Feb. 25, 1969 C. J. BECK ET AL 3,429,798

ELECTROCHEMICAL ETCHING OF SPIRAL LANDS

Filed May 19, 1967 Sheet 1 of 2

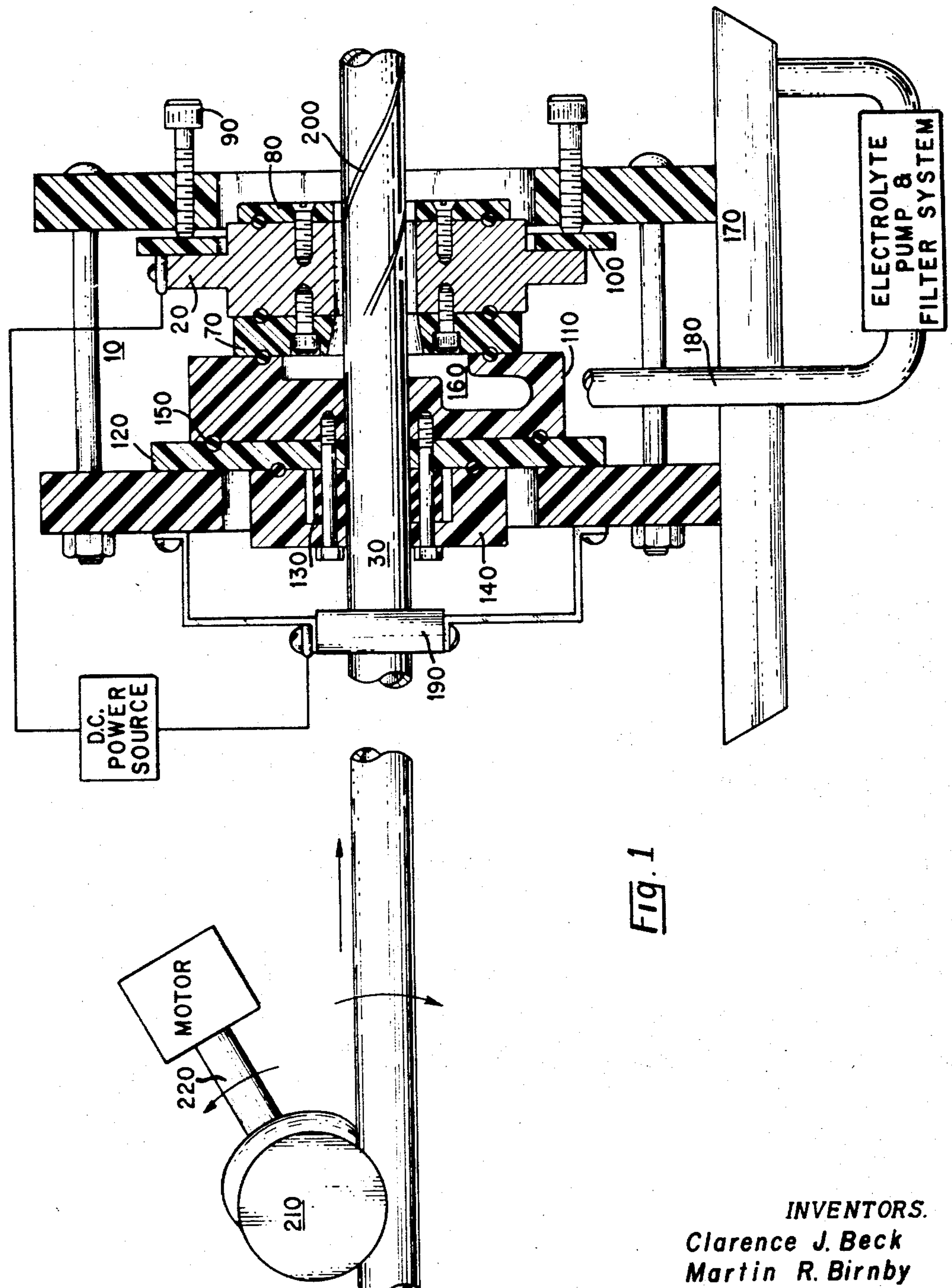

Fig. 1

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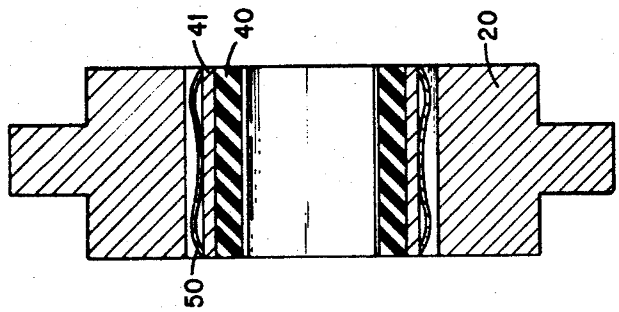

Fig. 3

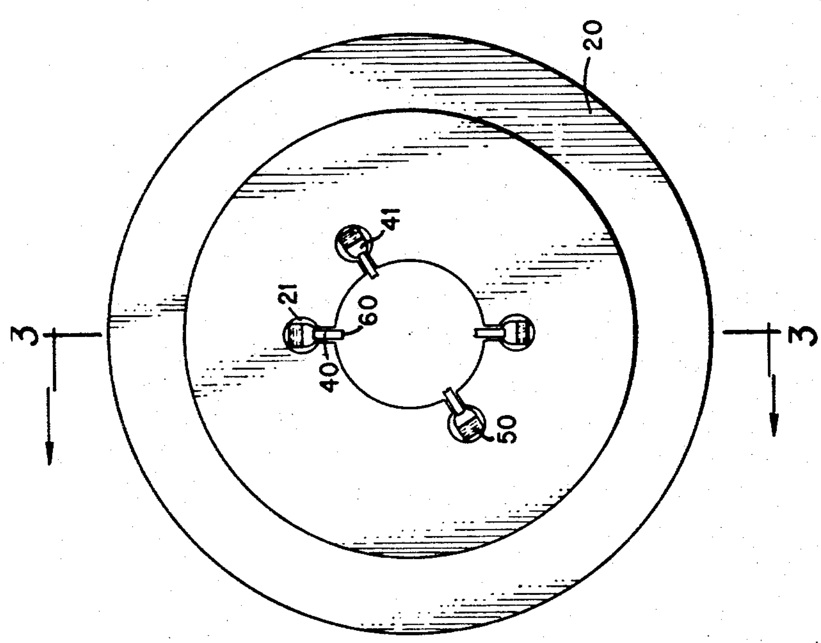

Fig. 2

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3,429,798
ELECTROCHEMICAL ETCHING OF SPIRAL LANDS

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U.S. Cl. 204—206 2 Claims
Int. Cl. C23b *5/72;* B23p *1/02*

ABSTRACT OF THE DISCLOSURE

Removal of metal by electrochemical etching in which spiral lands are formed on a tube. Portions of the outer surface of the rotating and longitudinally moving tube are isolated from the electrolyte by spring biased land covers located within the cathode.

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the U.S. Atomic Energy Commission.

This invention pertains to a method and apparatus directed to the electrolytic etching of localized areas of a tubular product whereby spiral lands are formed upon the product.

As evidenced by U.S. Patent 2,739,935, issued Mar. 27, 1956, and U.S. Patent 3,251,762, issued May 17, 1966, electrolytic cutting of metal is an established art. U.S. Patent 3,051,638, issued Aug. 28, 1962, pertains to the electrolytic etching of a male tapered thread on a tube. Remaining unsolved was the problem of uncontrolled electrolytic erosion which prevented the formation of a precise land.

SUMMARY OF THE INVENTION

Methods of producing spiral lands upon metal tubing by deformation processes produce undesirable stresses within the tube with a probable change in the metallurgical condition of portions of the tube structure. Complex chemical etching is too time consuming and costly. Electrochemical etching or cutting, which would eliminate the above-mentioned disadvantages, has been used to produce tapered threads upon tubing, but the lack of etching control would produce an eroded land where precise metal removal is required.

This invention provides for the precise removal of metal by electrochemical etching in the formation of lands by isolating portions of the outer surface of the tube from the electrolyte. The tube is inserted within a surrounding cathode ring or collar and is provided rotational as well as longitudinal motion with respect to the collar. Within the collar are electrically nonconductive spring biased land covers which rest upon the outer surface of the inserted tube. Electrolyte is caused to flow between the collar and inserted tube, around the land covers. Concurrently an electric current is caused to flow between the collar and the tube through the electrolyte. That portion of the tube protected by and land covers remains unetched by the electrolytic action thereby producing the land.

Accordingly, it is an object of this invention to form precise spiral lands on tubular products without the use of cutting tools or dies.

It is a further object of this invention to form precise spiral lands on tubular products without producing undesirable stresses within the tube.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is an illustration of the preferred embodiment of the invention showing a partial sectional view of the assembly housing.

FIGURE 2 is an end view of the cathode collar without the inserted tube.

FIGURE 3 is a sectional view of FIGURE 2 along line 3—3.

The preferred embodiment illustrated is not intended to be exhaustive or to limit the invention to the precise form disclosed. It is chosen and described in order to best explain the principles of the invention and the application and practical use to thereby enable others skilled in the art to best utilize the invention in various embodiments and modifications as are best adapted to the particular use contemplated.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of this invention consists of a cathode collar, an external D.C. power supply, a means for imparting combined relative rotational and longitudinal motion between the collar and the inserted tube, and an electrolyte.

Within a noncorrosive assembly housing **10** is contained a cathode collar **20**. The collar is made of an electrically conductive material and is of sufficient thickness to provide an adequate area for the electrolytic reaction to take place with good current conduction. The internal diameter of the collar **20** is of sufficient dimension to allow for the insertion of the tube **30** with sufficient peripheral spacing around the tube to allow for adequate electrolyte flow and resulting electrolytic reaction.

The collar is slotted in a radial direction around its internal circumference. Within each slot **21** is placed an electrically non-conductive insert **40**. The insert **40** has a rectangular cross section which lies in a plane normal to the axis of the collar. In this embodiment, the insert **40** is made of a polytetrafluoroethylene material. Each insert **40** is placed in contact with the outer surface of the inserted tube by a biasing spring **50**. The biasing spring **50** is juxtaposed between the base of the slot and the crimped metal base **41** of the insert **40** so that the insert exerts a force on the tube **30** in a direction normal to its axis. The width of the insert is equal to the intended land width. The end periphery **60** of the insert **40** is formed to coincide with the curvature of the outer surface of the inserted tube. The number and spacing between inserts, hereinafter referred to as land covers **40**, are dependent upon the desired number of lands and the desired spacing between them. In this embodiment there are four land covers, with spacings of 0, 60, 180, and 240 degrees. The spring bias is of sufficient force to provide sliding but intimate contact between the outer tube surface and the land cover **40** so that flowing electrolyte is continually excluded from that area of the moving tube which is covered by the cover. Also the spring **50** must have sufficient flexibility to accommodate small variations in the outer diameter of the tubes.

On the tube entrance side of the collar **20** is attached a tube guide **70**. On the opposite side of the collar is attached an exit guide seal **80**. Four biasing screws (2 shown) **90** are threaded through the assembly housing and biased against a pressure plate **100** adjacent a circumferential flange around the collar **20**. The tube guide **70**, because of its interconnection with the collar **20**, is, in turn, biased against an electrolyte housing **110** which has attached to it a tube entrance seal arrangement. This seal arrangement consists of an inner entrance seal **120**, followed by a flexible entrance seal **130** and an outer entrance seal **140**, all of which are attached to the electrolyte housing **110**. Through indirect pressure applied by the biasing screws **90**, the inner entrance seal **120** is biased against an opposing portion of the assembly housing thereby completing and preventing collapse of the collar assembly. With the exception of the collar **20** and biasing screws **90**, the aforementioned parts are made of electrically nonconductive material. The collar assembly is sealed, as indicated throughout FIGURE 1, by O-rings **150** to prevent the seepage of electrolyte between components. Tube supports (not shown) are placed outside the assembly housing to provide support for the tube as it moves through the collar assembly.

With the tube **30** inserted into the collar assembly, electrolyte is introduced into the electrolyte housing **110** by an exterior pumping means interconnected by a conduit **180** to a cavity **160** formed between the electrolyte housing and the tube guide. Due to the closeness of fit between the inserted tube and the electrolyte housing, the electrolyte principally flows around the tube through the tube guide **70**, collar **20**, and exit guide seal **80**, falling by gravity into a collecting pan **170** beneath the assembly. From there the electrolyte is filtered and recirculated. The pump maintains the electrolyte pressure at 60 to 70 p.s.i. The electrolyte may be of various compositions. One found to be particularly suitable is a saturated solution of NaCl in water.

A D.C. power source provides the electrolytic current. One electrical power contact (negative potential) is connected to the cathode collar **20** and the other contact (positive potential) is connected to the inserted tube **30**. To allow for the combined rotational and longitudinal movement of the tube as it passes through the collar, a slip-ring type electrical contact **190**, well known in the art, is used to connect the power contact to the tube.

Since a spiral land **200** is to be etched upon the outer surface of the tube, combined relative longitudinal and rotational motion between the tube and collar must take place. In other words, helical motion takes place between the tube and collar. This motion may be imparted in a number of different ways well within the skill of the art. In the illustrated embodiment, the assembly housing is stationary and motion is imparted to the inserted tube. A rotating friction wheel **210**, electrically insulated from its power source, in peripheral contact with the outer surface of the tube has its axis canted with respect to the axis of the tube so that both a thrust or longitudinal force and a rotational force are imparted to the tube. Reference is made to the wheel shaft **220** and tube directional arrows in FIGURE 1.

In operation, the tube is inserted into the collar assembly, entering, first, the outer entrance seal, proceeding through the collar, and exiting at the exit guide seal. The electrical power contact is connected to the tube. Electrolyte is introduced into the electrolyte housing, passing around the tube through the tube guide into the collar, bypassing the land covers. From the collar the electrolyte passes through the exit guide falling into a collecting pan. Predetermined combined longitudinal and rotation motion is imparted to the tube. The power source is energized to deliver a predetermined current to the electrolytic fluid passing through the collar. As the tube passes through the collar around the land covers, electrolytic action occurs with respect to that portion of the outer tube surface continually exposed between land covers, resulting in the production of precise spiral lands. Coolant water is allowed to flow through the center of the tube during the etching process to absorb a portion of the heat generated due to the electrical resistance of the tube to the flow of current between the electrical contact **190**, the cathode collar **20**, and flowing electrolyte.

Should axially directed lands be desired, the tube need only experience longitudinal motion in its passage through the collar.

In this particular embodiment, the collar was of a copper composition. The inserted tube consisted of Zircaloy-4. The electrolyte was, as noted before, a saturated solution of NaCl in water. With a current density of 405 amps./in.^{2} and a tube feed rate of 4 in./min., satisfactory etching occurred to a depth of between .0060 to .0085 inch in producing four spiral lands each .125 inch wide.

It will be understood that the invention is not to be limited to the details herein given but it may be modified within the scope of the appended claims.

We claim:

1. An apparatus for electrolytically cutting spiral lands on an electrically conductive cylinder comprising:

(a) an electrode means in intermittent nonconductive contact with the cylinder for delivering a prespaced electrolyzing current to the cylinder, said electrode means including an electrically conductive collar surrounding said cylinder and having spaced apart cutouts within its inner cylindrical periphery, nonconductive land covers housed within said collar cutouts and biased against the cylinder, whereby electrolyte following between the collar and the cylinder bypasses that portion of the cylinder covered by the land covers;

(b) a means for introducing an electrolyte within the electrode means and around the cylinder;

(c) a power source electrically connected to the electrode means and the cylinder; and

(d) a means for imparting combined relative rotational and longitudinal motion between the electrode means and the cylinder.

2. The apparatus of claim **1** wherein said means for imparting combined relative rotational and longitudinal motion between the electrode means and the cylinder comprises a driven drive wheel in touching relationship with the cylinder, the axis of said wheel forming an angle with the axis of the cylinder, whereby rotational and longitudinal motion is imparted to the cylinder by the wheel.

References Cited

UNITED STATES PATENTS

2,848,401	8/1958	Hartley ____________	204—143
3,051,638	8/1962	Clifford et al. ______	204—143
3,324,021	6/1967	Haggerty ___________	204—224

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U.S. Cl. X.R.

204—212, 143, 224; 90—10