

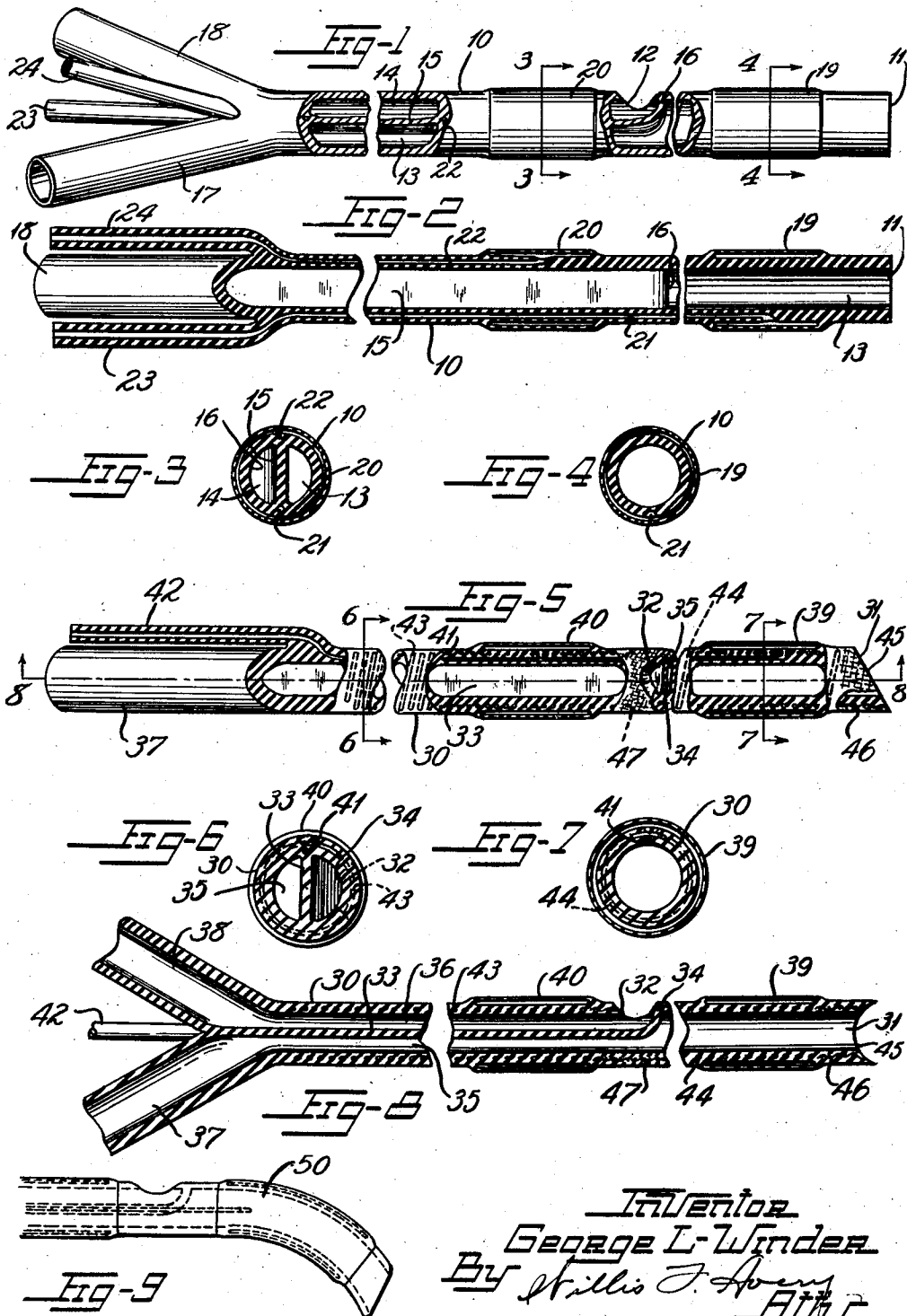
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CATHETER.

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CATHETER

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This invention relates to surgical accessories and particularly to catheters designed especially for use in broncho-spirometry.

Broncho-spirometry is a procedure recently developed for determining the functional capacity of the lungs and is particularly useful as an aid in judging the character and degree of treatment which may safely be attempted in an effort to cure pulmonary tuberculosis. In the procedure, the respiratory passages of the patient are closed and he is caused to breathe through tubes leading from the lungs to a spirometer, an instrument which measures and records characteristic factors concerning the gases inhaled and exhaled by the patient and thereby affords a basis for calculating the functional capacity of the lungs.

The devices heretofore utilized in broncho-spirometry for conducting the gases from the lungs to the spirometer have been only partially satisfactory, however, and it is accordingly the chief object of this invention to provide a wholly satisfactory catheter for use in broncho-spirometry. More specifically, it is an object of the invention to provide a compact, flexible, unitary catheter adapted to be inserted in the respiratory passages of a patient with the least possible trouble and pain to the patient and to insure against collapse of the structure as it is passed through the tortuous passages as well as while it is in use. It is a further object of the invention to provide such a catheter having separate fluid channels to communicate with the lungs individually, and to provide convenient and effective means for sealing the lungs from each other as well as from the outside atmosphere in order that the functioning of the individual lungs may be tested separately, and, if desired, simultaneously. It is a further object of the invention to provide the necessarily complicated structure of such a catheter in essentially unitary, one-piece, integral form affording maximum simplicity and safety, and contributing toward ease of thorough sterilization by eliminating all joints.

The manner in which these and other objects of the invention are attained will be apparent from the following detailed description of catheters embodying the invention in preferred forms. In the course of the description, reference will be had to the accompanying drawing, of which

Fig. 1 is an elevation showing a catheter for use in broncho-spirometry, portions of the catheter structure being broken away for clarity of illustration;

Fig. 2 is a sectional view of the catheter of Fig. 1, the section being taken through a central

plane including the two inflating ducts of the catheter;

Fig. 3 is a vertical section taken on line 3—3 of Fig. 1;

Fig. 4 is a vertical section taken on line 4—4 of Fig. 1;

Fig. 5 is an elevation showing another catheter for use in broncho-spirometry, considerable portions of the catheter structure being broken away for clarity of illustration;

Fig. 6 is a vertical section taken on line 6—6 of Fig. 5;

Fig. 7 is a vertical section taken on line 7—7 of Fig. 5;

Fig. 8 is a horizontal section taken on line 8—8 of Fig. 5;

Fig. 9 is a fragmentary elevation showing the distal end of a modified catheter generally similar to the catheters of the other figures.

The catheters illustrated in the drawing are adapted to be inserted in the respiratory passages of a patient and include appropriate separate fluid channels having separate outlets or openings for communicating with the lungs individually and also include spaced-apart inflatable sealing means with the necessary inflating ducts for sealing the respiratory passages at the required points.

Referring first to Figs. 1 to 4 inclusive, a typical catheter embodying the present invention comprises a main tubular structure 10 having an elongated configuration of sufficient length to extend through the respiratory passages of a patient at least from the mouth to a point within the main bronchus of one lung. The walls of the tubular structure 10 are provided with one opening 11 at a position adjacent the distal end of the catheter which is adapted to be positioned within the said bronchus. The opening 11 conveniently may be provided simply by leaving the distal end of the catheter open as shown. A second opening 12 is provided in the walls of the tubular structure 10 at a point proximal to the first opening 11 and which will be generally aligned with the main bronchus of, for example, the right lung when the first opening 11 is positioned within the main bronchus of the left lung. The lumen of the tubular structure is divided into two separate fluid channels 13 and 14 by means of a central partitioning web 15 extending from the proximal end of the tubular structure 10 to a point 16 between the two openings 11 and 12 at which point the web 15 curves toward and is attached to the walls of the tubular structure to terminate the channel 14. It is thus seen that the separate channels 13 and 14 communi-

cate respectively with the openings 11 and 12 at the distal end of the tubular structure 10. At the proximal end of the tubular structure, the fluid channels 13 and 14 diverge and terminate in separate tubular extensions 17 and 18 respectively, each adapted to be connected with appropriate fluid conductors such as conductors leading to separate spirometers.

For sealing the respiratory passages about the catheter, two inflatable collars 19 and 20 are provided encircling the tubular structure 10 at longitudinally spaced-apart positions, one inflatable collar 19 being positioned between the openings 11 and 12 at a position adapted to seal the main bronchus of one lung into which the distal end of the catheter is extended, and the second inflatable collar 20 being positioned proximal to both openings 11 and 12 in a position adapted to seal the trachea of a patient when the catheter is properly positioned for use.

For inflating collars 19 and 20, separate inflating ducts 21, 22 are provided extending longitudinally through the tubular structure 10 at circumferentially spaced-apart positions and communicating respectively with the inflatable collars 19 and 20. Adjacent the proximal end of the tubular structure 10, the ducts 21 and 22 diverge and terminate in separate tubular extensions 23, 24, respectively, each adapted to be connected to any appropriate conductor for supplying inflating fluid to the collars. By providing a separate inflating duct for each of the collars, the collars may be inflated individually and different pressures may be applied in the various collars.

A somewhat modified catheter embodying additional features of the invention is illustrated in Figs. 5 to 8 inclusive. In its general aspects, the catheter of Figs. 5 to 8 is similar to the previously described catheter of Figs. 1 to 4 and comprises a tubular structure 30 having an opening 31 at the distal end, a second opening 32 proximal thereto, a central partitioning web 33 extending longitudinally from the proximal end of the tubular structure 10 to a point 34 between the two openings 31 and 32 where the web joins the walls of the tubular structure 10, thereby dividing the lumen of the tubular structure 10 into separate fluid channels 35 and 36 communicating respectively with the openings 31 and 32 and which diverge at the proximal end and terminate in separate tubular extensions 37 and 38, respectively. The relative arrangement, purposes, and functions of the several elements thus far mentioned all are substantially identical with the relative arrangement, purposes and functions of corresponding elements of the catheter of Figs. 1 to 4 and will not be repeated here.

For sealing the respiratory passages about the tubular structure 30, two inflatable collars 39 and 40 similar to the collars 19 and 20 of Figs. 1 to 4 are provided at corresponding positions on the tubular structure 30, the collar 39 circling the structure 30 between the openings 31 and 32 and the collar 40 encircling the structure at a position proximal to both openings. Instead of providing a separate inflating duct for each of the collars as in Figs. 1 to 4, however, the catheter of Figs. 5 to 8 has a single inflating duct 41 extending longitudinally through the tubular structure 30 and communicating with both inflatable collars 39 and 40 for conducting inflating fluid thereto. The duct 41 diverges from the tubular structure 30 at the proximal end thereof and terminates in a tubular extension 42 adapted to be connected

with any suitable means for supplying inflating fluid under controlled pressure.

As more fully described hereinafter, the catheters of the present invention preferably are formed essentially of soft-vulcanized rubber or similar flexible material in order that the catheter may readily conform to the tortuous passages through which it must be passed. It is also desirable to make the walls of the catheter relatively thin in order to provide maximum lumen size for free passage of inhaled and exhaled gases. When this is done, however, the relatively large main tubular structure is subject to collapse and sometimes does collapse while being passed through the respiratory passages or later while being used in broncho-spirometry. Further, when the sealing collars are inflated, the catheter is subjected to localized severe collapsing pressures by the two collars and this pressure has sometimes caused the catheter to collapse at the collars.

For resisting such collapsing tendencies and for imparting a high degree of transverse rigidity to the normally collapsible tubular structure of the catheter without, however, materially detracting from its longitudinal flexibility reinforcing elements are embodied in the structure, preferably by completely embedding the reinforcing elements in the walls of the structure. A most effective combination of reinforcing elements illustrated in Figs. 5 to 8 includes a helical wire element 43 extending from the proximal end of the tubular structure 30 to a point just proximal to the opening 32. A second, similar, helical wire element 44 is provided extending from a point just distal to the opening 32 to a point at least past the distal end of the inflatable collar 39 and preferably to a point adjacent the heel of the angular distal end 45 of the catheter. The helical wire elements 43 and 44 conveniently may be formed of 0.007 inch gauge stainless steel wire and desirably should have a low but definite pitch of, for example, 20 convolutions to the inch so that successive convolutions will be definitely spaced-apart and completely surrounded by rubber or other wall material. For reinforcing the tubular structure in the zones about the opening 31 and 32, it has been found desirable to embed circumferentially extending fabric reinforcing elements 46 and 47, respectively, in the rubber. Such reinforcing elements formed of ordinary square-woven cotton fabric such as "cheesecloth" have been found to provide adequate transverse rigidity adjacent the openings and are convenient for manufacturing purposes as the fabric may either be pre-trimmed to proper size and shape before being embedded in the rubber or may be cut with the rubber in forming the openings after the tubular structure has been fabricated.

Such reinforcements providing transverse rigidity have been found to be highly desirable, if not absolutely essential, for safe and reliable use of the present type of catheter in broncho-spirometry where an undetected collapse of the tube in use obviously might seriously alter the data recorded by the spirometer and might even prove fatal to the patient, if the collapse were not detected promptly.

Any of the catheters embodying the present invention may be provided with a pre-formed and permanently-set arcuate configuration at the distal end, substantially as indicated at 50 in Fig. 9, for facilitating passage of the catheter into the bronchus of one of the lungs. Such arcuate configuration should conform generally to the

path of the respiratory passage from the trachea into the main bronchus of one lung.

The catheters of the present invention desirably are formed essentially of soft-vulcanized rubber or similar flexible material and preferably have a unitary structure in which the rubber parts present a one-piece integral structure, as such a catheter is more easily sterilized and, especially, is not subject to separation at joints while in use. The complicated structure of the present catheters including the embedded reinforcing elements may be provided by building up the various rubber portions by dipping suitable forms in liquid rubber latex and assembling the coated forms with the reinforcing elements and re-dipping. The inflatable collars may be provided by treating the desired local area or zone to prevent adhesion of subsequent dips and then applying further dips of latex. A catheter so made presents the desired one-piece unitary integral structure and exhibits the continuous grainless structure characteristic of rubber deposited in final form from latex. Although somewhat less desirable, the inflatable collars may be provided by cementing separately formed rubber membranes about the tubular structure at the proper points.

Although the catheters hereinabove described were designed particularly for use in broncho-spirometry, the principles of the invention as herein set forth obviously may be employed advantageously in catheters for other purposes and in surgical accessories in general. Likewise, numerous modifications and variations in the details herein described may be effected without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A surgical accessory comprising a tubular structure of elongated configuration having at least three longitudinal passageways each separate from the others, a plurality of inflatable collars encircling the tubular structure at longitudinally spaced-apart positions, each of said inflatable collars communicating with at least one of said longitudinal passageways for receiving inflating fluid therefrom, the walls of said tubular structure having a plurality of openings therein at longitudinally spaced-apart positions separated by at least one of said inflatable collars, each of said openings communicating with one of said longitudinal passageways and at least two of said passageways communicating with different openings, the proximal ends of said passageways being adapted to be connected with appropriate fluid conductors, said tubular structure being formed essentially of flexible rubber normally subject to collapse and having embedded therein a collapse-resisting reinforcement.

2. A surgical accessory comprising a tubular structure of elongated configuration having at least three longitudinal passageways each separate from the others, a plurality of inflatable collars encircling the tubular structure as longitudinally spaced-apart positions, each of said inflatable collars communicating with at least one of said longitudinal passageways for receiving inflating fluid therefrom, the walls of said tubular structure having a plurality of openings therein at longitudinally spaced-apart positions separated by at least one of said inflatable collars, each of said openings communicating with one of said longitudinal passageways and at least two of said passageways communicating with different openings, the proximal ends of said passageways being

adapted to be connected with appropriate fluid conductors, said tubular structure being formed essentially of flexible rubber normally subject to collapse and having embedded therein a collapse-resisting reinforcement comprising a wire helix of low but pronounced pitch so that successive convolutions of the helix are spaced-apart and completely surrounded by rubber, said helix extending at least the major portion of the length of said tubular structure.

3. A catheter for use in broncho-spirometry comprising a tubular structure adapted to extend from the mouth of a patient, through the trachea, at least to a point within the main bronchus of one lung, an inflatable collar encircling the tubular structure at a point adjacent the distal end thereof and adapted to be positioned within the said bronchus, a second inflatable collar encircling the tubular structure at a point proximal to the first collar and which will be positioned within the trachea when the first collar is within the bronchus, inflating duct means communicating with said inflatable collars for conducting inflating fluid thereto, the walls of said tubular structure having one opening distal to both inflatable collars and a second opening between the two collars, a partitioning web dividing the lumen of said tubular structure into separate fluid channels communicating, individually, with said openings, the proximal ends of said channels and of said inflating duct means being adapted to be connected with appropriate fluid conductors, said tubular structure being formed essentially of flexible rubber normally subject to collapse and having collapse-resisting reinforcements embedded therein, said reinforcements comprising a wire helix extending the major portion of the length of the tubular structure and a fabric reinforcement extending a minor portion of said length adjacent at least one of the openings in the walls of said tubular structure.

4. A catheter for use in broncho-spirometry comprising a tubular structure adapted to extend from the mouth of a patient, through the trachea, at least to a point within the main bronchus of one lung, an inflatable collar encircling the tubular structure at a point adjacent the distal end thereof and adapted to be positioned within the said bronchus, a second inflatable collar encircling the tubular structure at a point proximal to the first collar and which will be positioned within the trachea when the first collar is within the bronchus, inflating duct means communicating with said inflatable collars for conducting inflating fluid thereto, the walls of said tubular structure having one opening distal to both inflatable collars and a second opening between the two collars, a partitioning web dividing the lumen of said tubular structure into separate fluid channels communicating, individually, with said openings, the proximal ends of said channels and of said inflating duct means being adapted to be connected with appropriate fluid conductors, said tubular structure being formed essentially of flexible rubber normally subject to collapse and having collapse-resisting reinforcements embedded therein, said reinforcements comprising a wire helix extending substantially from the proximal end of the tubular structure to a point proximally adjacent to the opening in the wall thereof between the two inflatable collars, a second wire helix extending from a point distally adjacent to the said opening to a point adjacent the second opening at the distal end of the

structure, and a fabric reenforcement in the intervening region between the two helices.

- 5 A catheter comprising a tubular structure of elongated configuration adapted to be inserted in a body passage, the walls of said structure having an opening adjacent the distal end thereof and a second opening proximal to the first opening, a partitioning web dividing the lumen of said structure into separate fluid channels communicating individually with said openings, an inflatable collar encircling the tubular structure at a position between the said two openings, a second inflatable collar encircling the tubular structure at a position proximal to both said openings, an inflating duct extending longitudinally through said structure and communicat-

ing with said collars for conducting inflating fluid thereto, said channels and said inflating duct diverging at the proximal end of the tubular structure and terminating in separate tubular extensions, said catheter having a unitary structure and being formed essentially of flexible rubber normally subject to collapse but having collapse-resisting reenforcements embedded therein, said reenforcements comprising a wire helix extending for a major portion of the length of the tubular structure and a fabric reenforcement extending for a minor portion of said length adjacent at least one of the said openings in the wall of the tubular structure.

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