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Kozak

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[45] Jan. 2, 1973

[54] ELECTRODE JOINT HAVING UNDERCUT ELECTRODE SOCKETS

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[21] Appl. No.: **164,773**

[52] **U.S. Cl.** **13/18**
[51] **Int. Cl.** **H05b 7/14**
[58] **Field of Search** ....13/18; 287/127 E

[56] **References Cited**

UNITED STATES PATENTS

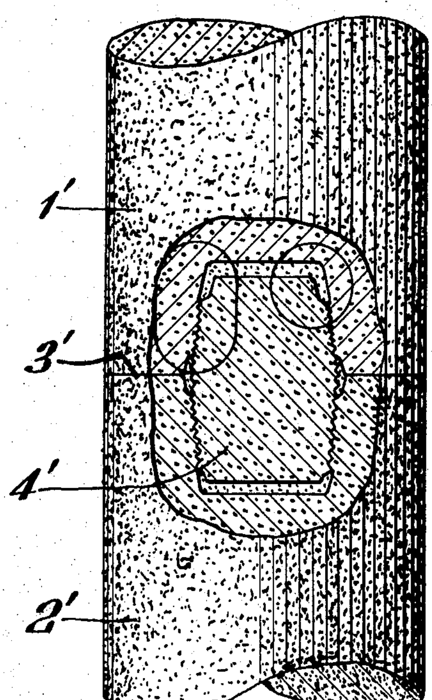
2,836,806 5/1958 Stroup ....13/18 X

Primary Examiner—Roy N. Envall, Jr.
Attorney—Paul A. Rose et al.

[57] **ABSTRACT**

An electrode joint comprising two end-face electrode sections having female threaded sockets designed for mating with a male threaded nipple so that when joined by the nipple, all the threads at the base of the electrode socket will be engaged with mating threads on the nipple.

2 Claims, 6 Drawing Figures



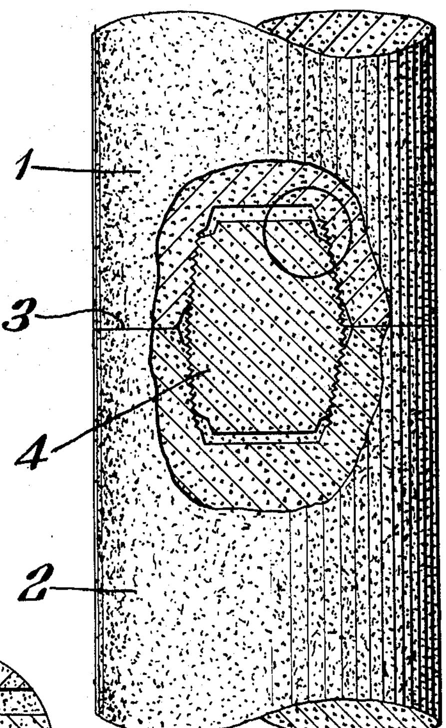


Fig.1

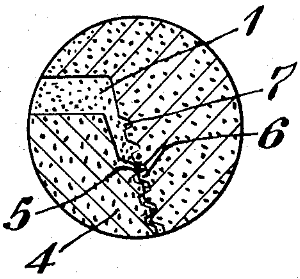


Fig.1a

Prior Art

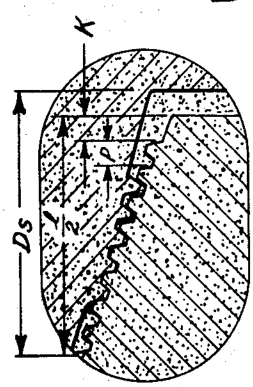


Fig.2b

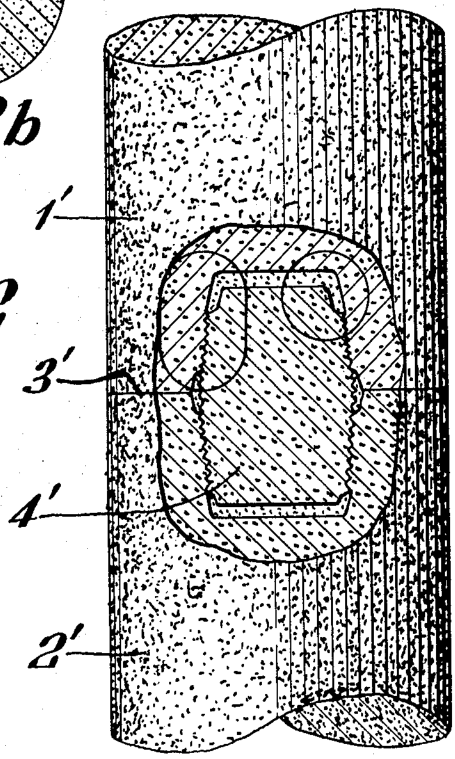


Fig.2

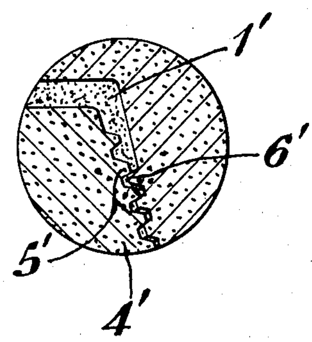


Fig.2a

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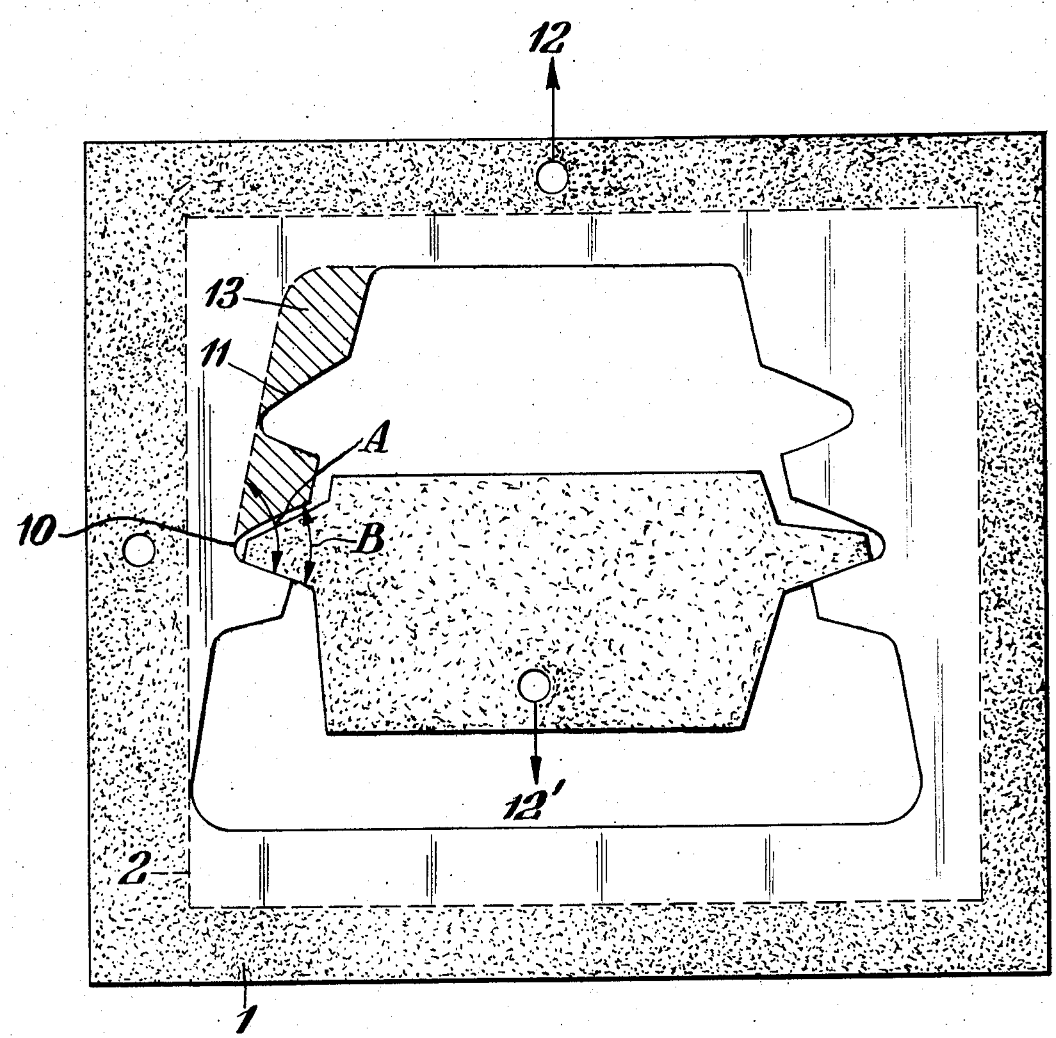

Fig. 3

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ELECTRODE JOINT HAVING UNDERCUT ELECTRODE SOCKETS

FIELD OF THE INVENTION

This invention relates to electric-furnace electrode columns composed of two or more electrode sections joined at their end-faces by male threaded nipples wherein the female threads at the base of each electrode section socket are all engaged with threads on the mating nipple.

DESCRIPTION OF THE PRIOR ART

Carbon and graphite electrodes used in the early development of the electric arc furnace for various electrometallurgical processes were not machined for endwise joining to provide for continuous feeding into a furnace. This resulted in considerable loss of material known as stub loss and in the loss of furnace operating time due to mandatory interruptions of the furnace required for connecting new electrodes after an electrode has been consumed.

To ameliorate this inefficient use of electrode sections, attempts were made to join the electrode sections by use of dowels, keys and dovetail connections. Presently, symmetrical threaded connecting pins are widely used for joining mating threaded socket ends of electrode sections to form an electrode column.

This approach of joining consumable electrode sections provides a means of continuously feeding electrodes into electric furnaces thus minimizing the frequency of interruption of the furnace operation thereby increasing the efficiency of the electrometallurgical process being performed. However, one major problem still facing the electrometallurgical industry resides in the fact that electrode joints sometime have a tendency to rupture during use. This is due to many factors such as mechanical shock, vibrations and thermal gradients encountered by the electrode joint when being fed into an operating electric furnace. Since it is known that materials expand proportionally with temperature, the connecting nipple and electrode sections expand different amounts thereby setting up thermal stresses in the threaded engagement area of the joint which sometimes causes cracks, splits and even complete rupture of the joint. These joint failures due to mechanical and thermal stresses are predominantly localized to the last threaded area in the base of the electrode socket or to the unengaged threaded area in the base of the socket.

The present invention provides a means whereby the stress concentration at the unengaged threads at the base of an electrode socket is eliminated by the elimination of such threads, and the stress concentration at the last engaged threaded area in the base is reduced thereby increasing the strength of the electrode joint.

SUMMARY OF THE INVENTION

Broadly stated, the invention relates to electrode sections and specifically to electrode sections having at least one threaded socket wherein the threads in the base of such socket are undercut sufficiently so that when two electrode sections are joined by threaded nipple means, there will be no unengaged electrode threads in the base of the sockets of the electrode joint.

The invention can best be described by referring to the drawing which shows:

FIG. 1 — A conventional type electrode joint (Prior Art).

FIG. 1*a* — An enlarged view of the threaded area in the base of the electrode section in FIG. 1.

FIG. 2 — An electrode joint employing an undercut electrode socket according to this invention.

FIG. 2*a* — An enlarged view of the threaded area in the base of the electrode section of FIG. 2.

FIG. 2B — An enlarged view of the threaded area in the electrode section of FIG. 2.

FIG. 3 — A simulated arrangement of a threaded section of an electrode column.

A conventional type electrode joint shown in FIG. 1 comprises an upper electrode section **1** and a lower electrode section **2** joined at their end-faces **3** by male threaded nipple **4**. An enlarged view of the threaded area at the base of the socket is shown in FIG. 1*a* wherein the last thread **5** on nipple **4** is engaged with thread **6** on electrode section **1**. The unengaged or inactive thread or threads **7** at the base of the electrode socket and the last engaged or active thread thereat are usually high stress areas due to the thermal and/or mechanical stress build-up concentrated thereat. The former stress is attributed mainly to the difference in the coefficients of thermal expansion between the threaded nipple **4** and the electrode section **1** when they are exposed to the high temperature environment of an operating electric furnace. The mechanical stress is due mainly to the mechanical shock and vibrations associated with lowering of a consumable electrode into an electric furnace. The combination of these stresses are sometimes sufficient to actually fracture the electrode near the base of the socket area either at the last active thread vicinity or at the inactive thread vicinity.

The undercut socket joint arrangement of this invention, shown in FIG. 2, comprises an upper electrode section **1'**, and a lower electrode section **2'** joined at their end-faces **3'** by male threaded nipple **4'**. The threaded area at the base of the socket is shown magnified in FIG. 2*a* wherein thread **5'** on nipple **4'** is engaged with the last thread **6'** on electrode section **1'**. Unlike the conventional type electrode joint shown in FIG. 1*a*, the unengaged threads at the base of the electrode socket shown in FIG. 2*a* are removed thereby increasing notch angle A defined as the angle formed by the loaded flank of the last electrode thread at the base of the socket and the wall of the electrode socket. This removal of unengaged threads in the base of the electrode socket which increases the notch angle at the last engaged thread in the base of the socket over the included angle of the threads in such socket forms the basis of this invention since it results in a reduction of the stresses concentrated at the last threaded engagement area of the socket while also eliminating the stress formerly concentrated at the unengaged threaded area. This stress reduction arising from tensile loading conditions (hanging column weight and/or bending moments) and thermal interference greatly decrease the frequency of fracture near the base of the socket area which results in stub losses into the furnace, such stub losses being associated with fractures at the first electrode joint above the arc tip of an operating furnace.

Thus the unexpected results obtained by removal of these unengaged threads is in less electrode stub loss thereby reducing the overall operating expense of an electric furnace. In addition, column loss, defined as losses due to fractures at the second or higher electrode joints above the arc tip, is also greatly reduced.

To demonstrate the actual reduction of stress at the base of an electrode socket, a simulated threaded plate section **1**, using modified acme threads similar to those used in actual electrode joints, was prepared as shown in FIG. **3**. The threaded simulated sample, measuring 14 inches by 7 inches by one-fourth inch thick was made of graphite commercially available as type AGX graphite. The area **2**, designated with broken lines and measuring 7¼ inches long and 6½ inches wide, was covered with an one-eighth inch thick sheet of Type PS-1A Photolastic material having a reflected aluminum surface so that under loading conditions, a conventional type polariscope could be used to analyze the stress concentrated at any point within the area. Photoelectric stress analysis utilizes the relationship between the state of stress in a material and the way the material transmits polarized light. Briefly, experimentation consists of observing an optical pattern for fringes which can be related to stress via the wave theory of light and the theory of elasticity. Further discussion on photoelasticity testing can be found in "A Treatise on Photoelasticity" by E. G. Coker and L. N. Fillon, Cambridge University Press, London, **1931**, and "Experimental Stress Analysis and Motion Measurement" by R. C. Dove and P. H. Adams, Charles and Morrill Books, Inc., Columbus, 1964.

A Model 232 digital readout compensator was used with a Model 031 polariscope (both manufactured by Photolastic, Inc.) so as to assure the accuracy of measurement of the fringe order in the particular stress area of the test sample. The digital readout was capable of measuring fringes to an accuracy of one fifty-third of one fringe and the unit of measurement employed was expressed as a "fringe unit." A reading of 1 fringe was divided into 53 segments so as to correlate with the degree of accuracy of the digital readout so that a 1 fringe unit would equal a reading of 53 over an accuracy of 53, i.e., 1 fringe unit = 53 reading/53 accuracy.

With the unengaged thread **11** being present, a force of 150 pounds was applied between points **12** and **12'**, as shown in FIG. **3**, to simulate the loading associated with a conventional threaded electrode joint. Area **10**, corresponding to the root of the last thread near the base of a socket, was investigated and using the polariscope and digital compensator was found to have a fringe unit of 154/53. Using the same sample but removing thread **11** as shown by the shaded area **13**, a force of 150 pounds was again applied between points **12** and **12'**. The notch angle A, measuring 110.5°, was greatly increased over the included angle of the thread B which measured 60°. Area **10** was again analyzed and found to have a fringe order of 128/53. This stress at area **10** with the unengaged thread present was 13 percent higher than the stress at the same area with the unengaged thread removed.

The removal of the unengaged thread or threads in the electrode socket so as to increase the notch angle by at least 30° can be accomplished once the size of the male threaded nipple is known. It has been found that the following formula can be employed in determining the minimum amount of undercut required in the base of a standard size electrode socket using standard size threaded nipples:

$$L = D_s - ½ + K + P + f$$

wherein in conjunction with FIG. **2B**

L = Length of Undercut
D_s = Depth of Socket
l = Length of Nipple
K = Nipple Boss Length
P = Pitch of thread
f = Float of Nipple (about 0.100 inch)

For example, the length of the minimum undercut in an electrode socket using the above formula for a standard 12½ inch diameter by 14 inch length nipple would be 1.25 inch and begin 6.230 inch away from the end-face of the electrode.

The concept of this invention is broad enough to be employed in the use of any type nipple connecting means made from any material. It is to be also understood that since precise machining of both the nipple and the mating electrode sections would be required to insure complete engagement of all threads on such components, the nipple may have unengaged threads at the base of the sockets without deviating from this invention.

What is claimed is:

1. An electrode joint comprising a first electrode section with a female threaded socket at its end-face, a second section with a female threaded socket at its end-face, and a male threaded nipple means joining said end-faces of said first and second electrode sections, the improvement which comprises having the base of each electrode socket in said electrode sections undercut at least a minimum length according to the following formula:

$$L = D_2 - ½ + K + P + f$$

wherein

L = Length of Undercut
D_s = Depth of Socket
l = Length of Nipple
K = Nipple Boss Length
P = Pitch of Thread
f = Float of Nipple

2. An electrode section having at least one female threaded socket for mating with a threaded nipple, the improvement which comprises the undercutting of its base of the socket at least a minimum length in accordance with the following formula:

$$L = D_s - ½ + K + P + f$$

wherein

L = Length of Undercut
D_s = Depth of Socket
l = Length of Nipple
K = Nipple Boss Length
P = Pitch of thread
f = Float of Nipple.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,708,601 Dated January 2, 1973

Inventor(s) P.E. Kozak

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

In the specification, column 4, lines 9 through 13 should read as follows:

$$L = D_s - \ell/2 + K + P + f$$

wherein in conjunction with FIG. 2B

L = Length of Undercut
D_s = Depth of Socket
ℓ = Length of Nipple

In the claims, claim 1, lines 41 through 45, and claim 2, lines 54 through 58 should each read as follows:

$$L = D_s - \ell/2 + K + P + f$$

wherein

L = Length of Undercut
D_s = Depth of Socket
ℓ = Length of Nipple

Signed and Sealed this

Twenty-first Day of *February 1978*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,708,601 Issue Date January 2, 1973

Inventor(s) P. E. Kozak

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

In the claims, claim 1, line 41, should read as follows:

$$L = D_s - 1/2 + K \pm P \pm f$$

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents