April 16, 1935. S. L. JOHNSON 1,997,935

METHOD OF AND APPARATUS FOR AGITATING MIXTURES

Filed Nov. 15, 1934

Fig. 1.

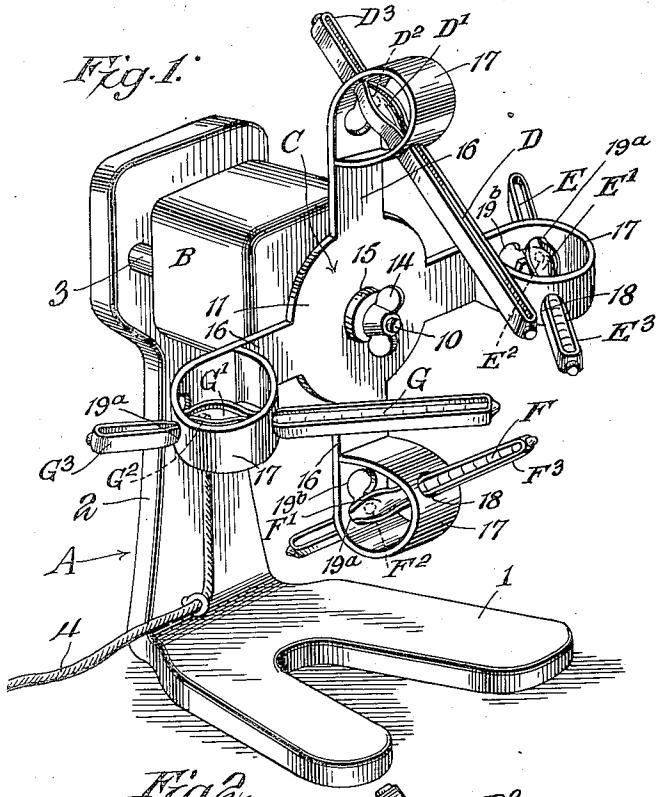


Fig. 2.

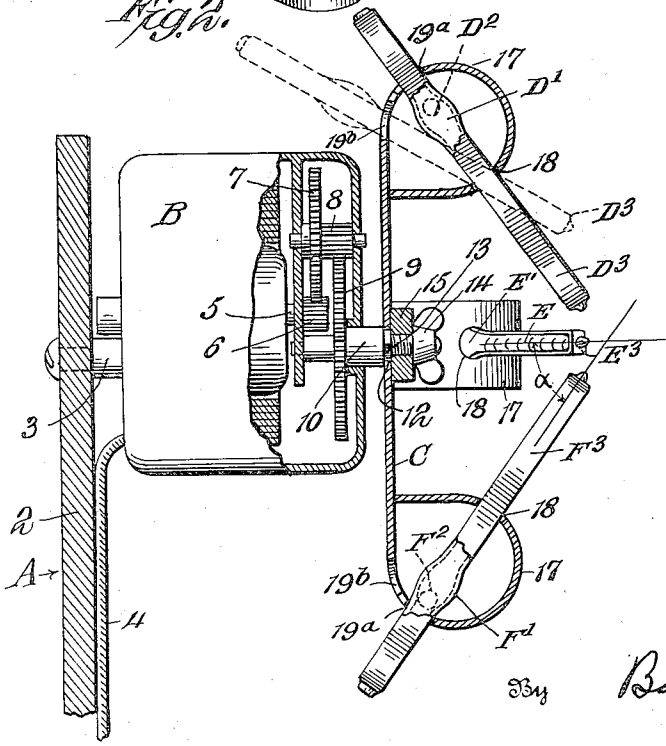


Fig. 3.

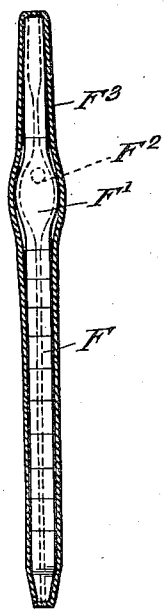
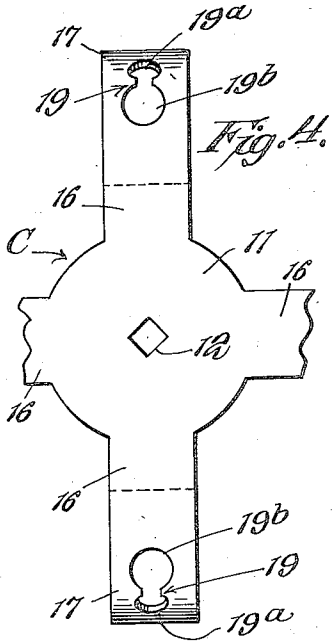


Fig. 4.



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METHOD OF AND APPARATUS FOR AGITATING MIXTURES

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10 Claims. (Cl. 259—57)

This invention relates to methods of and apparatus for agitating mixtures, more particularly mixtures of blood and diluents, as, for example, mixtures formed in the preparation of blood specimens for microscopic examination. Although the method and apparatus in accordance with my invention may be used for the agitation of other mixtures, they were developed with special regard to the requirements of such mixtures of blood and diluents, and the invention as developed for this purpose will be described for the purposes of illustration.

In the preparation of blood samples for analysis or study, the usual procedure is to place a measured quantity of the blood in a pipette tube formed with a capillary opening and with an enlargement or bulb intermediate the ends of the opening, and to dilute the sample in the tube with a measured quantity of suitable fluid, the amount and nature of the diluent depending upon the kind of study to be made. The mixture thus formed is then agitated in order to effect a thorough mixing of the blood and the diluent so as to disperse the blood corpuscles uniformly throughout the mixture in suspension. Heretofore the agitation has been effected by manual shaking of the pipette tubes, and, if the manual manipulation is performed thoroughly, good results are obtained. However, it is not uncommon for the thoroughness of the manual agitation to vary with different persons, and in fact appreciably different results have been observed in making two analyses of the same blood, the two samples of which were prepared by two different persons with different degrees of thoroughness of agitation.

An object of my invention is to provide a method of and apparatus for agitating mixtures of blood and diluent in such manner as to assure uniform and thorough mixing. A further object is to provide such a method and apparatus as are capable of effecting the desired uniform and thorough mixing in a lesser time than heretofore has been required. Other objects will become apparent from the following detailed description, the appended claims, and the accompanying drawing, in which:

Figure 1 is a perspective view of an apparatus embodying the invention;

Figure 2 is a view of the apparatus shown in Figure 1, partly in elevation and partly in vertical section, and drawn on an enlarged scale;

Figure 3 is a view in elevation of a pipette tube and an elastic band associated therewith and shown in section; and

Figure 4 is a fragmentary view in rear elevation of a tube-supporting spider.

In accordance with my improved method, the blood sample and diluent are placed in a suitable vessel, preferably a pipette tube formed with a bulb, and the tube is moved in an orbital circular path about a substantially horizontal axis at a radial distance from the axis and at a rotative speed so mutually related that the constituents of the mixture will move back and forth in the bulb and will not be held in the outermost confines of the bulb by centrifugal force. It will be appreciated that, if the relation between the radial distance of the vessel from the axis of rotation and the speed of rotation are so mutually related that considerable centrifugal force is exerted, the mixture will be thrown out against the outermost walls of the bulb, and that, instead of there being a thorough intermixing of the constituents and a uniform suspension of blood corpuscles, the latter will be thrown to the outermost confines of the bulb and will be segregated from the fluid constituents. It therefore is important that the radial distance of the bulb from the axis of rotation and the speed of rotation be so related that no substantial centrifugal force is exerted. In accordance with a further feature of my improved method, I preferably employ pipette tubes formed with oval bulbs or vessels and mount the tubes so that the major axes of the bulbs are disposed at an oblique angle to the axis of rotation. When tubes thus disposed are rotated at a low speed, the fluid mixture contained in the bulbs will slosh around in the bulb, moving both in the direction of the major axis and in the direction of the minor axis thereof, whereby efficient agitation and thorough mixing are effected. I may also employ the usual bead in the pipette tube bulb, which tumbles around and assists in the formation of a uniform mixture.

The amount of centrifugal force tending to throw the fluid mixture outwardly depends upon the acceleration of the mixture inwardly toward the axis of rotation, and this acceleration is expressed by the formula:

$$a=4\pi^2n^2r,$$

where a is the acceleration in inches per second per second, n is the revolutions per second, and r is the radial distance of the mixture from the axis of rotation in inches. Through experiments and tests in the preparation of actual samples subsequently subjected to microscopic studies, I have ascertained that best results are obtained when the value of the acceleration a is about one hundred inches per second per second. When the

radial distance from the axis of rotation and the rotative speed are so mutually related that the acceleration has approximately this value, the fluid is not flung outwardly against the outer walls of the bulb, but is permitted to slosh back and forth under the combined action of the rotative movement and gravity.

One suitable form of apparatus capable of effecting agitation in accordance with the invention is shown in the drawing as including a standard A comprising a base 1 and an upright portion 2, and a motor B mounted on the standard by means of posts 3 and provided with the usual cord 4 housing electrical conductors. The motor shaft 5 is provided with a pinion 6 meshing with a gear 7 which has secured to it a pinion 8 which meshes with a gear 9 secured to a driven shaft 10.

A spider or tube support C having a hub 11 formed with a square opening 12 fitting over a square portion 13 on the shaft 10 is secured in position on the shaft by means of a wing nut 14 and a washer 15 disposed between the wing nut and the hub 11. The spider C is provided with a plurality of arms 16 which are formed at their outer ends with loops 17, each loop being provided with an opening 18 and a second opening 19 spaced from the opening 18. Each opening 19 is formed as a bayonet slot having a smaller opening portion 19^a and a larger opening portion 19^b. The pairs of openings 18 and 19 serve conjointly to form seats for receiving pipette tubes D, E, F, and G which are formed respectively with oval bulbs or mixing vessels D^1, E^1, F^1, and G^1, and preferably tumbling beads D^2, E^2, F^2, and G^2 are located respectively in the bulbs D^1, E^1, F^1, and G^1.

The pipettes are open on both ends, and in order to close the ends of the tubes during agitation I prefer to employ rubber or other elastic bands D^3, E^3, F^3, and G^3 passing respectively over the opposite ends of the tubes D, E, F, and G and alongside the latter.

After the blood sample and diluent have been placed in the tubes and the elastic bands applied to the latter, the tubes with the bands thereon are inserted through the larger opening portions of the bayonet slots 19 and are projected through the openings 18 until the bulbs are disposed within the loops 17 and between the openings 18 and 19. The tubes are then moved from the larger openings 19^b of the bayonet slots into the smaller openings 19^a thereof, and are held in this position by means of the rubber bands which serve to cushion the tubes in their seats and to adapt the seats for tubes of different sizes, it being understood that the tubes may vary in size depending upon the nature of the examination to be made.

Tests have indicated that more thorough mixing of the blood and diluent can be effected in a shorter time when the tubes are disposed at an oblique angle to the axis of the shaft 10 because this arrangement results in movement of the mixture in at least two directions, i. e., in the direction of the major axes of the bulbs and also in the direction of the minor axes thereof. Although the exact amount of angularity is not critical, I have found that substantially better results are obtained when the angle α between the shaft axis and the axes of the tubes is from forty-five to sixty-five degrees, and preferably the angle should be about fifty-five degrees.

As previously stated, it is important that the mixture be not thrown outwardly appreciably by centrifugal force. With the bulbs of the pipette tubes disposed at a given distance from the axis of rotation, the tendency to throw the mixture outwardly will depend upon the rotative speed, and, conversely, for any particular rotative speed this tendency will depend upon the radial distance of the bulbs from the axis of rotation. Thus these two factors may be varied somewhat within practical limits, but their mutual relation should be such that no substantial centrifugal force is produced, and as a rough measure the relation should be such that the acceleration of the mixing vessels toward the axis of rotation is about one hundred inches per second per second. In the embodiment shown in the drawing, and as actually constructed and used in practice, the radial distance of the bulbs from the axis of rotation has been between two and a half and two and three-quarters inches, depending upon the seating of the tubes in their seats, which may vary to some extent owing to the flexibility of the seating arrangement. With the bulbs disposed at this distance from the axis of rotation, a rotative speed of one revolution per second has been found to produce the best results, and with this mutual relation between the radial distance from the axis of rotation and the rotative speed the acceleration is approximately one hundred inches per second per second.

It will be understood that within practical limits any number of arms may be provided on the spider C for carrying tubes, so that a large number of samples may be prepared for examination at the same time. The embodiment of the invention disclosed herein has been found to operate efficiently and to obtain the desired results, but it will be understood that various changes may be made in the specific construction and relative arrangement of the parts without departing from the invention as defined in the claims.

I claim:

1. The method of agitating mixtures to form suspensions which comprises moving a vessel containing the constituents of the mixture in a circular path about a substantially horizontal axis and at a radial distance and rotative speed so mutually related that the acceleration of the constituents towards said axis is approximately one hundred inches per second per second.

2. The method of agitating mixtures to form suspensions which comprises moving an oval vessel containing the constituents about a substantially horizontal axis with the major axis of said vessel inclined to said substantially horizontal axis at an angle of from forty-five degrees to sixty-five degrees and at a radial distance and rotative speed so mutually related that the acceleration of the constituents towards said axis is approximately one hundred inches per second per second.

3. The method of agitating mixtures to form suspensions which comprises moving an oval vessel containing the constituents about a substantially horizontal axis with the major axis of said vessel inclined to said substantially horizontal axis at an angle of from forty-five degrees to sixty-five degrees and at a radial distance and rotative speed so mutually related that the constituents will move in said vessel both in the direction of the major axis and in the direction of the minor axis, and will not be held in the outermost confines of the vessel by centrifugal force.

4. The method of agitating mixtures of blood and diluent which comprises moving an oval ves-

sel containing the constituents about a substantially horizontal axis with the major axis of said vessel inclined to said substantially horizontal axis at an angle of from forty-five degrees to sixty-five degrees and at a radial distance and rotative speed so mutually related that the constituents will move in said vessel both in the direction of the major axis and in the direction of the minor axis, and will not be held in the outermost confines of the vessel by centrifugal force.

5. Apparatus for agitating mixtures to form suspensions comprising a substantially horizontal rotatable shaft; a support fixed to said shaft; a pipette vessel for containing the ingredients of said mixture and being mounted on said support and spaced from the axis of said shaft with its major axis inclined with respect to said shaft; and means for rotating said support and said vessel about the axis of said shaft.

6. Apparatus for agitating mixtures to form suspensions comprising a substantially horizontal rotatable shaft; an arm secured to said shaft; a pipette tube formed with a bulb and supported on said arm at an angle of from forty-five degrees to sixty-five degrees with respect to said shaft, the bulb being spaced to one side of said shaft; and means for rotating said shaft.

7. Apparatus for agitating mixtures to form suspensions comprising a substantially horizontal rotatable shaft; an arm secured to said shaft; a pipette tube formed with a bulb and supported on said arm at an oblique angle with respect to said shaft, the bulb being spaced from the axis of the shaft; a tumbler bead in said bulb; and means for rotating said shaft.

8. In apparatus for agitating mixtures to form suspensions, the combination of a shaft; an arm carried by said shaft and formed with a tube-receiving seat; a pipette tube in said seat; and an elastic band passing over both ends of the tube and extending alongside of the tube and between the latter and said seat.

9. In apparatus for agitating mixtures to form suspensions, the combination of a shaft; means carried by said shaft provided with a plurality of tube-receiving seats adapted to receive pipette tubes of varying sizes within limits; a tube in one of said seats and being open at at least one of its ends; and an elastic band stretched over the ends of said tube and extending alongside of the tube between and in engagement with the latter and said seat whereby to close the open end of said tube and also to adapt the seat to the size of the tube.

10. In apparatus for agitating mixtures to form suspensions, the combination of a pipette tube having a bulb intermediate its ends; and a rotary support for said tube, said support being provided with two spaced openings, both of which are large enough to embrace said tube and one of which is formed as a bayonet slot, the larger opening of which is large enough to permit passage of said bulb.

S. LLOYD JOHNSON.