

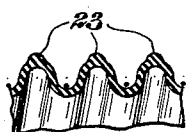
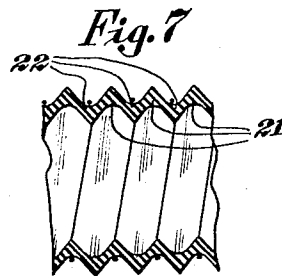
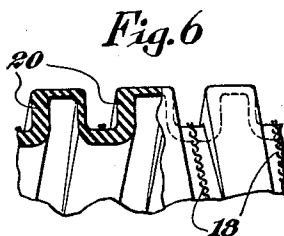
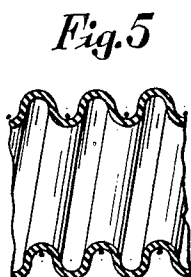
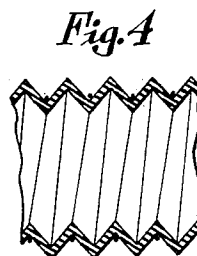
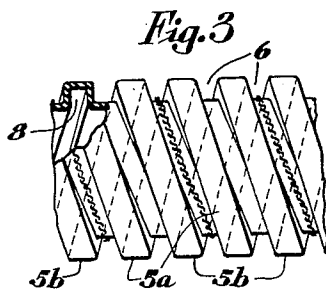
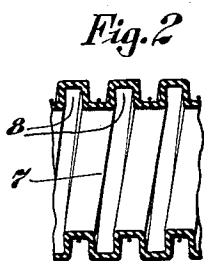
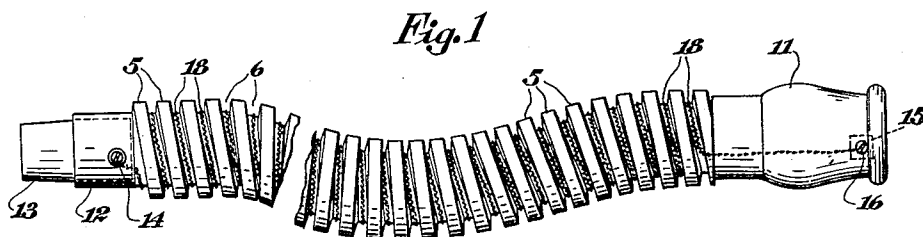
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K. CONNELL

2,073,335

BREATHING TUBE

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## UNITED STATES PATENT OFFICE

2,073,335

## BREATHING TUBE

Karl Connell, Branch, N. Y.

Application October 5, 1935, Serial No. 43,650

7 Claims. (Cl. 138-49)

This invention relates to breathing tubes.

An object of the invention is to provide a breathing tube which is flexible, non-collapsing, and of low breathing resistance, as well as having the inherent quality of being gas-tight.

A further object is to provide a breathing tube having the desirable qualities of ordinary tubes, but in which tendencies for the air to be caught in pockets and to form back eddies are decreased or eliminated.

Another object is to provide an improved breathing tube wherein electrical conducting means are provided.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, properties, and relation of elements which will be exemplified hereinafter and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a side view of a breathing tube embodying the invention;

Fig. 2 is an enlarged fragmentary longitudinal sectional view thereof;

Fig. 3 is a fragmentary side view of another form of tube;

Fig. 4 is a fragmentary longitudinal sectional view of still another form;

Fig. 5 is a similar view of an additional form;

Fig. 6 is an even more fragmentary view, illustrating a modification of the tube shown in Fig. 1;

Fig. 7 is a similar view illustrating a modification of the tube shown in Fig. 4;

Fig. 8 is a similar view illustrating a modification of the tube shown in Fig. 5; and

Fig. 9 is a fragmentary side view showing a simplified form of tube.

Breathing tubes have a wide variety of applications, including the administration of anaesthesia and other therapeutic uses, use as conduits for gas masks, such as used in war-time, and in mine rescue work, and use as conduits for gases and vapors in various fields. It is of importance in most therapeutic and protective uses that such breathing tubes be gas-tight, flexible, non-collapsing, of low breathing resistance and light in weight.

For the sake of facility of expression the term

"non-collapsing" is used herein as the equivalent of "highly resistant to collapse" and is to be so understood.

Ordinarily such tubes are composed of rubber, which for the sake of greater flexibility, is accordion pleated, with annular interior and exterior grooves, so that the inner cross sectional area varies continuously over the line of the tube. It has been found, however, that the annular interior grooves provide dead-air pockets and cause back eddies or reverse air currents which reduce the effectiveness and give rise to undesirable breathing resistance.

With a view to eliminating the foregoing and other difficulties, and to the provision of a breathing tube having a high degree of flexibility and resistance to collapse, a large capacity, and a low breathing resistance, the invention contemplates the provision of a breathing tube of helical contour.

In accordance with the invention, there is provided a tube having interior and exterior grooves disposed in staggered relationship and each continuing along the length of the tube for a substantial portion thereof. The in-and-out conformation of the tube may be provided by a single exterior groove and a single interior groove or by a plurality of each, and the grooves may have any of a variety of cross sectional contours. The spiral channel provided by the interior groove gives a swirl to the entire progressing gas currents on breathing, which tends to lower the resistance to the passage of gas, and to avoid dead-air pockets and eddy formation.

In accordance with the invention also tubes may be reinforced. When desired, by thickening such helical portions of the wall as will not interfere with the flexibility. By suitably placing such thickening means, there is obtained a greater flexibility than would be the case where an equal weight of material were evenly distributed.

In conducting combustible gas mixtures, such as of cyclo-propane and oxygen as used to induce anesthesia, it is of the utmost importance in avoiding accidental sparking that the conduit be electrically conductive from end to end, so as to keep the user and all parts of the anesthetic apparatus at the same electrical potential. To this end the invention contemplates the provision of improved means for intercoupling, across a dielectric breathing tube, such electrical condensing media as the patient and the anesthetic apparatus. In accordance with the invention an electrical conductor may be provided in one of

the exterior grooves wherein it will be in a position such that it will not decrease the flexibility of the tube, and will have no substantial tendency to cut the tube or to break. In previous tubes, wires have been run spirally or otherwise, either within the tube, imbedded in the wall or adherent to the outside. These arrangements have all been subject to disadvantages however, since wires running in the channel of the tube have been known to break and ignite the gases,—a source of the utmost danger, and since wires imbedded in the wall decrease the flexibility of the tube and tend to cut the wall and wires on the periphery of tubes are subject to abrasion and misplacement.

In Fig. 1, there is exemplified a breathing tube embodying the invention. This tube may be formed of soft rubber of the character commonly used in breathing tubes and is helical in contour, having a continuous helical projection 5 which renders the tube highly resistant to collapse during ordinary usage, and at the same time assures flexibility. Between the convolutions of the projection 5 is an exterior groove 6. The interior of the tube is composed of a central passageway 7 and a continuous interior groove 8 which is formed in the continuous projection 5 and which provides additional capacity for the tube without dead-air spaces. Such dead-air spaces are avoided by the continuity of the groove 8, which permits the air moving through the tube to spiral along the groove 8, this spiraling action being markedly assisted by the natural whirling tendencies of a moving gas. The wall of the tube may be thickened along helical lines to strengthen the same without interfering with the flexibility, as in a manner hereinafter described.

The exemplified tube is provided at one end with an integral portion in the form of a bulb or fitting 11 and at the opposite end with an integral portion 12 having inserted therein a metallic tube 13, a portion of which projects endwise. The bulb 11 is thicker and more rigid than the body of the tube and is adapted to be slipped over a metallic nipple connection on a suitable type of anesthetic apparatus; and the metallic sleeve 13 is adapted to be inserted into a fitting in a breathing mask. In order to provide an electrical connection with the mask, and thence through a connection in the mask to the patient, the end portion 12 is provided with a screw 14 extending from the outside of the tube into the metallic sleeve. In order to connect the inside of the bulbous fitting 11 with the metallic connection on an anesthetic apparatus, the bulb has molded therein a nut 15 through which a screw 16 extending from the outside to the inside of the tube may be inserted. On forcing the elastic bulb over the metallic nipple, the screw automatically makes contact with the nipple. Either the screw 16 or nut 15 may have attached thereto a short length of wire which is imbedded in the fitting 11 and which projects into the exterior groove sufficiently near its end so that the wire will not be subjected to bending stress. In order to electrically connect the two ends of the tube, a wire 18 may be secured to the short wire and be spiralled along the exterior groove, and preferably passed through the end of projection 5, to be connected with the screw 14. In this position, the wire is readily protected from breakage, but is without tendency to cut or wear the tube or to be displaced to any material extent. The only portions of the substance of

the tube through which it extends are those end portions of the projection 5 which are not subjected to bending. Not only is the conductor in such position that it is substantially free from breakage, but even if breakage occurs it is not exposed to the gases of the tube, which are commonly of an explosive nature so that a spark across the gap formed by a break would have disastrous results. The "wire" in the present instance, is in the form of a cable formed of individual wires wound together, but may be in any other suitable form, or of other suitable character. Desirably the wire or cable is made of stainless steel .020 of an inch thick and having a breaking strain of about 40 pounds.

While a single projection 5 is exemplified in Fig. 1, there may be utilized an arrangement having any suitable number of projections. In Fig. 3, there is shown an arrangement wherein the tube is formed with two projections 5a and 5b each having exterior grooves 6 therebetween and each having interior grooves 8 therein.

In Figs. 1 and 3 the cross sectional area of the exterior and interior grooves is substantially rectangular, such a form having been found to give excellent results from the standpoint of strength and flexibility. However, in various instances it is permissible or desirable to form such grooves of curved, V, or other shape. In Fig. 4, there is shown an arrangement wherein the tube has a zig-zag exterior and interior longitudinal conformation and wherein the exterior and interior grooves are generally V-shaped in cross section; and in Fig. 5 there is shown an arrangement wherein the tube has a generally curved exterior and interior longitudinal conformation and wherein the exterior and interior grooves are round in cross section.

In cases where reinforcement of the tube is desirable, the wall may be thickened along helical lines without interfering with the flexibility thereof to an extent which will render them unsatisfactory for the particular purposes for which they may be used. The portions thickened and the form and amount of thickening provided, may vary considerably.

In Fig. 6 there is shown a portion of a tube similar to the tube of Fig. 1 wherein one of the walls between the interior and exterior grooves is thickened throughout its length as at 20. By the use of such helical reinforcing means the tube has a high resistance to collapse, while the other wall-ports may be made so thin the tube is of great flexibility. A desirable thickness of the wall for anesthetic tubes employing rubber having a durometer test of 30 is .06". In such a tube a thickened portion adding .015" to the wall thickness gives a desirable reinforcement. In war mask tubes and mine rescue tubes it is preferable to use stiffer rubber, for instance, rubber of approximately tire tread quality, having a durometer test of 60 and a thickness of about .125". In this case a 20% to 25% increase in the thickness of the wall at the thickened portion may be desirable.

As above indicated the character of the reinforcement may be considerably varied. In Fig. 7 there is shown a tube having V-shaped grooves with a reinforcing fillet 21 in the base of the interior groove and a reinforcing fillet 22 of the same material as the tube, at the base of the exterior groove. In Fig. 8 there is exemplified a tube having curved grooves with a reinforcing fillet 23 at the apex of the interior groove. In this case the fillet is placed on the outside of the

wall rather than the inside of the wall.

As will be appreciated, breathing tubes have various uses wherein no electric conductor is necessary, but wherein the provision of a helical tube is of great advantage.

In Fig. 9 there is exemplified a tube which is similar to the tube of Fig. 1, except that no electric conductor is provided.

Tubes of various types to suit the requirements of various situations may be employed. A desirable type of tube of adult breathing capacity is provided by a tube, such as exemplified in Fig. 1, wherein the central passageway is  $\frac{7}{8}$ ths of an inch in diameter and having a spiral interior groove or passageway, the cross section of which is  $\frac{3}{8}$ ths of an inch in both directions and revolves about  $2\frac{1}{2}$  times to the inch. In this case, the interior spiral passageway has a carrying capacity about 40% of the carrying capacity of the central passageway. It has been found that the spiral passageway should preferably add between about 16% and about 50% to the diameter of the central passageway and between about 10% to about 80% to the area of the central passageway, to provide the best capacity and flexibility.

Tubes such as contemplated by the invention may be formed in the manner and by apparatus such as disclosed and claimed in my co-pending application, Serial No. 119,384, filed January 7, 1937, which is a division of this application, or by any other suitable procedure or apparatus. When a tube is formed between dies and a mandril, helical reinforcing means such as shown at 20 and 23, if employed, may be provided by so forming or disposing the mandril or dies as to provide such reinforcement along the desired helical lines, or, if desired, rubber fillets or other reinforcement, may be applied by hand or by suitable mechanical means after the tube has been stripped from the mandril.

Since certain changes in the above articles which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

The invention claimed is:

1. A flexible non-collapsing breathing tube substantially composed of rubber and having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, said side having a lateral extent which is at least substantially as great as the lateral extent of the groove at any other point thruout the depth of the groove.

2. A flexible non-collapsing breathing tube substantially composed of rubber and having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, said side having a lateral extent which is at least substantially as great as the lateral extent of the groove

at any other point thruout the depth of the groove, a helically extending wall portion of said tube being thickened to reinforce the tube.

3. A flexible non-collapsing breathing tube substantially composed of rubber and having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, said side having a lateral extent which is at least substantially as great as the lateral extent of the groove at any other point thruout the depth of the groove, the depth of said helical passageway or passageways being at least  $\frac{1}{16}$ th of the overall diameter of the tube.

4. A flexible non-collapsing breathing tube substantially composed of rubber and having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, said side having a lateral extent which is at least substantially as great as the lateral extent of the groove at any other point thruout the depth of the groove, the helical passageway or passageways having a depth of not over about 50% and not less than about 16% of the diameter of the central passageway.

5. A flexible non-collapsing breathing tube substantially composed of rubber and having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, said side having a lateral extent which is at least substantially as great as the lateral extent of the groove at any other point thruout the depth of the groove, and said tube having an electrical conductor wound in an external helical groove.

6. A flexible non-collapsing rubber breathing tube having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, the lateral walls of the grooves meeting the bottom walls thereof at a substantially sharp angle whereby a high degree of flexibility and resistance to collapse is secured.

7. A flexible non-collapsing rubber breathing tube having an outer wall of helical contour providing grooved outer and inner surfaces and a direct central passageway, the grooved inner surface providing at least one helical passageway one side of which opens into said central passageway, the lateral walls of the grooves meeting the bottom walls thereof at a substantially sharp angle whereby a high degree of flexibility and resistance to collapse is secured, at least one of said walls of the grooves being thickened to a greater extent than the remaining walls to reinforce said tube.

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