

Nov. 21, 1972

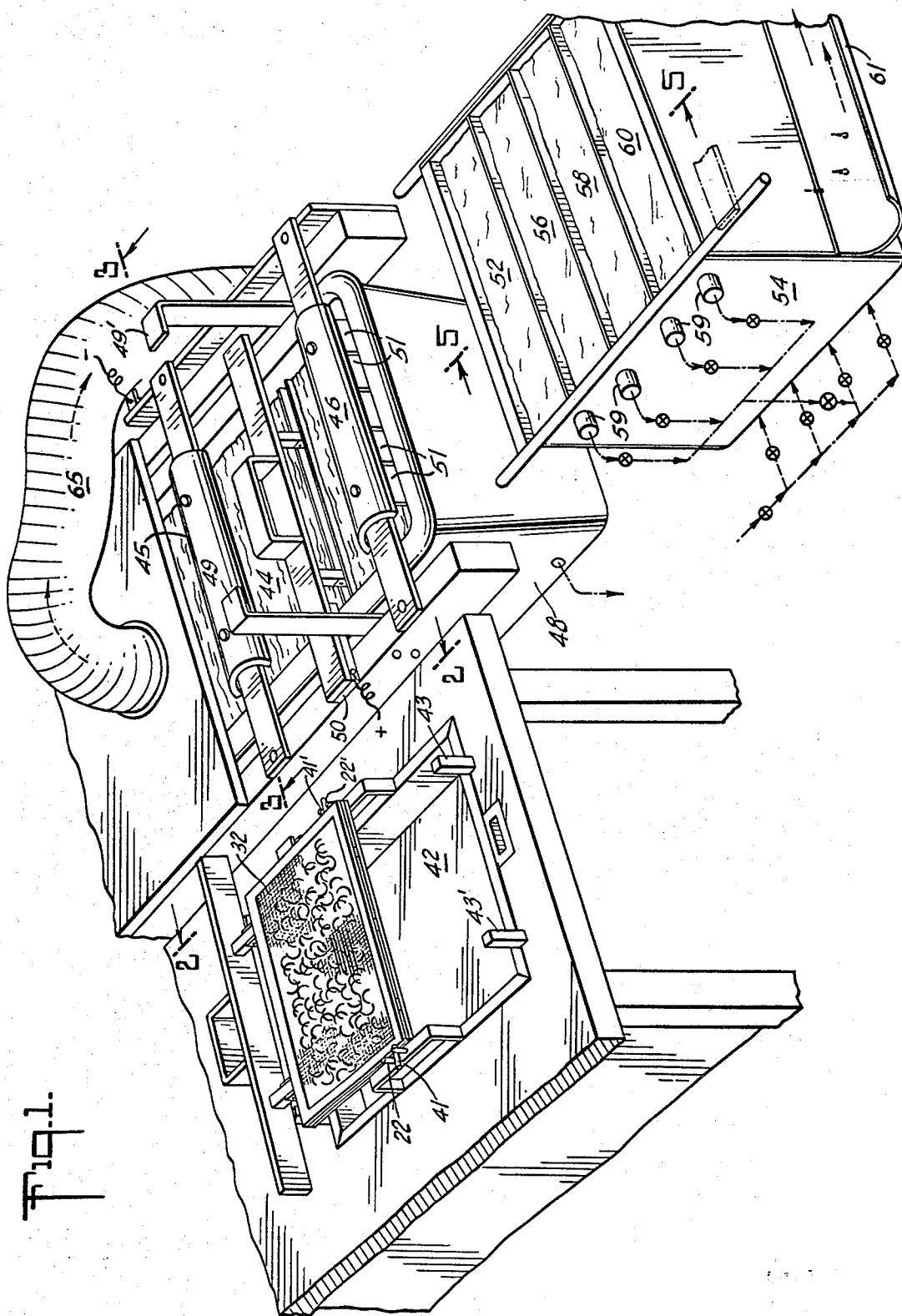
H. BEROFF ET AL

3,703,452

ELECTROPOLISHING OF DRILLED SURGICAL NEEDLES

Filed Jan. 27, 1972

4 Sheets-Sheet 1



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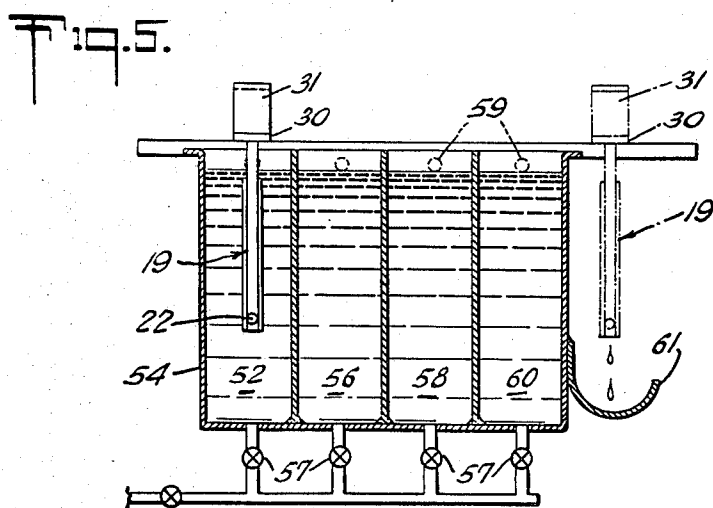
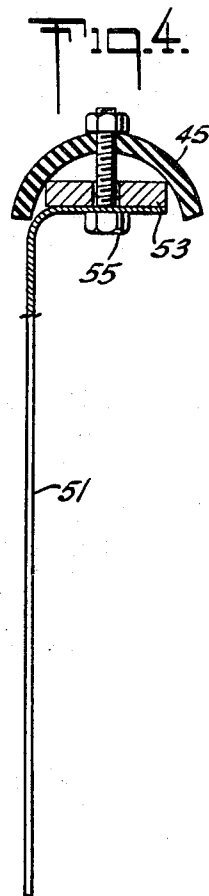
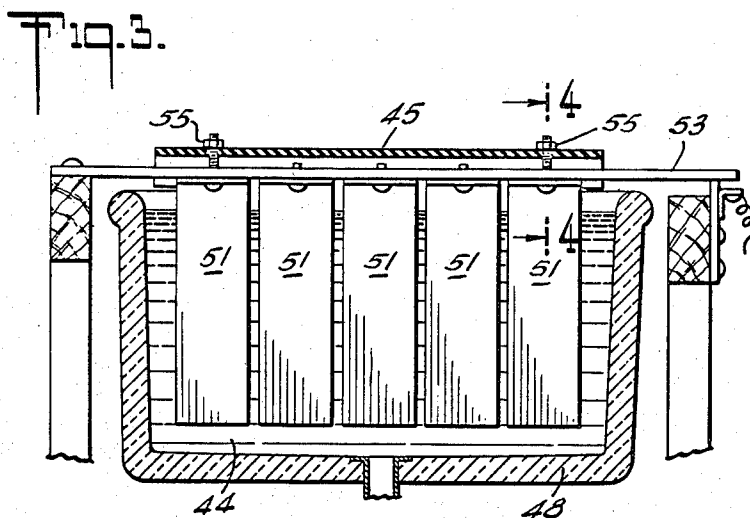
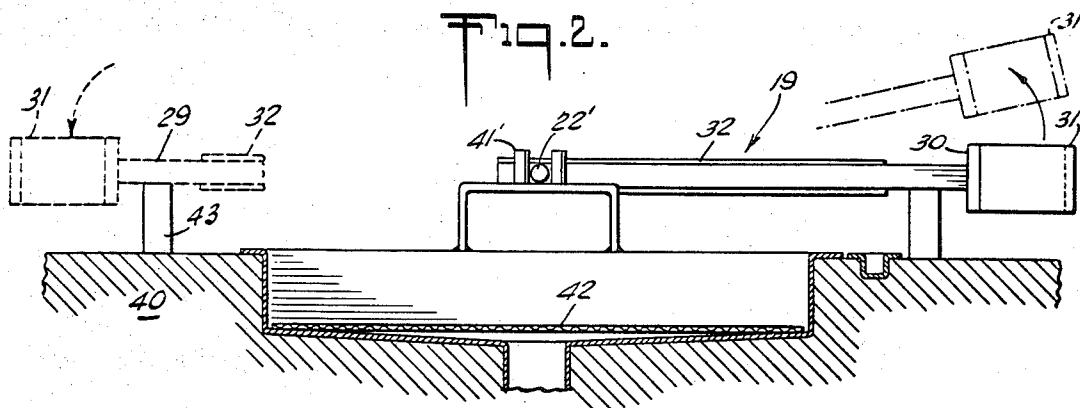
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ELECTROPOLISHING OF DRILLED SURGICAL NEEDLES

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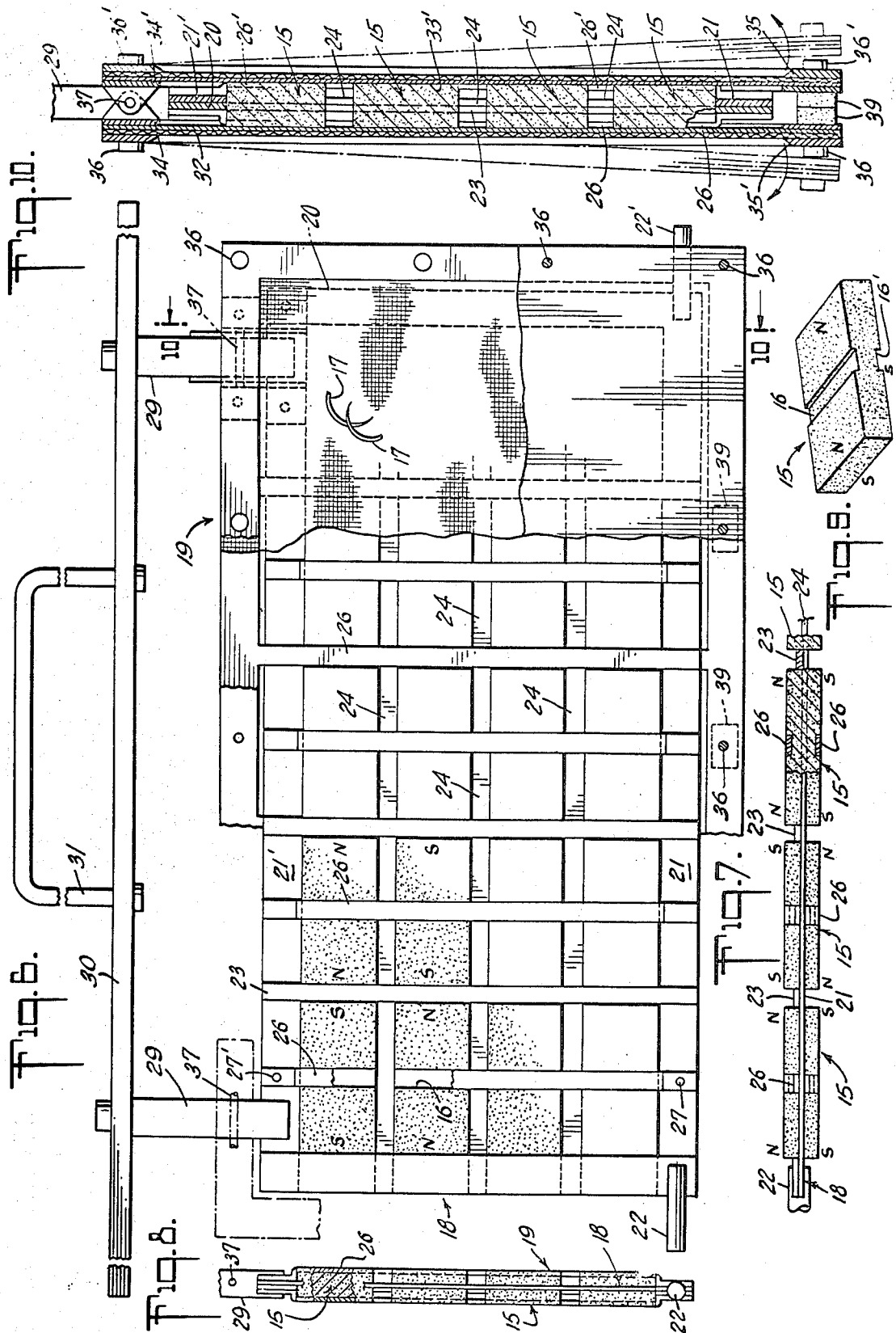
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ELECTROPOLISHING OF DRILLED SURGICAL NEEDLES

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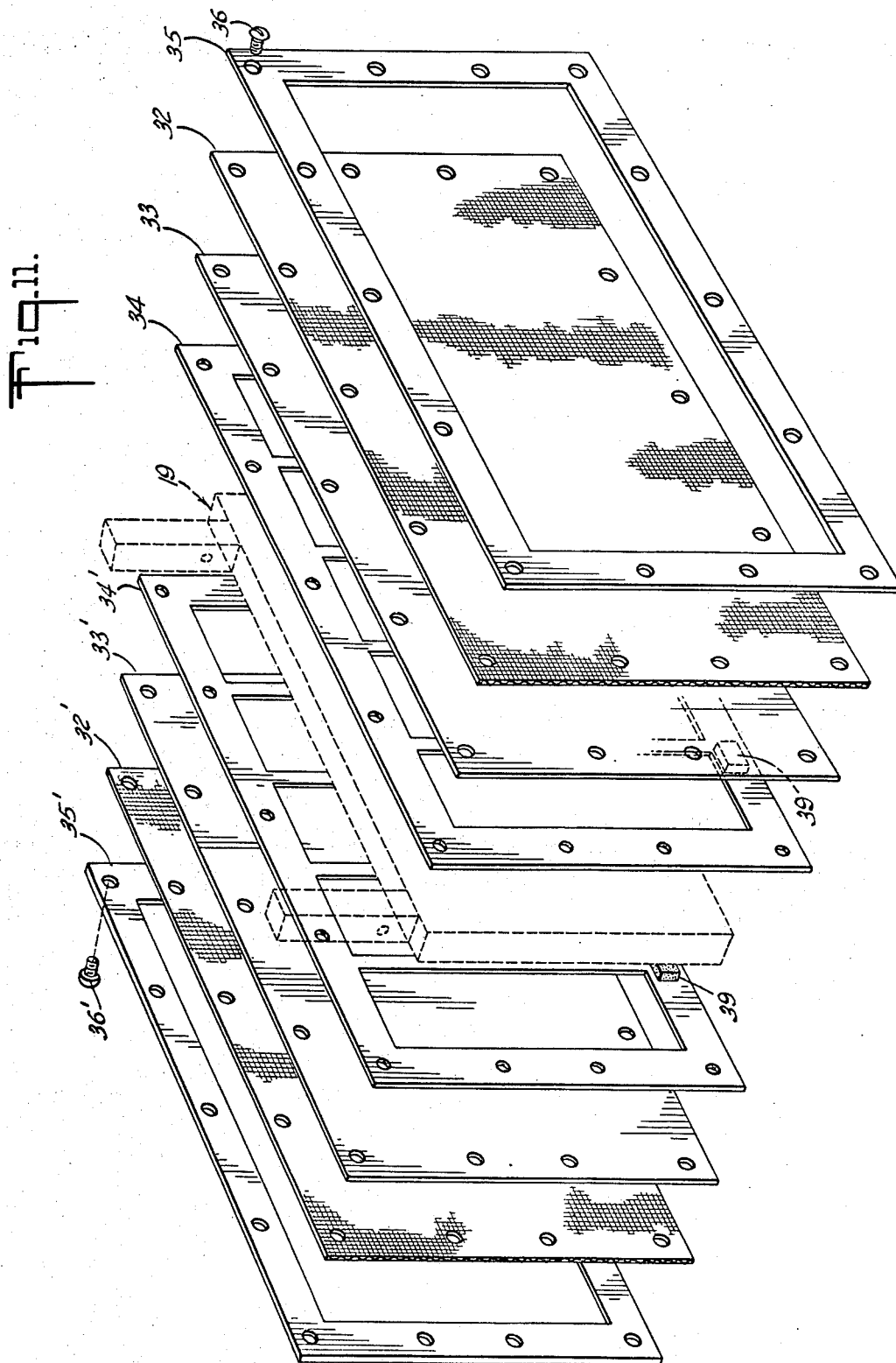
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ELECTROPOLISHING OF DRILLED SURGICAL NEEDLES

Howard Beroff, Somerville, and Ernest L. Richmond,
North Plainfield, N.J., assignors to Ethicon, Inc.
Continuation-in-part of application Ser. No. 6,878,
Jan. 29, 1970. This application Jan. 27, 1972, Ser.
No. 221,256

Int. Cl. C23b 3/06, 5/70; B23p 1/10

U.S. Cl. 204-129.1

12 Claims

ABSTRACT OF THE DISCLOSURE

A large number of steel surgical needles are supported in a magnetic field on a platinum, palladium, rhodium, iridium, or gold anode that is immersed in a magnetic electropolishing bath. The needles supported on the anode are polished by a current that flows through the solution and needles to produce a smooth needle surface that is free of flaws at the point of contact with other needles on the anode.

BACKGROUND OF THE INVENTION

This patent application is a continuation-in-part of copending, commonly-assigned patent application, Ser. No. 6,878, filed Jan. 29, 1970, and now abandoned.

The present invention relates to the electropolishing of surgical needles and more particularly to an improved apparatus for the electropolishing of drilled stainless steel needles. The needles produced by the apparatus of the present invention are free of scale, discoloration, and gross surface imperfections and have a mirror-like finish.

In the modern operating room there is available to the operating surgeon a variety of suture materials having affixed to one end thereof a surgical needle of the proper size and shape for the operation in progress. Thus, hundreds of thousands of surgical needles may be used every day in hospitals throughout the United States and are discarded after use to insure sharpness and to avoid the problems of resterilization.

Surgical needles are generally formed of stainless steel in order to resist the corrosion that may occur during storage in the tubing fluid. A preferred form of needle is a "drilled needle," which has a concentric cylindrical hole drilled in the blunt end of the needle. Such needles are formed from stainless steel wire which is straightened and cut to form a blank, one end of which is then deformed to produce a cutting edge or point. The cutting edges are then ground until sharp. Finally, the needle is formed to the desired shape and heat treated to improve the temper (increase the hardness of the needle without impairing brittleness). During this heat treatment step, the needles will frequently become discolored with a coating of oxide or scale that is removed in the polishing process.

It is well known among those skilled in the art of needle making that surgical needles subsequent to sharpening and tempering may be polished electrolytically by immersing the needle in an acid solution and passing a direct current through the solution and the needle being polished. The scale and discoloration that may result from the heat treatment is thereby removed and the needle is polished in that small surface imperfections are removed by anodic dissolution of metal. The electropolishing of surgical needles has always been an expensive and time consuming process, however, because it was necessary to exercise great care in supporting the needle within the polishing bath. One method of supporting the needles during the polishing step uses a magnetic needle rack as described in United States Pat. No. 3,268,428. It is a disadvantage of the magnetic rack described in that pat-

ent, however, that the precise positioning of the needle on the face of the magnet is a time consuming hand operation.

Another method of supporting surgical needles within the electrolytic polishing bath that has been used by the assignee of the present application in the manufacture of surgical needles was to secure the drilled end of the needle in a conductive metal clip. The needle is then placed below the surface of the electropolishing bath so that the entire needle surface is polished, except for the drilled end which contacts the clip. Again, however, a time consuming operation is involved since each individual needle must be precisely placed in its corresponding supporting clip so that the clip contacts the needle surface only at its remote drilled end. This precaution is necessary because the needle will be etched and roughened at the point of contact with its supporting clip. By supporting the needle at the butt end such imperfections are of minimum concern since the marks made during the electropolishing step are generally obscured during the swaging of the drilled needle to the suture material.

It has now been discovered that stainless steel surgical needles may be electropolished in large batches by placing a substantial number of such needles in an electrolytic fluid on a platinum, palladium, rhodium, iridium or gold polishing anode in random arrangement. The steel needles are held against the surface of the anode by magnetic force. While one would have expected that needles polished in this manner would have surface imperfections and cross-over marks on those areas in contact with adjacent needles during the polishing step, this did not occur. The process to be described reduces the time that is required for polishing since it is unnecessary to handle each individual needle. Moreover, it is possible to control the process to be described so accurately that less than 0.0005 inch of material is removed. Inasmuch as the diameter of surgical needles is controlled to within 0.001 inch, it is now possible for the first time to repolish a needle that retains a slight surface imperfection without removing more than the 0.001 inch permitted by quality control specifications. The object of the invention, therefore, is to provide a fast and reliable method for polishing a plurality of stainless steel needles in large batches whereby scale and surface imperfections that are present following the heat treating step are removed to provide a bright uniformly polished surface that is devoid of cross-over marks.

The foregoing object may be attained in accordance with the present invention which provides a novel electropolishing apparatus comprising an anode that is rectangular in cross-section having a magnetic central core. The central core has a titanium metal frame to which is secured a plurality of small ceramic magnets. The magnets serve the important function of retaining the needles to be polished in electrical contact with the surface of the anode and each other, and are part of a hinged assembly which permits the operator to discharge the needles after the polishing operation by swinging the surface of the anode and the needles supported thereon out of the magnetic field.

The apparatus of the present invention permits one to polish a large batch of needles, i.e., 200 to 3,000 at one time, depending upon the size of the needles. The needles to be polished may be scattered over the anode surface from a large container and discharged from the anode without the tedious and time-consuming hand operations formerly employed.

The polishing anode is designed for the rapid polishing of surgical needles and its construction is such that the needles contact only the exterior surfaces of the anode and each other. It has been discovered that a platinum, palladium, rhodium, iridium or gold surface is required

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to obtain the desired mirror-like polish on the needles. Other materials investigated did not produce polished needles of the same quality. The surface of the anode that contacts the needle to be polished must resist etching by the electropolishing bath throughout the polishing process. Moreover, the metal used for the anode must be one that does not form a surface coating during the use that will interfere with the electropolishing operation. Most metals that might otherwise be used for forming the polishing anode surface either dissolve in the electropolishing bath or form a surface coating during the electropolishing process that results in needles of inferior quality.

Particularly preferred as the anode surface is platinum gauze (No. 80 United States Standard Sieve Series, 177 micron). Alternatively, a titanium anode the surface of which is plated with platinum (matte finish) or a sheet of gold, palladium, rhodium, or iridium about 0.010 inch in thickness may be used.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings, which show by way of example, preferred embodiments of the inventive idea. Referring now to the drawings:

FIG. 1 is a perspective of the apparatus.

FIG. 2 shows a vertical cross-section of the unloading tray and associated parts, taken along line 2—2 of FIG. 1.

FIG. 3 is a vertical cross-section through the electrolytic bath taken on line 3—3 of FIG. 1.

FIG. 4 is an enlarged cross-section partly in elevation through one of the cathode plates and taken along line 4—4 of FIG. 3.

FIG. 5 shows a vertical cross-section of the wash tank taken along line 5—5 of FIG. 1.

FIG. 6 is a vertical face or elevational view of a magnetic tray unit; broken away in a cross-section. The right-hand side being in elevation and broken away to see the screen, titanium plate, and the grill portions beyond which the fixed magnet unit is seen.

FIG. 7 is an inverted fragmental edge elevation of FIG. 6 partly in section and partly in elevation.

FIG. 8 is an end elevation, broken away and in section of the left side of FIG. 6 showing only the centrally located magnet unit.

FIG. 9 shows a perspective of one of the magnets shown in FIGS. 6 to 9.

FIG. 10 is an enlarged cross-section taken along line 10—10 of FIG. 6 showing the laminated structures hinged at their upper ends, and

FIG. 11 is an exploded perspective of the laminations shown in FIG. 10.

The construction of the anode assembly is best shown in FIGS. 6 through 11. In the embodiment illustrated, the conductive metals used to build the assembly are platinum, which forms the surface of the anode, and titanium. It has been found that titanium quickly forms a titanium oxide surface coating under the conditions of use that is highly resistant to current flow. This greatly increases the efficiency of the polishing operation, and reduces the temperature rise of the electropolishing bath since the primary current flow is through the needles 17 being polished and the platinum support. There is very little current leakage through the titanium oxide surface of the anode assembly.

The magnetic field that retains the needles against the anode surface during the polishing operation may be provided by a plurality of small rectangular, permanent magnets best illustrated in FIG. 10. If the construction of the anode is such that the magnets are in contact with the electropolishing bath suitable non-conductive ceramic magnets may be obtained from Indiana General Corporation, Valparaiso, Ind. (INDOX 5). Shallow transverse channels 16 and 16' are provided in the magnet surfaces to facilitate clamping the magnet to a central frame

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18 which, together with a plurality of magnets 15, form the magnetic core 19 of the anode assembly.

The magnetic core 19 is best illustrated in FIGS. 6 through 8. It consists of the frame 18 that is rectangular in shape; the outer dimensions being fixed by the end members 20 and 20' and the longitudinal members 21 and 21'. Extruding outwardly from the lower frame member, as viewed in FIG. 6, are cylindrical pintles 22 and 22', the function of which will be described below. The frame is divided by cross-bars 23 and longitudinal bars 24 into a series of compartments, the dimensions of which correspond to the length and width of magnet 15. The magnets are oriented in the frame so that the north pole of each magnet is in proximity with the south pole of every adjacent magnet and are firmly secured in position by the clamping bars 26 and 26' which engage the channels 16 and 16' in the magnets 15 and are secured to the frame members 21 and 21' by screws 27 and 27'.

The top member 21' of the frame 18 is welded to vertical supports 29 that suspend the entire anode assembly from a bus bar 30.

A handle 31 is attached to the top of the bus bar and facilitates accurate positioning of the anode assembly in the electropolishing bath.

To complete the description of the anode there is positioned on both sides of the magnetic core assembly described above platinum screens 32 and 32' slightly greater in length and breadth than the frame 18.

The platinum screen 32 and a backing sheet of titanium 33, are held between a grill 34 and an outer frame 35 by the bolts 36 which engage threads in the grill 34. In a like manner, the platinum screen 32' and its backing sheet 33' are held between the grill 34' and outer frame 35' by the bolts 36' which engage threads in the grill 34'.

The platinum screen surfaces and their supporting frame are hinged by means of hinge pins 37 and hinge brackets 38 to the vertical members 29 which support the entire electropolishing anode assembly and function to conduct current to the anode during the electropolishing operation. Small ceramic magnets 39 are mounted on the lower edge of the grills 34 and 34'. These magnets act to hold the grills 34 and 34' together so that the platinum screens are parallel to each other and to the magnetic core assembly formed by the inner frame 18, magnets 15 and clamping bars 26.

Inasmuch as the ceramic magnets are corroded by the acid electropolishing bath and have a limited commercial life, a preferred embodiment of the present invention is to encapsulate the magnetic core within a titanium container, welding all joints to prevent contact between the electropolishing bath and the magnets.

Example 1.—Electropolishing of drilled ½ circle stainless steel surgical needles

As best shown in FIGS. 1 and 2, the magnetic anode described above having a dual surface area of about 200 square inches is supported on a work table 40 with the pintles 22 and 22' positioned between guide posts 41 and 41' above a catch screen 42 and a weighed quantity of the surgical needles 17 to be polished (about 350 needles; diameter 0.039 inch) is distributed evenly over the platinum surface 32 of the anode. The anode is then rotated toward the operator on the pintles 22 and 22', to the position shown in dotted lines in FIG. 2. The anode in that position is supported on the tray rests 43 and 43' with the other surface of the anode 32' facing upward. The needles on the lower surface 32 are retained by magnetic attraction.

An equal weight of surgical needles is evenly distributed in like manner over the opposite surface. The magnetic anode with the needles in place is then removed from the work table and placed in an electropolishing bath 44 between two cathodes 45 and 46. The two cathodes are similarly constructed of stainless steel as best illustrated

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in FIGS. 3 and 4. Individual separated cathode plates 51 are secured to the cathode bus bar 53 by bolts 55 and 55' and extend across a ceramic vat 48 equidistant from the platinum surfaces 32 and 32' of the polishing anode. As best illustrated in FIG. 1, the magnetic anode makes electrical contact with the polishing tank bus bar 50.

The electropolishing bath is a solution containing 70 parts by weight of phosphoric acid, 30 parts by weight hydroxyacetic acid. This electropolishing solution is contained in the ceramic vat 48.

Current is passed through the polishing bath and needles for 4 minutes. The current flow is 72 amperes at 10 volts, and the temperature of the polishing bath is 190° F. A DC rectifier that will supply 100 amperes at 12 volts is suitable as a power supply. Fumes and vapors from the electropolishing bath are carried away by the exhaust duct 65.

After polishing for 4 minutes, the anode is removed from the polishing bath and placed on the rest ledges 49 and 49' over the polishing bath to permit the acid polishing solution to drain from the needles and anode. The anode is then transferred to a first water rinse compartment 52 of a four-station rinse tank 54. The anode and needles are rinsed in the compartment 52 for 1 minute and then transferred to the second rinse compartment 56 for another minute to flush off any remaining polishing acid. The rinse tanks are continuously supplied with water through inlet valves 57 at a rate of 1 gallon per minute; and overflows through the exit ports 59; the temperature of the rinse water being maintained at 115° F.

After the water rinses, the anode is advanced to a third compartment 58 where the needles are submerged in a solution containing 183 parts by volume orthophosphoric acid, reagent grade; 20 parts by volume of a wetting agent (Triton X-100); and 6725 parts by volume water. This solution acts to complex any iron carried over from the polishing step and prevents discoloration of the needles. The needles are then advanced from the phosphoric acid solution to a final water rinse compartment 60, continuously supplied with warm water at the rate of 1 gallon per minute.

The anode together with the partially polished needles is then removed from the tank and supported over the drain 61 at the end of the tank 54 as shown in FIG. 5. After draining, the anode is placed over an absorbent paper towel and the platinum surface 32 is swung about the hinge pin 37 away from the magnetic core permitting the needles to drop onto the paper towel. In a similar manner, the needles on the platinum surface 32' may be collected.

The platinum screens of the anode assembly are repositioned over the magnetic core and the anode is replaced on the work table in position for loading. The partially polished needles are returned to the anode surfaces and evenly distributed as described above. The anode with the needles in place is then reinserted in the electropolishing bath and polished for an additional 3 minutes as described above. During this second polishing cycle the current flow is 70 amperes at 10 volts. The anode is removed from the polishing bath; the needles are rinsed with water, treated with phosphoric acid solution, and washed exactly as described above.

After draining, the needles may be transferred to a fiber board tray lined with paper towels by swinging the platinum surfaces away from the magnetic core of the anode assembly. The needles in the fiber board tray are then passed over a 60 cycle alternating current magnet until the needles in the tray lay flat indicating that no residual polarity remains.

Needles polished as described above upon inspection are found to have a mirror-like surface free of cross-over marks and other imperfections. The electropolishing process removes about 0.001 inch, i.e., a needle 0.039 inch in diameter before polishing will measure about 0.038 inch in diameter after polishing.

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Similar results may be obtained by substituting a thin sheet of platinum for the platinum screens 32 and 32'. Drilled one-half circle stainless steel needles (diameter 0.028 inch) may be successfully polished by the method described above. These smaller needles (650) were distributed evenly over the platinum surface of the anode. The total number of such needles polished at one time is about 1300.

Example II.—Electropolishing of drilled $\frac{3}{8}$ circle stainless steel surgical needles

About 1300 needles (diameter 0.026 inch) are polished by the procedure described in Example I above. The anode surfaces 32 and 32' are gold sheets 0.10 inch in thickness. The needles are randomly distributed over both anode surfaces (about 650 needles per side). Upon inspection, the needles so polished were found to have a mirror-like surface free of cross-over marks and other imperfections.

Example III.—Electropolishing of drilled $\frac{3}{8}$ circle stainless steel surgical needles

About 1200 needles (diameter 0.028 inch) are polished by the procedure described in Example I above. The anode surfaces 32 and 32' are palladium sheets 0.10 inch in thickness. The needles are randomly distributed over both anode surfaces (about 600 needles per side). Upon inspection, the needles so polished were found to have a mirror-like surface free of cross-over marks and other imperfections.

Example IV.—Electropolishing of drilled $\frac{3}{8}$ circle stainless steel surgical needles

About 900 needles (diameter 0.032 inch) are polished by the procedure described in Example I above. The anode surfaces 32 and 32' are rhodium sheets 0.10 inch in thickness. The needles are randomly distributed over both anode surfaces (about 450 needles per side). Upon inspection, the needles so polished were found to have a mirror-like surface free of cross-over marks and other imperfections.

Example V.—Electropolishing of drilled $\frac{3}{8}$ circle stainless steel surgical needles

About 800 needles (diameter 0.039 inch) are polished by the procedure described in Example I above. The anode surfaces 30 and 32 are iridium sheets 0.10 inch in thickness. The needles are randomly distributed over both anode surfaces (about 650 needles per side). Upon inspection, the needles so polished were found to have a mirror-like surface free of cross-over marks and other imperfections.

While the invention has been described in detail according to the preferred manner of carrying out the process and manufacturing the products, it will be obvious to those skilled in the art, after understanding the invention, that changes and modifications may be made therein without departing from the spirit or scope of the invention, and it is intended in the appended claims to cover such changes and modifications.

What is claimed is:

1. A method for electropolishing a batch of surgical needles which comprises:
 - supporting a large number of randomly oriented needles in a magnetic field on a platinum anode;
 - immersing said anode and needles supported thereon in an electropolishing bath;
 - passing an electric current through the polishing bath and needles until the needles are polished;
 - removing the anode and the needles supported thereon from said polishing bath;
 - rinsing the needles;
 - removing the needles from the anode; and,

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subsequently drying the polished needles.

2. The method of claim 1 wherein said anode is a sheet of platinum gauze.

3. The method of claim 1 wherein said anode is constructed of titanium at least one surface of which is coated with platinum.

4. The method of claim 1 wherein said needles prior to the drying step are replaced in a random manner on the anode; immersed a second time in the electropolishing bath; and the polishing and rinsing steps are repeated, after which the polished needles are dried.

5. A method for electropolishing a batch of surgical needles which comprises:

supporting a large number of randomly oriented needles in a magnetic field on a gold anode; immersing said anode and needles supported thereon in an electropolishing bath; passing an electric current through the polishing bath and needles until the needles are polished; removing the anode and the needles supported thereon from said polishing bath; rinsing the needles; removing the needles from the anode; and, subsequently drying the polished needles.

6. The method of claim 5 wherein said needles prior to the drying step are replaced in a random manner on the anode; immersed a second time in the electropolishing bath; and the polishing and rinsing steps are repeated, after which the polished needles are dried.

7. A method for electropolishing a batch of surgical needles which comprises:

supporting a large number of randomly oriented needles in a magnetic field on a palladium anode; immersing said anode and needles supported thereon in an electropolishing bath; passing an electric current through the polishing bath and needles until the needles are polished; removing the anode and the needles supported thereon from said polishing bath; rinsing the needles; removing the needles from the anode; and, subsequently drying the polished needles.

8. The method of claim 7 wherein said needles prior to the drying step are replaced in a random manner on the anode; immersed a second time in the electropolishing bath; and the polishing and rinsing steps are repeated, after which the polished needles are dried.

9. A method for electropolishing a batch of surgical needles which comprises:

supporting a large number of randomly oriented needles in a magnetic field on a rhodium anode;

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immersing said anode and needles supported thereon in an electropolishing bath;

passing an electric current through the polishing bath and needles until the needles are polished;

removing the anode and the needles supported thereon from said polishing bath;

rinsing the needles;

removing the needles from the anode; and,

subsequently drying the polished needles.

10. The method of claim 9 wherein said needles prior to the drying step are replaced in a random manner on the anode; immersed a second time in the electropolishing bath; and the polishing and rinsing steps are repeated, after which the polished needles are dried.

11. A method for electropolishing a batch of surgical needles which comprises:

supporting a large number of randomly oriented needles in a magnetic field on an iridium anode; immersing said anode and needles supported thereon in an electropolishing bath; passing an electric current through the polishing bath and needles until the needles are polished; removing the anode and the needles supported thereon from said polishing bath; rinsing the needles; removing the needles from the anode; and, subsequently drying the polished needles.

12. The method of claim 11 wherein said needles prior to the drying step are replaced in a random manner on the anode; immersed a second time in the electropolishing bath; and the polishing and rinsing steps are repeated, after which the polished needles are dried.

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U.S. Cl. X.R.

204—285, 297 M, 129.55, 145 R

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,703,452 Dated November 21, 1972

Inventor(s) Howard Beroff and Ernest L. Richmond

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In Column 4, line 62, "evently" should read --- evenly ---.

In Column 5, line 8, "or-thophosphoric" should read
--- orthophosphoric ---.

In Column 5, line 33, "ocntaining" should read --- containing ---.

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents