

[54] **METHOD AND APPARATUS FOR AIDING SEVERED NERVES TO JOIN**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 193,389, Oct. 28, 1971, abandoned.

[52] U.S. Cl. **128/334 R, 128/346**

[51] Int. Cl. **A61b 17/04**

[58] Field of Search 128/334 R, 334 C, 346, 1, 298, 128/299

[56]

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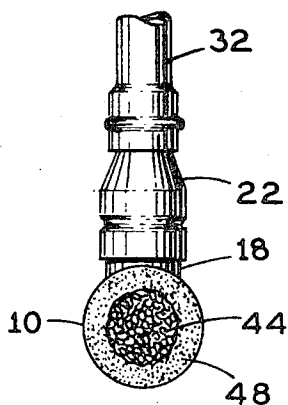
Attorney, Agent, or Firm—Oltman & Flynn

[57]

ABSTRACT

Method and apparatus in which severed nerve ends are placed inside a tube which aligns the nerve ends and guides them to promote joining of the nerve ends. An ambience may be provided inside the tube which further promotes joining of the nerve ends.

11 Claims, 19 Drawing Figures



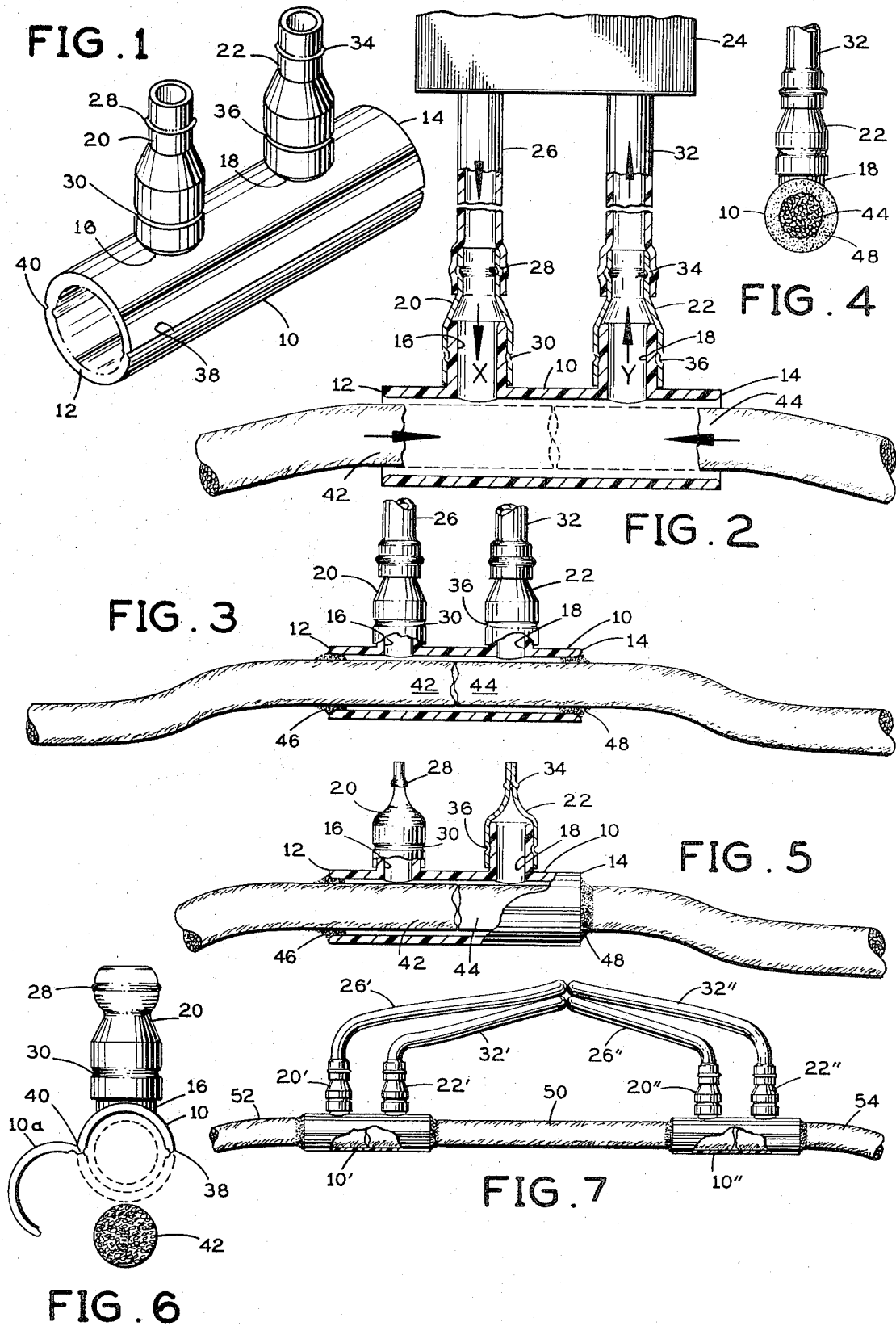


FIG. 8

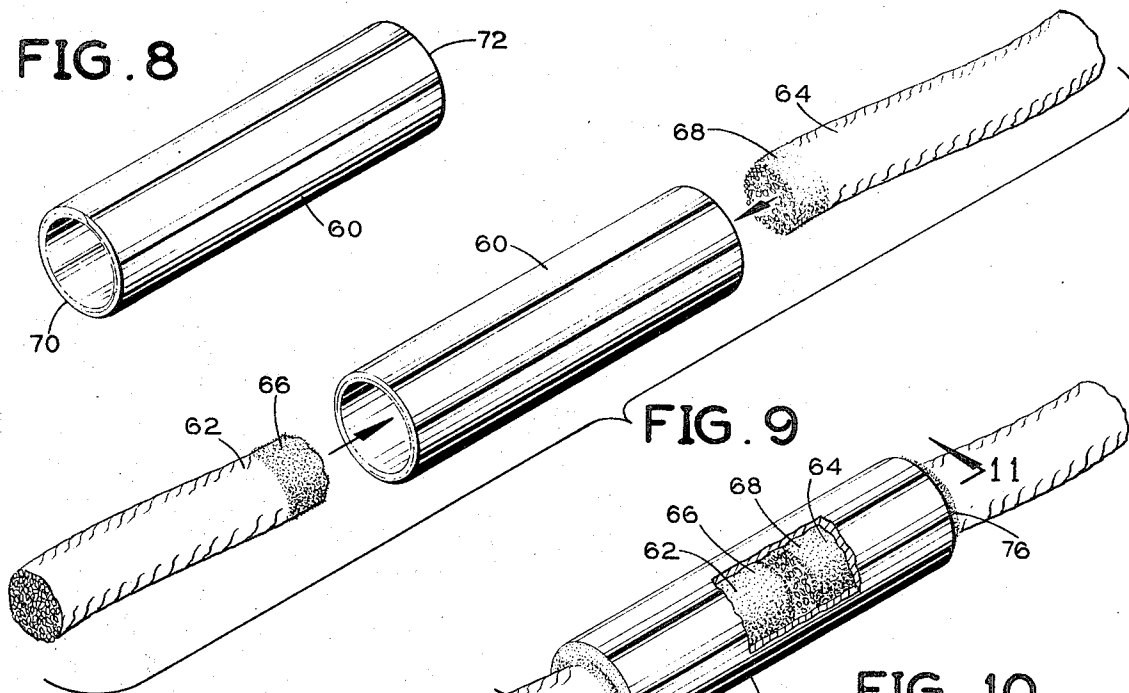


FIG. 9

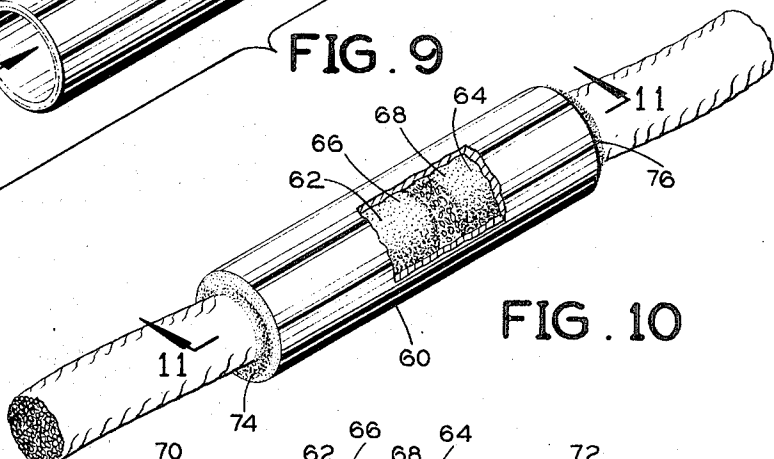


FIG. 10

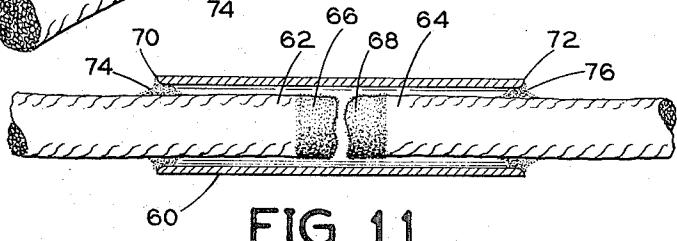


FIG. 11

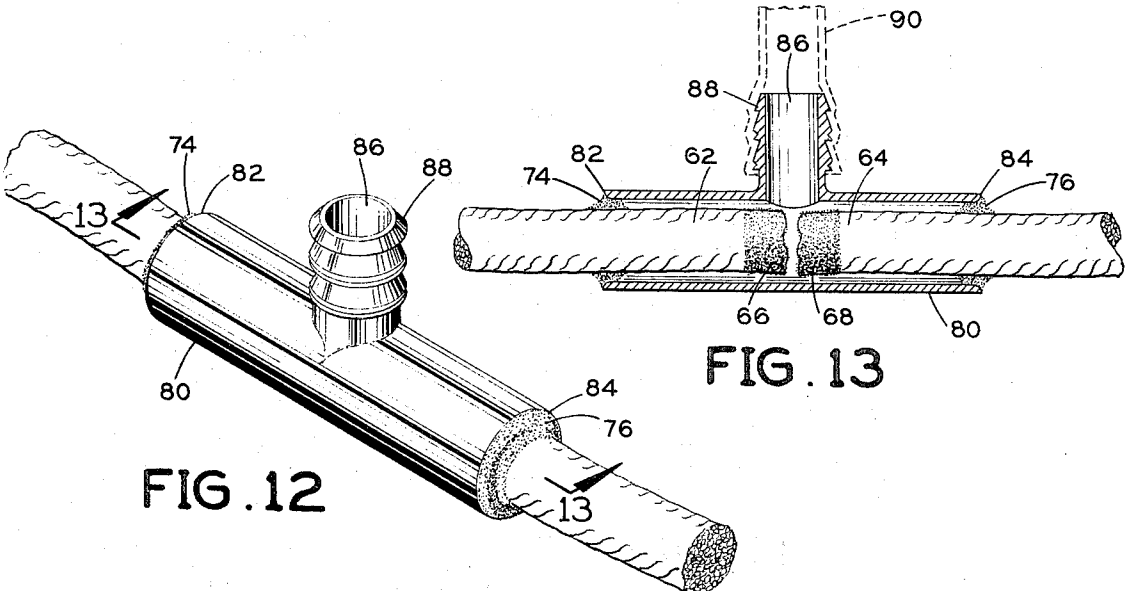
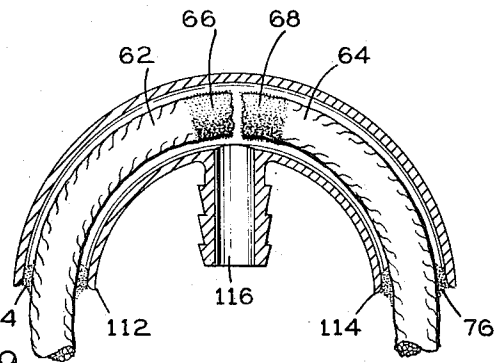
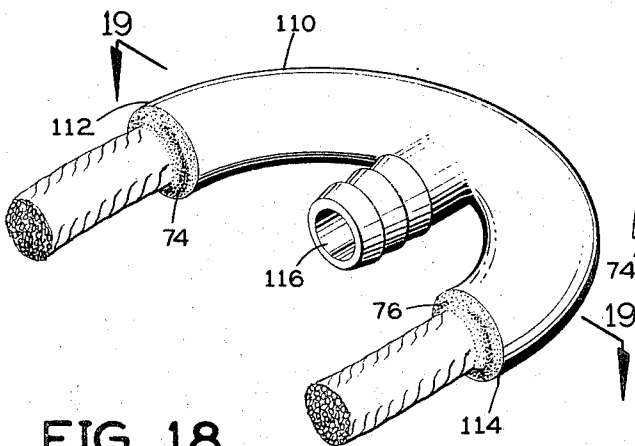
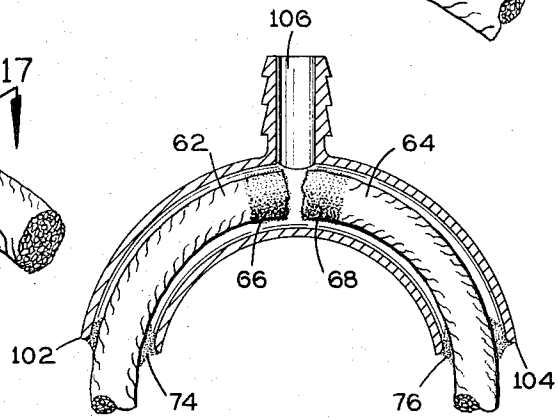
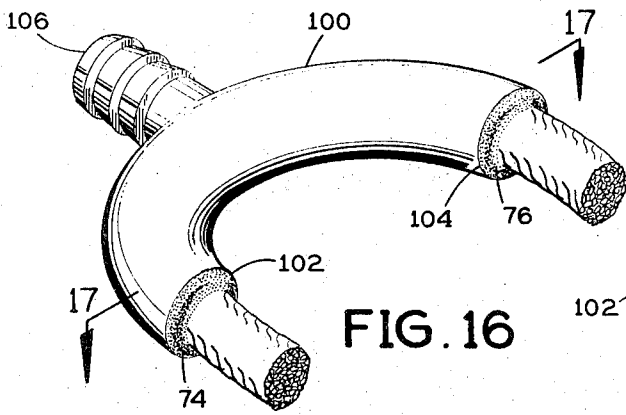
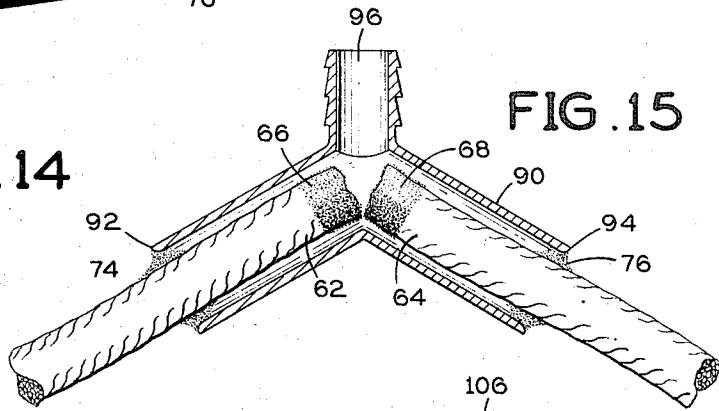
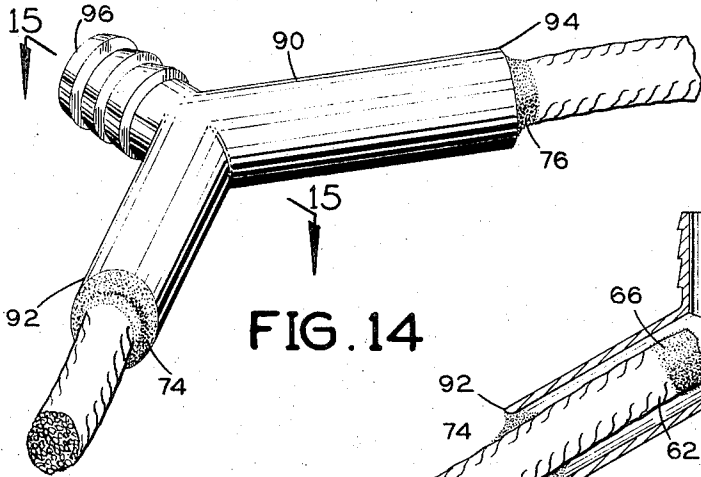


FIG. 12

FIG. 13



METHOD AND APPARATUS FOR AIDING SEVERED NERVES TO JOIN

RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 193,389 filed on Oct. 28, 1971, now abandoned.

BACKGROUND OF THE INVENTION

Nerve cells are generally considered to be non-reproducing. In some cases, however, it has been found that if severed nerves are aligned with each other they will heal. It has also been found that if a fine needle is put into a nerve, an area of damage is created that will not conduct impulses. The subject does not feel pain from the area in which the fibers have been destroyed. However, it has also been found that a percentage of subjects get a return of pain, and in these cases it is obvious that the nerve fibers are working again. Thus, it appears that in some cases, damaged nerve fibers do heal.

SUMMARY OF THE INVENTION

The present invention is directed to increasing the chance that severed nerve ends will join by placing the nerve ends in proximity inside a tube which guides them so that they can join. An ambience may be provided around the nerve ends inside the tube which further increases the chance of their joining.

The invention will be explained with reference to the accompanying drawings which illustrate preferred embodiments of the method and apparatus of the invention.

ON THE DRAWINGS

FIG. 1 is a perspective view of a tube in which nerve ends are placed, the tube having an inlet and an outlet at the side thereof in accordance with one embodiment of the invention;

FIG. 2 is a sectional view illustrating the nerve ends being placed in the tube and also showing a supply of non-oxidizing fluid and means for introducing the fluid into the inlet and withdrawing fluid from the outlet of the tube;

FIG. 3 is a sectional view similar to FIG. 2 showing the nerve ends in contact with each other at the center of the tube;

FIG. 4 is a cross section of the tube showing nerve fibers therein;

FIG. 5 is a cross section similar to FIG. 3 but showing tips on the inlet and outlet after they have been squeezed closed;

FIG. 6 is a schematic view showing how the tube can be ruptured to remove it from the nerve ends after they have joined;

FIG. 7 is a view illustrating how two tubes can be used in transplanting a section of nerve tissue;

FIGS. 8 through 11 illustrate a simplified embodiment wherein severed nerve ends are treated with a healing substance and place inside a simple tube which aligns and guides them to promote joining of the nerve ends;

FIG. 12 is a perspective view illustrating a modification of the tube to provide another embodiment of the invention;

FIG. 13 is a cross sectional view taken along line 13—13 of FIG. 12 and looking in the direction of the arrows;

FIG. 14 is a perspective view illustrating another modification of the tube to provide another embodiment of the invention;

FIG. 15 is a cross sectional view taken along line 15—15 of FIG. 14;

FIG. 16 shows a curved tube in accordance with a further embodiment;

FIG. 17 is a cross sectional view taken along line 17—17 of FIG. 16;

FIG. 18 is a perspective view similar to FIG. 16 but showing an opening in different locations; and

FIG. 19 is a cross sectional view of the embodiment of FIG. 18.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

DETAILED DESCRIPTION

The apparatus of the embodiment illustrated in FIGS. 1—7 includes a tube 10 having open ends 12 and 14 into which the severed ends of a nerve can be inserted. The inside diameter of the tube is slightly greater than the diameter of the nerve ends. The tube 10 has an inlet 16 leading into a side of the tube and an outlet 18 leading out from a side of the tube. The inlet and outlet are utilized to introduce fluid into and withdraw fluid from the tube as will be explained. The inlet and outlet 16 and 18 preferably have tips 20 and 22 which can be closed by squeezing and these tips 20 and 22 may be in the form of metal sleeves fitting on the inlet and outlet as shown.

The apparatus also includes a source 24 of a fluid or other substance. The fluid may be a liquid such as saline solution, or a gas such as nitrogen. Alternatively, an electrolyte may be introduced to conduct nerve impulses. The electrolyte may be a gel, powder or solid. Other substances may be used. A conduit 26, such as rubber tubing, leads from the source 24 to the inlet 16, and the end of conduit 26 fits on the tip 20 as shown. Tip 20 may have a ridge 28 projecting out around its circumference to help secure the conduit 26 to the tip 20. Tip 20 may have another depressed ridge 30 at its lower end engaging the outlet 16 to secure the tip in place. Another conduit 32 leads from the outlet 18 to the source 26, and the lower end of conduit 32 fits on the tip 22 as shown. Tip 22 also has an outwardly projecting ridge 34 over which the end of the conduit 32 fits to help hold the conduit in place. An inwardly projecting ridge 36 is provided at the lower end of tip 22 to engage the outlet 18 and help hold the tip 22 in place.

The tips 20 and 22 are preferably of metal and can be closed by squeezing in the manner shown in FIG. 5 where the upper ends of the tips 20 and 22 have been pinched shut. These upper ends may be squeezed with a cold welding tool which cold welds the tips closed.

The tube 10 may have grooves 38 and 40 extending along its length on opposite sides, and the tube can be

ruptured at one or both of these grooves in the manner shown in FIG. 6. When it is desired to remove the tube from the nerve ends after they have joined, the tube is squeezed to rupture it along at least one of the grooves 38 and 40. As shown in FIG. 6, a section 10a of the tube can then be peeled from the nerve, and the whole tube can be removed.

The steps of the first method embodiment are illustrated in FIGS. 2 through 6 inclusive. Referring first to FIG. 2, the ends 42 and 44 of a severed nerve are inserted into the ends 12 and 14 of the tube 10 until the nerve ends 42 and 44 are close to each other or touch each other at the center of the tube as shown by the dashed lines in FIG. 2. The inserting of the nerves may be aided by applying suction to one or both of the tips 20 and 22. If suction is applied to one tip only, the other tip is closed. The suction could be applied to the tips alternately to draw first one nerve end toward the center of the tube and then draw the other nerve end toward the center.

The source 24 of fluid (preferably nitrogen) is brought into the vicinity of the tube 10, and the supply conduit 26 and the exhaust conduit 32 are attached respectively to the tips 20 and 22. Liquid could be used rather than gas, but the invention will be described referring to gas. Valves may be provided in the conduits 26 and 32 (valves not shown), but in any event gas is introduced from the source 24 through conduit 26 and inlet 16 into the tube 10, and gas is withdrawn from the tube through outlet 18 and conduit 32 to flow back to a vent or exhaust connected with the source 24.

Before the gas is introduced into the tube 10, the ends 12 and 14 of the tube are sealed with medical sealing material as shown at 46 and 48 on FIG. 3. Then, when gas is flowing along the path indicated by the arrows X and Y in FIG. 2, the gas does not escape from the ends 12 and 14 of the tube. The gas flows in the inlet 16, around the nerve ends 42 and 44 inside the tube, and out the outlet 18. The gas provides an atmosphere inside the tube which is not harmful to the nerve ends and thus helps the nerve ends to join together.

The next step is illustrated in FIG. 5. In this step, the tips 20 and 22 are closed by squeezing them as previously mentioned. It is possible to actually cold weld the tips closed to prevent escape of gas. In order to accomplish this, the squeezing operation is preferably carried out with a cold welding tool. It is believed, however, that cold welding is not absolutely essential, and that a satisfactory seal of the tubes 20 and 22 can be achieved without cold welding. For example, it is possible to apply medical sealing material to the upper ends of the tips 20 and 22 after they have been squeezed shut to assure that the tips are fully sealed.

After the tips 20 and 22 have been sealed, the non-oxidizing fluid is completely sealed inside the tube 10. The conduits 26 and 32 are removed from the inlet and outlet. The area of the body at which the nerve ends have been exposed may then be closed with the tube 10 inside. After an extended period of time during which the nerve ends are allowed to heal and join together, the area is again opened to expose the tube 10.

The tube 10 is next removed from the nerve ends where they have joined in the manner shown in FIG. 6. One way of removing the tube is to squeeze it so that it will rupture along the grooves 38 and 40. For this purpose, the tube is preferably made of a relatively brit-

tle plastic material. However, the tube may also be removed by slicing it and opening it up.

FIG. 7 illustrates that a nerve segment or section 50 may be transplanted to two nerve ends 52 and 54 by using two of the tubes 10' and 10''. The tubes 10' and 10'' are identical to the tube 10 shown in FIG. 1. The purpose of FIG. 7 is merely to illustrate that a tube 10' is placed at one end of nerve section 50 where it joins nerve end 52, and another tube 10'' is placed at the other end of nerve section 50 where it joins nerve end 54. Fluid is introduced into each of the tubes 10' and 10'', and they are sealed in the manner described previously. After the nerves have joined inside the tubes, the tubes are removed.

FIGS. 8 through 11 illustrate a simplified method embodiment of the invention. FIG. 8 shows a simple tube 60 in which severed nerve ends may be placed as shown in FIGS. 9, 10 and 11. The tube 60 has a diameter slightly greater than the diameter of the nerve ends 62 and 64. By way of example, the tube 60 may be made of a soluble substance which can be absorbed in the body. Such soluble materials are sometimes used for making pills or capsules, and the same material can be used for the tube 60 as well as the other tubes illustrated herein.

In the embodiment of FIGS. 8-11, the nerve ends 62 and 64 are treated with a healing substance as shown at 66 and 68. The invention is not directed to the nature of the healing substance, but it will be understood that the substance may be in solid form such as a powder, or in liquid form. A liquid can be sprayed onto the nerve ends 62 and 64.

The nerve ends are then placed in proximity to each other inside the tube 60 as shown in FIG. 10. The nerve ends may be inserted as with tweezers or other manipulating means, if desired. The treating substance at 66 and 68 provides an ambience around the nerve ends inside the tube 60 which promotes healing and joining of the nerve ends. The tube 60 aligns the nerve ends with each other and guides them to promote joining of the nerve ends.

The openings of the tube at 70 and 72 may be sealed with a medical sealing material as shown at 74 and 76. It is believed to be desirable to seal the openings 70 and 72, but it may not be essential.

Referring to FIGS. 12 and 13, the tube 80 is used to replace the tube 60 of FIGS. 8-11, but the method is carried out in substantially the same manner. The tube 80 may be made of soluble material in accordance with the previous description. The tube 80 has open ends 82 and 84, and the nerve ends 62 and 64 are inserted through the open ends 82 and 84. In accordance with the previous description, the nerve ends 62 and 64 may be treated with a healing substance 66 and 68. The tube 80 has a third opening 86 formed by a stem 88. The stem 88 may be serrated as shown to receive and hold tubing 90 as shown in FIG. 13. The purpose of the stem 88 is to allow suction to be applied to the stem while the nerve ends 62 and 64 are being inserted into the openings 82 and 84 so as to suck the nerve ends into contact or proximity with each other inside the tube. Vacuum is applied through the tubing 90 for this purpose. After the nerve ends have been inserted, the openings 82 and 84 are sealed with medical sealing material 74 and 76 in accordance with the previous description, and this same sealing material may be applied over the opening 86 to seal that opening.

Again, the invention is not limited to the nature of the particular substance which is applied to the nerve ends at 66 and 68. A healing substance is envisioned, and the substance may be solid or liquid. In the embodiment of FIGS. 12 and 13, it is also envisioned that gaseous substance may be drawn through the openings 82 and 84 while the nerve ends are being inserted, with this introduction of gaseous substance being promoted by suction applied to the opening 86. Similarly, a gaseous substance could be introduced into the tube 60 in the method carried out in accordance with FIGS. 8 through 11 if the insertion of the nerve ends is carried out in a gaseous ambience other than air.

FIGS. 14 and 15 illustrate a tube 90 having open ends 92 and 94 and a third opening 96. This tube 90 is very similar to the tube 80 of FIGS. 12 and 13, the only difference being that the tube 90 is angled rather than being straight. The method of the invention is carried out using the tube 90 is exactly the same way as has been described in connection with FIGS. 12 and 13, so this description will not be repeated.

FIGS. 16 and 17 illustrate another embodiment of the tube, and this embodiment is designated 100. The tube 100 has open ends 102 and 104, and a third opening 106. The tube 100 is also very similar to the tube 80 of FIGS. 12 and 13, the only difference being that the tube 100 is curved rather than being straight. The method of the invention is carried out using the tube 100 in exactly the same manner as has been described in connection with FIGS. 12 and 13, so this description will not be repeated.

FIGS. 18 and 19 illustrate a tube 110 which is almost identical to the tube 100 except that the opening 116 is provided on the inside of the curve rather than the outside of the curve. The ends 112 and 114 are also open. The method of the invention is carried out using the tube 110 exactly in accordance with the description of FIGS. 12 and 13, so this description will not be repeated.

Thus, the invention provides a method and apparatus which increases the chance that severed nerves will join together by guiding the nerves into contact with each other in an ambience which promotes healing and joining of the nerves.

Having thus described my invention, I claim:

1. A method for aiding severed nerves to join, comprising the steps of:

- a. placing the severed nerve ends in proximity to each other inside a tube having open ends and having an inlet and an outlet between said open ends,
- b. sealing said open ends of said tube where said nerve ends enter the same,

c. introducing fluid through said inlet into said tube about said nerve ends therein and withdrawing fluid from said outlet to provide a healing ambience in said tube, and

d. sealing said inlet and said outlet to trap said fluid in said tube for aiding the nerve ends to join in said tube.

2. The method as claimed in claim 1 including the additional step after step (d) of rupturing said tube and removing the same from the nerve ends after they have joined.

3. The method as claimed in claim 1 in which said inlet and said outlet have metal tips, and said step of sealing said inlet and outlet is carried out by squeezing said metal tips to close the same.

4. The method as claimed in claim 3 in which said squeezing of said tips cold welds said tips closed.

5. Apparatus for aiding severed nerves to join, said apparatus comprising a tube having opposite open ends into which the nerve ends can be inserted, the inside diameter of the tube being slightly greater than the diameter of the nerve ends, an inlet leading into a side of said tube, and an outlet leading out from a side of said tube, and means to supply fluid into said tube through said inlet and to withdraw fluid through said outlet.

6. The apparatus as claimed in claim 5 in which said inlet and said outlet have metal tips which can be closed by squeezing the same.

7. The apparatus as claimed in claim 5 in which said means to supply fluid into said inlet and means to withdraw fluid from said outlet includes a source of non-oxidizing gas and tubing connected to said source and to said inlet and outlet.

8. The apparatus as claimed in claim 8 in which said gas is nitrogen.

9. The apparatus as claimed in claim 8 in which said inlet and said outlet have portions capable of being squeezed closed to trap said gas in said tube.

10. Apparatus for aiding severed nerves to join comprising a tube having opposite open ends into which the nerve ends can be inserted, the inside diameter of the tube being slightly greater than the diameter of the nerve ends, an inlet leading into said tube at one side thereof between said opposite open ends, and an outlet leading into said tube at said one side thereof between said opposite open ends.

11. Apparatus according to claim 10, wherein said inlet and said outlet extend transverse to said tube and are substantially aligned with each other longitudinally of the tube.

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