US005595514A

United States Patent [19]

Romano et al.

[11] **Patent Number: 5,595,514**

[45] **Date of Patent: Jan. 21, 1997**

[54] **FEEDTHROUGH PIN AND PROCESS FOR ITS PREPARATION, AND ELECTRICAL FEEDTHROUGH MADE THEREWITH**

[75] Inventors: **Timothy S. Romano**; **Tom K. Evans**; **Gary B. Hughes**, all of Goleta; **Karl H. Neumann**, Santa Barbara, all of Calif.

[73] Assignee: **Santa Barbara Research Center**, Goleta, Calif.

[21] Appl. No.: **277,560**

[22] Filed: **Jul. 19, 1994**

[51] **Int. Cl.**[6] **H01R 13/03**

[52] **U.S. Cl.** **439/886**; 439/935; 29/874

[58] **Field of Search** 439/886, 887, 439/935, 611; 29/874, 878, 879, 880, 846; 174/151, 152, 900

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,897,584	8/1959	Schumpelt	439/886
3,257,636	6/1966	Horssen	439/874
4,479,069	10/1984	Miller	439/85
4,657,337	4/1987	Kyle	439/887
5,221,874	6/1993	Dayton	439/611

FOREIGN PATENT DOCUMENTS

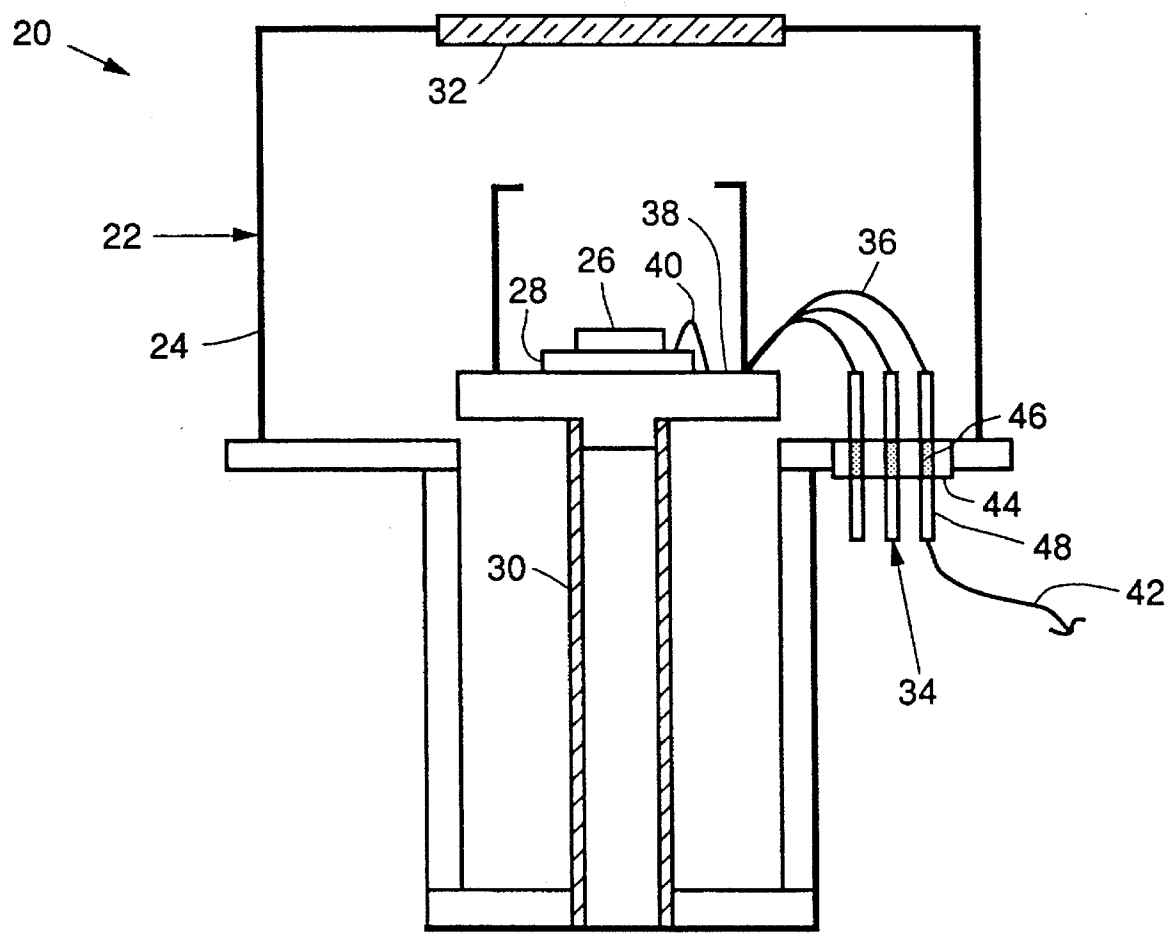
449408	1/1973	U.S.S.R.	439/887

Primary Examiner—Gary F. Paumen
Assistant Examiner—T. C. Patel
Attorney, Agent, or Firm—W. C. Schubert; W. K. Denson-Low

[57] **ABSTRACT**

A feedthrough (**34**) is formed of a feedthrough plate (**44**) having at least one bore (**46**) therethrough and a feedthrough pin (**48**) hermetically sealed into the bore (**46**). The feedthrough pin (**48**) includes an elongated pin (**50**) having an axis of elongation (**52**), a recess (**54**) in at least one end of the pin (**50**), the recess (**54**) extending parallel to the axis of elongation (**52**), and a gold coating (**56**) within the recess (**54**). There are preferably a plurality of bores (**46**) in the feedthrough plate (**48**) and a corresponding plurality of the feedthrough pins (**48**). The gold coatings (**56**) at the ends of the feedthrough pins (**48**) are desirably lapped to ensure coplanarity and a smooth surface finish especially suited for wire bonding or tab bonding.

19 Claims, 2 Drawing Sheets



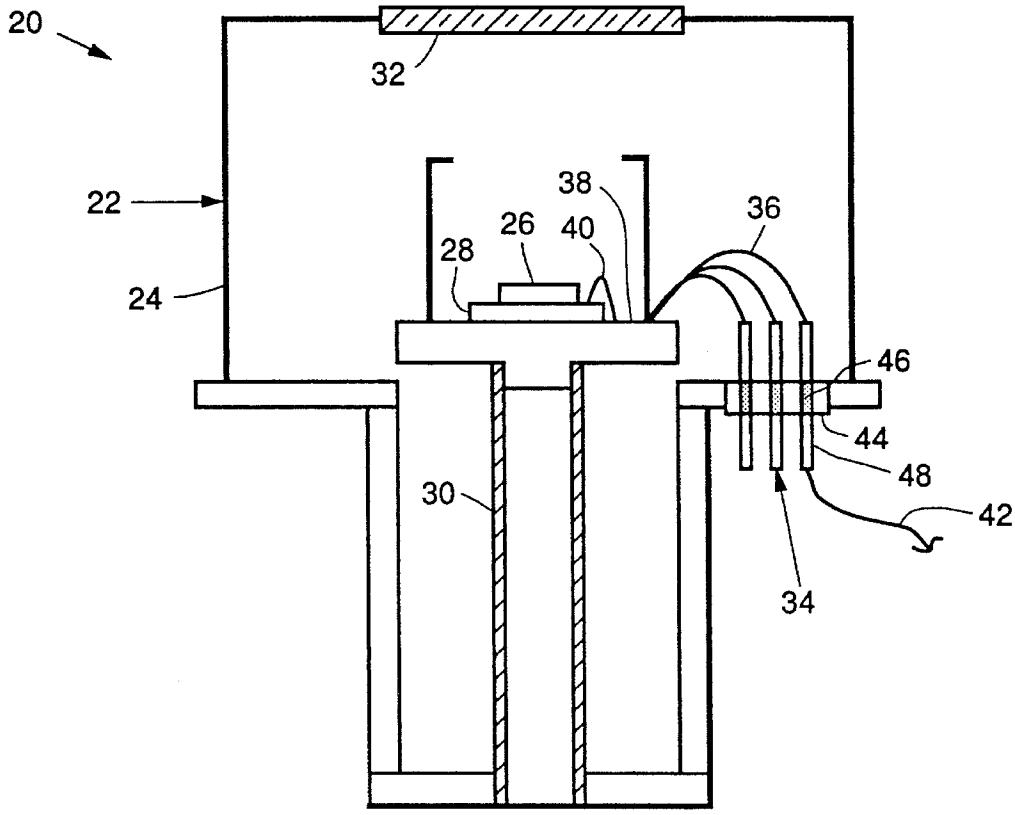
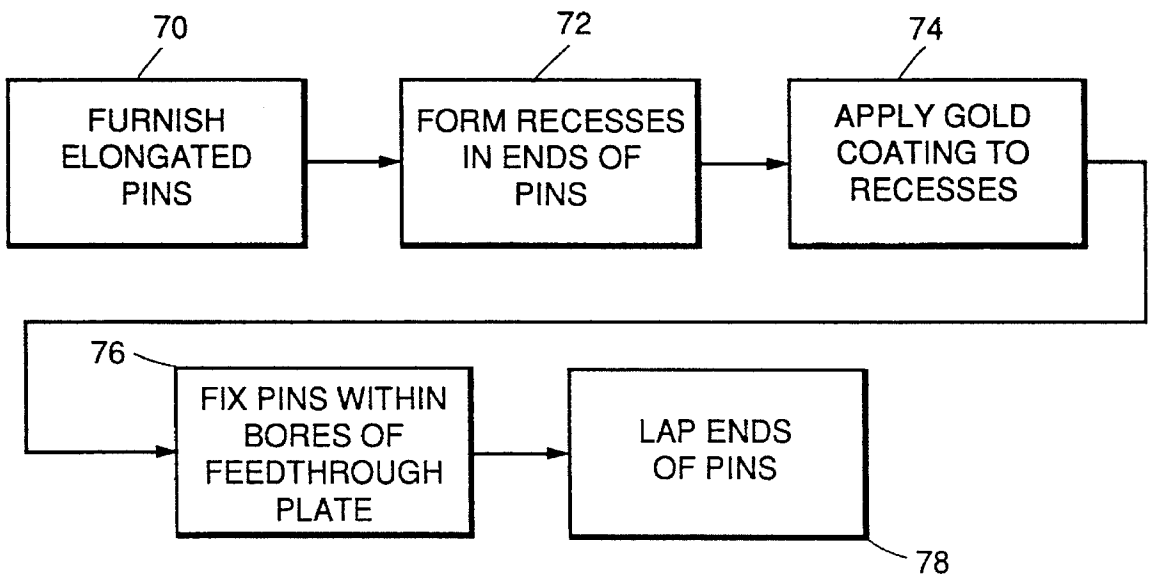

20
32
22
24
38
26
40
28
36
46
44
48
42
30
34

FIG. 1.

FIG. 2.


70
FURNISH ELONGATED PINS
72
FORM RECESSES IN ENDS OF PINS
74
APPLY GOLD COATING TO RECESSES
76
FIX PINS WITHIN BORES OF FEEDTHROUGH PLATE
LAP ENDS OF PINS
78

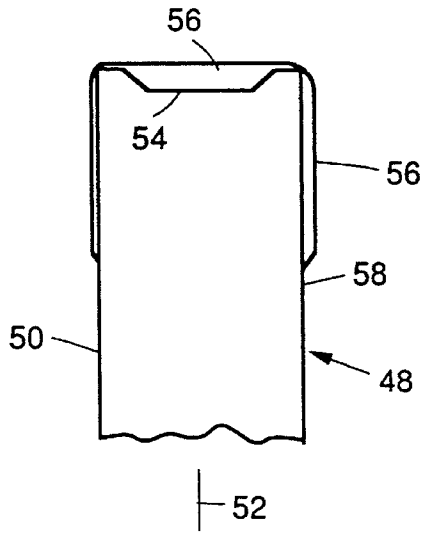
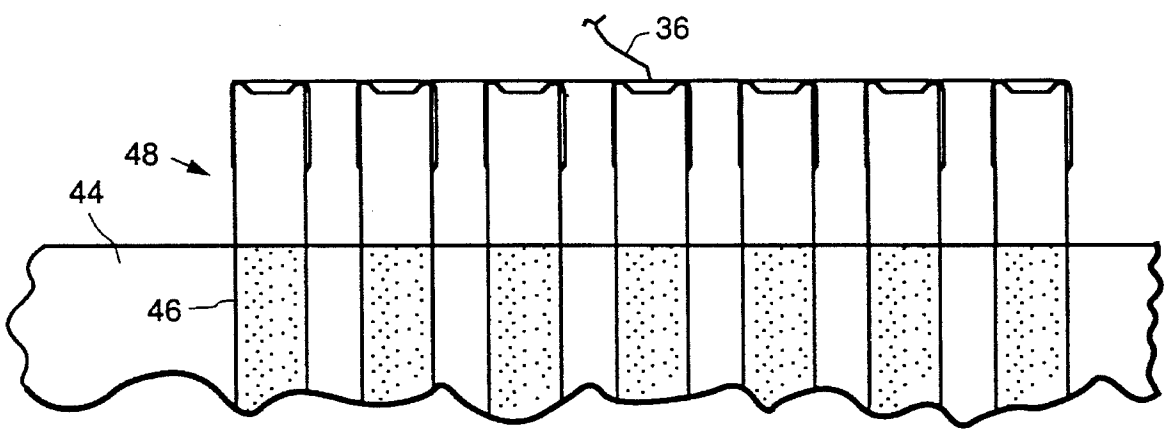


FIG. 3.

FIG. 4.



FEEDTHROUGH PIN AND PROCESS FOR ITS PREPARATION, AND ELECTRICAL FEEDTHROUGH MADE THEREWITH

BACKGROUND OF THE INVENTION

This invention relates to electrical feedthroughs, and, more particularly, for feedthrough pins utilized in the feedthroughs.

Many types of apparatus utilize an electrical feedthrough across a wall that separates two environments. The electrical feedthrough permits electrical signals and power to be conducted across the wall, but prevents any movement of mass, such as gas leakage, across the wall. As an example, an infrared sensor is typically contained in a vacuum enclosure. The sensor is cooled to cryogenic temperatures, typically about 77° K. or less. Output signals are conducted from the sensor to electronic devices located exterior to the vacuum enclosure, without losing the hermetic vacuum seal, via an electrical feedthrough in the wall of the enclosure.

The feedthrough is usually constructed with a plurality of feedthrough pins hermetically sealed in bores in a feedthrough plate made of an insulating material such as a ceramic. The feedthrough plate is hermetically sealed to the remainder of the wall of the package structure, here the vacuum enclosure. The ceramic insulator electrically isolates the feedthrough pins from the wall and from each other.

An electrical connection is made to each end of the feedthrough pin. In order to achieve a reliable, uniform connection to the feedthrough pins by techniques such as wire bonding or tab bonding, the ends of the set of feedthrough pins should be closely coplanar. The ends of the feedthrough pins should also have a good quality, smooth surface finish. In order to achieve coplanar, smooth ends of the feedthrough pins, the ends may be lapped or otherwise processed after the feedthrough pins are fixed to the feedthrough plate.

It is difficult to achieve the required coplanarity and surface finish on the ends of the feedthrough pins at the operation which bonds the pins to the plate, using conventional techniques. There is therefore a need for an improved approach to achieving coplanar, bondable feedthrough pins, and the feedthrough construction. The present invention fulfills this need, and further provides related advantages.

SUMMARY OF THE INVENTION

The present invention provides an electrical feedthrough pin that is particularly adapted to use in feedthroughs. The ends of the feedthrough pins of a feedthrough are readily brought into coplanarity. The ends may also be provided an excellent, smooth surface finish. The feedthrough pins have excellent connectability by wire bonding, tab bonding, or other techniques. The pins also have excellent mechanical properties and strength, and low electrical connection resistance. The feedthrough pins of the invertion are reliably made with little or no waste of the expensive gold coating material.

In accordance with the invention, a feedthrough pin comprises an elongated pin having an axis of elongation, a recess in at least one end of the pin, the recess extending parallel to the axis of elongation, and a coating of gold within the recess. An electrical feedthrough has a feedthrough plate having at least one bore therethrough, and a feedthrough pin hermetically sealed within the at least one bore of the feedthrough plate. The feedthrough pin has the structure just described.

The recess In the ends of the feedthrough pins aids in their being aligned and, where necessary, lapped to achieve good coplanarity and surface finish of the ends. Even after material is removed in the surface finishing and lapping process, a uniform end of each feedthrough pin is presented for external connection.

Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of a package structure utilizing an electrical feedthrough;

FIG. **2** is a process flow chart for the method of preparing the electrical feedthrough pins;

FIG. **3** is a schematic side sectional view of a portion of a feedthrough pin made according to the invention; and

FIG. **4** is a schematic side sectional view of a portion of a set of feedthrough pins after the plns have been fixed to the feedthrough plate and the ends of the plns have been lapped.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** depicts an apparatus **20** having a vacuum package enclosure **22** with a wall **24**. Within the vacuum package enclosure **22** is a device **26**, in this case an infrared sensor, that requires an electrical interconnection with electronic circuitry (not shown) external to the apparatus **20**. The device **26** is mounted on a base **28**, which in turn is mounted on a pedestal **30** that is attached to the interior of the vacuum package enclosure **22**. The pedestal **30** and thence the device **26** are cooled by a Joule-Thomson cryostat or other cooling means (not shown) to a temperature that is typically about 77° K. or less. The device **26** faces forwardly through a window **32** which is supported in the wall **24**.

In the assembled and operating form of the apparatus **20**, the contained volume within the vacuum package enclosure **22** is evacuated. The wall **24** therefore separates an evacuated space from ambient air. An hermetic seal must be maintained between the interior of the vacuum package enclosure **22** and the exterior.

The apparatus **20** includes an electrical feedthrough **34**. The feedthrough **34** provides a portion of the electrical connection path from the device **26** to the exterior of the apparatus **20**. To connect from the feedthrough **34** to the device **26**, there is a fine-wire internal lead **36** from the feedthrough **34** to a conductor trace **38** on the surface of the base **28**, which in turn connects to another lead **40** that connects to the device **26**. Exterior to the feedthrough **34**, there is an external electrical connection, here shown to be a soldered lead **42**, but which could be a permanent connector, a disconnectable connector, or any other suitable connection means.

The feedthrough **34** is formed of a generally flat feedthrough plate **44** of a ceramic material such as aluminum oxide. Bores **46** are formed through the feedthrough plate **36**. Electrical feedthrough pins **48** are hermetically sealed into the bores **38**.

The present invention is concerned with the structure of the feedthrough **34**, and more particularly with the feedthrough pins **48**. FIG. **2** depicts the process for preparing feedthrough pins **48** and their use in the feedthrough **34**. FIG. **3** is an enlarged view of a single feedthrough pin **48** in accordance with the invention, and FIG. **4** shows a number of the feedthrough pins **48** fixed to the feedthrough plate **44**.

Referring to FIGS. **2–3**, elongated pins **50** having a pin axis **52** are furnished, numeral **70**. The pins are preferably made of molybdenum. (As used herein, "molybdenum" includes either pure molybdenum or a molybdenum alloy.) In a typical case, the pins **50** are generally in the form of cylinders about 0.320 inches long and 0.018 inches in diameter.

A recess **54** is formed in at least one end of each pin **50**, numeral **72**. The recess **54** extends into the end of the pin **50** parallel to the pin axis **52**. In the case of the 0.320 inch long, 0.018 inch diameter pin discussed above, the recess **54** is about 0.015+/–0.0025 inches deep, and has a diameter of about 0.010+/–0.0025 inches. The sides of the recess **54** are desirably angled inwardly to impart a cuplike shape to the recess **54**.

A gold coating **56** is applied to the pin **50**, numeral **74**. The gold coating **56** is applied to fill the recess **54**, and may also be applied overlying at least a portion of a longitudinal side **58** of the pin **50**. The gold coating is produced by forming a slurry of about 90 parts by volume of fine gold particles, about 8 parts by volume of a binder such as acrylic binder solution, and about 2 parts by volume of a carrier such as acetone. The slurry is painted onto the pin **50** in the locations where a gold coating is desired. An advantage of this approach is that the slurry layer may be thick in the recess **54**, to fill the recess, and thinner along the longitudinal sides of the pin. After the slurry is painted onto the pins **50**, the slurry is allowed to dry. The slurry-coated pin is then heated to a temperature above the melting point of gold, preferably 2040° F., so that the binder burns away and the gold melts. The gold flows to even out any irregularities so that, after cooling, there is a smooth gold coating on the pins **50**. The coating in this case is thicker in the interior of the recess **54** and thinner along the longitudinal sides **58** of the pins **50**. Preferably, only those portions of the sides **58** of the pins **50** near the ends of the pins are coated with gold. The finished structures are the feedthrough pins **48**.

The gold-coated feedthrough pins **48** are inserted into the bores **46** and hermetically fixed into the ceramic feedthrough plate **44**, numeral **76**. The feedthrough pins **48** may be fixed in place by any operable technique such as, for example, a glass seal, a ceramic seal, or active brazing. FIG. **4** shows a plurality of the feedthrough pins **48** fixed into place in the feedthrough plate **44**.

After the feedthrough pins **48** are fixed in place, electrical connections may be made to the ends of the feedthrough pins **48**. A lead **36** is bonded to the end of one of the feedthrough pins **48** in FIG. **4**, for Illustration, but in practice there would be leads **36** bonded to the ends of most or all of the feedthrough pins **48**.

Prior to the formation of the electrical connections, the ends of the feedthrough pins **48** may optionally be lapped, numeral **78**, to cause the ends to be coplanar and provide the ends with a smooth finish that is beneficial in making the electrical connections. To perform the lapping operation, the feedthrough plate **44** is inverted over a lapping wheel or other surface, so that the ends of the feedthrough pins **48** contact the lapping surface. Material is lapped from the gold coating **56** overlying the recess **54**. A sufficient amount of gold is removed so that all of the ends are coplanar and smooth. In trials of the invention, coplanarity within less than 0.0005 inches and a gold surface finish of less than 2 micrometers RMS variation have been achieved. Such results can be repeatably produced, which has not been possible in the absence of the recesses in the ends of the pins, because in the prior approach the gold is removed during the lapping operation. In the case of the present pin having the recess **54**, even after lapping a gold layer remains for attachment of the leads **36**.

With the ends of the feedthrough pins **48** made coplanar in this fashion, the leads **96** are readily wire bonded or tab bonded in a single automated operation. Although a particular embodiment of the invention has been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited except as by the appended claims.

What is claimed is:

1. A feedthrough pin, comprising:

an elongated pin having an axis of elongation;

a recess in at least one end of the pin, the recess extending parallel to the axis of elongation; and

a coating of gold within the recess, the gold being present in an amount sufficient to fill the recess.

2. The feedthrough pin of claim **1**, wherein the coating of gold has a lapped surface.

3. The feedthrough pin of claim **1**, wherein the elongated pin is made of molybdenum.

4. The feedthrough pin of claim **1**, wherein the recess has a depth of about 0.015 inches.

5. The feedthrough pin of claim **1**, wherein the coating of gold extends outside of the recess and onto a lateral surface of the elongated pin.

6. The feedthrough pin of claim **1**, wherein there is a recess in each end of the pin extending parallel to the axis of elongation, and a coating of gold within each recess.

7. A feedthrough, comprising:

a feedthrough plate having at least one bore therethrough; and

a feedthrough pin hermetically sealed in the at least one bore of the feedthrough plate, the feedthrough pin comprising

an elongated pin having an axis of elongation,

a recess in at least one end of the pin, the recess extending parallel to the axis of elongation, and

a coating of gold within the recess, the gold being present in an amount sufficient to fill the recess.

8. The feedthrough of claim **7**, wherein the coating of gold has a lapped surface.

9. The feedthrough of claim **7**, wherein the elongated pin is made of molybdenum.

10. The feedthrough of claim **7**, wherein the recess has a depth of about 0.015 inches.

11. The feedthrough of claim **7**, wherein the coating of gold extends outside of the recess and onto a lateral surface of the elongated pin.

12. The feedthrough of claim **7**, wherein there is a recess in each end of the pin extending parallel to the axis of elongation, and a coating of gold within each recess.

13. The feedthrough of claim **7**, wherein there are a plurality of bores in the feedthrough plate, and wherein there is a feedthrough pin sealed into each of the bores, each feedthrough pin comprising an elongated pin having an axis of elongation, a recess in at least one end of the pin, the recess extending parallel to the axis of elongation, and a

coating of gold within the recess, the gold being present in an amount sufficient to fill the recess.

14. The feedthrough of claim **13**, wherein the coating of gold on each feedthrough pin has a lapped surface, and wherein the lapped surfaces of the plurality of feedthrough pins are coplanar.

15. A method for preparing a feedthrough pin, comprising the steps of

furnishing an elongated pin having an axis of elongation;

forming a recess in at least one end of the pin, the recess extending parallel to the axis of elongation; and

applying a coating of gold within the recess, the gold being present in an amount sufficient to fill the recess.

16. The method of claim **15**, including the additional step, after the step of applying a coating of gold, of

lapping the end of the pin to form a lapped surface on the coating of gold.

17. A feedthrough pin prepared by the process of claim **15**.

18. The method of claim **15**, wherein the step of applying a coating includes the step of

furnishing a gold-containing slurry,

applying the slurry to the recess, and

heating the slurry to a temperature above the melting point of gold.

19. A feedthrough, comprising:

a feedthrough plate having a plurality of bores therethrough; and

a feedthrough pin hermetically sealed in each of the plurality of bores, each feedthrough pin comprising

an elongated pin having an axis of elongation,

a recess in an end of the pin, the recess extending parallel to the axis of elongation, and

a coating of gold within the recess and having an exposed surface, the gold being present in an amount sufficient to fill the recess, wherein the exposed surfaces of the gold coatings of the plurality of feedthrough pins are coplanar.

* * * * *