

Jan. 19, 1971

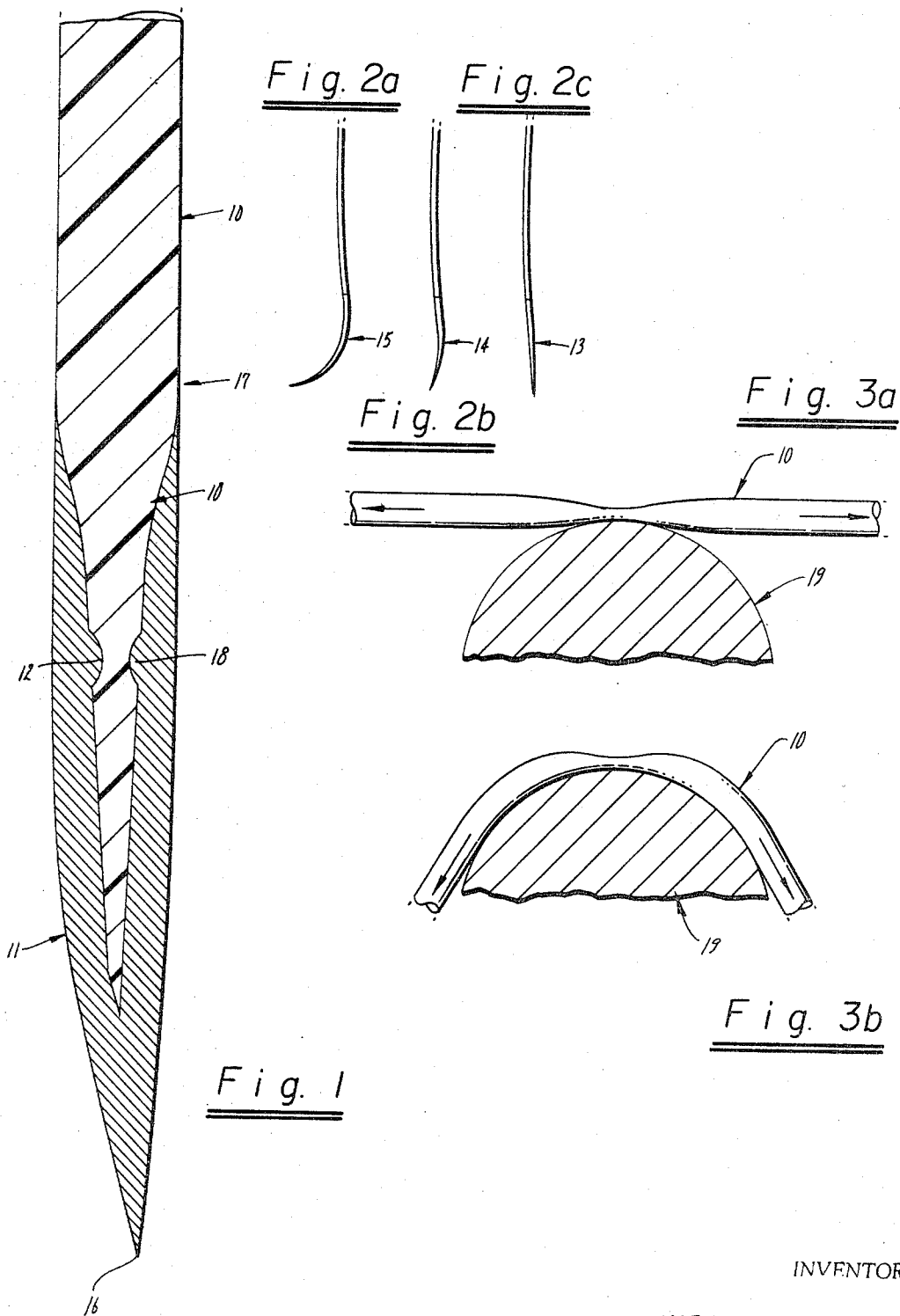
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3,556,953

MICROSURGERY SUTURE-NEEDLE AND OF ITS METHOD OF MANUFACTURE

Filed Oct. 19, 1964

3 Sheets-Sheet 1



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Fig. 4

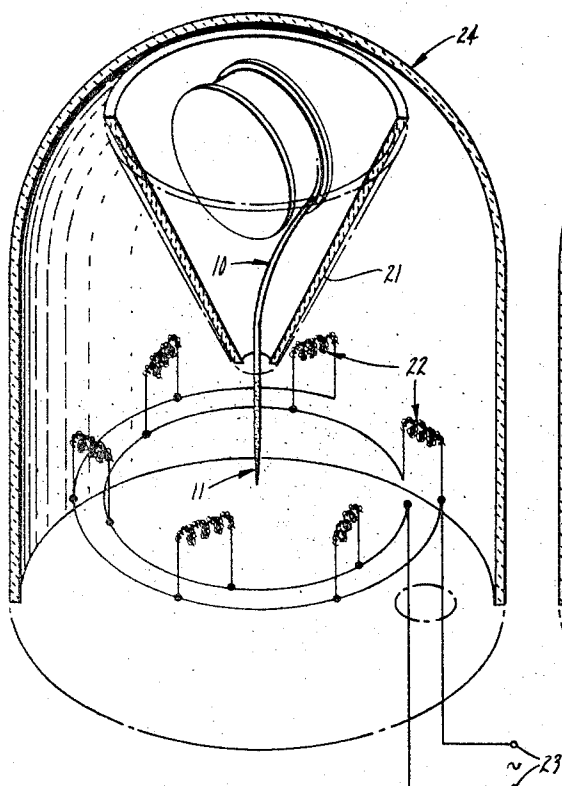


Fig. 5

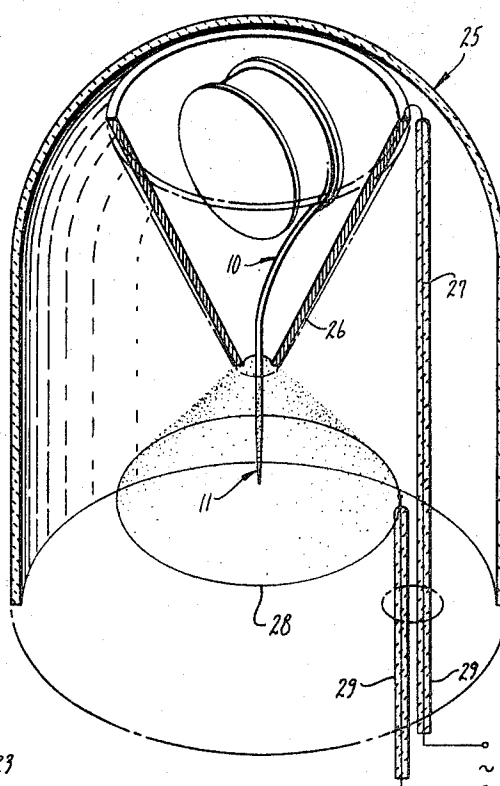
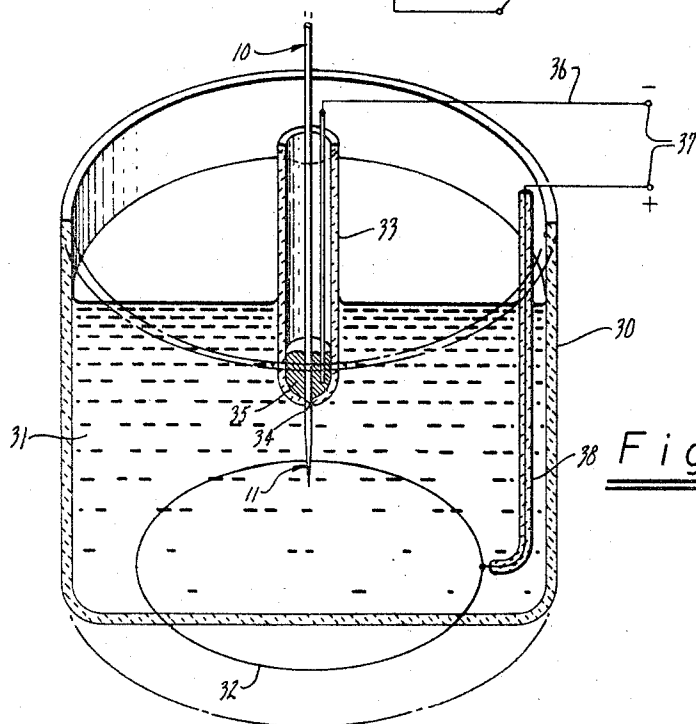


Fig. 6

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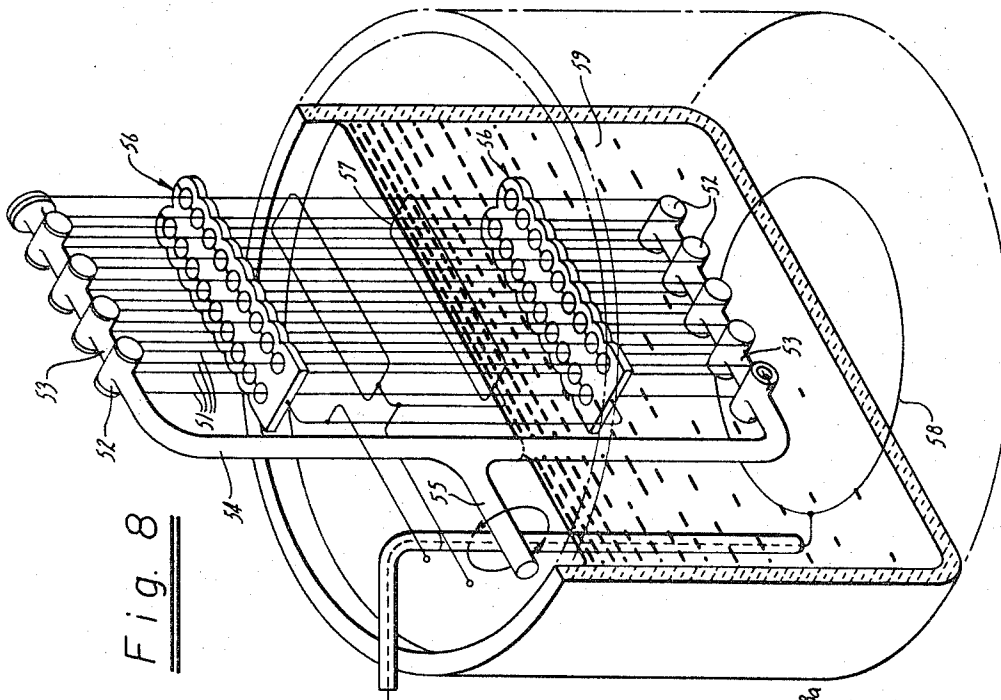
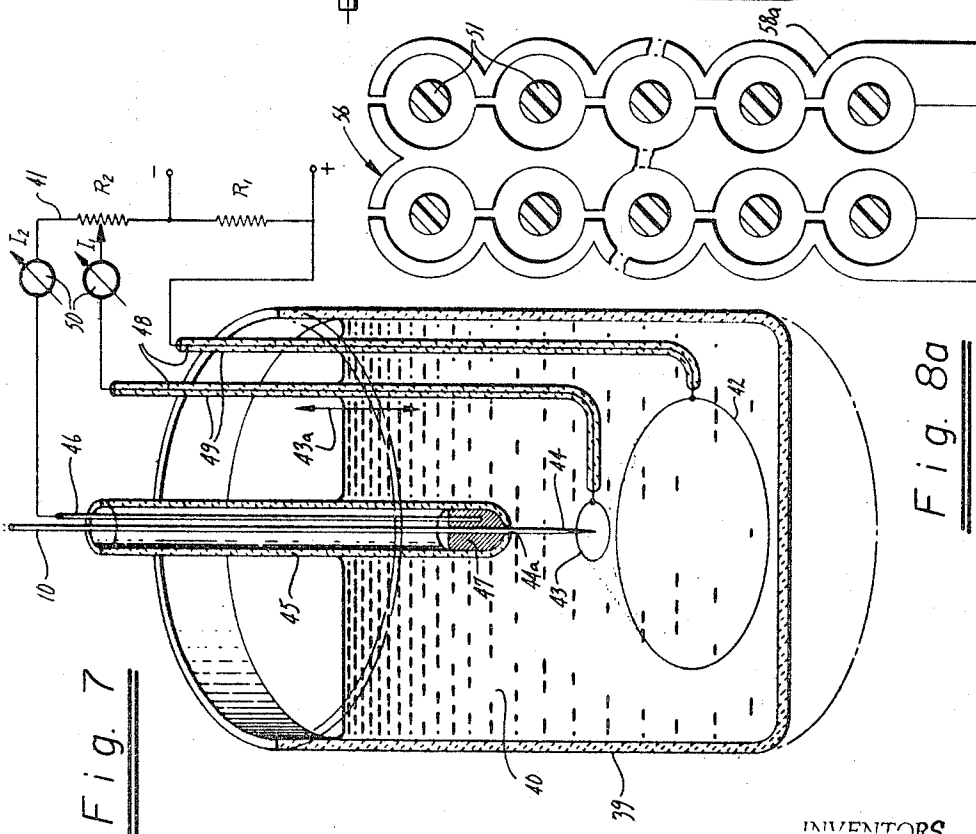
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# MICROSURGERY SUTURE-NEEDLE AND OF ITS METHOD OF MANUFACTURE

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3. Sheets-Sheet 3



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## MICROSURGERY SUTURE-NEEDLE AND OF ITS METHOD OF MANUFACTURE

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13 Claims

### ABSTRACT OF THE DISCLOSURE

A process of manufacturing microminiature suture-needles whose cross sectional diameters are as small as 5 to 8 microns. They are useful in performing surgical operations where very small blood vessels or other delicate tissue must be sewn together. The steps of this process are initially to form and shape a non-conductor material strand and then to plate it and finish it, so that the plated part and the rest of the strand become an integral unit which is called a suture-needle.

The steps of the process include bending the suture around a mandrel such as a heated graphite rod, cutting the suture to form a point, deforming the point to increase the adhesion of a subsequently applied metal coating by etching or indentation, and then metallizing the point to form a needle of approximately the same diameter as the suture and integral with the suture.

The steps of the process include bending the suture and primarily, though not exclusively, to micro surgery suture-needles and to their method of manufacture.

Various types of needles and sutures have been well known in human and animal surgery for the purpose of sewing many kinds of tissues. The finer the tissue or the smaller the artery, vein, or blood vessel, the more important it is to find appropriate delicate means to mend any kind of injury inflicted upon them.

Some of the prior solutions used heretofore to sew together human and animal tissue consisted of reduced-size, ordinary needles made of stainless steel, tempered steel, or steel alloys. Their shape could be straight, ski-type, or hook type. Regardless of the shape adopted, however, there is a limit as to how large a needle can be used in order to accomplish minute repairs. For instance, if a blood vessel is two millimeters in diameter, or even one millimeter, it would seem clear that the chances of aggravating the damage to this blood vessel are greater than if a proportionally smaller needle is used. That is to say, the finer the needle the less additional injury is produced during the repair of a very small blood vessel. This is particularly important with blood vessels where any trauma to the intima or the endothelial lining of the vessel will induce clot formation and thrombosis of blockage of the lumen.

In addition to needles, other methods and devices have been used for the purpose of sewing human or animal tissue. In the stapler method, the tissue to be sewn is everted or lifted up over a fitting. Then staples are driven across two opposing and lifted portions of broken tissue. In this manner, the tissue is held together. In other methods, a severed vein or blood vessel can be held together by a metallic bushing placed exactly at the break. Other approaches make use of various types of glues in order to repair tissues.

In all these methods and devices, there are some significant disadvantages which prevent the proper healing of the damaged tissue. In the large needle method, the large holes made produce disproportionate additional trauma to the tissues. In the stapler method and in the external bushing technique, the metallic elements introduced hinder

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the dynamic variations in size of the veins or blood vessels in accordance with vascular movements or temperature changes. In addition, a metallic joint may actually prevent the free passage of blood, because it is incapable of expanding and contracting in accordance with the larger or smaller volume of blood being pumped through the veins and blood vessels. In the case of the various types of glues, as well as in all the other methods above mentioned, most of the substances introduced in the system are toxic to living tissue or create a "foreign body reaction."

Accordingly, a device is needed and a method of producing such a device, which will make possible the sewing together of very small pieces of human or animal tissue or very small blood vessels, while positively contributing to the process of healing by creating minimal additional trauma and introducing in a system a minimal amount of foreign body material.

In addition, this device and the method of producing it should eliminate the problems heretofore associated with the large holes caused by the relatively large needles previously employed. It should also remove the problems connected with the difficulty found in threading the needles formerly used whether they may be those with a hole which is located at one end and transverse to the axis of the needle or those with a hole located also at the end but right into its longitudinal axis of the needle. Furthermore, it does away with the problems resulting from the abnormal functioning of the veins or tissue because of the introduction of metallic non-resilient joints exactly at the place where the damage is being repaired. Moreover, it removes the problems related to the introduction of toxic substances in human or animal organisms at a location where the damaged tissue needs healing aids and medication. Finally, and of the greatest importance, this approach to the manufacture of surgical needles does away with the old concept that instruments designed for surgical sewing must be simply a reduced-size bar stock needle with a hole at one end through which or into which the suture itself is threaded.

The importance of this invention will stand out in relief by pointing out that it will be used in microminiature surgery operations. The term microminiature has been reserved to describe repairs on arteries and veins whose outside diameter is 0.040 inch and even smaller. Vessels of this size are extremely delicate in texture and have a wall thickness of 0.001 to 0.003 inch in thickness. their cross sections expand and contract as much as 200% in response to changes in blood pressure and other local stimuli. Any repair to such vessels must leave unaltered the dynamic and expansible characteristic of healthy tissue. For this reason, repairs must be accomplished with a flacid and fine material that will stay in position comfortably without distorting the vessel wall. In addition, the union must be hydrostatically and hemostatically sound, and completed in such manner that there is intima (the lining of the vessel) to intima contact throughout the union.

For all these reasons, this invention is uniquely suited for such repairs, because the transition from the tip to the suture of the suture-needle is almost of the same diameter as the suture itself. This contention becomes clear if it is noted that monofilament nylon of 0.0005 inch in diameter, whose tip is metallized to a micropoint by the techniques hereinafter described, has proved in experiments to be an ideal device for such repairs. Furthermore, these suture-needles, whether straight or ski-type, require less manipulation in order to reposition them in the needle holder, ready for the next stitch. In addition, their microscopic tip point facilitates the penetration of tissue to be sewn.

In order to accomplish these repairs, stay sutures of the everting horizontal mattress variety are first placed on either side of the vessel and are held there by an atraumatic microclamp. Next, running everting horizontal mattress sutures are placed between the stay sutures, first on the anterior surface, then on the posterior surface after rotating the clamp 180 degrees. The fine point and small diameter of this invention produce minimal trauma to the tissue and prevent leakage from the holes made by the suture. Furthermore, the fine flexible materials of the filament do not distort the union, while the everting mattress suture produces eversion of the vessel ends and ensures intima to intima contact. In contrast, larger needles produce proportionally greater trauma, leakage throughout the suture holes, and small clot formations, which lead to thrombosis at the site of the anastomosis. Moreover, thicker sutures distort the anastomosis because they are not as flexible as the tissues being repaired.

For all these reasons, while prior methods and instruments for sewing damaged human and animal tissue may be satisfactory in some types of surgical sewing, they leave much to be desired when the torn tissues or blood vessels are very small or where the space to perform an operation is very limited.

Consequently, it is a general object of the present invention to provide a device which is sufficiently small to perform very delicate sewing operations of animal tissue such as veins, blood vessels, cornea tissue, inner-ear sewing, etc.

Another general object of this invention is to provide a method of producing a very small surgical suture-needle which is reliable, inexpensive, and easy to handle in surgical sewing.

Another feature of this invention is to provide a suture-needle whose size is sufficiently small to enable a surgeon to operate on minute blood vessels or tissue being repaired, while causing minimal additional trauma.

A further feature of this invention is to provide a suture-needle which will save a considerable amount of time in preparing for surgical sewing because there is no threading to be done at any time, either during the manufacturing stages as it happens with the needles with a hole located longitudinally to its axis of figure or just before an operation as is the case with needles with a hole located transversally.

Another feature of this invention is to provide a suture-needle that will save time during a surgical operation because it will be possible to maneuver it within very small spaces and on very small portions of tissue. The time saved is, in many instances, very essential to the life of the tissue and success of the operation.

A further feature of this invention is to provide a suture-needle which perfectly combines the advantages of a very small needle with the strength of the larger surgical needles.

Another feature of the present invention is to provide a suture-needle which can be made in many shapes depending on the need and yet be very reliable and inexpensive.

Another object of the present invention is to provide a method of producing suture-needles which assure a smooth transition between the tip of the suture needle and the rest of the device because the transition cross-section is of almost the same diameter as the suture itself.

It is another object of this invention to provide a method of manufacturing suture-needles which uses a few, simple elements to produce such devices.

A further feature of this invention is to furnish a method of making suture-needles by means of which these devices can be produced by following a few, simple, easy-to-follow steps.

A further object of this invention is to provide a method of making suture-needles which is easily adaptable to making these devices in large numbers.

A further feature of this invention is to provide a method of making suture-needles which are consistently strong for surgical sewing.

These objects, as well as additional features of this invention, will become evident from a perusal of the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the embodiments of the invention depicted in these drawings are for the purpose of illustration only, and not of limitation.

FIG. 1 shows a side view of the suture-needle.

FIG. 2 illustrates the different shapes of suture-needles.

FIG. 3 depicts the manner of reducing the cross-section of the fiber and how it is shaped.

FIG. 4 shows the apparatus used in the evaporation method of coating.

FIG. 5 shows the apparatus employed in the A.C. sputtering method of coating.

FIG. 6 displays the devices used to plate the tip of the suture-needle.

FIG. 7 shows the devices used in the differential focusing electrode method of plating.

FIG. 8 illustrates the arrangement used in the mass producing of suture-needles.

With reference to FIG. 1, generally the suture-needle embodying the present invention includes a suture **10** and a tip **11**. The suture **10** comprises a fiber. Examples of fiber materials used in this invention are: nylon, silk, wool, Orlon, Perlon, and even cotton. The diameter of the cross-section of this fiber can be as small as 2 to 8 microns and could be even smaller. However, its pulling strength should be 4 to 6 grams per micron. Consequently, this requirement establishes the lower limit of the dimensions of the cross-section of the strand. In the case of nylon, the lowest strength of its cross-section can be as large as 10 grams per micron. Other materials, such as conductive materials, could also be used as long as their strength per unit of cross-section is as large as that of the above mentioned materials.

The tip could have any one of a series of needle shapes as is illustrated in FIG. 2. It could be straight, FIG. 2c in order to have strength and penetrate easily; it could have ski-point shape, FIG. 2b in order to make it possible to sew in places where there is little room, while conserving the strength of the straight tip; or it could be curved FIG. 2a, like the circumference of a circle in order to be employed in places where the operating room is very limited. However, because of the smallness of the suture-needle tip, a straight suture-needle could be used very effectively in most cases with the aid of a curved pair of tweezers.

One embodiment of the tip is shown in FIG. 1. It has a conical shape with a very acute angle forming the tip. It ends in a very sharp point **16** which is microscopically small. At the other end, the tip is connected to the suture-needle by a smooth transition **17**, with no sharp edges at all, as shown in FIG. 1.

The tip is formed by the following elements: a strand of fiber **10** as the base and plating on top of this fiber. The strand has a circular indentation **12** into which a ring-like plating projection **18** penetrates. Such an arrangement prevents the metallic tip from slipping off the strand.

It is important to point out that before the strand is plated, it must be prepared in the following manner: first the strand is cleaned and degreased. Now the tip is ready for the forming and shaping operations. However, the latter procedure varies depending on the size of the cross-section of the strand. If its diameter exceeds 0.001 inch, the forming and shaping takes place in a radiant heat medium. Once the strand is uniformly heated, its cross-section is reduced by pulling it, FIG. 3a. Then it is bent over a graphite rod, FIG. 3b, heated to between 80 and 100 degrees centigrade in order to give the strand an almost circular radius of curvature. At this point the normally flexible strand acquires a definite circular shape.

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It seems that a molecular re-arrangement takes place in the fiber, its moisture is taken out and this increases the stiffness of the strand. After acquiring this semicircular shape, the stiff circular fiber strand is placed under a microscope and cut not orthogonally to its longitudinal axis, but diagonally at an angle **20** of between  $15^\circ$  and  $20^\circ$ . This cut will produce a strand with a very sharp end.

In cases where the cross section of the strand is smaller than 0.001 inch, it is sufficient to heat the strand uniformly and thoroughly by means of a radiant heat source. Then it can be shaped without the aid of the graphite rod, and cut just as in the previous case. Now the strand is ready for the second step of this process.

The Second Step. In their natural state most fibers cannot be plated. For this reason, it is essential to prepare them for this operation. First, the fiber must be cleaned and degreased. Then any one of the following methods can be chosen in preparing the strand:

(a) The tip can be prepared for its final plating by treating an end of the strand with a solution which can be painted or sprayed on. This solution is composed of about 70% colloidal graphite, 20% distilled water, 6% acetone to increase the drying action, the ammonium water is used to lower the viscosity of the graphite, the acetone to increase the drying action, the ammonium hydroxide to get rid of the acid traces and also to neutralize the electrolytic charges in the colloidal graphite. After treating the strand with several coatings of this solution a smooth graphite layer will be produced which will stick fast to the fiber. When it dries, the tip will be ready for the final plating.

(b) The tip can be prepared for plating by evaporating on it atoms of iron, nickel, or chromium. The method of evaporation as illustrated in FIG. 4, is the following: the fiber strand is placed inside an evacuated bell-jar **24**. In the bell-jar **24** a protective sleeve or tube **21** covers most of the strand **10** and only the tip **11** of the strand **10** is exposed to the evaporation of the atoms. Inside the jar **24**, molybdenum or tungsten wound filament-electrodes **22** are connected in parallel. These electrodes **22**, covered with nickel, chromium or ferromagnetic alloys or wound with wires of these same materials, are connected to an alternating current source **23**. When the source is switched on, the electrodes **22** will evaporate atoms on to the uncovered tip of the strand **10** and produce a smooth metallic layer on it. These atoms impregnate on the surface of the tip, because when the fiber is evenly heated by the radiant heat of the filaments, the expansion difference of its surface layers opens up gaps in their molecular configuration into which gaps the evaporated atoms penetrate. These atoms, which are capable of attaining a strong bond, form a compression vapor-film on to which a plating layer can be easily added later.

(c) The tip can be prepared for plating by a sputtering process, FIG. 5. This process takes place inside a hermetically closed bell jar **25** within which there is an argon atmosphere or some type of inert gas atmosphere. This medium will facilitate the formulation of metallic ions. The tip **11**, as in the prior method, is uncovered while the rest of the strand **10** is covered with a sleeve or tube **26**. The latter element, in addition to protecting the strand from ion bombardment, serves as an electrode to which the metallic ions are attracted. In this manner, when the alternating variable current source **27** is connected, an ion bombardment is induced and at the same time controlled. The other electrode is a ring **28** made out of the same material as the sleeve-electrode. The leads connecting the electrodes **26** and **28**, with the voltage source **27** are covered with an insulating tubing **29**. This material is the metal with which the tip will be plated. In the present method, the tip is metallized because of the high speed with which the metallic ions are generated and later in crust themselves on the surface layers of the fiber strand. As a result of the bombardment, there is formed at the

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tip a layer in which its metallic density increases from the inside to the outside.

(d) The tip can be prepared for plating by applying to it a conductive base paint. This is a paint with which metallic powder can be mixed. For this reason, it is possible to select with a great deal of accuracy the density of the metallic layer that will prepare the fiber strand for the final plating.

This metallic preparation layer should provide the tip with a coating which is from 5,000 to 10,000 angstroms in thickness. Later, the final plating will give the tip an additional layer whose thickness ranges between 10,000 and 50,000 angstroms, depending on the diameter of the fiber. This final plating will take place after the fiber has been prepared by one of the above described methods.

Final Plating. In the final plating, a metallic solution is employed. However, the type of metals used need not be the same as the ones in the preparation layer. The metals chosen should be, in any event, hard, oxidation-resistant metals of the ferromagnetic family and their alloys or metals sufficiently hard to penetrate human or animal tissue.

The plating takes place in a beaker **30** which contains **31** of nickel, chromium, or some other metallic solution. Submerged in the solution, there is a ring-like electrode **32**. The lead from this electrode **32** to the source **37** is insulated with tubing **38**. The other electrode is the conductive tip of the suture-needle which is also submerged in the plating solution. One such solution is made up by dissolving 40 ounces of nickel sulfate, 8 ounces of nickel chloride, 5.5 ounces of boric acid in one gallon of distilled water, heated to  $150^\circ$  Fahrenheit. Then it is treated with peroxide of 1 milliliter per gallon of 30% by volume. The solution is allowed to settle for two hours, and then it is filtered. Before it is ready for use, it is heated between  $115^\circ$  and  $150^\circ$  Fahrenheit at which point Brightner No. 2-RL—0.125%, non-pitter No. 22—0.5%, and Brightner No. 7—2.0%, all by volume, are added to this bath. This method is illustrated in FIG. 6.

It is important to point out how the suture-needle is held for the plating operation. At the end of a test tube **33**, a hole **34** is made through which the suture-needle tip is passed. While holding the suture-needle by suture **10**, mercury **35** or graphite powder is poured into the bottom of the test tube. This is done in order to achieve a smooth, uniform grip and electrical contact of the suture-needle tip, which for this operation serves, as above mentioned, also as an electrode. If the tip were held during this operation by a hard-pressing metal contact, undesirable indentations would be made in the very fragile tip.

Inasmuch as the tip **11** is an electrode for this operation, a part of it should be within the mercury or graphite powder **35**, because into the latter mass also comes one of the leads **36** of the current source **37**. In this manner, the circuit is closed and ready for the plating operation.

Once the circuit is switched on, the tip **11** will be plated with a smooth, uniform coating, as a current of 3 volts and 3 milliamps supplies the energy for this operation. This plating should be thick enough to provide the tip with sufficient strength to sew human or animal tissue. It will furnish the suture-needle with a smooth transition between the tip of the suture-needle and the suture itself. This type of transition is accomplished by reducing the cross-section of the fiber strand after it is uniformly heated as above described, by carefully plating the tip, and finally by carefully etching away the surplusage resulting from the plating operation. This etching operation will be discussed later. It is of capital importance to create the above mentioned smooth transition, because if the latter were abrupt, the sharp edges thus created would cut and damage the tissue being repaired. This characteristic, in addition to others, is a feature of this invention.

The tip can be plated also by means of a differential plating technique which is accomplished by using the

following setup: inside a beaker 39 filled with the same metallic solution 40 as the one above described, there are placed three electrodes which are connected to a voltage divider 41. The first electrode 42, whose shape is annular, is connected to the positive terminal of the divider 41. The second electrode 43 is also of annular shape, but much smaller than the first, and is connected to the negative input terminal. It can be moved up or down in order to form the plating of the needle tip 43a. Its electrical position can be varied along the divider 41. In this manner, the intensity and configuration of the ion field in the solution can be directed on to the tip 44 of the suture-needle, and thus the plating of the tip can be accurately controlled. The third electrode 44 is the tip of the suture-needle itself, which emerges into the above mentioned solution from a small hole 44a at the bottom of a test tube 45. It is connected to the other end of the voltage divider 41 by means of a wire, from which the divider terminal ends in a drop 47 of mercury or graphite powder where electrical contact is made, at the bottom end of the test tube 45. The metal-coated tip 43 of the suture-needle is partially covered by this drop in order to close the circuit. The test tube 45, or other covering, protects the rest of the suture-needle 10 from being also plated. The electrode leads 48 inside the solution have a protective covering 49 in order to avoid any metallic deposits on them. Serving as controls for the plating operation, each of the last two electrodes 43 and 44 has a current meter 50 which aids in adjusting the current of the electrodes. Refer to FIG. 7.

When the switch is turned on and the voltages of the electrodes are adequately set up, the large annular electrode 42 will emit ions. These ions will be attracted to the second electrode 43 which in reality is a differential focusing electrode. This electrode sets up a conical ion field. At or near the apex of this field the suture-needle tip electrode 44 is placed with the proper potential in order to receive the metallic ions of this field all around its surface, and thus, become plated. Furthermore, by controlling this field and by moving the differential electrode up or down, it is possible to build at the end of the coated suture a sharp tip which joins the suture by a smooth transition and extends beyond the end of the suture itself.

After plating, the tip of the suture-needle is etched so as to get rid of the surplus plating at the tip. The etching takes place in the following manner: the etching solution whose acidity is 5 to 10% by volume, is placed in a beaker in which there is an electrode of the same material as the tip connected to one of the terminals of an alternating current source. This source operates on about 16 milliamps at 2 volts. The other terminal is connected to a permanently magnetized bar covered with a noble metal. With this bar the tip of the suture-needle is picked up and dipped into the etching solution. The tip acquires a smooth surface by using an alternating current source in order to prevent it from being surrounded by air bubbles which may induce unequal etching.

In the final product, the relative thickness of the plating at the tip is up to 10% of the diameter of the cross-section of the suture. This relative thickness can be controlled because the density and temperature of the plating solution are known. Thus, the length of time during which the tip is exposed to the plating solution determines the thickness of the plating. As a result of this plating, the suture-needle tip will be just as strong as needles made out of thinned down steel bars.

Mass production of suture-needles is made possible by adapting for this purpose one of the above described techniques. The following is an example of this adaptation: from the beginning to the end a single strand suture 51 is wrapped around the transversal bars 52 of the arms 53 of a U-shaped lucyte frame 54, which has a handle 55 for easy handling. The strands 51 then are given a coating by using the conductive base paint method described un-

der (e) above or by spraying it with a graphite solution described under (a) above. The painting or spraying is administered only to the portion of the wrapped strands 51 close to the arms 53 of the U-shaped frame 54 over a length of about one inch from each arm 53. After this preparation coating has been placed on the strands 51, they are ready for the final plating. This is accomplished by surrounding each strand 51, wrapped around the U-frame 54, with a differential focusing electrode 56 which controls the field, right in front of the strand length covered with the preparation coating. Another electrode 57 is, for mass production purposes, a graphite-loaded felt strip or a conductive silicon strip which is pressed against the strands 51. It should be mentioned that the outside of the differential focusing electrodes is covered by an insulating material 58a. As in the methods above described, the base electrode 58 is of annular shape and much larger than any of the differential focusing electrodes 56. These electrodes are connected to a voltage source. This method is illustrated in FIG. 8 and FIG. 8a.

For plating, first one end of the frame is submerged in the solution 59, whose chemical composition is the same as the solution used in the single suture-needle plating mentioned above. Then, the other end goes into the solution, until a plating of sufficient thickness has attached to the portions of the filaments which received a preparation coating.

After the plating operation is finished, the filaments are cut loose from the frame so that only a suture-needle tip of about one quarter of an inch or less is left at the end of the suture after cutting. The tip is formed and plated to cover the uncovered end of the filament by submerging the very tip of the suture-needles into the solution. Then, the suture-needles are ready for etching and sharpening of their tips.

Clearly, various other modifications in the described devices and methods of manufacture embodying those methods can be made without departing from the spirit of the invention; and accordingly the foregoing description of certain specific arrangements is to be considered as purely exemplary and not in a limiting sense. The actual scope of the invention is to be indicated by reference to the appended claims.

What is claimed is:

1. A method for making a suture including an integral suture-needle comprising the steps of forming the end of a non-conductive filament strand into the size and shape of a suture needle, forming said formed strand end into a semi-circular shape, cutting through the shaped strand diagonally to form a joint, deforming the strand near the point to improve the adhesion of a subsequently applied metal coating, applying a conductive coating to the formed end, and electroplating the coated end to form a suture needle of approximately the same diameter as the suture.

2. A method such as the one described in claim 1 wherein the conductive coating is deposited by evaporation of atoms on said fiber strand.

3. A method such as the one described in claim 1 wherein the conductive coating is deposited by sputtering metallic ions on said filament strand.

4. A method such as the one described in claim 1 wherein the conductive coating is deposited by painting a metallizing and conductive base paint on said filament strand.

5. A method such as the one described in claim 1 wherein said filament strand is plated with a material selected from ferromagnetic substances and their alloys.

6. A method such as the one described in claim 1 wherein a differential focusing electrode is used to plate said filament strand.

7. A method such as the one described in claim 1 wherein a heated cylindrical graphite rod is used for shaping said filament strand.

8. A method for making a suture including an integral suture-needle comprising the steps of forming the end of

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a flexible non-conductive filament strand into the size and shape of a suture-needle, forcing said filament strand into a semi-circular shape, applying a conductive coating to the formed end, electroplating the coated end to form a suture needle of approximately the same diameter as the suture, and etching away the surplus plating deposited on said strand.

9. A method such as the one described in claim 8 wherein the conductive coating is selected from ferromagnetic substances and their alloys.

10. A method such as the one described in claim 8 wherein the conductive coating is selected from compounds useful in the manufacture of electrical conductors.

11. A method such as the one described in claim 8 wherein the conductive coating is deposited by sputtering ions on said fiber strand.

12. A method such as the one described in claim 8 wherein the forming step takes place after exposing said filament strand to radiant heating, and the electroplating step is carried out by means of a third electrode which directs and controls the ion field around the tip of said filament strand.

13. A method for mass producing suture-needles comprising wrapping a monofilament fiber of non-conductive material including silk around projections from the arms of a U-frame, spraying a length of said wrapped monofilament with a conductive coating, surrounding each of said

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monofilaments at said coated portion with a differential focusing electrode, pressing another electrode against said fibers, placing a third electrode inside a solution container, plating with a metallic substance the said coated fiber lengths, cutting said plated lengths, submerging said cut fibers into the plating solution in order to plate the tips, etching away the surplus plating deposited on said tips of said fiber strands.

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