Dec. 14, 1971 S. L. ADLER, JR., ET AL 3,627,495

DECANTATION FITTING

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FIG. 1

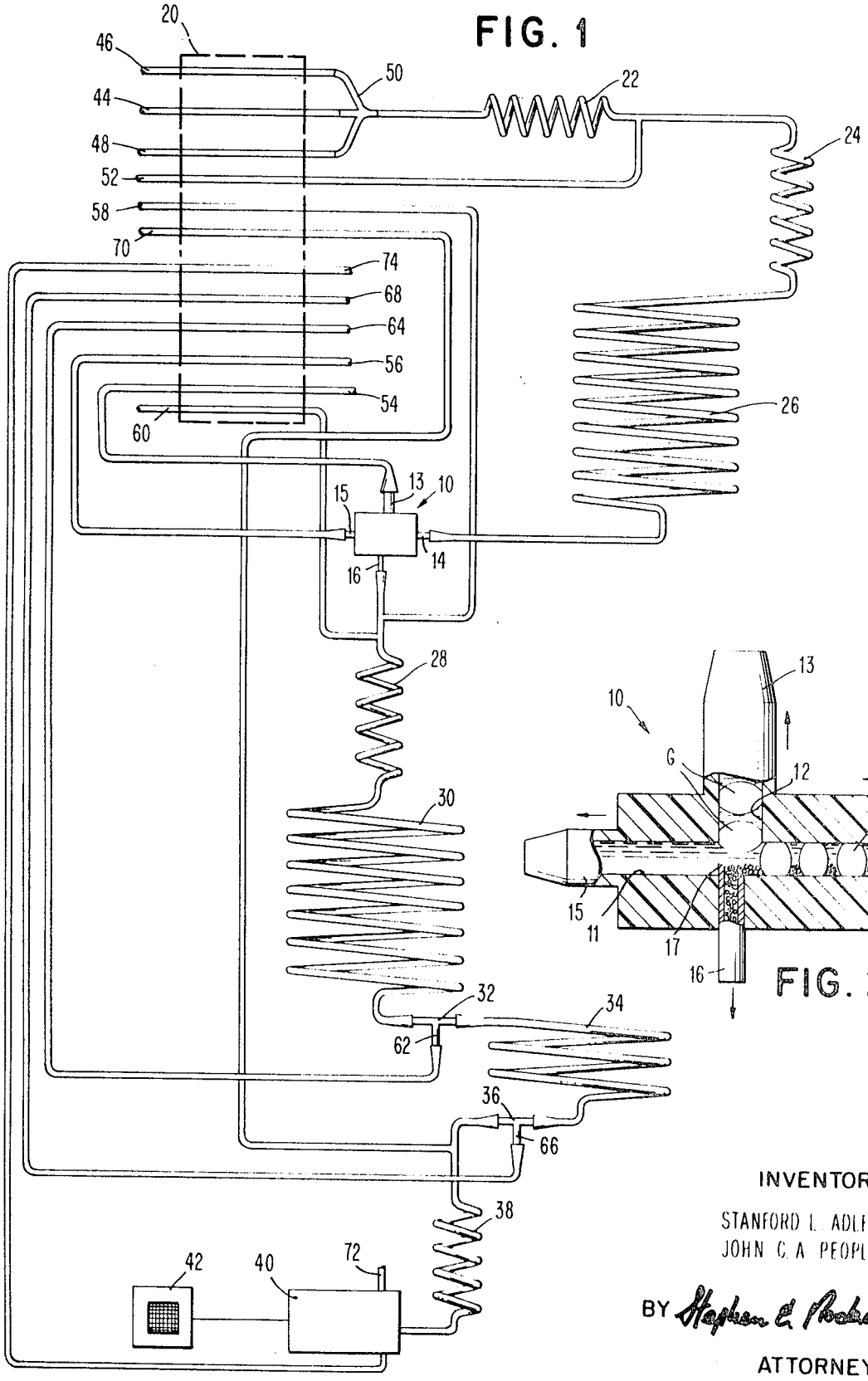


FIG. 2

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DECANTATION FITTING

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ABSTRACT OF THE DISCLOSURE

A decantation fitting for fluid analysis having a body with an elongated relatively horizontal passageway portion with one end positively inletted at a predetermined volumetric rate for a gas-segmented sample-reagent stream and positively outletted at the other end at a predetermined volumetric rate for a supernatant portion of the stream. Intermediate the ends of the passageway portion and in communication therewith, is an upwardly extending passageway portion positively outletted at a predetermined volumetric rate for the gas in the stream and a small part of the supernatant portion. Below the last-mentioned passageway portion and extending a distance into the first-mentioned passageway portion is a downwardly extending decantation tube for the stream remainder including precipitate or settled-out material therein.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to a decantation fitting for use in fluid analysis systems in which gas-segmented sample-reagent streams flow; and in which streams particulate matter may be separated by gravity, or matter may be separated as in precipitation.

(2) Prior art

Apparatus for the continuous analysis of fluids are well known. Such an apparatus is disclosed in U.S. Pat. 2,797,149, issued June 25, 1957. U.S. Pat. 2,879,141, issued Mar. 24, 1959, discloses an analysis apparatus of an automated type in which samples are fed in a flowing stream by means of an offtake device which aspirates liquid from each of a plurality of sample containers which are sequentially presented thereto by a sampler assembly. Such apparatus is commonly employed for the analysis of body fluids. Similar apparatus is employed for other analytical purposes such as monitoring industrial operations, for example.

In many such types of analyses, a settling or precipitation occurs in the flowing sample stream. For example, red blood cells may be agglutinated or aggregated as in blood typing determinations or in the screening of blood for atypical antibodies. It is common to segment such precipate-containing streams with air or an inert gas employed for the purpose of maintaining sample integrity and isolation, and also for cleaning the conduits in which such streams flow.

Further, it is traditional to separate certain components of such streams by decantation, as illustrated and described in U.S. Pat. 3,334,018, issued Aug. 1, 1967. Such a decantation fitting is shown in FIG. 2 of the drawing of the last-mentioned patent. This fitting allows agglutinated red cells in each liquid segment, separated from its neighbours by gas segments or bubbles, flowing in a tube through the action of a pump, to fall by gravity into another tube in communication with the first-mentioned tube, which is subjected to negative pressure. The supernatant liquid, together with the gas bubbles, passes off from the first tube at the outlet end thereof together with any residual agglutinated cells. The separation of the aforementioned components of the stream is not as efficient as it might be and is lacking in reproducibility to the extent which it is desired to achieve.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a decantation fitting for separating components of a stream such as described and which employs a debubbling feature to enhance decantation of the supernatant liquid from the agglutinated material when employed, by way of example, in a system for an analysis such as that described in U.S. Pat. 3,334,018 supra, but which is not limited thereto or to the separation of an agglutinate. In the debubbling action, the bubbles, in accordance with the invention, actually push the precipitate or agglutinated cells into a decantation tube which has a beveled end protruding into the stream and with which the bubbles sequentially co-act as they pass into a gas-removal stream over the last-mentioned decantation tube, while the supernatant portion of the stream passes beyond the aforementioned decantation tube. The gas and supernatant streams of the fitting are positively outletted so that the aforementioned decantation tube is outletted by a volumetric rate differential.

Decantation by this fitting has relatively high reproducibility, and more effective decantation is provided. The fitting is of relatively simple and economical construction.

The fitting includes a body portion with an elongated relatively horizontal passageway having one end positively inletted at a predetermined volumetric rate for a gas-segmented stream of treated liquid and positively outletted at the other end at a predetermined volumetric rate for a supernatant portion of the stream. An upwardly extending passageway is provided intermediate the ends of the first-mentioned passageway and in communication therewith, which is positively outletted at a predetermined volumetric rate for the gas in the stream and a small portion of the supernatant stream. Co-acting with the last-mentioned passageway and located therebelow, extending a distance into the first-mentioned passageway, a downwardly extending decantation tube is provided for the stream remainder including precipitate therein.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is diagrammatic view of fluid analysis apparatus incorporating a differential decantation fitting embodying the invention, and

FIG. 2 is a fragmentary, greatly enlarged view in elevation, partially in longitudinal section, of the decantation fitting.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 2 in detail, the differential decantation fitting comprises a body **10** having a horizontal bore **11** extending therethrough of uniform diameter. In the form shown, the body is structured of a material sold under the trademark Lucite, but as will become apparent hereinafter it may be formed conveniently of a material such as glass which may be of the type sold under trademark Pyrex. In the form being described, the internal diameter of the bore **11** is .080 inch. Substantially midway between the ends of the latter, the body **10** is provided with a vertical bore **12** in communication with the first-mentioned bore and having an internal diameter of .154 inch.

The portion of the body forming the bore **12** is provided with an externally tapered outlet nipple **13** for connection to a suction line of the fluid system. A similar nipple **14** is provided on the body at the inlet end of the

bore **11**, and at the outlet end of the last-mentioned bore, a similar nipple **15** is provided.

Below the bore **12** of body **10**, there is provided a vertically arranged tube **16** extending into the bore **11** in the manner shown in FIG. 2. The tube **16** is preferably formed of non-corrosive metal such as stainless steel and may take the form of a hypodermic needle having the beveled end thereof projecting into the bore **11**. The tube **16** has an internal diameter of .020 inch, and the tube **16** is secured in the body **10** as by a press-fit in a suitably drilled bore in the body. It will be apparent from the foregoing that the body **10** with the bore **11** and the bore **12** may be formed of tubular glass parts, suitably fused together, or otherwise secured, and suitably receiving and secured to the metal tube **16**.

The construction and arrangement of the tube **16** in the body **10** is important. The end **17** of the tube should be beveled at an angle of substantially 45° as shown, with the bevel arranged so as to incline downwardly toward the inlet end **14** of the fluid passage **11**. The lowest extremity of the bevel should be in line with the bottom of the bore **11**. The spacing between this extremity of the bevel and the point of the bore **12** nearest the inlet **14** must be equal to or greater than the diameter of the bore **11**. It is preferably in the range of .080 to .095 inch.

This spacing requirement results in the nonconcentricity of the tube **16** with reference to the bore **12** which is apparent in FIG. 2. Further, the reason for this spacing requirement will be apparent from an examination of FIG. 2 wherein the gas present in the bore **11** is in the form of bubbles G, separated from one another, of a size to extend across the diameter of the bore **11**. It is important that the gas of these bubbles separate and isolate for sample integrity portions of the stream therebetween while, at the same time, it is important to inhibit this gas finding its way down into the tube **16**, a situation which might occur in the use of the decantation fitting of aforementioned U.S. Pat. 3,334,018. Such entrainment of gas in the tube **16** would result in excessive gas in the fluid system downstream of the decantation fitting which would result in "noise" in the signal output as will be apparent hereinafter with reference to the described use of the decantation fitting in a fluid analysis system.

To effectively tend to insure that all the gas previously introduced into the stream flowing into the inlet **14** is removed in the decantation fitting, the bore **12** of the fitting and the volumetric flow through the outlet of the nipple **13**, associated therewith, is such that slightly more fluid is removed by the fitting through the bore **12** than the volume of gas previously introduced into the system. This results in the removal in a bore **12** of a small amount of the supernatant liquid with the previously introduced gas. The volumetric flow rate at the outlet **15** of the fitting is sufficient to remove substantially all of the supernatant liquid. As the gas bubbles pass from the bore **11** to the bore **12**, they sweep up the beveled surface of the tube **16**, previously described, forming a ramp, following the line of least resistance, entering the bore **12** from which gas is removed in the aforementioned manner. In moving in this manner, the gas bubbles sweep the settled-out or agglutinated material into the last-mentioned end of the tube **16**, for removal of this material by the difference between the input in the inlet **13** and the total volumetric outlet rates of the outlets **13** and **15**. For example, the input at the inlet **14** may be 3.52 ml. per minute; the output at outlet **13**, 1.2 ml. per minute; the output at outlet **15**, .8 ml. per minute; and the output through tube **16**, 1.52 ml. per minute.

It should be noted that the portion of the end **17** of the tube **16** which provides an upwardly diminishing transversely arced surface, owing to the bevel of the tube end, which is arranged in opposing relation to the fitting inlet, very effectively acts as a trap for settled-out material. This material which, as it is carried along in the stream in bore **11**, is trapped by the last-mentioned surface passes into the tube **16** in a downward direction. It passes into the tube **16** in a far more effective manner than would be the case without the aforementioned tube projection into the bore **11**. The volumetric rate of flow in the tube **16** may be predetermined in accordance with the volumetric input of sample and reagent upstream and the anticipated volume of material which may be settled in the lower portion of the stream.

It is noted that apart from the aforementioned concept of the positively inletted and outletted bore **11** and the positively outletted bore **12**, wherein the volumetric rate of flow in the outlet **16** makes up the difference, there is provided a simple and effective stream divider including a gas-segment-deflecting element which in the illustrated form is embodied in the beveled end **17** of the tube **16** which projects into the bore **11**.

The use of the differential decantation fitting of FIG. 2 will now be explained with reference to the fluid analysis system shown in FIG. 1. According to the fluid analysis system of FIG. 1, briefly described, the liquid sample, in the form of a stream, is treated with a processing liquid during the flow of the sample, and the processing liquid is of a type which forms a substance in the stream which is separable from the stream because of the greater specific gravity of the substance in relation to that of the liquid of the stream. The presence and amount of such a formed substance is an indication of the effect of the processing liquid on the liquid sample and, during the flow of the treated stream, at least a major portion of the separable substance is removed therefrom, and the stream is thereafter analyzed to provide a measurement of the effect of the processing liquid on the sample.

The disclosed fluid analysis system of FIG. 1 is especially useful for, although not limited to, the determination of blood types. As is well understood, type A blood is responsive to type A anti-serum, type B blood is responsive to type B anti-serum, and type O blood is not responsive to either of these anti-sera, so that when type O blood is treated with either type of anti-sera, no agglutination of the red cells occurs. When either type A or type B blood is treated with its correspondingly identifying anti-serum, the red cells of the blood agglutinate. This agglutination reaction of the red blood cells is utilized in the disclosed fluid analysis system for determining blood types.

More particularly, a series of unique sanguineous samples, such as blood samples, more particularly red cells of unknown types, in the form of a stream is treated with a particular anti-serum, for example type A. The samples which are type A react to the type A anti-serum and agglutinated red cells are formed therein while the type B and O blood samples do not react and, therefore, no agglutinated red cells are formed. The resulting stream of anti-serum treated blood cells is passed through a series of separating devices, more particularly, decantation devices, which remove the relatively denser, agglutinated red cells from the samples. Thereafter, the blood samples of the resulting stream are hemolyzed and the stream is colorimetrically analyzed with respect to its hemoglobin content. Those blood samples which are type A will indicate a relatively low hemoglobin content due to the removal of the agglutinated red cells, while the blood samples which are not type A indicate a much higher hemoglobin content, since no agglutinates of red cells were formed. In this manner determinations of blood types can be made accurately and in a relatively simple and expeditious manner.

The apparatus comprises a proportioning pump **20** of the resiliently compressible tube type, a horizontal helical mixing coil **22** formed of glass tubing or other suitable material, and identical mixing coil **24**, a vertical helical time-delay and settling-out coil **26** of tubing formed of glass or other material which may be immersed in a temperature controlling bath, not shown, the decentation fitting of FIG. 2 including the aforementioned body **10**, an-

other horizontal mixing coil **28**, another vertical time-delay and settling-out coil **30**, a decantation fitting **32** identical to the decantation fitting **20** of FIG. 2 of Pat. 3,334,018, supra, a time-delay and settling-out coil **34** shorter than the coils **26** and **30**, a decantation device **36** identical to the decantation device **32**, another mixing coil **38** similar to those previously described, a conventional colorimeter **40** having a flow cell (not shown) therein, and a recorder **42** operable under the control of the colorimeter.

The foregoing components of the apparatus are connected in fluid-flow communication with each other for the continuous treatment and analysis of one or more blood samples, more particularly red blood cells, which are supplied in the form of a stream to a pump tube **44** by a suitable liquid sample supply device such as previously described. It will be understood that the blood samples are longitudinally spaced from each other in the stream, and that each is separated from another by an intervening segment of air, provided by the operation of the sample supply device.

Simultaneously with the supply of the samples to tube **44**, air is supplied to pump tube **46** and the anti-serum is supplied to pump tube **48**. The fluids join each other at fitting **50** and a segmented stream is formed consisting of longitudinally spaced liquid segments, each containing a portion of the sample and anti-serum, and the liquid segments are separated from each other by an intervening air segment which, as previously described, helps maintain the internal walls of the tubular passages of the apparatus clean to prevent contamination of a sample due to deposits of material from a preceding sample. The segmented stream is transmitted from fitting **50** to the mixing coil **22**, which has a relatively short flow path, for mixing the constituents of each liquid segment together.

Pump tube **52** supplies diluent to the stream downstream of the coil **22** and upstream of the mixing coil **24** to which the stream then passes. Each liquid segment is mixed in the coil **24**. The stream then passes to the settling-out and time-delay coil **26**. Coil **26** has a series of substantially horizontal convolutions that provide a relatively long flow path for the stream to provide time for the reaction of the blood samples of the type corresponding to the anti-serum. As indicated previously, the reaction results in agglutination of the red cells in the blood sample and clumps of the red cells are thereby formed in an amount depending upon the effect of the anti-serum on the blood sample. As the sample travels through the convolutions of the last-mentioned coil, the relatively heavy agglutinated red cells settle at the bottom of the stream as described in U.S. Pat. No. 3,334,018, supra.

The reacted stream, containing the settled-out or agglutinated red cells, is transmitted from the bottom of coil **26** to the body **10** of the differential decantation fitting best shown in FIG. 2 through the inlet **14**. The stream is debubbled as aforesaid, with the gas being removed through the outlet **13** by a pump tube **54**. The supernatant liquid leaves the outlet **15** of the fitting in the aforesaid manner, through pump tube **56**. The agglutinated red cells leave the differential decantation fitting in the aforesaid manner, through the tube **16** connected to the inlet of the coil **28** as shown in FIG. 1.

However, air is introduced in the line through pump tube **58** for wash purposes, intermediate the outlet of the tube **16** and the mixing coil **28**. Saline solution for the dispersion of false agglutinate is introduced in the line through pump tube **60**, intermediate the last-mentioned air inlet and the coil **28**. Mixture occurs in the coil **28** in each of the sample segments of the resulting stream separated by air bubbles last introduced, and any unagglutinated red cells which have settled out are again suspended in the liquid.

The stream is transmitted from the mixing coil **28** to the aforementioned coil **30** which permits additional agglutinated red cells to settle out to facilitate the removal of the agglutinated red cells at the aforementioned decantation fitting **32**. The agglutinated material passes through outlet **62** of the fitting **32** by means of pump tube **64**. The effluent flows from the decantation fitting **32** to the shorter time-delay and settling-out coil **34** in which any carry-over of settling-out or agglutinating material tends to fall to the bottom of the stream. The stream passes from the last-mentioned coil into decantation fitting **36**, previously described, having its decantation outlet **66** connected to pump tube **68** for the removal of additional settled-out or agglutinated red cells.

Pump tube **70** connects to the effluent stream from the decantation fitting **36** to supply a hemolyzing agent to the stream which still contains air or gas bubbles and is segmented thereby. The stream passes next through mixing coil **38** in which each of the treated liquid segments is mixed, and the stream passes next to the colorimeter **40** wherein the hemoglobin content of the samples is colorimetrically determined in a conventional manner after the removal from the stream of the gas bubbles to waste through tube **72** in the usual fashion. If desired, the gas-segmented stream may pass through the flow cell, not shown, of the colorimeter. The pull-through of the flow cell is connected to pump tube **74**.

The recorder **42** is conventionally connected to and operated by the colorimeter **40** to record the colorimetric analysis of each sample with reference to its hemoglobin content which indicates thereby whether or not an agglutination-type reaction has taken place. As previously explained, the blood samples which are type A react to the type A anti-serum and agglutinated red cells are formed therein while type B and O blood samples do not react, and therefore, no agglutinated red cells are formed. The samples which are type B react with type B anti-serum, and neither type A anti-serum nor type B anti-serum react with type O blood samples.

While only one embodiment of the invention has been illustrated and described, it will be understood that the invention may take other forms and is susceptible to various modifications and changes within the skill of those versed in the art, without departing from the principles of the invention.

What is claimed is:

1. Apparatus for fluid analysis comprising first means defining an elongated, relatively horizontal first passageway portion having one end positively inletted at a predetermined volumetric rate for a gas-segmented, sample-reagent liquid stream and positively outletted at the other end thereof at a predetermined volumetric rate for a supernatant portion of the stream, second means intermediate the ends of said first passageway portion defining an upwardly extending second passageway portion from said first passageway portion, positively outletted at a predetermined volumetric rate for the gas segments in the stream and a small part of the supernatant portion, and third means below and substantially aligned with said second passageway portion including a trap for settled-out material in the lower portion of the stream, said trap including a third passageway portion for the egress of said material from said first passageway portion at a volumetric rate which represents the difference between said inletted volume and the total of said positively outletted volumes and, also, extending into said first passageway in an upwardly diminishing, transversely arced surface in opposing relation to said inlet for contact with said gas segments, along which said gas segments move toward said second passageway portion, said second and third passageway portions having respective axes perpendicular to the axis of said first passageway portion.

2. Apparatus as defined in claim **1**, wherein said third means is constituted by a hypodermic needle having the beveled end portion thereof forming said trap and arranged in opposing relation to said inlet, and occluding only the lower part of said first passageway portion, said needle having its axis perpendicular to the axis of said first passageway portion.

3. Apparatus as defined in claim 1, wherein said third means is constituted by a tube having a sloping end portion projecting into said first passageway portion and arranged in opposing relation to said inlet thereof.

4. Apparatus as defining in claim 1, wherein said third means is constituted by a tube having a sloping end portion projecting into said first passageway portion and arranged in opposing relation to said inlet thereof, said slope being formed on an angle of approximately 45° to the axis of the tube.

5. Apparatus as defined in claim 1, wherein said third means is constituted by a tube having a sloping end portion projecting into said first passageway portion and arranged in opposing relation to said inlet thereof, said slope being formed on an angle of approximately 45° to the axis of the tube, said second passageway portion being larger in diameter than the first, and said sloping portion of the tube terminating at the bottom of said first passageway portion, the point on the outer tube diameter nearest said inlet being spaced from the point on the inner diameter of said second passageway portion nearest said inlet by a distance approximating the inner diameter of said first passageway portion but not less than the latter.

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