ABSTRACT OF THE DISCLOSURE

A sample tube transporter which is particularly suited for use in conjunction with automatic chemical analysis equipment. The transporter includes a frame having an endless horizontal channel in which a multiplicity of vertical sleeves are intermittently advanced in single file. Each sleeve is adapted to receive a sample tube and thereby transport the tube through a plurality of stations along the channel where treatment and analytical steps may be performed. The contents of the sample tubes are maintained at constant temperature and after such tubes have been transported through all of the treating and analyzing stations such tubes and their remaining contents are automatically discarded.

BACKGROUND

While transport mechanisms for automatic analysis equipment are known, such mechanisms are generally complex in structure and operation and are subject to problems of maladjustment and breakdown. In one such construction, measured amounts of samples are automatically transferred from sample tubes to conditioning tubes or cavities, the latter tubes or cavities requiring emptying and washing following conditioning and analyzing steps. While washing of the tubes may be performed automatically, such a procedure not only increases the complexity of the apparatus but also introduces a possible source of sample contamination.

While the importance of maintaining precise temperature control over samples has been recognized, the difficulties of maintaining such control in existing equipment are substantial because of the complexity of such equipment and because certain of the operations, such as the automatic washing procedures mentioned above, may tend to interfere with precise temperature adjustments.

DESCRIPTION

FIG. 1 is a perspective view illustrating a transporter in operative condition mounted in the table surface of an automatic analyzer;

FIG. 2 is an exploded perspective view, shown partially diagrammatically, illustrating the components of the transporter;

FIG. 3 is an enlarged vertical sectional view taken along line 3–3 of FIG. 1;

FIG. 4 is an enlarged longitudinal sectional view taken along line 4–4 of FIG. 1.

The frame includes a horizontal bottom platform, a top plate and an intermediate plate. All three elements are securely connected together in spaced parallel relation by vertical posts which consist of a bolt and a pair of tubular spacers and a pair of tubular spacers (FIG. 3). Each of the plates and the intermediate plate has an elongated central opening and therein. Within each opening is a horizontally elongated plate member and the two plate members or plates being secured together in spaced parallel relation, and being affixed to platform, by posts which are similar in construction to posts.

Member is disposed in the same horizontal plane as top plate, and member in the same plane as intermediate plate.

Within the openings, and the superimposed plates and, at one end of the island formed by members and , is an upstanding shaft equipped with star wheels and disposed at the same levels as plates and , respectively (FIG. 3). Shaft extends downwardly through an opening in the platform and, together with motor which is suitably mounted beneath the frame, comprises the driving means for advancing sleeves and tubes.

The edges of plates and which define openings , and, the lateral edges of members , and of star wheels and , form an endless elongated channel or passage of substantially uniform width for slidably receiving the sleeve members which in turn loosely receive the sample tubes. Referring to FIGS. 3 and 4, it will be observed that each sleeve member is generally cylindrical in shape, having end portions of reduced diameter and an enlarged central or shoulder portion. The external diameter of end portions is slightly less than the width of channel, whereas the shoulder portion is of greater diameter than the channel and has axial vertical dimensions just slightly less than the distance between plates and . Thus, the cylindrical sleeves are restrained against vertical movement with respect to the frame but are free to move horizontally along the channel. Each of the sleeve members has a vertical bore extending completely therethrough, the bore having a diameter slightly larger than that of the sample tube F loosely received therein.

The sleeve members may be formed of any suitable material. It has been found, however, that particularly effective results are obtained where the sleeves are formed from tetrafluoroethylene resin because of the solvent and chemical resistance of such material and, in particular,
its low co-efficient of friction. Plate members 13 and 14 are preferably formed of metal, such as stainless steel, and sample tubes F are formed of glass. As will be brought out more fully hereinafter, the cylindrical sleeves 28 are in sliding contact with both the tubes and the plates; therefore, by forming such sleeves from tetrafluoroethylene resin a self-lubricating assembly is obtained.

FIGS. 1 and 4 reveal that the parallel sleeves E are in side-by-side contact with each other to form an endless chain of such sleeves along horizontal channel 26. While a series of 34 of such sleeves is illustrated in FIG. 1, it will also be understood that a greater or smaller number might be provided, depending on the size of the transport unit as a whole and on the type of tests to be performed in the analyzer. The recesses of the star wheels or sprockets 22 and 23 conform to the curvature of sleeves E so that such sleeves may be received in and advanced by the recesses. The driving force transmitted by the star wheels and sprocket wheels constitutes that, if the sleeves above be released from the sprocket recesses—is transmitted by such sleeve to the sleeve directly in front of it, that sleeve in turn pushing the one directly before it, and so on. Thus, even though there is no positive connection between the multiple sleeves of the “chain,” all of the sleeves are connected by the sleeves directly in front of them, and any movement in any direction except along channel 26 and are advanced along the channel by a pushing force transmitted through the chain and originating with the sleeve or sleeves in engagement with the sprocket assembly.

The entire frame A is disposed in container B with platform 12 submerged in a body of water or other liquid 30 disposed in the container (FIGS. 3 and 4). Specifically, the platform is disposed far enough below the surface of the liquid so that sample tubes F resting upon the platform will have their lower portions disposed in the liquid bath. Recirculating and heating means D of any conventional construction serves to maintain the bath at constant temperature. As shown in FIG. 2, a drain tube 31 extends upwardly from the bottom of the container to the desired level of the liquid; any liquid overflowing the top of the tube is heated to a preselected temperature and is returned to the container through inlet tube 32. By constantly recirculating the fluid in the container, the temperature of the bath, and of the samples contained within tubes F, may be precisely controlled.

At the opposite end of the elongated container is an upwarding tube 33 which is coaxial with drive shaft 21 and which, as shown in FIG. 3, projects above the level of bath 30. The tube is welded or otherwise suitably sealed to the bottom of the container about an opening 34 in the bottom wall through which shaft 21 extends.

Adjacent to upwarding tube 33 is a second tube 35 which, like tube 33, has its upper end disposed above the level of bath 30. Tube 35 extends upwardly through the bottom wall of the container and through an opening 36 in plate 12 and constitutes one element of a tube discharge chute assembly. Tube 35 is of larger internal diameter than the outside diameter of each sample tube F and is disposed directly in the path of movement of such sample tubes as they advance along channel 26. A ramp 37 also extends along the path of movement of the tubes in advance of discharge tube 35 and, as shown in FIG. 4, slopes upwardly from the surface of platform 12 to which it is secured to the top of discharge tube 35.

In the operation of the transport, a technician first places a sample tube F into a sleeve at the position indicated by an arrow or other indicia 38 affixed to top plate 13 (FIG. 1). The intermittent drive of the unit advances the tube along the channel in a counter-clockwise direction, as viewed in FIG. 1. As the tube is so advanced, it passes through different stations where suitable reagents may be added through feed tubes 39, 40, and 41, depending upon the particular test involved and upon the programming of the unit as a whole. Finally, after the tube has nearly completed the circuit, it passes beneath an extraction device 42 which is adapted to withdraw at least a portion of the contents of the tube for automatic chemical analysis. Thereafter, the sample tube rides upwardly upon ramp 37 until it is positioned directly over the discharge chute 35 and drops through the chute into a suitable waste receiver 43. The empty sleeves E that pass to the starting position where the operator may insert a new sample tube and the entire cycle of operation is repeated.

It will be observed that each of the sample tubes F rides or slides upon the smooth top surface of platform 12 and is therefore maintained in its vertical position throughout nearly the entire cycle by that platform. The channel-defining plates 13, 14, 18, and 19 serve to guide the sleeves and sample tubes in horizontal directions while the platform and ramp 37 control the vertical positioning of the sample tubes.

While in the foregoing I have disclosed an embodiment of the invention in considerable detail for purposes of illustration, it will be understood by those skilled in the art that many of these details may be varied without departing from the spirit and scope of the invention.

I claim:

1. A transporter for sample tubes in chemical analysis equipment comprising a frame having horizontal members defining a horizontal channel of finite width; a plurality of sleeves each having an opening extending vertical therethrough and having an external dimension slightly less than the width of said channel; said sleeves being constrained by said frame only for movement along said channel and engaging each other in single file to form an endless chain of sleeves along said channel; driving means successively engageable with each sleeve to advance said sleeve along said channel, the driving force exerted by said means against any one of said sleeves being transmitted by mutual engagement of said sleeves to all of the sleeves in said chain; said sleeves each being adapted to loosely and removably receive a sample tube in the vertical opening thereof.

2. The structure of claim 1 in which said sample tubes are loosely and removably received in the openings of said sleeves; and platform means provided by said frame beneath said horizontal members for slidably supporting the bottom ends of said sample tubes as the same are advanced along said channel.

3. The structure of claim 1 in which said sleeves are generally cylindrical in shape.

4. The structure of claim 3 in which each of said cylindrical sleeves is provided with an external shoulder of greater width than said channel; said horizontal frame members including spaced horizontal plates disposed above and below the shoulder of each cylindrical sleeve; whereby said cylindrical sleeves are restrained against vertical movement relative to said frame.

5. The structure of claim 1 in which said channel is in the shape of an elongated endless track.

6. The structure of claim 3 in which said driving means includes a star wheel rotatable about a vertical axis and engageable with each of said cylindrical sleeves as they advance along said channel.

7. The structure of claim 1 in which said sleeves are formed of tetrafluoroethylene resin.

8. The structure of claim 2 in which said frame is provided with a sample tube discharge opening at a selected point along the path of travel of said sample tubes for the sequential release from said sleeves of sample tubes advanced along said channel.

9. The structure of claim 8 in which said frame is disposed in an elongated horizontal container supporting a body of liquid having a level substantially above the surface of said platform means; a tubular discharge chute extending upwardly through said opening in said platform to a point above the level of the liquid body in said container; and ramp means for guiding the lower ends of sample tubes from the level of said platform to the open
upper end of said tubular chute as said sample tubes are advanced along said channel.

10. The structure of claim 9 in which means are provided for maintaining said liquid within said container at a constant pre-selected temperature.

11. A transporter for sample tubes in chemical analysis equipment comprising a frame having members defining an elongated horizontal channel of uniform width; a plurality of vertical cylinders having openings extending axially therethrough and each having an external dimension slightly narrower than said channel; said cylinders engaging each other in single-file relation and being constrained by said frame for horizontal movement along said channel; means for advancing said cylinders along said channel; a platform spaced below said members and providing a smooth horizontal surface for slidably supporting the lower ends of upstanding sample tubes loosely received in said cylinders; and a tube discharge chute through said platform at a selected point along said channel for the sequential release from said cylinders of sample tubes advanced along said channel.

12. The structure of claim 11 in which said frame is disposed in an open-topped container supporting a body of liquid having a level substantially above the surface of said platform; said discharge chute comprising an opening in said platform, a vertical tubular member having its lower end sealed to said platform about the edges of said platform opening and having its open upper end disposed above the level of said liquid, and ramp means for guiding the lower ends of sample tubes from the level of said platform to the open upper end of said tubular member as said tubes are advanced along said channel.

13. The structure of claim 12 in which means are provided for maintaining said liquid within said container at a constant pre-selected temperature.

14. The structure of claim 11 in which each of said cylinders is provided with an external shoulder of greater width than said channel; said frame members comprising vertically-spaced plates disposed above and below the shoulders of each cylinder; whereby said cylinders are restrained against vertical movement relative to said frame.

15. The structure of claim 11 in which said cylinders are formed of tetrafluoroethylene resin.

References Cited

UNITED STATES PATENTS

3,202,188 8/1965 Allington .......... 141—130

MORRIS O. WOLK, Primary Examiner
R. E. SERWIN, Assistant Examiner

U.S. Cl. X.R.

23—253, 292; 141—130