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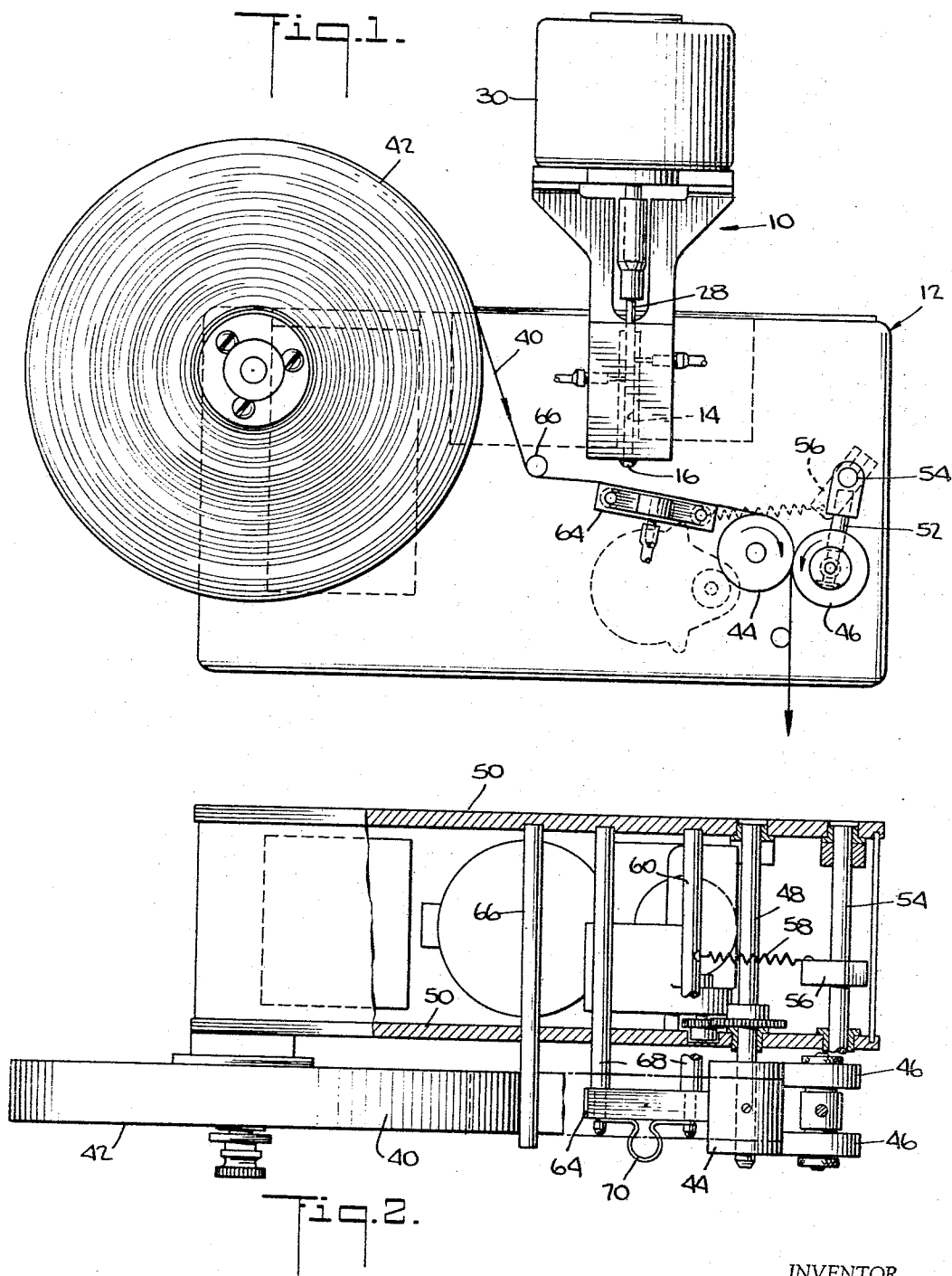
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METHOD OF FORMING A PRECIPITATE IN A STREAM OF LIQUID SAMPLES

Original Filed July 13, 1961

2 Sheets-Sheet 1



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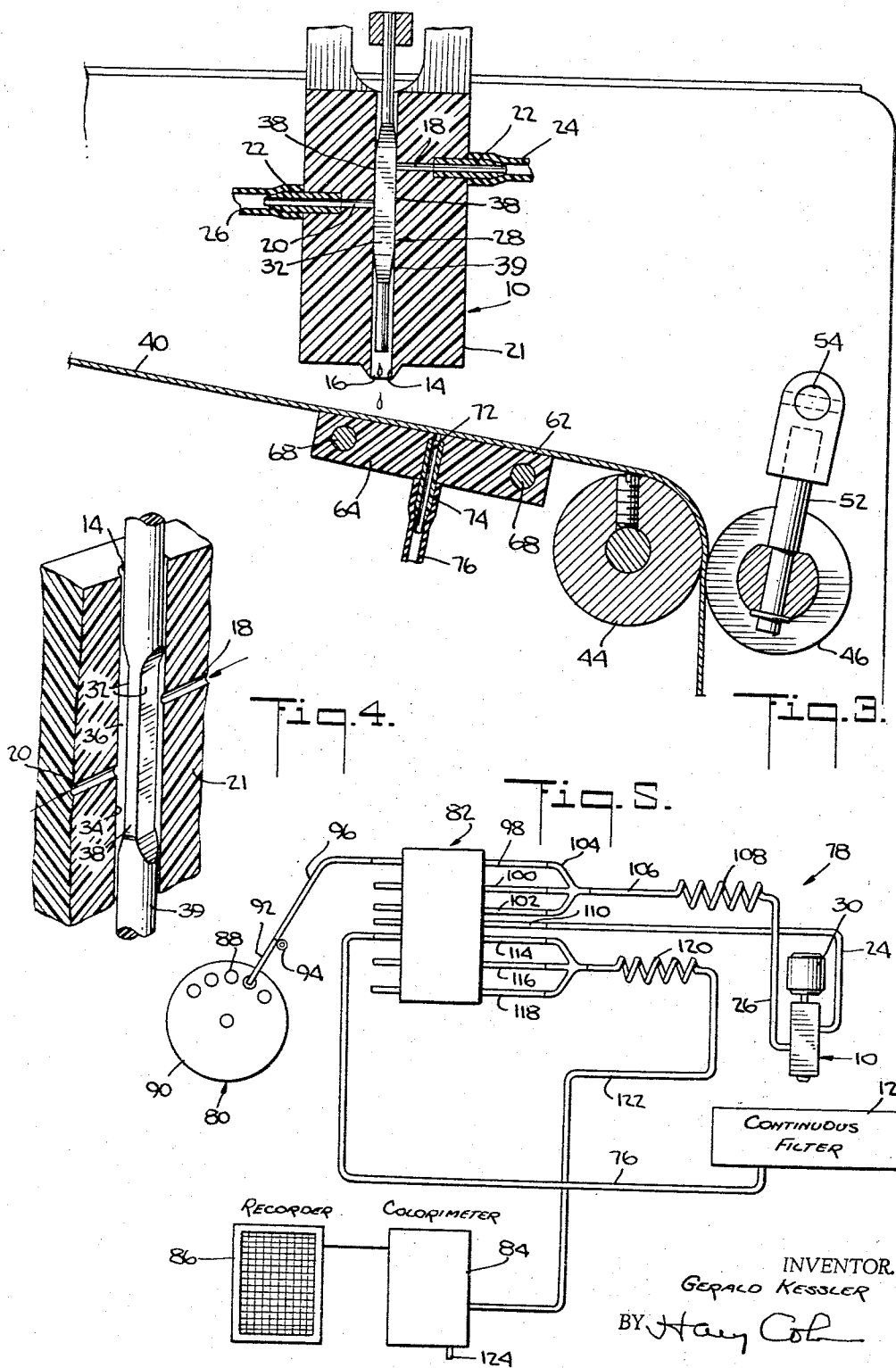
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METHOD OF FORMING A PRECIPITATE IN A STREAM OF LIQUID SAMPLES

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Continuation of application Ser. No. 123,722, July 13, 1961. This application Oct. 29, 1964, Ser. No. 407,957

1 Claim. (Cl. 259—8)

This application is a continuation of S.N. 123,722, filed on July 13, 1961, now abandoned.

This invention relates to the mixing of fluids and, more particularly, to the mixing of the fluid of one stream with the fluid of another stream in a fluid processing system.

In certain liquid analysis or other processing systems a stream of liquid is treated with a precipitant to remove particular material therefrom and a continuously operable filter is employed for obtaining a filtrate which contains a particular ingredient of the liquid under analysis, free of the precipitate. For example in the quantitative analysis of blood serum or blood plasma in respect to its cholesterol content, the serum or plasma is treated with isopropyl alcohol to precipitate the proteins and the resulting mixture is filtered to obtain a filtrate which contains the cholesterol free of proteins or other solid materials which would interfere with the analysis. The analysis is accomplished in a continuous fashion in an apparatus of the type which includes a plurality of relatively small passages through which the various treatment fluids flow and heretofore the precipitant was introduced into one of these passages and joined a stream of the sample to form the precipitate. This resulted in the formation of the precipitate in the small passages of the apparatus which often resulted in the clogging of these passages by the precipitate or otherwise interfered with the free flow of the liquids through the passages.

In accordance with the present invention and pursuant to one of its objects, a stream of precipitant is mixed with a stream of the liquid under analysis in such a way as to prevent clogging of the passages which might otherwise occur.

The above and other objects, features and advantages of this invention will be more fully understood from the following description of the presently preferred embodiment of the invention considered in connection with the accompanying drawings which are to be considered as illustrative of the invention but not in limitation thereof.

In the drawings:

FIG. 1 is a side elevational view of a filter apparatus and mixer according to the present invention;

FIG. 2 is a top plan view of the apparatus of FIG. 1;

FIG. 3 is a vertical sectional view, on a larger scale, of part of the apparatus of FIG. 1;

FIG. 4 is a perspective view, on a larger scale, of part of the mixer; and

FIG. 5 is a diagrammatic view of a fluid processing system or apparatus provided with the fluid mixing means of the present invention.

Referring now to the drawings in detail, the fluid mixing apparatus is indicated by the reference numeral 10 and the continuous filter apparatus is indicated by the reference numeral 12. As here shown, the mixing apparatus comprises a vertical cylindrical passage 14 which is provided with an outlet opening 16 at its lower end and inlet openings 18 and 20 above the outlet opening 16, vertically spaced from each other, and preferably disposed at opposite sides of passage 14. The passage 14 and openings 18 and 20 are preferably provided in a transparent block 21 of a suitable material, for example a plastic material, and the inlet openings are each provided with a nipple 22 to which conduits 24 and 26 are

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connected. A mixing rod 28 extends longitudinally in passage 14 and is connected at its upper end to the operating shaft of a motor 30 which is operable to rotate the rod for the mixing operation.

As best seen in FIGS. 3 and 4, rod 28 is provided with a pair of flattened opposite sides 32 which are spaced from the cylindrical internal wall 34 of passage 14 to form opposite confronting mixing chambers 36 with said wall. The opposite side edges 38 of the rod are adjacent to the wall 34 of the passage and are only slightly spaced therefrom to permit the free rotational movement of the rod in said passage for the mixing operation. The lower end 39 of the rod is reduced to provide a peripheral space between said end and the wall 34 of the passage for the free flow of the mixed fluids to and through outlet 16.

In the operation of the mixing apparatus 10, the fluid streams are transmitted to passage 14 through conduits 22 and 24 and as they enter said passage, successive fractional portions of each of the incoming streams are separated from the respective stream as edge 38 of the rod passes across the corresponding inlet opening. The separated portion of the stream from the upper inlet 18 flows downwardly in the adjacent chamber 36 and is carried in said chamber to the opposite side of passage 14 by the rotation of the rod and impinges on the liquid of the incoming stream from inlet 20 and mixes with said liquid. This operation is repeated with the opposite side edge 38 of the rod with respect to inlet opening 20 and the separated portion of the liquid from said inlet opening is carried in the opposite chamber 36, which is adjacent said opening to the opposite side of the passage and the downwardly flowing liquid from inlet 18 joins said separated portion of the liquid and mixes therewith. The mixed liquids continue to flow downwardly and exit from passage 14 through outlet opening 16. In this manner the mixing of the fluids takes place between fractional portions of the incoming streams which are separated from the streams by the action of the opposite sides 38 of the rod as it passes over the inlet openings 18 and 20. It will be observed that the mixing of the liquids occurs in a manner which does not interfere with the free flow of the liquids and in the case where one of the liquids contains a precipitant, it will be readily apparent that at least part of the precipitate is formed in passage 14 and the precipitate does not interfere with the flow of the liquids through the conduits 24 and 26. Unless the liquids are introduced under substantial pressure no packing or stuffing box for passage 14 above the flattened sides 32 of the rod is necessary.

The continuous filter apparatus 12 is preferably of the suction or vacuum type and comprises a continuous strip or web 40 of a suitable filter material, for example filter paper, which can be supplied from a supply roll 42 and is moved in the direction of its length by suitable means, herein shown as a motor operated withdrawing roller 44 and a cooperating pair of rollers 46. Roller 44 is supported on a shaft 48 which is supported in the spaced plates 50 which also support the shaft for supply roll 42. Rollers 46 are mounted on a shaft which is suspended by an arm 52 from a rotary shaft 54 which is supported at its ends in bearings mounted in plates 50. An arm 56 is secured to shaft 54 and one end of a tension spring 58 is connected to said arm and the opposite end of the spring is connected to a stationary shaft 60, whereby rollers 46 are spring biased into engagement with one side of the filter web. The rollers 44 and 46 are operative to withdraw the web from the supply roll and move it past and below the outlet opening 16 of passage 14 of the mixing apparatus 10 which is suitably supported on the outer plate 50 of the filter apparatus.

The filter web 40 is continuously drawn over the up-

per flat surface 62 of a vacuum or suction filtrate receiver 64 and is in sliding contact with said upper surface. A roller 66 guides the direction of movement of the filter web so that it is in sliding contact with the upper surface of the filtrate receiver. The filtrate receiver is made preferably from a rectangular block of a suitable material, for example a transparent plastic material, and is supported with its upper surface 62 in a downwardly inclined position by a pair of support rods 68 and is releasably retained on said rods by a spring clip 70. The filtrate receiver is provided with a filtrate opening or passage 72 and the outlet end of the passage is provided with a nipple 74 to which a suction tube 76 is connected. It is to be observed that the inlet end of opening 72 is positioned downstream of opening 16 of passage 14 so that as succeeding portions of the filter material 40 move past outlet 16, the mixed liquid flows thereon and is carried by the moving web to outlet 72 and during this movement the liquid is absorbed by the adjacent portion of the filter material. As the portion of the filter material passes over opening 72, a portion of the filterable material is transmitted by the action of the suction through the filter material and conduit 76 for further treatment in a manner which will be discussed more in detail hereafter. It will be understood that it is within the scope of the invention to provide a receptacle below the outlet of opening 72, in lieu of the suction tube 76, for receiving filtrate without the aid of a suction.

From the foregoing description it is seen that the filter web 40 is withdrawn from a supply roll 42 and moves continuously past the outlet 16 of passage 14 of the mixing apparatus so that succeeding unused or clean portions of the web are continuously disposed below said outlet to receive the mixed liquid for the filtering operation. In this manner, a fresh filtering surface is continuously presented at outlet 16 to receive liquid therefrom for the filtering operation. The filtrate is forced through a portion of the filter material which is under the influence of the vacuum as it passes over the filtrate opening 72 and the precipitate or other material not passing through the filter material is carried away on the moving web. The used filter material may be disposed of or cleaned for reuse or otherwise, as desired, or as required.

Referring now to FIG. 5, there is shown a liquid analysis or treatment apparatus 78 which includes the fluid mixing apparatus 10 and the continuous filter apparatus 12. In addition, the apparatus comprises a sample supply device 80, a proportioning pump 82, a colorimeter 84 of the flow cuvette type and a recorder 86 operable under the control of the colorimeter. The liquid samples which are to be treated for analysis or other processing are provided in open top receptacles 88 which are arranged in a circular row on a rotary support plate 90 which is intermittently rotated to position the receptacle below the inlet end of an inlet aspirating tube 92. The inlet tube is pivoted at 94 for movement into and out of each receptacle as it is moved into position by the rotation of support plate 90 and a portion of the sample from each receptacle is aspirated from its respective receptacle by the action of pump 82 and flows as a stream through supply tube 96 and pump tube 98 where it joins a stream of inert gas, for example air, which is supplied through pump tube 100, and a stream of processing liquid or diluent, which is supplied through pump tube 102. The separate streams merge at fitting 104 and form a segmented stream consisting of a series of liquid segments separated from each other by intervening segments of air. The introduction of air or other inert gas into the tubes or passages through which the sample flows provides a self-cleansing action for said passages, as explained in U.S. Patent No. 2,797,149 issued June 25, 1957 to the assignee of the present application.

The sample supply device 80 can be of the type shown in U.S. Patent No. 2,946,665 issued July 26, 1960 to the assignee of the present application, but is preferably of

the type shown and described in the U.S. application of Jack Isreeli, Ser. No. 664,403 filed June 18, 1957, assigned to the assignee of the present application. The plate 90 is rotated intermittently about its vertical axis by a Geneva gear mechanism (not shown) and the aspirating tube 92 is pivoted at 94 for pivotal movement into and out of the receptacles 88 while the rotary plate 90 is stationary. When the aspirating tube is retracted from the cups, air is aspirated therethrough and through pump tube 98 by the action of the proportioning pump 82, whereby the successive samples of liquid are separated from each other by intervening air segments. Moreover, when the aspirating tube is retracted from the receptacles, processing liquid as well as air are continuously supplied through pump tubes 102 and 100, respectively, because pump 82 is operating continuously. Accordingly, successive samples from the sample cups are separated from each other not only by said intervening segments of air but also by intervening portions of the processing liquid which are in the form of separate liquid segments separated from each other by intervening air segments.

The segmented stream is transmitted by the action of the pump through conduit 106 to a horizontal helical mixing coil 108 wherein the constituents of the liquid segments of the stream are mixed together and the mixed stream is transmitted to the mixer 10 through conduit 26 and enters passage 14 through inlet opening 20.

Concurrently with the transmission of the sample to the mixer 10, a precipitant in the form of the liquid stream is pumped through pump tube 110 and the previously mentioned conduit 24 and enters the passage 16 of the mixer via inlet opening 18. Successive portions of each of the streams are mixed together, as previously described, and flow from the mixer through outlet 16 in the form of a series of drops and it is to be observed that the precipitant joins the sample liquid in passage 16 and is thoroughly mixed therein so that all of the precipitate is formed before the resulting liquid reaches the filter web 40. It will be appreciated that by providing the inlet opening 18 into the mixing passageway 14 for the precipitant above the inlet opening 20 for the sample, the higher entering precipitant will continually wash from the surfaces of the mixing passage 14 and the mixing rod 38 any of the lower entering sample or precipitate which might otherwise deposit thereon. This cleansing action will be particularly significant between samples when the precipitant continues to enter the mixing passageway 14 through its inlet opening 18 while only air is entering the mixing passageway 14 through the inlet opening 20. Thus a washing out of the mixing passageway 14 is ensured between samples, and contamination of a succeeding sample by a preceeding sample is precluded. An excess quantity of the precipitant is preferably supplied to insure that all of the precipitable material is formed into the precipitate and the excess precipitant provides a carrier for the filterable material as well as a wetting agent for the filter material of the filter which facilitates the filtering operation and permits the filterable material to flow more readily through the filter material. It is to be observed that the downwardly inclined filter web causes the liquid to flow toward the filtrate opening 72.

The filtrate is transmitted from the filter through the suction tube 76 by the action of pump 82 which is operable to effect a vacuum in the tube during the operation of the pump since the suction tube is connected to a pump tube 114. The filtrate is pumped through said pump tube and concurrently with the pumping of the filtrate there is pumped air or other inert fluid and a suitable color producing reagent through pump tubes 116 and 118, respectively. The segmented stream is transmitted by the action of the pump to helical mixing coil 120 and the segmented color stream is transmitted from the mixing coil to the flow cuvette (not shown) of the colorimeter 84 via conduit 122, wherein the color density

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or light absorption characteristic of the stream is measured and recorded on the recorder 86 which is operated under the control of the colorimeter and provides a measurement which is indicative of the quantity of a substance present in the sample stream supplied by supply device 80. The stream is discharged from the flow cuvette of the colorimeter through outlet 124. In this manner samples in the form of a flowing stream may be continuously treated in a filter for analysis and a continuous recording may be made indicating the quantity of a particular constituent of the sample.

It will be understood that the apparatus may be used for the treatment of many fluids for analysis with respect to an ingredient thereof and the choice of the processing liquids and color reagents used will depend upon the fluid being analyzed. It will be understood that the present invention is independent of any specific method of chemical analysis or treatment but, on the contrary, may be employed in performing any method which necessarily or advantageously makes use of a mixer and a filter for removing or extracting a particular substance or material from another.

Proportioning pump 82, which is schematically illustrated, is preferably of the type shown and described in U.S. Patent No. 2,935,028 issued May 3, 1960. In such pump, the pump tubes are resiliently flexible and are compressed progressively along their lengths by pressure rollers which are moved in engagement with the tubes longitudinally thereof. The quantities of fluids pumped through the various tubes depend upon the internal diameter of the respective tubes since the tubes are simultaneously compressed by the rollers as they move longitudinally along the tubes for the pumping operation. It is within the scope of the present invention to provide pumps other than that indicated and if desired or necessary, separate pumps may be provided for pumping the individual fluid in lieu of the proportioning pump as indicated.

As indicated previously, colorimeter 84 is of the continuous flow cuvette type and the recorder 86 is operated under control of the colorimeter in a well known manner. Since both the colorimeter and recorder are well known devices and do not, per se, form part of the invention, further description of these devices is unneces-

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sary. It is within the scope of the invention to provide measuring means other than a colorimeter.

Although the liquid treatment apparatus 78 is shown with a sample supply device 80 for supplying a plurality of individual samples in succession to the treatment apparatus, it is within the scope of this invention to supply the continuous sample stream for treatment as, for example, in a monitoring operation. It is also within the scope of the present invention to treat or analyze the precipitate or solid material or other material remaining on the strip of filter material 40 in respect to the particular ingredient in the liquid specimen stream, and this analysis of the precipitate or other material may be done in addition to the analysis of the filtrate or in lieu thereof, as desired or as may be required.

What is claimed is:

A method of forming a precipitate in a stream of liquid samples comprising: continuously transmitting the samples seriatim and spaced apart as a stream from an inlet into a mixing chamber; continuously transmitting a liquid precipitant as a stream into the mixing chamber from an inlet above the sample stream inlet; continuously intermixing the contents of the mixing chamber; continuously outletting the contents of the mixing chamber from the bottom thereof; whereby the liquid precipitant is mixed seriatim with each sample to form a precipitate therein, and between the inletted samples serves to wash out the surfaces of the mixing chamber impinged upon by the samples.

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