

Aug. 20, 1968

R. BONFILS ETAL
PREBAKED CARBON ANODES AND ANODE ASSEMBLY FOR
THE PRODUCTION OF ALUMINUM

3,398,081

Filed April 5, 1966

4 Sheets-Sheet 1

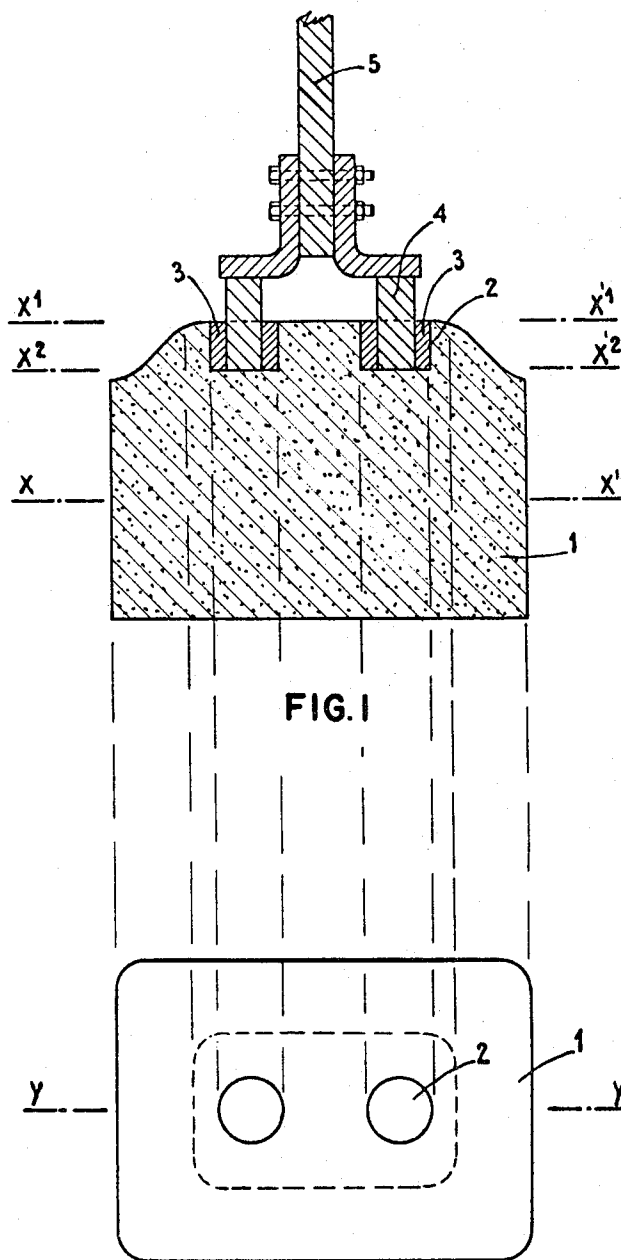


FIG. 1

FIG. 2

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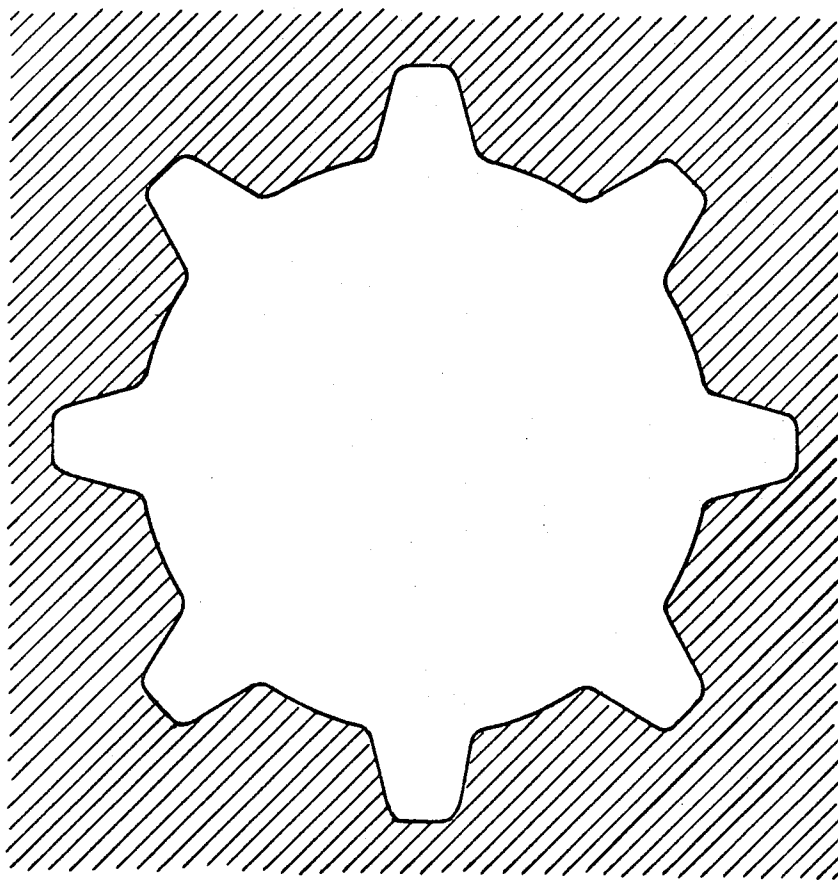


FIG. 3

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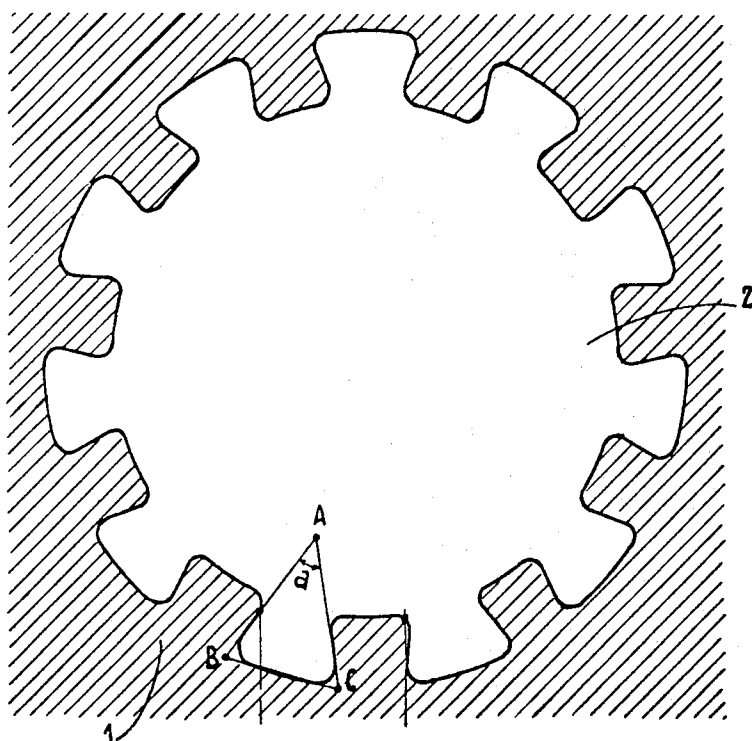


FIG. 4

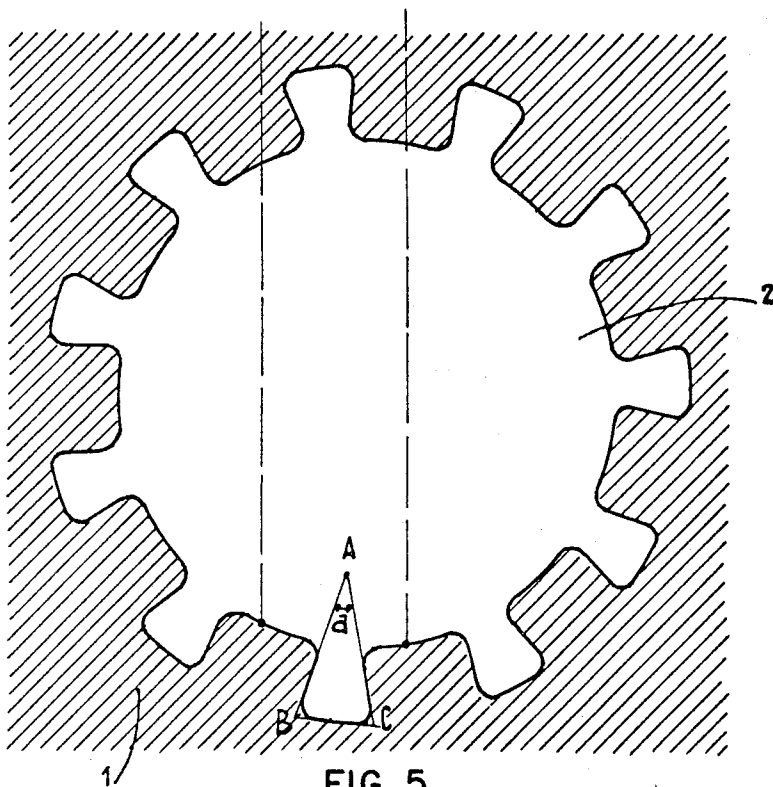


FIG. 5

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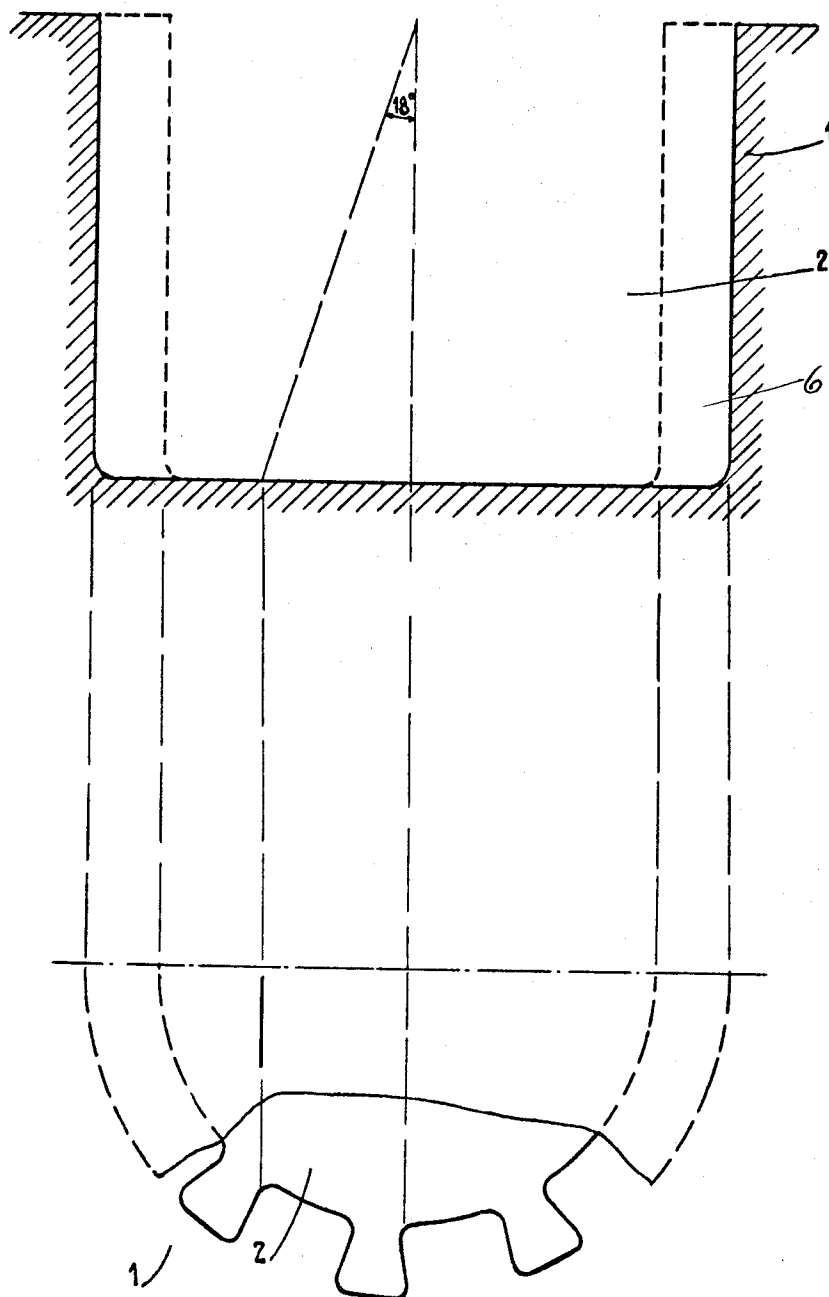


FIG. 6

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PREBAKED CARBON ANODES AND ANODE ASSEMBLY FOR THE PRODUCTION OF ALUMINUM

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This invention relates to the manufacture of prebaked carbon electrodes and relates more particularly to a new and improved prebaked carbon anode adapted for use in the preparation of aluminum by electrolytic technique from a molten bath.

In practice, the prebaked anode is suspended from the positive frame of an electrolytic tank with the lower portion of the anode immersed in the electrolyte. For purposes of interconnecting the anode with the frame, for support of the anode while maintaining an electrically conductive relationship therebetween, the anode is molded with cavities in the upper end for receipt of feet on the lower end of a stem by which the assembly is suspended from the tank.

It is desirable to effect a good seal between the feet and the anode to maintain a good electrical conductive relationship therebetween. For this purpose, the space remaining between the feet, when inserted into the cavity, is filled with a conductive material of high strength, such as cast iron.

The cast iron solidifies as it cools and makes the desired mechanical and electrical bond between the carbon anode and the steel feet. When the anode is used up, it is withdrawn from the bath and the anode feet are recovered by a cast iron removal operation which relies upon the more brittle character of the cast iron to enable breakage from the feet in response to impact. Generally, the anode foot is in the form of a cylindrical bar which extends into the cavity formed in the upper end of the anode. The steel foot is of such mechanical strength as to resist breakage during the cast iron removal process. Anode feet of elongated form have also been tried but their resistance to the cast iron removal process has been found to be inadequate.

From the standpoint of electrical connection, a substantial voltage drop occurs between the carbon anode and the cast iron. From the standpoint of the mechanical connection, breaks in the seal of the anode, referred to as seal breakages, occur fairly frequently and, on such occurrences, the anode drops into the bath.

Attempts have been made to rectify these drawbacks by forming the cavity with vertical or helical grooves which extend from the top to the bottom of the lateral wall of the cavity to increase the area of contact between the anode and the cast iron. For the formation of such helical grooves, the cavities are formed of dies having ribs formed along a vertical axis about which the dies can rotate during removal of the anode from the mold.

It is an object of this invention to produce and to provide a method for producing a new and improved electrode which overcomes many of the difficulties heretofore encountered, which minimizes the voltage drop at the sealing level and it is a related object to produce a carbon electrode and elements employed in combination therewith to produce an assembly which gives an improved performance especially in the manufacture of aluminum by electrolysis.

Another object is to produce a prebaked carbon electrode having improved electrical and mechanical connection to the anode feet and in which a good electrical and mechanical connection is maintained substantially

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throughout the period of use of the anode in the production of aluminum.

A further object is to produce a mold for use in shaping prebaked carbon anodes wherein the mold comprises a die, preferably movable, which includes a core formed to provide grooves of trapezoidal (swallowtail) profile in the side walls of the formed cavity.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings in which:

FIGURE 1 is a sectional view of an anode assembly which is representative of present practice, taken along the line Y-Y' of FIGURE 2;

FIGURE 2 is a sectional view taken along the line X-X' of FIGURE 1;

FIGURE 3 is a sectional view taken along the line X₁-X₁' of FIGURE 1;

FIGURE 4 is a corresponding sectional view taken along the line X₁-X₁' of FIGURE 1 when the anode is constructed in accordance with the practice of this invention;

FIGURE 5 is a sectional view taken along the line X₂-X₂' of FIGURE 1 when the anode embodies the features of this invention; and,

FIGURE 6 is a vertical sectional view of the cavity formed in an anode embodying the features of this invention.

In the drawing, the numeral 1 represents the prebaked carbon anode, 2 is the cavity formed in the upper end of the anode, 3 the cast iron sealing material, 4 the foot on the lower end of the cylindrical bar of steel and 5 is the anode rod. The numeral 6 represents the grooves formed in the side walls of the cavity.

It will be seen by comparison between the horizontal cross section of the cavity at the top in FIGURE 4 and at the bottom in FIGURE 5 that the groove 6 is of helical form i.e., helical grooves inclined at an angle of about 18° in the drawing, as shown in FIGURE 6.

As shown in FIGURES 4 and 5, the sides of the grooves may be extended to form a substantially isosceles triangle ABC having an apex angle α . FIGURES 4 and 5 have been placed one above the other more clearly to illustrate the relationship between the grooves at the upper portion of the cavity by comparison with the shape of the grooves farther down and particularly the back-off existing between the top and bottom of each groove. Likewise, the lower part of FIGURE 4 has been shown below FIGURE 6 more clearly to illustrate the inclination of the grooves with respect to the vertical, that is to say, their helical nature.

The object of the invention resides in the improvement in prebaked carbon anodes intended for the production of aluminum by igneous electrolysis in which at least one cavity is provided in the upper portion of each anode for sealing the prebaked anode to the metal foot of the supporting stem. Each cavity is provided on its side wall with grooves 6 extending from the top of the bottom and in which the grooves are of trapezoidal shape, such as a swallowtail profile whereby, upon cooling the sealing cast iron, a squeezing or gripping action is effected against the walls of the cavity.

In accordance with a particular embodiment of the invention, the profile of the grooves is adapted to define a substantially isosceles triangle in which the apex angle α is selected to be within the range of 20 to 60° and preferably within the range of 30 to 50°. In accordance with another feature of this invention, the groove is in the form of a helical groove in which the apex angle diminishes from the top to the bottom of the groove. In other words, there is a considerable back-off, generally within the range of 5 to 10°, between the top and bottom of

the groove. The advantage of this arrangement is to facilitate removal of the die and to diminish or even nullify the possibility of tearing the threads or removing portions of the side walls of the groove during mold stripping.

The angle of inclination of the groove with respect to the vertical is generally within the range of 15 to 20°. For example, the angle is 18° in the modification which is shown in FIGURES 4, 5 and 6. The angle at the apex α of the substantially isosceles triangle ABC, formed by the extension of the groove, is 46° at the upper portion of the impression (see FIGURE 4) and 40° at the bottom portion (see FIGURE 5, corresponding to a back-off of 6°). The foregoing is given by way of illustration and not by way of limitation.

One of the important improvements of this invention resides in the increase in contact area between the cast iron sealing material and the carbon wall of the anode thereby to improve the electrical and mechanical contact.

Other advantages include ease of removal of the dies without damage of the threads or grooves when the anode imprint die is removed from the anode to leave the corresponding cavity. Anodes of increased mechanical strength are produced thereby to minimize and practically eliminate instances of anode seal breakages in use.

Moreover, because of the trapezoidal (swallowtail) shape of the grooves, as the cast iron used for sealing shrinks upon cooling, a squeezing effect takes place which enhances contact with the anode. By virtue of this squeezing effect, the electrical contact between the carbon anode and the sealing cast iron is greatly improved. More particularly, prebaked anodes, prepared in accordance with the practice of this invention, do not give rise to abnormal voltage drops between the carbon anode and the cast iron even during the early stages of use.

In the following table, comparison is made of the voltage drop between anodes prepared according to the prior state of art, is represented by FIGURES 1, 2 and 3 and anodes prepared in accordance with the practice of this invention, as represented by FIGURES 4, 5 and 6. The voltage drop measurement is taken between the cast iron sealing material and the bottom of the anode. The voltage drop readings were made on the days set forth in the table. The current density was 0.75 amps per square cm. under the anode. The thickness of the carbon in the new anode between the sealing cast iron was approximately 43 cm. After 23 days of use, the anode was removed from the bath of electrolyte and the thickness of carbon below the cast iron was no more than 1 cm.

	2nd day	3rd day	5th day	10th day	15th day	20th day	23rd day
According to the prior state of the art.....	0.35	0.33	0.30	0.25	0.20	0.17	0.15
According to the invention.....	0.27	0.23	0.19	0.13	0.09	0.09	0.05

It will be seen from the foregoing example that the average voltage gain is 0.1 volt as compared to the conventional method. This represents a gain of 350 kw./hr. per metric ton of aluminum produced for consumption of 15,000 kw./hour per metric ton.

As previously pointed out, the mechanical strength of the carbon anode-cast iron connection is greatly improved whereby the frequency of anode seal breakages is markedly reduced as demonstrated by the following. In a series of 104 commercial tanks, each containing 28 prebaked anodes, the number of seal breakages prior to the practice of this invention was an average of 7.5 daily. The anodes of this invention were gradually introduced into the commercial practice with the result that the number of seal breakages dropped rapidly and averaged only 0.7 anode

per day when the entire series had been replaced with the anodes embodying the features of this invention.

In addition, the invention offers the advantage of providing cavities in the anode having a shape and position particularly well adapted to the form of the anode and for allowing regular and uniform distribution of current passing from the cast iron seal to the carbon anode.

The invention has been found to be particularly easy and economical in application. The press for making the anodes differs very little from conventional presses except for the shape of the die used to produce the cavity. In addition, the invention makes it possible to make use of anode feet of substantial dimension so as to enable impacting to remove the cast iron seal without damage thereof.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of invention especially as defined in the following claims.

We claim:

1. A prebaked carbon anode having a cavity in the upper end portion for receiving an anode foot for attachment thereto in which the cavity is formed with helical grooves extending downwardly from the upper end of the cavity in the side walls thereof and in which the side walls of the groove define a section of trapezoidal shape.

2. A prebaked carbon anode as claimed in claim 1 in which the grooves extend continuously from the top of the cavity to the bottom.

3. A prebaked carbon anode as claimed in claim 1 in which the helicoidal grooves have an angle of inclination within the range of 15° to 20°.

4. An anode assembly comprising the combination of the prebaked carbon anode claimed in claim 1, an anode stem, a foot on the lower end of the anode stem which extends into the cavity, and cast iron filling the space between the foot and the side walls of the cavity to effect a sealing relationship therebetween and in which the cast iron squeezes the carbon anode in response to shrinkage which occurs during solidification of the cast iron when poured into the cavity to fill the space.

5. A prebaked carbon anode as claimed in claim 1 in which the side walls, when extended, define a substantially isosceles triangle having an apex angle within the range of 20° to 60°.

6. A prebaked carbon anode as claimed in claim 5 in which the apex angle is within the range of 30° to 50°.

7. A prebaked carbon anode as claimed in claim 1 in which the apex angle at the top of the grooves is greater

than the apex angle in the lower portions of the groove.

8. A prebaked carbon anode as claimed in claim 7 in which the backoff between the apex angle at the top to the apex angle at the bottom is within the range of 5° to 10°.

References Cited

UNITED STATES PATENTS

1,467,060	9/1923	Munning	204—288
2,769,113	10/1956	Graybeal	204—286 XR
2,939,829	6/1960	Allen	204—243
3,258,416	6/1966	Mantovanello	204—280
3,314,044	4/1967	Powell	287—126 XR

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