Sept. 8, 1953 V. C. HALL 2,651,724

MACHINE FOR IRRADIATING LIQUIDS

Original Filed Nov. 3, 1948

Fig. 1

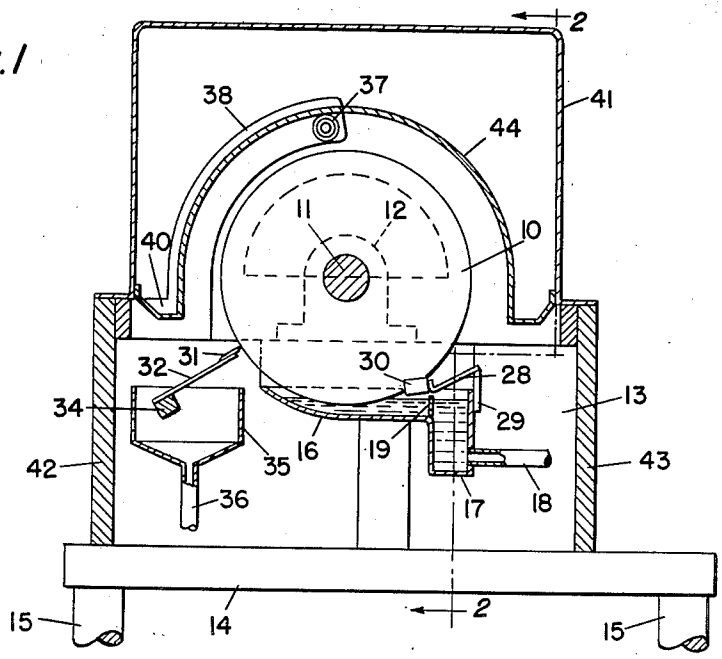


Fig. 4

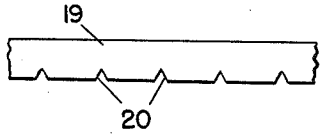


Fig. 2

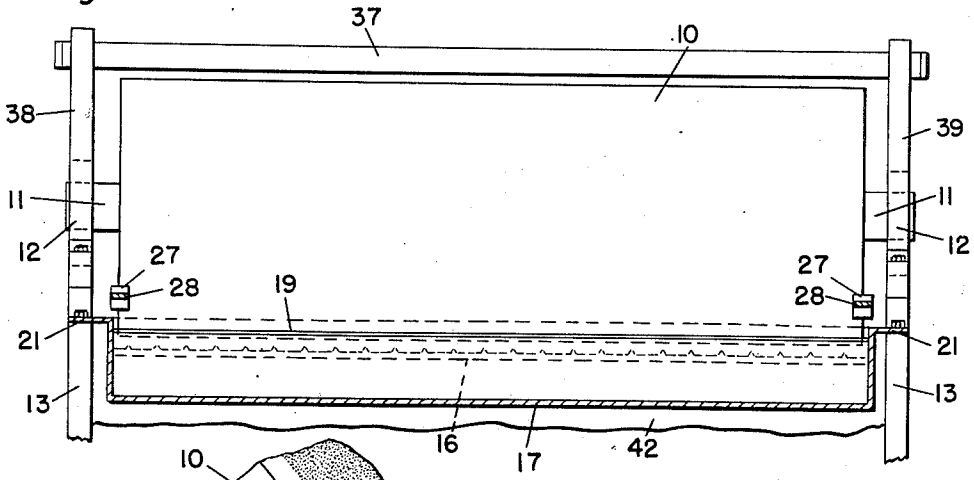
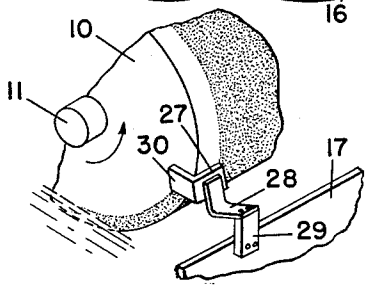


Fig. 3



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MACHINE FOR IRRADIATING LIQUIDS

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4 Claims. (Cl. 250—49)

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This invention relates to a machine for sterilizing liquids and more particularly to an apparatus of this character for destroying bacteria and viruses by the use of ultraviolet radiation.

The invention has particular utility in the sterilization of human blood plasma, but it is to be understood that the apparatus may be employed equally as well for destroying bacteria and viruses in other liquids. For example, the invention may be applied for the treatment of blood serum, milk, virus vaccines, and even the purification of water.

The invention is of particular importance for the sterilization of human blood plasma for the reason that this material presents an especially troublesome problem because of the necessity of not destroying any of the properties of the plasma. It has been found that plasma as it is initially obtained sometimes contains a virus which brings about a disease of the liver in the person to whom the plasma is administered. Prior attempts to destroy this virus in plasma have not been satisfactory.

To make certain that all of the bacteria or virus which is present in the liquid being treated is completely killed, it is of the utmost importance that these contaminating micro-organisms be completely subjected to the ultraviolet radiation. As the machine operates upon the general principle of spreading the liquid out into a thin film which is exposed to the radiant energy, it is of primary importance that this film be maintained of uniformly thin depth. Moreover, it is important that there exist no possibility for any liquid to pass through the machine which is not exposed to ultraviolet light.

It is therefore a primary object of the present invention to subject human plasma to the action of ultraviolet radiation in such a manner that all of the contaminating virus and bacteria contained therein will be exposed with absolute certainty to the killing action of the radiant energy and that this occur without any destructive action upon the plasma itself.

A preferred embodiment of the invention is illustrated in the accompanying drawings in which:

Figure 1 is a transverse cross sectional view through the machine.

Figure 2 is a sectional view of the line 2—2 of Figure 1.

Figure 3 is a perspective view of an end portion of the roller showing the wiper blade action.

Figure 4 is an enlarged view of a portion of the dam.

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In general, the machine consists of a drum rotating on a horizontal axis, and having its lower portion lying in a body of the plasma which is to be subjected to irradiation. The rotation of the drum causes it to pick up a thin film of the plasma and to carry it with the drum in its rotation. The upper side of the drum is exposed to intense ultraviolet radiation from a suitable lamp or lamps so that the virus or bacteria contained in the plasma are destroyed. After the plasma has passed the source of radiation, it is removed from the drum by a wiping blade and is then delivered to a storage container.

It has been found to be of the utmost importance that the film of plasma which is formed upon the drum be of extremely small thickness, for example, on the order of one-tenth of a millimeter, and that this film remain of relatively uniform thickness while it is being advanced from the pick-up trough, beneath the source of radiation and to the removing blade. The features of the machine which obtain these operations and results will become evident from the following description.

Referring now to the drawings, the drum which serves to pick up the plasma to be treated is indicated at 10. The ends of this drum should be closed and it is not material whether this is accomplished by forming the drum of a solid body or by making the drum of hollow construction. Trunnions 11 project axially from opposite ends of the drum 10 so that it may be rotatably mounted upon a horizontal axis. These trunnions 11 rotate in pillow blocks or bearings 12 which are carried by suitable supports 13, projecting upwardly from the base plate or table 14.

It is preferable that the base plate 14 be elevated above the floor and this obviously may be accomplished in any desired manner. For example, the plate 14 may merely rest upon a table, or as here shown, it may be supported by legs 15 above the floor. To rotate the drum 10, any suitable means may be employed. For example, one of its trunnions 11 may be connected to a source of power.

To supply the plasma which is to be sterilized to the roller 10, a feed pan 16 is disposed beneath the drum 10. It is important to observe that the portion of this pan which is directly beneath the drum is shallow and that the bottom of the pan conforms to the curvature of the drum and is disposed close to the surface of the drum. This relationship is especially true and is of primary importance at the left hand side of the

feed pan as it is shown in Figure 1; this being the side of the pan into which the rotation of the drum brings the surface of the drum for its initial contact with the pool of plasma. Preferably, the average radial distance between the drum and pan 16 should be less than 3/8 inch. Because of this relationship, the tendency for any surging of the plasma to occur beneath the rotating drum is reduced to a minimum.

This close spacing between the drum surface and the pan surface is important because it assures the continuance of a relatively quiescent pool of plasma beneath the drum and minimizes the tendency for movement within the plasma which would tend to cause an increased thickness of the film on various portions of the drum. Moreover, by the maintenance of a very thin depth of plasma beneath the drum, any tendency for the occurrence of a churning action which might form bubbles, is overcome.

Moreover, by having only a small volume of plasma below the drum 10, greater assurance is had that the fresh, incoming plasma is picked up sooner on the drum so that the time period that it remains in the feed pan 16 is reduced to a minimum. For this reason there is little likelihood that any portion of the plasma will be retained in the feed pan 16 for an appreciable time and merely be agitated by the roller.

As a consequence, therefore, of the relationship which is established between the rotating drum and the feed pan 16, a uniform and extremely thin film of plasma is constantly being formed upon the rotating drum. During the rotation of the drum this thin film maintains itself and there is no tendency for the formation of rivulets such as might occur if the liquid tended to flow backward down the drum as it is being carried up and over the top side of the drum during rotation. These considerations are of the utmost importance because otherwise, bubbles or thickened portions of the plasma may be formed on the rotating drum. If this occurs, the plasma either would not receive sufficient irradiation to destroy the virus contained therein, or the plasma would be subjected to such a high concentration of radiant energy that its physical or chemical properties may be destroyed.

It is important that the plasma which is to be treated be delivered into the feed pan 16 and beneath the drum 10 at a uniform rate throughout the length of the drum and without the occurrence of any turbulence. For this reason the feed pan includes a sump portion 17 which is of greater depth than the portion of the pan which is disposed immediately below the drum 10. Also this sump portion extends throughout the entire length of the feed pan 16 to serve as a feeder into the portion of the pan which underlies the drum 10. The plasma which is to be treated is delivered into this sump 17 adjacent to the bottom thereof through a pipe 18. This is for the purpose of causing the incoming plasma to flow into a relatively large body of the plasma within the sump 17 so that the velocity of flow of the incoming plasma is reduced and its tendency to cause turbulence within the body of plasma in sump 17 is reduced. The plasma, therefore, flows laterally throughout the length of the sump 17 and overflows over the elevated portion between it and the portion which underlies the drum.

To further assure a smooth flow of plasma from the supply to beneath the drum and make certain that no turbulence occurs, a dam 19 is

disposed in the path of flow of the plasma from the sump 17. This dam 19, as here shown, consists of an upright blade which extends throughout the length of the feed pan 16. As an important feature of the invention, dam 19 is formed with a plurality of notches 20 in its lower edge through which the plasma must flow. This lower edge of the dam 19 should lie against or at least quite close to the bottom of the pan 16 to tend to hold back the plasma within the sump 17 and prevent any disturbances which arise within the sump from being carried over into the portion beneath the drum 10.

It will be observed that the plasma flows from sump 17 into pan 16 beneath the dam 19 and not over the top of the dam 19. This makes it unnecessary to accurately level the top edge of the dam, and assures uniform flow into pan 16 along the entire length of pan 16.

To support the feed pan 16 in proper position beneath the drum 10, it is formed with outwardly extending lips 21 which rest upon the tops of upright plates 13. These plates 13 are secured to the base plate 14 in any suitable manner. Also, dam 19 is held in place in pan 16 by any appropriate means.

The pipe 18, which is connected into the sump 17, may receive plasma to be treated from any suitable source. For example, the plasma may be delivered either by gravity or by a pressure feed. It is important that the level of the plasma within the feed pan be maintained at a substantially constant point and this may be accomplished by any common means such as by the use of a float valve, or more accurate means known in the art.

The rotation of the drum 10 within the plasma contained in the feed pan 16 causes the plasma to be picked up on the surface of the drum 10 so that a thin film of plasma is carried upwardly with the rotation of the drum. It has been found important, as a feature of this invention, that the plasma be confined to the surface of the drum inwardly from the extreme ends thereof. This is desirable because experience has indicated that any tendency for the plasma to flow back downwardly along the surface of the drum instead of remaining with it during the upward movement of the drum, occurs generally at the ends of the drum. This is probably due to the fact that some of the plasma is necessarily picked up by the end faces of the drum with the result that it flows downwardly during the rotation of the drum and combines with the plasma at the extreme ends of the cylindrical surface of the drum to form zones of increased thickness. As it is important that the plasma which is being treated be of uniform thickness upon the drum, it is important that this plasma which is present at the end portions of the drum be removed before it is acted upon by the irradiation lights.

To remove the plasma from the end portions of the drum, wiper blades 27 are attached to spring leaf metal 28. Each wiper blade 27 is preferably made of a strong, resilient, plastic material as, for example, Teflon, which is inert with respect to the plasma. The blades 27 may be attached to the spring leaves 28 by any suitable means such as the screws indicated. The opposite end of each of the spring leaves 28 is attached to an upright bracket 29 which in turn is attached to the rearward edge of the sump 17.

It is also desirable that the wiper blades 27 be of notched or stepped formation so that the end portions 30 will press against the end faces of the drum to remove the plasma which is picked up

by these end faces. It will be observed that the wiper blades 27 are disposed immediately above the surface of the plasma so that it is removed at once from the drum and is returned downwardly into the feed pan 16. In this manner it is apparent that the plasma which moves upwardly with the rotation of the drum is confined inwardly from the extreme ends of the drum.

It may be mentioned at this point, that it is important that the drum 10 be immersed a distance of from ⅛ to ⅜ inch and preferably about $\frac{3}{16}$ inch in the pool of plasma, as this has been found important to obtain a clean wiping action by the blades 27. Thus, if the drum dips into the plasma a radial distance which is less than about ⅛ inch, it will be found that the wiping blades 27 cause variations in the thickness of the plasma film at the edge of its removal from the cylindrical surface. These variations in thickness at the edges of the plasma film remaining on the drum resemble curtain-like undulations in appearance.

The thin film of plasma which is formed upon the surface of the drum is exposed to the action of ultraviolet radiation of a specific character, and this portion of the apparatus will be explained later. It will suffice for the present to point out that this source of radiant energy is a conventional tubular lamp.

After the plasma has been subjected to this radiant energy, it is removed from the drum by means of a blade 31. Blade 31 is preferably made of the same material as the wiper blades 27 so that it will not mar the surface of the drum and due to its resiliency will remain in contact with the surface of the drum throughout the length thereof. The removal blade 31 is carried by a flexible supporting sheet 32 which is secured to a bar 34 in any desired manner.

It is desirable to maintain the bar 34 and thereby the supporting sheet 32 for the removing blade 31 in fixed position so that the blade 31 will be maintained firmly against the surface of the drum 10.

This assembly, constituted of the bar 34 and the supporting sheet 32, is held in proper relationship with respect to the drum 10 by means of its attachment to the collecting trough 35 in any suitable manner. It may here be noted that the bottom of the collecting trough 35 slopes downwardly to a central discharge tube 36. The collecting trough 35 may be supported in any desired manner, but it is desirable that this support be adjustable so that the removing blade 31 can be brought against the surface of the drum 10 with the desired pressure.

It will be observed that the removing blade 31 is disposed at such an angle with respect to the surface of the rotating drum 10 that it makes an acute angle with respect to the approaching surface of the drum. This is desirable so that the removing blade 31 does not chatter against the moving surface of the drum and it has been found that with this relationship it will effectively remove the plasma from the surface of the drum despite the extreme thinness of this film. Also it will be observed that the removing blade 31 is disposed on the under side of the drum 10 so that the plasma film is upon a maximum portion of the drum to receive the radiant energy from the lamp.

It has been noted that the top of the drum 10 is exposed to a source of radiant energy and that this irradiation serves to kill the virus or bacteria which is present in the plasma. In the illustrated apparatus, this irradiation is produced by

means of a lamp 37. This lamp is an elongated tube having electrical connections at its opposite ends.

It is important that this tubular lamp 37 be disposed as close as possible to the surface of the drum 10 so that the maximum concentration of radiation will be directed upon the plasma. To arrange the lamp 37 in this fashion, holders 38 and 39 are disposed immediately beyond the opposite end of the drum 10. Each of these holders is formed with an opening which receives the ends of the lamp 37 and thereby supports it in place. The projecting ends of the tube 37 are connected by individual wires to a transformer or energizing device. To support the holders 38 and 39 in their proper positions at the opposite ends of the drum 10, they are formed with lateral extensions 40.

It is desirable that the entire portion of the irradiation lamp 37 be enclosed both for the purpose of shielding the irradiation from operators who are attending the machine, and to prevent the fall of dust within the room upon the functional parts of the machine. For this reason an elongated hood 41 is provided and it is supported upon the front and rear upright plates 42 and 43 which are fastened to base plate 14.

In order to obtain the maximum efficiency from the radiant lamp 37, it is desirable that a reflector be provided to direct the radiant energy downwardly against the surface of the drum 10. For this reason a curved reflector 44 which has a surface of a suitable composition for reflecting ultraviolet radiation, is disposed close to the drum 10. For example, the reflector can be made of polished "Alzac" aluminum alloy. It is desirable that this reflector 44 be formed with a plurality of openings to make certain that any heat which is generated above the drum and within the tubes, can rise and pass outwardly through louvres in the overlying portion of the hood 41. The reflector 44 may be attached in any desired manner to the internal wall of the hood as shown.

It is preferable that the plates 42 and 43 be of transparent material such as glass or an acrylic resin as "Lucite" so that the interior of the machine may be viewed. A tight connection is established at the vertical corners where the plates 42 and 43 meet the upright end plates 13.

The combined action of the flow regulating ram 19 and the end wiper blades 27 assures irradiation of all of the liquid which is delivered by the drum 10 from the supply to the discharge portions of the machine. This is because an extremely uniform film of liquid is caused to be present upon the drum inwardly from the ends thereof so that every portion of the liquid being carried over to the collecting trough 35 is fully irradiated and the contaminating micro-organisms are killed.

This application is a division of my copending application Serial No. 58,086, filed November 3, 1948, now abandoned.

What I claim is:

1. An apparatus for the sterilization of liquids which comprises a drum, means mounting the drum for rotation, a feed pan disposed beneath the drum for applying liquid to be treated to the surface of the drum, means frictionally bearing upon the drum for removing the applied liquid from the end portions of the surface of the drum so that the liquid is confined to a central zone thereof, means for removing the liquid from the drum at a circumferential distance therefrom

and a source of irradiation to emanate ultraviolet light to the liquid during its passage between the applying and the removal means.

2. An apparatus for the sterilization of liquids which comprises a drum, means mounting the drum for rotation, a feed pan disposed beneath the drum for applying liquid to be treated to the surface of the drum, wiper blades frictionally bearing upon the drum for removing the applied liquid from the end portions of the surface of the drum so that the liquid is confined to a central zone thereof, means for removing the liquid from the drum at a circumferential distance therefrom and a source of irradiation to emanate ultraviolet light to the liquid during its passage between the applying and the removal means.

3. An apparatus for the sterilization of liquids which comprises a drum, means mounting the drum for rotation, a feed pan having a portion disposed beneath the drum and having its bottom surface conforming to the surface of the drum and disposed in close proximity thereto, the feed pan also having a laterally disposed sump portion into the bottom of which liquid to be treated is delivered to prevent surges of liquid into the portion underlying the drum, and a dam disposed beneath the sump and the underlying portion of the feed pan to distribute the liquid from the sump portion, a collecting trough disposed beneath the drum on the side toward which the surface of the drum is advancing due to its rotation, a liquid removing blade bearing against the drum to remove liquid therefrom and deliver it into the said trough, and a source of radiant energy disposed immediately adjacent the upper side of the drum for emanating ultraviolet light upon the liquid.

4. An apparatus for the sterilization of liquids which comprises a drum, means mounting the drum for rotation, a feed pan having a portion disposed beneath the drum and having its bottom surface conforming to the surface of the drum and disposed in close proximity thereto, the feed pan also having a laterally disposed sump portion into the bottom of which liquid to be treated is delivered to prevent surges of liquid into the portion underlying the drum, and a dam disposed beneath the sump and the underlying portion of the feed pan to distribute the liquid from the sump portion, said dam being notched along its lower edge to evenly distribute the flow of liquid from the sump portion into the feed pan, a collecting trough disposed beneath the drum on the side toward which the surface of the drum is advancing due to its rotation, a liquid removing blade bearing against the drum to remove liquid therefrom and deliver it into the said trough, and a source of radiant energy disposed immediately adjacent the upper side of the drum for emanating ultraviolet light upon the liquid.

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