The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The invention relates to windows for internal observation of living experimental animals and the like.

In the biological sciences there exists a need for internal observation of physiological processes in living animals. Such observation is best when it can be accomplished without unduly hampering or handicapping the animal so that the physiological processes, reactions, reflexes, etc., proceed in a normal fashion or at least so that they are not influenced or hindered by such observation. The window to be described can be employed in a variety of investigations and demonstrations in several biological fields such as physiology, pharmacology and experimental surgery. It permits direct visualization of the internal organs of the animal body for purposes of observation, manipulation or recording.

Biological windows that can be tolerated by living tissue are one such method for internal observation. The difficulty of their use, however, lies in the fact that the usual transparent nontoxic materials such as glass, resins, celluloid, quartz or plastics cannot be tolerated in direct contact by living tissue, and either tend to be sloughed off or to set up a local irritation so that the transparent material cannot be firmly bonded to the tissue. Furthermore, with some of the transparent window techniques employed hitherto, a type of scar tissue starts to form on the inner surface of the window making observation difficult. Where the window is inserted, more or less permanently such tissue formation is difficult to remove. Moreover, where the window cannot be removed, the scar tissue forms more rapidly causing the window to become useless after a comparatively short while.

It is an object of the present invention to provide biological windows that are compatible with body tissue and fluids and that are movable to permit cleaning and debridation of fibrous tissue.

Other objects and advantages of the invention will appear in the following description of preferred embodiments of the invention made in connection with the attached drawings, of which:

FIG. 1 is a plan view of the animal's abdomen showing the bottom flange member of one embodiment of the invention in place;

FIG. 2 is a view similar to FIG. 1 with the entire apparatus in situ;

FIG. 3 is a plan view of the bottom flange member of one embodiment of the invention;

FIG. 4 is an exploded view of one embodiment of the invention; the parts being shown in section;

FIG. 5 is a vertical section on line 5—5 of FIG. 2;

FIG. 6 is a plan view of the upper flange member of a second embodiment;

FIG. 7 is a central sectional view of the upper flange member of FIG. 6;

FIG. 8 is a plan view of the lower flange member of the second embodiment;

FIG. 9 is a central sectional view of FIG. 8;

FIG. 10 is a central vertical section of the second embodiment in assembled condition;

FIGS. 11 to 14 inclusive, illustrate a third embodiment of the invention in which FIG. 11 is a plan view of a retainer ring;

FIG. 12 is a plan view of the lower flange member of the third embodiment;

FIG. 13 is a central vertical section of the lower flange member;

FIG. 14 is a central vertical section of the third embodiment in assembled condition.

FIGS. 1 through 5 illustrate one embodiment of the invention consisting of three basic parts. These are a bottom flange member shown generally at 3, a retaining ring 7 and a removable barrel 4. The bottom flange member 3 has a plurality of pins 6 around the perpendicular cylindrical portion 3 a and extending outwardly from the outer lip 3 c of its base. The retaining ring 7 is ring-shaped and fits over the flange member's cylindrical portion having holes machined in it to receive pins 6. The bottom flange member 3 is threaded on the inner surface of the cylindrical portion so as to receive the barrel 4 which is correspondingly threaded at its periphery. Prior to screwing the barrel section 4 into place, a washer 8, preferably made of neoprene rubber, is inserted inside bottom flange member 3 and seated on inner lip 3 d of the base. This washer 8 will prevent seepage of peritoneal exudate. The glass 5 used in the barrel section 4 is ordinary single strength window glass cut to the appropriate diameter and permanently cemented into the barrel. The top edge of the barrel section 4 has two notches 11 machined in it so that a spanner wrench may be used to tighten the barrel or to remove it. The pins 6 which are threaded and screwed into blind threaded holes equally spaced around the outer lip of the base of bottom flange member 3 are sharpened to a point and left permanently screwed in place. The tightening nuts 9 are turned preferably from "Lucite" and threaded to screw on to the pins 6.

The barrel, flange member, retaining ring, and pins are all made of a metal compatible with body tissue and fluids. "Inconel" was used in the present invention. It is a high nickel-chromium-iron alloy and is available commercially from the International Nickel Company. Aluminum or magnesium coated with silver or gold can also be used. The purpose of the aluminum or magnesium is to make the apparatus as light weight as possible, while the coating of silver or gold is to make the apparatus compatible with body tissue and fluids.

To insert the above-described embodiment into the abdomen of an animal, the hair is first removed from the abdomen of the animal 1 in a circular area slightly larger than the diameter of the lower flange 3 either by shaving the area or using a chemical depilatory. It is best to remove the hair beginning about 1 centimeter caudal to the inter-crest line and extend this area anteriorly to approximately the level of the first lumbar vertebra. All component parts of the window are sterilized and all surgical procedures are carried out under sterile conditions. At this point the animal is placed under an anesthetic. It should be mentioned at this point that the operative procedure being described is with reference to the abdomen of an adult albino rat. It is to be understood that insertion of the window in the dorsal wall, perhaps in the lumbar region of a different experimental animal would, of course, call for different operative procedures.

The area from which the hair has been previously removed is washed with 1% aqueous solution of Zephiran 70 or other accepted sterilizing agent. A circular section
of hide is removed in a diameter slightly smaller than the outer wall of the bottom flange or approximately 2.5 centimeters in diameter. This is most easily accomplished with a pair of small curved tip scissors while holding the hide up from the body with a small forceps. The posterior edge of the incision should be about 1 centimeter caudad to the inter-crest line. The anterior edge of the incision should be about 2.5 centimeters from the posterior edge of the incision should be about 1.3 centimeters each side of the midventral line. The under-lying tissue moorings and the connective tissue should be removed over the same area similarly. At this point there will be exposed muscularris rectus abdominis and a small portion of the right and left oblique abdominus externus.

Again using a small curved tip scissors and a small forceps, a circular area corresponding to the area of hide previously removed should then be excised. This will ex-pose the visceral cavity. This step completes the operative procedure which can be accomplished in from 5 to 10 minutes by an experienced operator. At this point the bottom flange 3 with the pins 6 up is placed at an angle so that one edge of the bottom flange can be placed in the incision under the muscle and a pin pushed through the muscle and overlying hide. The two layers of muscle and hide are depicted as 10 in FIG. 5. A plastic nut 9 is then screwed onto the pin 6 just a few turns to anchor the bottom flange 3 and prevent it from coming out of the muscle and hide while the rest of the pins 6 are being worked into position and pushed through the muscle and hide layers 10. When all the pins have been properly positioned, the edges of the circular incision should be proximate to the wall of the bottom flange 3 and the undersurface of the muscle should be resting on the outer lip of the bottom flange. This view is depicted in FIG. 1. The plastic nut 9 previously screwed on to hold the first pin while the remainder of the pins are being positioned is now removed. The retaining ring 7 is then placed in position over the bottom flange 3 with the sharpened pins 6 fitting through the holes in the periphery of the retaining ring 7. The plastic nuts 9 are then threaded on all of the pins 6 and screwed down until the retaining ring and bottom flange have gripped the muscle and hide 10 securely. Excessive pressure between these two compo-nents is not necessary and, in fact, should be avoided as this might cause necrosis of the tissues involved. The circular washer 8 is then seated against the inner lip 3d of the bottom flange 3 as shown in FIG. 5. The barre1 4 with the glass 5 cemented in place is screwed down tightly inside the bottom flange 3 and against the neoprene washer 8 to form a fluid-tight seal. Liquid collodion (not shown) is then flowed around the edges of the top flange 7 and the hide to form a seal for the flange itself. At this point anesthesia is discontinued and the animal placed in a recovery cage. This completes the insertion of the window and the window in situ is shown in FIG. 2. The total time required for the entire procedure including surgery is about 15 minutes.

Subsequent to insertion of the window, the animal should always be kept in a smooth walled and floored cage since the plastic nuts might tend to catch in the mesh of the conventional wire cage. No other special post operative precautions are required. When the ani-mal has recovered sufficiently from the surgery, there will be observed a tendency for it to gnaw at the collodion around the edge of the retaining ring. This area should be inspected daily and renewed as required. Appro-ximately every two days, the incision should be anasthe-mized and the barrel containing the glass removed and re-placed with a spare clean and sterile barrel. When the barrel has been removed, the visceral cavity should be ir-rigated with a warm, sterile, saline solution and any fibrinous tissue that has started to form should be de-brided.

FIGS. 6 through 10 illustrate the component parts and assembly of a second embodiment of the instant invention. It consists of an upper flange member 16, a lower flange member 15, a barrel 19 having inserts 20 for a spanner wrench, circular glass window 22 and a neo-prene washer 21. This window provides an alternative method of implantation in an experimental animal. The lower flange 15 has a plurality of pairs of small holes equidistantly placed around its base. The cylindrical portion of the lower flange is threaded internally and externally. The upper flange 16 screws on the external threads while the removable barrel 19 screws into the lower flange internal threading.

Implantation of this type window in the abdominal wall of a white rat will be hereinafter described. This implantation would necessarily have to be modified if other than rats are used and/or if the window is to be implanted elsewhere.

The animal is anaesthetized and the hair removed from the abdominal area. This area is then cleaned and ster-ilized with some appropriate solution such as ½% aqueous Zephran and painted with merthiolate. All surgical procedures are performed under sterile condi-tions. A circular section of hide is removed, the diameter of the outer wall of the bottom flange 15. This will be approximately 2.5 centimeters in diameter, the posterior edge of the incision being 2.5 centimeters from the anterior edge. Laterally the incision should be approximately 1.3 centimeters each side of the midventral line. Underlying connective tissue is similarly removed. A circular area of the rectus abdominus muscle is then removed corresponding to the previously removed circular area of hide and connective tissue. A Murphy purse string suture (not shown) is placed in the opened rectus abdominus muscle. The muscle is retracted and the bottom flange 15 is inserted under the muscle 18 in such fashion that the muscle 18 rests on the outer lip of the base of bottom flange 15. Previously, the neoprene washer 21 has been cemented into place in the bottom flange 15 as shown in FIG. 10. The purse string suture is made secure and the bottom flange 15 is sutured to the muscle 18 through the pairs of holes in the outer lip of the base of bottom flange 15. The hide 17 is then secured with a few sutures to the muscle 18 and a Murphy purse string suture placed in the hide 17 will draw it up tight to the cylindrical por-tion of the bottom flange 15. The entire surface around the wall of the upper flange 16 is given a coat of flexible collodion (not shown) and the upper flange 16 is screwed on to the bottom flange 15. Thus, the muscle and hide will be between the lips of the upper flange 16 and lower flange 15. The upper flange should not be screwed on too tightly that circulation to the peripheral edges of the incision is impaired. The circular glass window 22 is cemented into place in the barrel 19 and the barrel is then screwed into the lower flanges 15 and anesthesia is discontinued. Post operative procedures are similar to those used with the previously described window; how-ever, the danger of the pins catching on external objects is obviated with hair discontinuance.

Still another species of window embodying the same generic features of the other embodiments is shown in FIGS. 11 through 14. This type of window is more ap-propriate for larger experimental animals such as cats and dogs.

This window consists of a lower flange 27, a retaining ring 26, a removable barrel 28 having slots 29 for spanner wrench adjustment, a cellulose acetate washer 32, neoprene washer 33 and the circular glass window permanently cemented in the barrel. The barrel 28 can be removed from the lower flange 27 providing access to the body cavity once the lower flange and retaining ring with attached cellulose acetate washer have been posi tioned in the experimental animal.

The technique of implantation of this type window as
to preparation of the animal, size, place and type of incision follows the techniques already described. Thereafter the abdominal muscle is then retracted and the lower flange 27 is slipped into the incision so that the cylindrical portion of the flange projects through the abdominal wall and the muscle 31 rests on the outer lip of the base of lower flange 27. The incision is then drawn tightly against the cylindrical portion of the lower flange 27 by means of a purse string suture (not shown) and the muscle 31 is then sutured to the lower flange 27 using the pairs of holes in the outer lip of the base of the lower flange member. Prior to surgery the retaining ring 26 is sutured to the center of a sheet of cellulose acetate approximately twice the diameter of the retaining ring 26. The cellulose acetate inside the retaining ring is removed whereby the remainder of the cellulose acetate forms the washer 32. A plurality of small holes are punched into the washer. The ring 26 with the attached washer 32 is then slipped over the lower flange 27 and the cellulose acetate washer 32 is slipped between the hide 30 and the muscle 31. It may be necessary to slit the hide 30 in quadrants in order to fit the washer 32 in place. Several small sutures are placed through the washer 32 and the muscle 31 immediately adjacent the retaining ring 26 in a circular fashion. The ring 26 is cemented to the outer wall of the cylindrical portion of the lower flange 27 with acetone at a position which places the washer 32 snugly against the muscle 31 without squeezing the muscle to the point of impairment of circulation. The hide which has previously been slit into quadrants to permit insertion of the washer 32 is then sutured together. A purse string suture is then applied to the edge of the hide to draw it tightly against the outer wall of flange 27. Several sutures are put in place going through the hide, the cellulose acetate and the muscle binding all three together. Flexible liquid collodion is flowed around the outside wall of the flange 27, and the hide, making a fluid tight seal. The barrel 28 is then screwed tightly into the flange 27 against washer 33.

Postoperative technique follows those previously described in connection with the other embodiments. It can be seen that this embodiment although employing the same basic idea of a removable barrel obviates the danger encountered in nipping the muscularis too severely and possibly causing necrosis.

The above specifically described embodiments of my invention should be taken as illustrative only, as obviously many changes may be made therein without departing from the spirit or scope of the invention.

I claim:

1. A biological window to be surgically embedded in the surface tissues of a live animal to permit observation of the internal organs of the animal comprising:
   (a) a flange member having a base with an inner and an outer edge and a threaded cylindrical portion intermediate said inner and outer edges and perpendicular to the plane of said base, said cylindrical portion forming an outer lip and an inner lip on said base;
   (b) a plurality of pins adjacent the periphery of said outer lip, said pins being spaced around the cylindrical portion of the flange member and extending outwardly from said base in the same direction as said cylindrical portion;
   (c) a retaining ring having holes adapted to receive said pins;
   (d) fastening means adapted to engage said pins and fasten said ring and said flange member in place in the animal; and
   (e) a removable barrel including a sealed transparent window adapted to be screwed into the threaded cylindrical portion of said flange member until stopped by the inner lip of the base of said flange member.

2. A biological window to be surgically embedded in the surface tissues of a live animal to permit observation of the internal organs of the animal comprising:
   (a) a lower flange member having a base with an inner and outer edge and a cylindrical portion, threaded both internally and externally, intermediate said inner and outer edges and perpendicular to the plane of said base, said cylindrical portion forming an outer lip and an inner lip on said base;
   (b) an upper flange member having an outer lip and a cylindrical portion with a threaded inner wall adapted to be screwed onto the external threads of the cylindrical portion of the lower flange member thereby causing the outer lips of the lower flange member and upper flange member to juxtapose and to hold animal tissue between them; and
   (c) a removable barrel including a sealed transparent window adapted to be screwed into the interior threads of the cylindrical portion of the lower flange member until stopped by the inner lip of the base of said lower flange member.

3. A biological window as described in claim 2, wherein the outer lip of the lower flange member is perforated and thereby adapted to be sutured to adjacent animal tissue.

4. A biological window to be surgically embedded in the surface tissues of a live animal to permit observation of the internal organs of the animal comprising:
   (a) a flange member having a base with an inner and an outer edge and a threaded cylindrical portion intermediate said inner and outer edges and perpendicular to the plane of said base, said cylindrical portion forming an outer lip and an inner lip on said base;
   (b) a relatively wide flexible washer encircling said cylindrical portion;
   (c) a retaining ring encircling said cylindrical portion;
   (d) said outer lip, said flexible washer, and said retaining ring each being perforated and thereby adapted to be sutured to adjacent animal tissue; and
   (e) a removable barrel including a sealed transparent window adapted to be screwed into the threaded cylindrical portion of said flange member until stopped by the inner lip of the base of said flange member.

5. A biological window to be surgically embedded in the surface tissues of a live animal to permit observation of the internal organs of the animal comprising:
   (a) a flange member having a base with an inner and an outer edge and a threaded cylindrical portion intermediate said inner and outer edges and perpendicular to the plane of said base, said cylindrical portion forming an outer lip and an inner lip on said base;
   (b) means for attaching animal tissue to the outer lip of the base of said flange member for securing the flange member in an incision in the animal; and
   (c) a removable barrel including a sealed transparent window adapted to be screwed into the threaded cylindrical portion of said flange member until stopped by the inner lip of the base of said flange member.

6. A biological window to be surgically embedded in the surface tissues of a live animal to permit observation of the internal organs of the animal comprising:
   (a) a flange member having a base with an inner and an outer edge and a threaded cylindrical portion intermediate said inner and outer edges and perpendicular to the plane of said base, said cylindrical portion forming an outer lip and an inner lip on said base;
   (b) means for attaching animal tissue to the outer lip of the base of said flange member including a plurality of threaded pins adjacent the periphery of said outer lip, said pins surrounding the cylindrical por-
tion and uniformly spaced therefrom, and extending outwardly from the base of the flange member in the same direction as said cylindrical portion;

(c) a retaining ring having holes adapted to receive said pins;

(d) threaded nuts to fasten said retaining ring and said flange member in place in the animal; and

(e) a removable barrel including a sealed transparent window adapted to be screwed into the threaded cylindrical portion of said flange member until stopped by the inner lip of the base of said flange member.

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