Jan. 26, 1943. E. K. KNOTT 2,309,124

ULTRA-VIOLET EXPOSURE CHAMBER

Filed Nov. 16, 1940

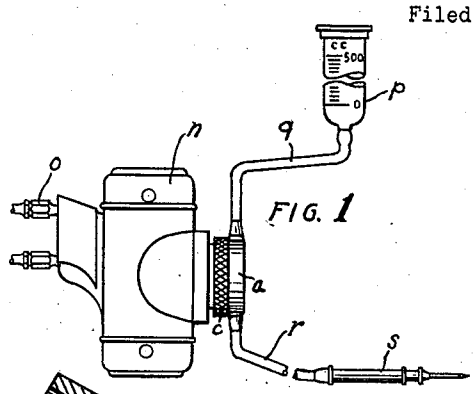

FIG. 1

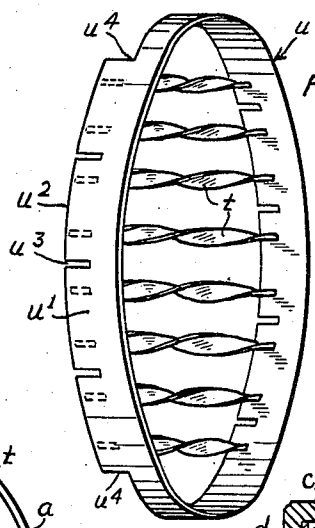

FIG. 5

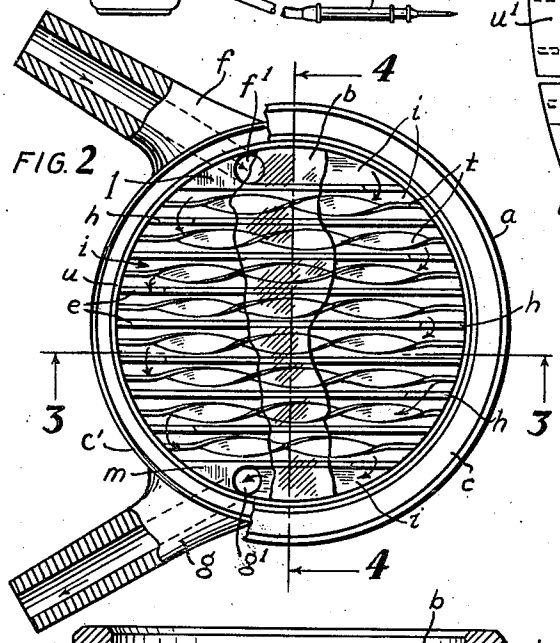

FIG. 2

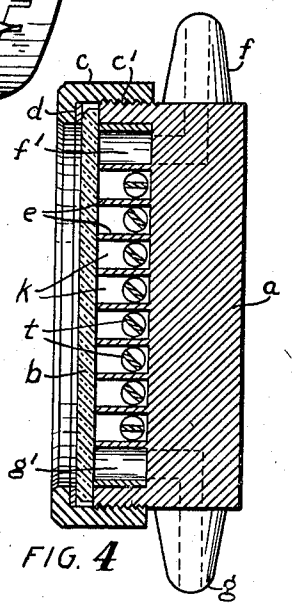

FIG. 4

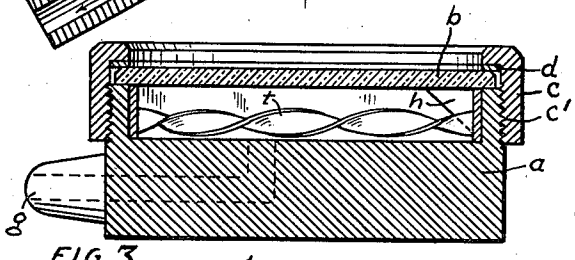

FIG. 3

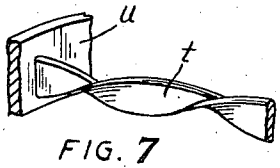

FIG. 7

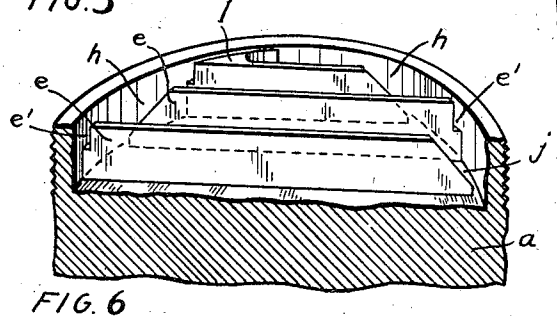

FIG. 6

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ULTRAVIOLET EXPOSURE CHAMBER

Emmet K. Knott, Seattle, Wash.

Application November 16, 1940, Serial No. 365,855

9 Claims. (Cl. 250—48)

My invention relates to the art of surgery and medicine and has for its specific object the provision of an exposure chamber which may be used effectively for irradiating blood flowing therethru. In this connection it is used in practising the invention described in United States Letters Patent No. 1,683,877, issued September 11, 1928, to myself and to L. A. Edblom entitled Means for treating blood stream infection.

This application is intended as a continuation in part of my copending application for patent entitled Ultra-violet exposure device for blood, filed February 19, 1938, Serial No. 191,468, which application has been abandoned.

The primary object of my invention is to provide an exposure chamber of this character in which blood is directed along a tortuous passageway beneath a window permeable to ultra-violet radiation and said stream of blood flowing along said passageway is given gentle turbulence to cause it to flow towards and from said window.

In my co-pending application for patent entitled Method and means for irradiating blood, filed May 1, 1939, Serial No. 271,072, I discuss the reasons for a thorough irradiation of all portions of the blood to be exposed to ultra-violet radiation and the danger of over-irradiation. I have determined that each particle of blood to be irradiated should be exposed for only a limited time, possibly only a fractional portion of a second and that in a layer of blood even as thin as one centimeter, its lowermost portion is opaque to radiation, and the particles of blood flowing along the under side of said stratum are not radiated effectively, if at all.

The object of my present invention is attained by arranging in a chambered receptacle having a series of passageways extending transversely of said chamber, a series of spirally twisted devices which lie centrally of said transverse passageways. The spirally twisted devices are adapted to give a substantial lift to the blood thus flowing to direct the undermost portions of the stream toward the permeable window to displace other portions which have previously occupied this space. Thus, the flow of blood through said chamber moves at a substantially uniform rate and is rendered gently turbulent so that all particles of blood composing said stream will be exposed to ultra-violet radiation and none will be whipped suddenly to destroy or injure the constituent portions of the blood.

Other and further objects and features of my invention are hereinafter described with reference to the accompanying drawing, in which:

Fig. 1 is a more or less diagrammatic illustration of an arrangement of apparatus for irradiating blood which includes my novel exposure chamber;

Fig. 2 is an elevation of said chamber with portions shown broken away to disclosed structural details, the flow of the blood stream through said exposure chamber being indicated by arrows;

Fig. 3 is a sectional view of said exposure chamber taken on the line 3—3 in Fig. 2;

Fig. 4 is a sectional view taken substantially on the line 4—4 in Fig. 2;

Fig. 5 is a perspective detail of an annular member carrying spirally twisted devices for imparting gentle turbulence and movement to the blood to cause it to move towards and from the window of an exposure chamber embodying my invention;

Fig. 6 is a sectional detail view of a chamber embodying my invention with the cover and retaining ring shown removed therefrom to illustrate the manner in which the baffles are arranged within said chamber; and

Fig. 7 is a fragmentary perspective detail view illustrating the manner in which the spirally twisted devices are carried by the annular member.

An exposure chamber embodying my invention comprises a chambered receptacle *a* which is substantially cup-shaped, and the open mouth of which is adapted to be closed by a removable cover *b*. Said removable cover constitutes a transparent window made of quartz or other material permeable to ultra-violet radiation between 1800 and 4000 Angstrom units. Said cover is held in place upon said chambered receptacle by a cap *c* which is secured to the receptacle by screw threads *c'*. I preferably provide a gasket *d* made of some resilient material so that pressure exerted by the cap upon the cover will not be localized to fracture said cover. Said cover fits tightly upon the mouth of the receptacle and bears uniformly about the entire surface thereof. The receptacle *a* has a series of upstanding parallel baffles extending transversely thereof, and said baffles upon their upper edges bear against the under surface of the cover.

Two spaced conduits *f* and *g* direct fluid into said chamber and open through ports *f'* and *g'*, respectively, to said chamber. At alternate ends of said baffles are arranged openings *h* which join adjacent spaces between baffles one with the other. In this way, I form a continuous tortuous passageway within the receptacle and below said cover extending from port *f'* and port *g'*. The

passageway *i* thus formed is substantially of uniform cross-sectional area except at the openings *h*. There said passageway is restricted by the size of said openings *h*. Said openings preferably are formed with an oblique under side extending from adjacent the floor *j* of the receptacle to the under side of the cover *b*. Thus blood flowing from the space between one baffle and the adjacent one is lifted from the floor and directed towards the under face of the cover *b*, thus to effect substantial turbulence as well as lift.

Referring to Fig. 4, it will be noticed that the spaces *k* between baffles *e* are slightly deeper than they are wide. The depth of the passageway as dictated by the distance in which blood can be maintained turbulent and when thus rendered turbulent will be permeated by ultra-violet radiation directed through the cover *b*. Immediately adjacent the ports *f'* and *g'* I provide solid portions *l* and *m* which prevent blood from passing beyond said ports and to create stagnant pools in which blood might collect and become over-irradiated. That is, said solid portions eliminate areas through which there would be no forced flow of blood within said chambered receptacle.

My exposure chamber is adapted to be used in connection with a water-cooled ultra-violet generator *n*. Energy is transmitted to said generator through electrical connections *o*. Blood is removed from the patient to be treated and is placed in a graduated vessel *p*, for example, and if thus placed, said vessel is arranged above the exposure device to produce a static head sufficient to induce flow of blood through the exposure chamber. Blood flows from said graduated vessel to the exposure chamber through a conduit *q*, and from the exposure chamber through a conduit *r* to a veni-puncture needle *s*. The graduations on the sides of said vessel can be observed to determine whether the rate of flow from said vessel is correct. The capacity of the chambered receptacle is known and the exposure time is predetermined and thus the rate of flow through the exposure chamber can be determined by watching the flow from the graduated vessel. The rate of flow can be controlled from said vessel either by varying the static head or by restricting the flow of blood through the conduits.

The chambered receptacle preferably is arranged in operating position on its side as is illustrated in Fig. 2. Thus blood is admitted into the interior of the chambered receptacle through port *f'*, flows along the tortuous passageway *i*, and out through the port *g'*.

The flow of blood through the chambered receptacle along the tortuous passageway is the matter with which my present invention is most concerned. I deem turbulence essential and flow towards and from the under surface of the cover *b* so that no portion of the blood can flow through the chamber without passing at least once immediately adjacent the under surface of said cover. This is accomplished by the arrangement of the openings *h* at the alternate ends of the baffles *e* and of the ports *f'* and *g'*, but I deem it desirable to provide auxiliary devices for increasing said turbulence without causing said turbulence to become excessive.

To this end I provide a spirally twisted flute *t* in each of the spaces *k* of the chambered receptacle *a*. Said flutes extend longitudinally of said spaces and I deem it preferable, although not essential, that said flutes lie in close proximity to the floor of each of said spaces. This is the way they are illustrated in Fig. 3. The reason I deem this arrangement desirable is that it tends to lift up the underlying portions of the blood in the stream flowing along the passageway and moves said underlying portions towards the under surface of the cover to displace the portions previously flowing along the under surface of the cover. The flutes, when arranged at the bottom of the space thus do not overlie any of the upper portions of the stream and I have determined that it is in the upper portions of the stream that the greatest effective radiation is present to act upon the particles of blood to be affected.

Said flutes are fixed transversely of an annular member *u* which is adapted to fit tightly within the chambered receptacle. This is illustrated in Fig. 5, and it is to be noticed that the rim portion *u'* of said member is notched, or otherwise relieved, upon the inner edge *u2* so as to straddle the end of each of the baffles which is not cut away to define openings *h*. Each of said baffles is likewise cut away or relieved as at *e'*, to accommodate the notches *u3* in the annular member *u*, and when thus arranged, the annular member *u* is fixed in position within the chambered receptacle. Other portions of said rim are cut away as *u4* so as to straddle the solid portions *l* and *m* previously described. The spirally twisted flutes are quite thin and the edges are made smooth and rounded as is illustrated in Fig. 7, so that no portions of blood will tend to fibrinate by being caught upon said edges. The notches and cut away portions of the annular member, and of the baffles, are formed to fit tightly one over the other so as to eliminate roughened portions or apertures at their point of joinder, for like reasons.

Blood being exposed in said chambered receptacle thus is caused to move along at a uniform rate and is not whipped about or churned unduly, but is given gentle turbulence so that all portions may be uniformly exposed to ultra-violet radiation directed thru the cover *b*. The cover, cap, gasket, and annular member *u* are separable and removable from the receptacle so that absolute cleanliness and sterile conditions may be maintained.

I claim:

1. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle lying immediately below said cover and extending from one conduit connection to the other, each of said ends terminating at an oblique angle to said cover.

2. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle lying immediately below said cover and extending from one conduit connection to the other, said openings being of gradually increasing width toward the cover so as to effect a substantial lift toward said cover and to produce turbulence in the stream flow thru said openings.

3. In a device of the character described, a

chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle lying immediately below said cover and extending from one conduit connection to the other, said openings being of greater width adjacent the cover so as to effect a substantial lift toward said cover and to produce turbulence in the stream flow thru said openings.

4. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, stationary means arranged in said passageway to effect a substantial lift toward said cover and to produce turbulence in the stream flow thru said passageway and toward and from said cover.

5. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, stationary spiral flutes arranged in said passageway to effect a substantial lift and to produce turbulence in the stream flow thru said passageway and toward and from said cover.

6. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, a removable annular member adapted to fit within said receptacle and provided with turbulence producing devices adapted to lie between said baffles.

7. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, a removable annular member adapted to fit within said receptacle and provided with spirally twisted devices adapted to lie between said baffles.

8. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, a removable annular member adapted to fit within said receptacle and provided with spirally twisted devices adapted to lie centrally between said baffles.

9. In a device of the character described, a chambered receptacle having a cover therefor permeable to ultra-violet radiation, two spaced conduit connections opening into said receptacle, a series of spaced baffles having openings formed in alternate ends thereof defining a continuous tortuous passageway in said receptacle below said cover extending from one conduit connection to the other, a removable annular member adapted to fit within said receptacle and provided with devices adapted to lie between said baffles, said annular member and said baffles being relieved relatively to accommodate each other and to fix said member within said receptacle.

EMMET K. KNOTT.