the only difference being that each of the gates 38 and 39 has a single opening for receiving a single tablet from the corresponding dispensing tube 30*e* or 30*h*. The opening in the gate 38 is indicated at 54, and that in the gate 39 is indicated at 55.

In order to avoid confusion the elements for operating the gate 38 for delivery of a tablet at station *e* are indicated by the reference numerals 41*e*, 42*e*, 43*e*, 44*e*, etc., and the corresponding elements for operating the gate 39 for delivery of a tablet at station *h* are indicated by the reference numerals 41*h*, 42*h*, 43*h*, 44*h*, etc.

It will be understood from the above mentioned patent that it is necessary to heat the contents of each test tube while it is traveling from station to station, and to maintain the contents of the test tube at the proper temperature at each station. For this purpose there is provided a continuous electrically heated unit 56 which has a straight section 57 extending from station *b* to station *c*, and which is bent at station *c* to present the two U-shaped portions 58 that are connected by an inverted U-shaped portion 59, this shape serving to heat the tube 16 at station *c* to the desired temperature. A similar configuration of the heating unit is formed at station *d*, and from station *d* the heating unit has relatively straight sections 60 and 61 which are so located relative to the path of the tube 16 as to maintain the tubes at the desired temperature.

The preferred type of test tube is shown in Fig. 8, it having a diverging upper end portion 47 which terminates at its lower end in a shoulder 62, the purpose of which will be presently described.

The test tubes containing the blood samples are placed in the tube holders at some point between stations *j* and *a*, and as the turntable or rotatable carrier rotates to bring each tube successively to station *c* the two tablets will be delivered into the test tube, as above described, and while the tube is at station *c* it will be heated sufficiently to coagulate the blood proteins which rise to the top of the tube where they will adhere to the funnel shaped end 47 of the tube, as indicated in dotted lines Fig. 8, the shoulder 62 retaining this coagulated mass in this position.

As each tube moves through subsequent stations and receives another tablet at station *e* the processing of the blood which is in the tube continues in a well-known way. Just before the tube reaches station *h* it is tilted as shown in Fig. 2 to carry the lower end thereof over the wall of a cooling tank 64, each tube assuming a vertical position as soon as it has passed over said wall 65. The tilting of each tube is accomplished by a cam plate 66 situated to be engaged by the lower end of the tube and having a shape to tilt the tube as it is carried forward by the rotatable carrier.

The tank 64 is mounted on the base 1 and con-

6

tains a coolant in which the lower end of the test tube 16 is immersed, as shown in Fig. 5. While the lower end of each tube is in the cooling bath it is vibrated or agitated, and for this purpose there is provided an oscillating agitator member 67 which is mounted on a vertical oscillating post 68 that is mounted in bearings 69 with which the wall of the tank 64 is provided.

Each tube is tilted to enable it to pass over the wall 65 of the tank 64 as said tube passes through station *g* and the tube remains in the tank 64 while stationary at stations *h* and *i*, as shown in Fig. 4. The agitator member 67 is of a length to engage a tube at station *h* and also one at station *i*, as best seen in Fig. 4, and both tubes are therefore simultaneously acted on by the agitator.

The shaft 68 of the agitator is coupled to a driven shaft 70 mounted in the base 1, and said shaft 70 has fast thereon an arm 71 which is pivotally connected by a link 72 with another arm 73 pivoted at 74. The arm 73 has a tooth 75 which engages ratchet teeth 76 formed on the periphery of the disk 21. The tooth 75 is maintained in engagement with the ratchet teeth 76 by means of a spring 77 which acts on an arm 78 rigid with the shaft 70.

As the disk 21 rotates with its clockwise movement, Fig. 4, the engagement of each tooth 76 with the tooth 75 of the member 73 will swing said lever outwardly, thereby turning the agitator 67 in a clockwise direction, Fig. 4, and as the tooth 75 drops off from each tooth 76 the spring 77 will return the agitator to its initial position. The agitator 67 will thus have a relatively rapid oscillatory movement which will properly agitate the tubes 16 while they are being cooled by the coolant in the tank 64.

The tank 64 is provided with means for maintaining the cooling liquid therein at a proper temperature. For this purpose the tank 64 has a false bottom 79 beneath which is a circulating passage 98 through which a cooling liquid flows. The side walls of the tank extend below the false bottom and rest on a bottom plate member 84 which is secured to the tank body by screws 85. The false bottom 79 has radially extending fins 80, 81 depending from its lower face which form with the bottom plate the circuitous passage 98 that extends around the inner ends of the fins 80 and around the outer ends of the fins 81, as seen in Fig. 4.

82 and 83 indicate inlet and outlet connections leading to and from the circulating passage 98. The flow of cooling liquid through said passage maintains the false bottom 79 sufficiently cool to prevent the coolant in the tank 64 from becoming unduly heated by transfer of heat thereto from the heated tubes 16.

The tank assembly is removably mounted on the base 1 and the bottom plate 84 is shown in Fig. 5 as having a depending flange 87 which is received in a groove with which the base is provided and is retained in position by the pin 86.

As each tube 16 leaves the tank 64 at station *j* it is delivered into a storage rack 89. Said rack comprises two rails 88 spaced properly to receive between them the body of a tube 16, the receiving ends 100 of the rails being situated to receive between them each tube as it passes over the end wall of the tank 64 and assumes a vertical position. As the rotary carrier moves each tube 16 away from station *j*, the engagement of the tube with the end 100 of the inner rail of the rack withdraws it from its tube holder 8, and thereby

7

the tube is transferred to the rack 89 in which the processed tubes accumulate as seen in Fig. 4.

It has been stated above that the tank 64 is removable from the base, and to provide for this the coupling between the post 68 and the shaft 70 is a separable coupling. The post 68 has a slot in its lower end in which is received a fin 110 formed on the upper end of shaft 70.

We claim:

1. Apparatus of the class described comprising 10 a rotatable carrier, test tube holders mounted on said carrier, means rotating said carrier with a step-by-step movement and a period of rest after each step, a plurality of tablet dispensers, means stationarily mounting said dispensers above the rotary carrier and at points having a less radial distance from the axis of the carrier than the tube holders, means actuated by a tube held in each tube holder as it approaches each tablet dispenser to dispense a tablet therefrom, and tablet 20 guiding means carried by and rotatable with the rotary carrier to guide each tablet as it is dispensed from its dispenser into said tube.

2. Apparatus as defined in claim 1 which includes means for heating each test tube as it travels through one portion of its step-by-step journey, cooling means for cooling the tube during another portion of said journey, a spring biased oscillatory vibrator to engage each tube while it is being cooled by the cooling means, and means actuated by the carrier-rotating means to give the vibrator periodically an oscillating movement in opposition to said spring.

3. Apparatus as defined in claim 1 which includes means for heating each test tube as it travels through one portion of its step-by-step journey, means for cooling each tube as it travels through another portion of its step-by-step journey, an oscillatory vibrator of a length to engage the tubes in two adjacent tube holders while the carrier is at rest and said two tubes are being cooled by the cooling means, and means connected to and operated by the carrier-rotating means to oscillate the vibrators.

4. Apparatus of the class described comprising 45 a rotatable carrier, test tube holders mounted on said carrier, means rotating said carrier with a step-by-step movement and a period of rest after each step, a plurality of tablet dispensers, means supporting each tablet dispenser in stationary position above the rotary carrier, said rotary carrier having a plurality of chutes situated above the tube holders and below the tablet dispensers, there being one chute for each tube holder situated to deliver a tablet into a tube held thereby, means actuated by a test tube in any holder as it approaches each tablet dispenser 55

8

to dispense a tablet therefrom and deliver it into the corresponding chute from which it is delivered into said test tube.

5. Apparatus as defined in claim 4 in which each chute presents an upstanding wall on each side and at the bottom and is provided at the bottom with a discharge opening through which the tablets are discharged into the tubes.

6. Apparatus of the class described comprising a rotary carrier, a plurality of test tube holders carried by said carrier, means rotating said carrier with a step-by-step movement and a period of rest after each movement, a stationary cap member above the rotary carrier, a plurality of tablet dispensers mounted on said cap member, said rotary carrier having a plurality of chutes situated below the cap member and above the test tube holders, there being one chute for each test tube holder, and each chute being positioned to pass directly beneath the tablet dispensers during the step-by-step movement of the rotary carrier and having its delivery end directly over a tube held by the corresponding tube holder, means actuated by a tube in any holder as it approaches each tablet dispenser during its step-by-step rotary movement to dispense a tablet from said dispenser and deliver it into the corresponding chute from which it is delivered to said tube.

7. Apparatus of the class described comprising a base member, a stationary post rising therefrom centrally thereof, a tube holding member rotatable about said post and supported by the base, said tube holder having provision for holding a plurality of tubes, a chute-carrying member separable from the tube holding member and loosely resting thereon and supported thereby, a pin rising from the tube holding member and fitting a socket in the bottom of the chute carrying member, said chute carrying member having a plurality of chutes, one leading to each tube carried by the tube holder, a stationary cap member detachably mounted on said post above the chute carrying member, a tablet dispenser carried by the cap member, means to rotate the tube holding member and chute carrying member with a step-by-step movement, and means actuated by a tube carried by the tube holding member to dispense a tablet from the dispenser into the chute leading to said tube.

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