This invention relates to carbon electrodes and a process for making them from high temperature fluid coke. The present invention relates to a method of making improved carbon electrodes and to novel electrode formulations. More particularly, it relates to an all high temperature fluid coke electrode which is made without separately calcining the coke aggregate, without the need for large, coarse aggregate particles in the electrode formulation, and with a minimum amount of binder material.

Specifically, the present invention relates to a high temperature fluid coke which is made by the pyrolysis of a hydrocarbon feed at temperatures of 1800–2000°F. to produce hydrogen and coke. The coke aggregate from which the improved electrode is formulated comprises coke as produced in the fluid coke process and ground fine coke prepared by grinding a portion of the coke from the calcining process. The coke electrodes prepared from this formulation use a minimum amount of binder which results in superior coke electrodes. More specifically, the present invention relates to a method of preparing improved coke electrodes which can be used for obtaining aluminum from aluminum ores.

Heretofore, coke electrodes were formed by mixing a calcined coke aggregate with a binder material, molding the mixture under pressure and baking it at elevated temperatures for several hours. The baking or heating of the electrode at elevated temperatures carbonizes and volatilizes the volatile constituents of the binder material leaving about 50 wt. percent of the binder material as a binder coke. The two principal types of petroleum coke materials which have been used in formulating coke electrodes for reduction of aluminum are delayed coke formed by batch destructive distillation of hydrocarbons and fluid coke formed by surface deposition of coke on coke particles at relatively low temperatures. In the low temperature fluid coke processes, aromatic hydrocarbons and olefinic hydrocarbons are also produced.

The delayed coke is crushed or ground to obtain a particle size distribution of particles of less than about 200 mesh up to about 3/4 inch in diameter and then calcined. The calcined delayed coke has high true particle density. Since delayed coke aggregate formulations require particles of up to about 3/4 inch, it had been thought that it was necessary to have the coarse aggregate particles of up to about 3/4 inch in all coke aggregate formulations in order to obtain electrodes having high bulk density and good resistivities. It was necessary with delayed coke to have the large coke particles to prevent cracking of the electrodes during the baking step with prebake electrodes where shrinking occurs due to the carbonization and volatilization of the binder material, or in baking Soderberg electrodes in the reduction cells due to volatilization of the binder material due to the heat from the reduction cells.

In producing a low temperature fluid coke which would be satisfactory for electrode formulation, it was found necessary to produce agglomerates from a portion of the fluid coke first, which agglomerates were calcined and crushed to produce coarse coke aggregates of the same particle size used in a delayed coke electrode aggregate, i.e., to produce crushed coke agglomerates of up to 1/2 to 3/4 inch in diameter to provide the coarse coke aggregate for the electrode formulations. In utilizing low temperature fluid coke to make an all fluid coke electrode, a portion of the fluid coke as received from the reactor would be ground and mixed with a suitable binder to form agglomerates, and the agglomerates would be calcined and then crushed to form the coarse coke aggregate. This was necessary because of the small size of the fluid coke particles as produced in the conventional fluid coke operating. The low temperature fluid coke process is carried out at temperatures between 900 and about 1400°F. to produce coke and light hydrocarbon byproducts. The production of substantially larger particles which would be suitable in the formulation of coke electrodes in the fluid coke process was inconsistent with satisfactory operation of the fluid bed.

Another step involved in using either delayed or low temperature fluid coke to make coke electrodes was that the coke as received from the reactor had to be first calcined at temperatures of 1800–2800°F. The raw or green fluid coke received from the reactor is variable in chemical and physical properties and has to be calcined. This was necessary because the coke, when used in electrode manufacture, would cause excessive shrinking and cracking of the coke electrodes during baking due to volatilization of the volatile materials in the green coke. The coke agglomerates also had to be calcined to remove volatile binder materials.

In the manufacture of carbon electrodes, sufficient binder is required to coat each particle of carbon with a thin film of binder and the relative amount of binder required to produce a satisfactory carbon electrode is influenced by a number of factors, including the mesh size and the porosity of the particles. Generally, the delayed coke aggregate has greater porosity and more binder material is required for electrode production. The porosity is due to larger pore openings in the coke which is due primarily to the manner in which the delayed coke is made. The low temperature fluid coke which has not been crushed or ground is relatively less porous and will generally require less binder. However, the pores present are internal pores and cannot be readily filled with binder. This generally results in an inferior electrode unless aggregates are included in the electrode. Grinding of the low temperature fluid coke and crushing agglomerates exposes the internal voids. In the usual practice of making carbon electrodes in the aluminum industry, 14–18% by weight of binder is used for prebaked electrodes while 26–34 by weight of binder is used for self-baking Soderberg electrodes. These percentages are based on the weight of the coke aggregate plus binder.

The principal criteria of molded electrodes for aluminum reduction are a minimum compression strength of >4000 p.s.i., a minimum real density of about >1.45 g/cc, and a maximum resistivity of <3 x 10^-3 ohm/inch.

In accordance with the conventional processes for making coke electrodes for the aluminum industry, the coke is obtained either from the delayed coke process or a conventional low temperature fluid coke process. In the delayed coke process, the coke obtained is calcined and crushed to form a suitable particle size distribution, including particles up to 3/4 inch in diameter, before it is added and it is molded into an electrode and baked. Utilization of a low temperature fluid coke in an electrode requires grinding of a portion of the fluid coke, mixing
The heat for carrying out the endothermic coking reaction can be generated in a burner vessel, in which case a stream of coke is transferred from the reactor to the burner vessel employing a standpipe and riser system, gas being burned in the riser for conveying the solids to the burner. Sufficient fuel is burned in the burner vessel to bring the solids therein to a temperature sufficiently above the temperature in the reactor to maintain the system in heat balance. In a transfer line heater, the temperature of the coke is raised to about 200 to 600°F above the temperature in the reactor to supply heat to the reaction.

Coke produced in the above manner has unique physical properties which permit it to be used directly in the manufacture of carbon electrodes without further thermal treatment. Furthermore, these properties permit the use of the coke in new formulations to prepare carbon electrodes and carbon bodies. A particular property of the coke which permits unique carbon electrode formulations is the extreme dense nature of the high temperature coke particles relative to calcined delayed coke and calcined low temperature fluid coke. This difference is readily apparent upon examination of photomicrographs of cross-sections of the three types of cokes. It is also evident when one compares (see Table I below) the densities of the three types of coke as determined by hydrocarbon displacement and the packed or settled density of a narrow particle size fraction of these three cokes:

<table>
<thead>
<tr>
<th>Coke Type</th>
<th>Calcined Delayed</th>
<th>Calcined Low Temp. Fluid</th>
<th>High Temp. Coke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, gm./ce, by Hydrocarbon (Vessels) Displacement</td>
<td>2.07</td>
<td>1.97</td>
<td>1.66</td>
</tr>
<tr>
<td>Density, gm./ce of 48-100 Mesh Coke Packed in 150 cc Pyrex</td>
<td>1.06</td>
<td>1.10</td>
<td>1.32</td>
</tr>
<tr>
<td>Calculated Void Volume, percent</td>
<td>48</td>
<td>41</td>
<td>29</td>
</tr>
</tbody>
</table>

The above packed densities represent the highest values obtained on several calcined delayed and calcined low temperature fluid cokes. Therefore, the void volumes shown are minimums for these types of cokes. The low void volume of the high temperature coke is due to the absence of large internal voids which can be penetrated by liquid hydrocarbons, e.g., binders. This permits the formulation of unexpectedly good carbon electrodes with considerably less binder. Also, the lower binder content of these formulations results in less volatiles released during the baking step and allows the use of smaller particle size coke (i.e., does not require large aggregates) in electrode formulation without cracking of the electrode in the baking operation. An example of the as produced coke and the ground coke particle size distribution is given below in Table II.

<table>
<thead>
<tr>
<th>Coke Used, Cumulative</th>
<th>As Produced</th>
<th>Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. percent on---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Mesh (389 microns)</td>
<td>28.0</td>
<td>28.0</td>
</tr>
<tr>
<td>35 Mesh (275 microns)</td>
<td>61.6</td>
<td>61.6</td>
</tr>
<tr>
<td>48 Mesh (200 microns)</td>
<td>84.0</td>
<td>84.0</td>
</tr>
<tr>
<td>65 Mesh (125 microns)</td>
<td>97.0</td>
<td>97.0</td>
</tr>
<tr>
<td>100 Mesh (100 microns)</td>
<td>99.8</td>
<td>99.8</td>
</tr>
<tr>
<td>200 Mesh (75 microns)</td>
<td>99.9</td>
<td>99.9</td>
</tr>
<tr>
<td>355 Mesh (44 microns)</td>
<td>99.9</td>
<td>99.9</td>
</tr>
</tbody>
</table>

High temperature coke prepared in the above described manner has high density, low porosity, and is relatively large in size. The coke also is generally spherical in shape, and is made up of a highly compact laminar formation of coke deposited on the coke seed particles at the
3,284,334 high temperatures. The cross-section of the coke presents a tightly packed onion skin appearance. Close examination of the photomicrograph shows almost complete absence of internal voids in the coke particle. This allows the use of substantially less binder in cementing the particles together and also provides materials which have a very high packing density.

It is desirable to operate to obtain the largest particle size and average particle size from the fluid coke operation so that when grinding a portion of the as produced fluid coke the fines obtained, when mixed with the as produced large coke particles, result in a maximum density aggregate formulation.

Unique characteristics of the high temperature coke have been discovered by applicants. High temperature coke does not require an additional calcining step which is required with both the delayed coke and the low temperature fluid coke. This eliminates one of the costly steps of using petroleum coke for making coke electrodes. Also, applicants unexpectedly found that the high temperature fluid coke did not require the additional of coarse aggregate of up to ¼ to ¾ inch in size to make good coke electrodes. Applicants found that the separate agglomeration and crushing step used with low temperature fluid coke to make coarse aggregates was not required when utilizing the high temperature coke to make coke electrodes.

In accordance with the present invention, applicants found that the high temperature coke as obtained from the reactor having particles between about 150 microns and 600 microns with an average particle size of 200 to 350 microns when mixed with a portion of high temperature coke ground to a particle size of 25 to 75 microns produced electrodes with unusually high crushing strength and low resistivity. The coke as produced is mixed with the ground coke at a ratio of 1:1 to 5:1. The ratio of average size of the as produced coke to the ground coke is between about 4:1 to about 20:1.

In general, two types of electrodes are employed by the industry. They are (a) prebaked and (b) Soderberg self-baking electrodes. In the former, a mixture comprising 78–82% of calcined coke aggregate and 18–22% of coal tar pitch is molded at pressures of about 3000–5000 p.s.i. or extruded and then baked for periods up to 10 hours at 1800–2000°F. The prebaked electrodes are then used in electrolytic cells being slowly lowered in the molten alumina as they are consumed. Usually, buts of the un consumed electrodes are reground and used in subsequent electrode formulations.

The Soderberg process involves the continuous or intermittent removal of the coke and coal tar cake from the top of the cell as the electrode components in the lower part of the cell are consumed. In this operation, the paste represents a blend of about 66–72% coke aggregate and 28–34% of pitch. The cell operates usually at temperatures of 1700–1900°F. The mix is baked into an electrode by the hot cell gases and heat conducted by the electrode in the period between the time it is added at the top and the time it is used. This process does not produce butts which could be later ground to provide coarse aggregate.

In accordance with applicants' process, high temperature coke is obtained by coking hydrocarbon feed in a fluid bed at temperatures of about 1800–2500°F to produce essentially coke and petroleum coke when formulated into electrodes produces electrodes of unexpectedly superior properties. These electrodes can be made without separate calcining steps for the coke, without the need for large coke aggregate of ¼ to ¾ inch size, and utilizes a minimum amount of coke binder. The use of minimum coke binder provides a molded coke electrode which, on baking, has present a minimum amount of volatile materials which crack, vaporize, and are lost from the baked electrode. The bulk density of the electrodes formed in accordance with applicants' invention is very high and the electrodes have unusually high crushing strengths.

Applicants' process substantially eliminates cracking and substantially reduces shrinking of the electrodes during baking and provides an improved electrode of substantially increased crushing strength and lower resistivity. The hydrocarbon feed to the process can be any gaseous, liquid, or heavy residual hydrocarbon which can be solid at ambient temperatures. Generally, however, heavy hydrocarbon oil feeds that are suitable for the coking process are heavy or residual crude, vacuum bottoms, pitch, asphalt, and other heavy hydrocarbon petroleum residua, or mixtures thereof. Typically, such feeds can have an initial boiling point of about 300°F or higher, an API gravity of about 0–20°, and a Conradson carbon residue content of about 5–40 wt. percent.

In the manufacture of the electrodes, the coke is admixed with a carbonaceous binder. The binder materials used are the known ones conventionally used to make electrodes. Such binder materials generally have melting points lying within the range of 70–120°C. They contain small amounts of hydrogen (about 5% or less). The concentration of benzene and nitrobenzene insoluble portions represent preferably about 20–35% and 5–15%, respectively, of the binder. The binder used in accordance with the present invention with the high temperature coke is utilized in an amount of 2–3 wt. percent for prebaked electrodes and 18–24 wt. percent for Soderberg electrodes. This represents a substantial decrease in the amount of binder required to obtain suitable electrodes with either calcined delayed or calcined fluid coke and results in better electrode formulations than obtained when using conventional amounts of binder even with high temperature coke.

Applicants found that one of the primary reasons why success has been obtained with this particular coke material and with a minimum amount of binder material has been the very nature and characteristics of the coke used. The high temperature coke is relatively non-porous, extremely hard, and very dense. Applicants found that less binder was needed to coat the particles and obtain good cohesion between the particles because there are very few pores and/or voids for the binder to penetrate into the coke. This is true even of the ground coke which is used to make the binder filter material. Since coke is extremely hard and the coke layers extremely tightly packed, even the ground coke with jagged edges has substantially fewer openings or voids for the binder material to go into. This was readily shown by comparing a cross sectional piece of low temperature fluid coke with the high temperature fluid coke used in accordance with this invention. The low temperature fluid coke has substantially more internal voids than the high temperature coke.

In accordance with the present invention, binder is used in the amount of 9–13 wt. percent, preferably 10–12 wt. percent, with prebaked electrodes, and with Soderberg electrodes the binder is used in the amount of 18–24 wt. percent, preferably 20–22 wt. percent based on total aggregate and binder.

In accordance with the present invention, an all high temperature fluid coke electrode can be made without calcining the coke, without separately agglomerating, calcining and crushing coke agglomerates to make a large coke aggregate material, and can be made with a minimum of binder which minimizes the amount of shrinking and tendency to crack of the molded coke electrode during the baking step.

The high temperature fluid coker is operated to obtain a particular size product having a particle size range of minus 5000 microns to plus 50 microns, and preferably about 600 microns to 150 microns. The average particle size of the coke as obtained from the reactor will be 200 to 500 microns, and preferably about 250 to 350 microns.
A portion of the product coke is separated and ground to make the fine portion of the coke aggregate to a size which the particle size distribution will be 200 microns to minus 40 microns, and preferably about 85 microns to minus 40 microns. Of the finely ground coke, 40–60 wt. percent would be minus 40 microns. The grinding is carried out in such a manner that the average particle size of the ground portion will be 25 to 75 microns, and preferably 40 to 50 microns. The ratio of the average size of the coke obtained from the reactor to the ground coke will be 4:1 to 20:1, and preferably 6:1 to 10:1. The amount of coke produced from the reactor to ground coke will depend upon the particular particle size distribution and the average particle size of the ground and fine coke. However, generally it can be said that the ratio of coarse to fine coke in the aggregate will be 1:1 to 5:1, and preferably 2:1 to 3:1.

In selecting the particle size distribution for a particular coke aggregate formulation, it is preferable to have a dumbbell type distribution of below about 10 wt. percent overlap between the as produced and ground particle sizes in the formulation. It is preferred that the fines matrix be sufficiently small that they, in conjunction with the binder, will form a suitable filler material able to cement the as produced coarse coke together into a high density, high crush resistant molded electrode.

In the Soderberg aluminum reduction process, the entire electrode is consumed. That is, there are no butt or unworn portions of the electrodes remaining. However, in prebaked electrode reduction cells, the cells are operated in such a manner that usually 15–30% of the carbon electrode is not consumed. The unused butt can be crushed and blended back with additional coke and again formed into useful electrodes. The coke butts could be ground to form the fine fraction which is combined with the as produced or coarse coke obtained from the reactor but generally it is preferred to do a minimum of grinding of the butts and to form a more coarse coke fraction. This has both economic advantages as well as possible particle distribution size advantages. Applicants found that the amount of crushed butts to be added and the particle size of the crushed butts as related to the as produced coke and the fines coke for producing good electrodes were important. Electrodes with satisfactory crushing strength and resistivity can be obtained from the temperature fluid coke obtained with this invention, when 15–30 wt. percent of crushed butts are blended back with the as produced and ground coke with the particle size distribution of the as produced and ground coke as previously described.

In one embodiment of the invention the butts consisting of particles of 1 inch to 4 mesh are blended back with an as produced coke-fine coke aggregate as previously described. In such a formulation, the ground butts, for example, being 4 inch to about 1 inch in size, would constitute about 20 wt. percent of the total aggregate. Unground as produced coke of minus 800 to plus 150 microns would constitute about 55 wt. percent, and finely ground coke of about 75 to minus 40 microns would constitute about 25 wt. percent of the aggregate. Of the finely ground coke, 40–60 wt. percent would be minus 40 microns. In the mixture, there are lean areas of the particle size of the size between the ground fluid coke particles and finely ground coke particles. This particle size distribution, therefore, represents a triple dumbbell type distribution with a small amount of coke particles in the lean areas between the three particle sizes with the most particles. Thus, it will be seen that there is not a grading of size in the coke particles but gaps or breaks in order to obtain maximum packing density and to permit the use of minimum amount of carbonaceous binder in the electrode mixture.

The conditions at which the high temperature fluid coking step or process is carried out are critical. The broad temperature range of the fluid coke bed reactor can be 1800–2500 °F., and preferably 1950–2200 °F. The average superficial linear velocity of the fluidizing gas which consists of evolved hydrogen in the fluid bed of the reactor can be 0.3 to 5 ft./sec, and the preferred range is 0.5 to 3 ft./sec. The temperature in the transfer line burner is generally 200–500 °F. higher than the temperature in the fluid bed reactor and can be 2100–3000 °F., and more generally 2100–2500 °F. The contact time in the reactor is generally 1–10 sec.

The invention and its advantages will be better illustrated by the following examples of electrodes prepared in accordance with applicants' invention.

**Example 1**

The coke electrode aggregate formulation was prepared by mixing a ratio of 65  parts of as produced coke (refer to Table II) with 35  parts of ground coke which was separated into two portions to which was added 12 wt. percent and 14 wt. percent coal tar binder (based on total mix) and two electrodes were prepared. In each case the coke and pitch were mixed at a temperature of about 50 °C. above the softening point of the pitch which was about 230 °F. The mix was placed in a mold and pressed at about 3000 p.s.i.g. to form molded green carbon electrodes. The green electrodes were packed in fine carbon and baked at 2000 °F. The green electrodes were gradually heated from ambient temperature to the 2800 °F. temperature over a period of up to 24 hours. After baking, the electrodes were inspected and results obtained are shown below in Table III.

**Table III**

<table>
<thead>
<tr>
<th>Electrode Composition</th>
<th>Pitch Content, Wt. percent</th>
<th>As Produced Coke, Wt. percent</th>
<th>Ground Coke, Wt. percent</th>
<th>Final Product Electrode, Wt. percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>30.1</td>
<td>30.1</td>
<td>30.1</td>
<td>30.1</td>
</tr>
</tbody>
</table>

From the above data it can be clearly seen that the physical properties of the electrode prepared with 12 wt. percent binder are far superior to the electrode prepared with 14 wt. percent binder. The loss on baking of the electrode with 14 wt. percent binder was substantially greater than the loss on baking of the electrode with 12 wt. percent binder due primarily to the volatilization on the excess binder added to that formulation. The bulk density and the resistivity are about the same, after baking, the volatile materials of the binder are removed by cracking and volatilization. The completely unexpected result, however, is in the substantial increase in crushing strength of the electrode containing the 12% binder, primarily 12,400 p.s.i. as compared with 8,420 p.s.i. for the electrode containing 14 wt. percent binder. The crushing strength of the electrode with 14 wt. percent binder, however, is still very high as compared to electrodes made with calcined low temperature fluid coke and calcined delayed coke. However, fine cracks appeared in the electrodes containing 14 wt. percent binder. Therefore, though the physical properties of the electrode prepared with the 12 wt. percent binder and 14 wt. percent binder are both good, the electrode containing 14 wt. percent pitch binder had fine cracks which cannot be tolerated in good carbon electrodes. The above example shows the criticality of the maximum amount of binder which can be used in a good electrode to be about 13 wt. percent.

In this example, the coke aggregate consisted of as produced coke having an average diameter at least 6 times as large as the average diameter of the smaller ground coke, and the weight ratio of the coarse to fine coke was about 2:1. The distinguishing feature in this
3,284,334 formulation was the critical concentration of binder which was used with this new high temperature coke to make superior electrodes. In order to further show the superiority of the coke electrodes of the present invention over the electrodes prepared in a conventional manner, the following electrodes were prepared: Two separate coke formulations were prepared: from calcined delayed coke and calcined low temperature fluid coke having substantially the same particle size distribution as used in the electrodes prepared above (see Table II for particle size distribution). In each case the coarse and ground coke were mixed in a ratio of about 45 to 35 parts by weight. In each case 12 wt. percent coal tar binder was used to make electrodes. The coke and pitch binders were mixed for 5/15 hour at a temperature of about 50° F. above the softening point of the pitch. The mix in each case was placed in a mold and pressed at 5000 p.s.i.g. to form green electrodes. The green electrodes were removed from the molds and packed in fine carbon and baked at a temperature of 2000° F. The maximum temperature of 2000° F. was obtained after baking for a period of up to about 48 hours. The electrodes were removed from the baking oven and tested and were found to exhibit the characteristics shown below in Table IV.

### Table IV

<table>
<thead>
<tr>
<th>Coke Source</th>
<th>Collected Delayed</th>
<th>Collected Fluid</th>
<th>High Temperature Coke (From Table III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finished Electrode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss in Baking, Wt. percent</td>
<td>2.40</td>
<td>3.26</td>
<td>3.27</td>
</tr>
<tr>
<td>Bulk Density, gr./cc, in.</td>
<td>1.40</td>
<td>1.44</td>
<td>1.08</td>
</tr>
<tr>
<td>Crushing Strength, p.s.i.</td>
<td>570</td>
<td>4410</td>
<td>12400</td>
</tr>
<tr>
<td>Electrical Resistivity, ohms in.</td>
<td>0.0055</td>
<td>0.0053</td>
<td>0.0025</td>
</tr>
</tbody>
</table>

*All electrodes were prepared with essentially identical particle size distribution and with the same preparation procedure and amount of pitch binder.

The above data clearly show that the high temperature fluid coke used in accordance with the present invention results in obtaining coke electrodes of superior quality to the electrodes prepared in the same manner from calcined delayed coke and calcined low temperature fluid coke.

**Example 2**

A Soderberg electrode is prepared from a coke electrode formulation having a particle size distribution about the same as that shown in Table II. In this formulation a ratio of coarse as produced coke to fine coke of about 2:1 is used having a ratio of average particle size of coarse to fine of about 6:1. A coal tar pitch is added and mixed to prepare a formulation containing the binder and the coke aggregate. The formulation contains about 82 wt. percent coke aggregate and about 18 wt. percent of pitch. The formulation is fed to an electrode cell operated at a temperature of 1750° F. As the formulation is fed to the cell, the binder is baked out and the high density, high crush strength, low resistivity coke electrode is formed by the time the formulation reaches the molten aluminum bath. The formulation is baked into a solid electrode by heat conduction and the hot cell gases in the period between the time it is added at the top of the cell and the time that it is consumed in the reduction of aluminum ore to aluminum. By using the high temperature fluid coke in accordance with the present invention in the electrode formulation, a substantial improvement over other Soderberg electrode coke formulations is obtained.

In this process the coke is used as produced and does not undergo a separate calcining step. Large coarse coke aggregate is not used. The coke therefore does not have to be agglomerated and crushed to provide large coke aggregate.

The above described procedure results in substantial savings in preparing Soderberg electrodes.

The high temperature fluid coke used to make the improved coke electrodes in accordance with the present invention can be prepared in a fluid bed wherein the heat is provided in a transfer line burner, a moving bed or fluid bed burner by burning a suitable fuel, or where the heat is provided by resistance heating of electrodes either in a separate heater vessel or in the reactor. The heat can be provided by burning an extraneous fuel in the burner, such as a hydrocarbon or hydrogen. Any coke prepared by thermal decomposition of hydrocarbons at temperatures between 1800° to 2500° F. to produce essentially coke and hydrogen whereby carbon, dense, low porosity coke where the coke deposits to form laminar onion skin layers on the seed coke can be used.

The coke formulations of the present invention can be used as high temperature lining, heating electrodes, electrodes in electrolytic reduction of aluminum ore to metallic alumina, or of other metal ores to molten metal and anywhere where reactivity, crushing strength, or electrical resistivity of the carbon in a carbon body is important.

These electrodes find greatest utility in their use as anodes for the obtaining of aluminum from its ore by the electrolytic process. The principles involved can be utilized, however, in the preparation of other electrodes. It is to be understood that the invention is not limited to the specific examples which have been offered merely as illustrations and that modifications may be made without departing from the scope of the invention.

What is claimed is:

1. A molded coke body comprising a coke aggregate containing coarse coke particles having an average size between 200 to 500 microns and fine coke particles having an average size between 25 to 75 microns, and 9 to 13 wt. percent, based on total weight of said body, of a carbonaceous bound indio material, said coarse and said fine coke particles being produced by the thermal decomposition of a hydrocarbon feed in a fluidized bed of coke particles at a temperature of 1800° to 2500° F.

2. The molded coke body of claim 1 wherein the binder concentration is 10 to 12 wt. percent.

3. The molded coke body of claim 1 wherein the ratio of coarse to fine coke is 1:1 to 5:1 parts by weight.

4. The molded coke body of claim 1 wherein the ratio of the average particle size of the coarse coke to the fine coke is 4:1 to 20:1.

5. A Soderberg electrode coke formulation comprising a coke aggregate containing coarse coke particles having an average size between 200 to 500 microns and fine coke particles having an average size between 25 to 75 microns and 10 to 12 wt. percent, based on total weight of said body, of a carbonaceous binder material, said coarse and said fine coke particles being produced by the thermal decomposition of a hydrocarbon feed in a fluidized bed of coke particles at a temperature of 1800° to 2500° F.

6. The composition of claim 5 wherein the ratio of coarse to fine coke is 1:1 to 5:1 parts by weight.

7. The composition of claim 5 wherein the ratio of the average particle size of the coarse coke to the fine coke is 4:1 to 20:1.

8. A green pre bake electrode formulation consisting essentially of coarse coke having an average particle size of 250 to 350 microns, fine coke having an average particle size of 40 to 50 microns, a ratio of coarse coke to fine coke of 2:1 to 3:1 and a ratio of the average size of coarse to fine coke of 6:1 to 10:1, and containing 9 to 13 wt. percent of carbonaceous binder, said coarse coke and said fine coke being produced by the thermal decomposition of a hydrocarbon feed in a fluidized bed of coke particles at a temperature of 1800° to 2500° F.

9. The composition of claim 8 wherein 15 to 30 wt.
percent of ground prebake electrode butts having a particle size of up to 3/8 to 3/4 inch are included in the formulation.

10. A green Soderberg electrode formulation consisting essential of coarse coke having an average particle size of 250 to 350 microns, fine coke having an average particle size of 40 to 50 microns, a ratio of coarse coke to fine coke of 2:1 to 3:1 and a ratio of the average size of coarse coke to fine coke of 6:1 to 10:1, and containing 18 to less than 24 wt. percent of carbonaceous binder, said coarse coke and said fine coke being produced by the thermal decomposition of a hydrocarbon feed in a fluidized bed of coke particles at a temperature of 1800 to 2500° F.

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JOHN H. MACK, Primary Examiner.
H. S. WILLIAMS, Assistant Examiner.