

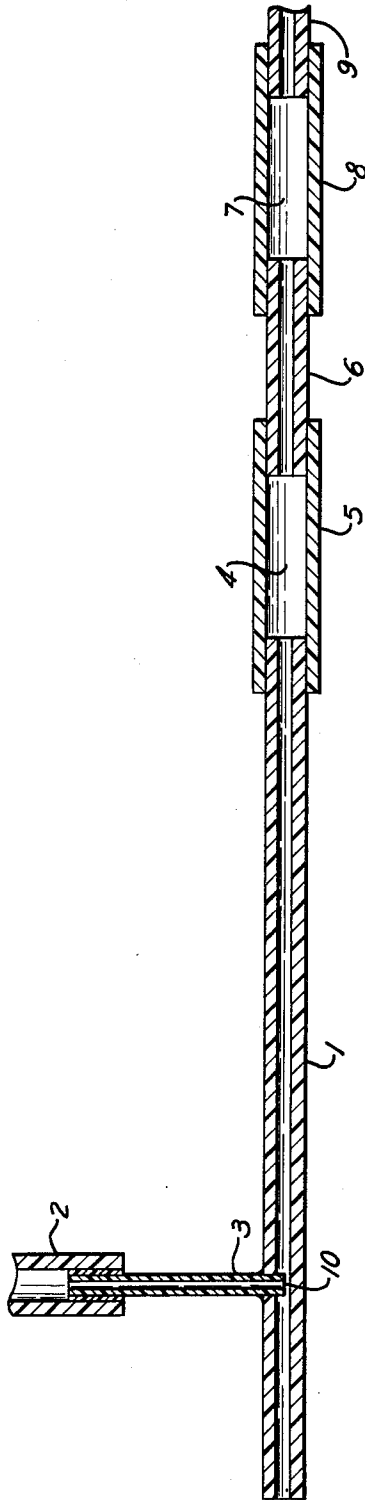
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J. A. PLATTE ETAL

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DEVICE FOR COMMINGLING SLOWLY FLOWING LIQUIDS

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3,128,993

DEVICE FOR COMMINGLING SLOWLY FLOWING LIQUIDS

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2 Claims. (Cl. 259-4)

This invention is a device for continuously mixing a liquid reagent with a continuous liquid sample to be analyzed colorimetrically or by other means.

Continuous colorimetric analyzers have been developed recently for monitoring a source or conduit of water, such as boiler water, to record its composition with respect to one or more constituents. Measurements may be made in terms of parts per billion, parts per million, or milligrams per liter. It is common for silica, for example, to be determined colorimetrically in the range of 0-300 parts per billion parts of water.

One difficult problem in the design of such a precision continuous colorimetric analyzer is proper mixing of the reagent and sample to obtain a colored solution free of discrete streams, clouds, or the like. Obviously, a results. Especially where results are measured in terms of parts per billion, the color resulting from addition of the reagent must be evenly distributed throughout the sample by the time it reaches the sample cell. For the sake of economy of reagent and other practical considerations, the flow of sample in continuous colorimetric analyzers is generally very slow, say, in the neighborhood of 5-7 cc. per minute. The flow of reagent is only about 0.3 cc. per minute. The reagent must not only be continuously added to the slowly flowing sample in the correct proportion, but it must also be evenly distributed throughout. The flow rates of the sample stream and the reagent stream may be maintained in the correct proportion through the use of known apparatus not described herein. Our invention is concerned with the introduction of the slowly flowing reagent into the sample stream and distributing it evenly throughout any given section thereof.

A blade-type mixer of any substantial volume cannot be used to mix the reagent with the sample because the continuous sample must be analyzed in the sequence it is drawn from its source; with the slow flow rate involved here, serious errors could result from analyzing a sample taken from a relatively large mixing chamber. Relatively large mixing chambers of any type are unsatisfactory for the reason that they necessarily disturb the continuity of the sample. Long and arduous studies of coil-type mixers, which do not disturb the sample continuity, have shown that they do not satisfactorily accomplish the desired result of homogeneous mixing. The liquid in a coil tends to move in discrete streams through the entire length of the coil and to form clouds or similar curling effects when it enters the sample cell. The coil mixer is designed to utilize differences in specific gravities of the sample and the reagent solution; in practice, however, these differences are not great enough to achieve the desired mixing.

We have invented a device which continuously intimately mixes a reagent in the correct proportion in a flowing sample of liquid without significantly disturbing the order of the flow. Our invention is particularly suited to the analyzer described and claimed in the patent application of Robert H. Luppold, Jr. et al., S.N. 861,589 filed December 23, 1959, and assigned to the assignee herein.

The presently preferred embodiment of our invention

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is illustrated in the drawing, which is a side sectional view of our invention showing the inlets for sample and reagent, and the mixing device.

The presently preferred device comprises a sample inlet tube 1, a reagent inlet tube 2, a reagent injector 3, a pressure drop chamber 4 formed by a large tube section 5, a restricted connecting tube 6, a second pressure drop chamber 7 formed by a large tube section 8, and a restricted exit 9.

Operation of the device is as follows:

The sample proceeds through tube 1 preferably at a rate of about 5 or 7 cc. per minute. This flow rate may be controlled precisely by a suitable pump or the like. The reagent solution is present in tube 2, where it flows preferably at a rate of about 0.3 cc. per minute or in any desired proportion to the sample flow. Both of these flow rates are maintained and/or continuously proportioned by devices not shown. The reagent is forced into reagent injector 3, which intersects tube 1. Being under a slight pressure, the reagent accelerates in reagent injector 3 and is injected into tube 1 at a velocity somewhat higher than that at which it was previously traveling. Its velocity is preferably not any greater than the velocity of the sample.

Reagent injector 3 has a projected tip 10 extending approximately into the center of tube 1. We have found that if the tip of reagent injector 3 is flush with the wall of sample tube 1, undesirable fluctuations in the introduction rate of reagent solution will result because of the tendency of the slowly flowing reagent to cling to itself and consequently project globules into the sample stream. With the use of our preferred design, the reagent solution flows steadily into the sample stream in spite of its low velocity. The inner diameter of the preferred reagent injector tube is about .028-.031 inch. Preferably it projects into the sample tube for a distance about 1/4 to about 3/4 the internal diameter of the sample tube.

The reagent is not intimately mixed with the sample as it flows through tube 1. However, the sudden pressure drop in chamber 4 brings about a turbulence which causes the desired mixing of the reagent and sample in the chamber. On the other hand, the continuity and sequence of the sample is substantially preserved. No still pockets are formed in the chamber. There are no projections, obstructions, blades, or the like which could tend to produce an erratic flow. Thus, the recording made by the automatic analyzer will accurately reflect the concentration of the tested constituent in the correct and undisturbed sequence with relation to time. The inner diameter of tube 1 is in the preferred form 1/16 inch. The inner diameter of chambers 4 and 7 are preferably about 3/16 inch. Thus, the area of a cross section of the chamber is nine times the area of a cross section of the tube. We find that this is a particularly desirable ratio in the range of dimensions which are practical for continuous colorimetric analyzers.

The flow is restricted again in connecting tube 6 and enters the second pressure drop chamber 7 to insure complete mixing. The pressure drop in chamber 7 causes the same type of turbulence as in the initial chamber, again mixing the reagent and sample without substantially disturbing the order of the sample. Turbulence is again caused to some extent upon the sample's entering restricted exit 9. The sample stream is then carried, completely and intimately commingled, and in substantially the same order as it was taken from the source to the sample cell where light is passed through it to determine the depth of color. A particularly desirable sample cell which is excellent for its ability to preserve the order of the sample is that described and claimed in Ralph N. Thompson in U.S. patent application S.N. 850,-

669, now abandoned, filed November 3, 1959, and assigned to assignee herein.

Many colorimetric determinations require the addition of more than one reagent to the sample. More than one of the units described herein may be used sequentially, to introduce a plurality of reagents to the sample stream. Where a time delay is required to complete a reagent reaction before the second or other reagent is added, a tube of the proper volume and length may be inserted between units to provide a time delay depending on the flow of the sample. More than one injector tube for a desired number of reagents may be connected to sample tube 1 in cases where the several reagents may be mixed simultaneously.

Several other variations in construction of our device may be noted, although it should be distinctly understood that our invention is not limited to these forms. For example, the ratio of the internal diameter of the mixing chamber to the internal diameter of the sample tube may range from about 1.5 to 1 to about 4 to 1. The internal diameter of the sample tube may be made considerably smaller than the preferred form of $\frac{1}{16}$ inch, since the sample's velocity may be increased accordingly or a smaller sample may be used. For practical colorimetric analysis, the sample tube should have an internal diameter of less than about $\frac{3}{8}$ inch. It is preferred not to use a sample tube no greater than $\frac{3}{32}$ inch internal diameter where the preferred ratio of mixing chamber diameter to sample tube internal diameter of 3 to 1 is to be maintained. We need not use two mixing chambers as in the illustrated device. One chamber will be sufficient for some applications; or, it may be desired to use three or more. Other variations will occur to those familiar with the art to which the invention pertains.

Our invention may, of course, be used for purposes other than mixing reagents and samples for continuous colorimetric analysis. Any other type of analysis or other process or device requiring the continuous addition and mixing of a small amount of a slowly flowing liquid

in a relatively large amount of another slowly flowing liquid will benefit from our invention.

The illustrated device is the presently preferred form. Other variations and embodiments of our invention may be constructed within the scope of the following claims.

We claim:

1. A continuous liquid sample and reagent mixing device comprising:

(a) a sample tube;

(b) a reagent injector tube of smaller internal diameter than said sample tube, said reagent injector tube projecting through the wall of said sample tube to a point within the interior of said sample tube and having an open end whose axis is substantially perpendicular to said sample tube;

(c) a mixing chamber forming a continuation of the sample tube downstream from said reagent injector tube, said mixing chamber comprising a short length of tubing having an internal diameter of from about two to about four times the internal diameter of said sample tube; and

(d) an exit tube having an internal diameter smaller than that of the mixing chamber.

2. A continuous chemical reagent injector for a continuous liquid sampling system comprising:

(a) a sample tube having an internal diameter of from about $\frac{1}{32}$ inch to about $\frac{3}{8}$ inch; and

(b) a reagent injector tube having an internal diameter of about $\frac{1}{4}$ to about $\frac{3}{4}$ the internal diameter of the sample tube, said injector tube projecting into said sample tube to a point from about $\frac{1}{4}$ to about $\frac{3}{4}$ of the internal diameter of said sample tube and terminating at an open end whose axis is substantially perpendicular to said sample tube.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,128,993

April 14, 1964

Jerome A. Platte et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 26, before "results", first occurrence, insert -- cloudy pattern in the sample cell will produce erratic --.

Signed and sealed this 4th day of August 1964.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents