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W. J. BODENDORF ET AL

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CARBON-FILLED SHEET AND METHOD FOR ITS MANUFACTURE

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FIG. 1

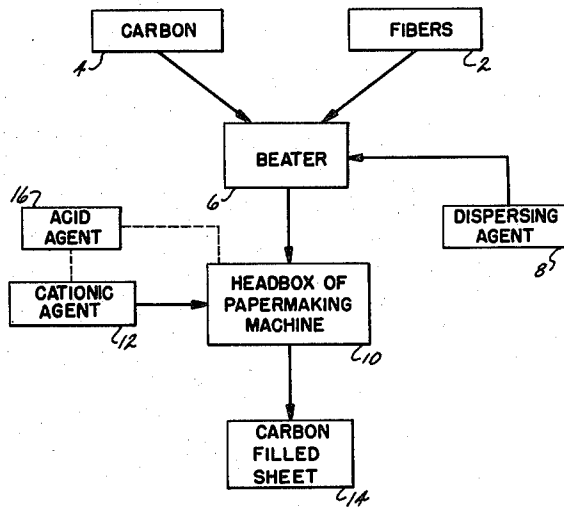
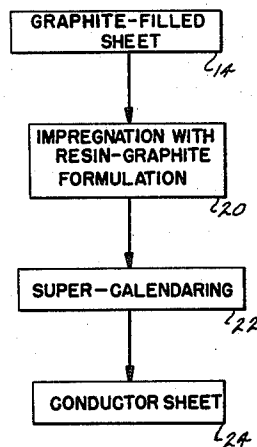


FIG. 2



INVENTORS
WARREN J. BODENDORF
FAY H. OSBORNE

BY

Lindsey, Prutzman and Hayes
ATTORNEYS

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CARBON-FILLED SHEET AND METHOD FOR ITS MANUFACTURE

Warren J. Bodendorf, Montgomery, Mass., and Fay H. Osborne, Windsor Locks, Conn., assignors to C. H. Dexter & Sons, Inc., Windsor Locks, Conn., a corporation of Connecticut

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The present invention relates to carbon-filled sheet structures and more particularly to a fibrous sheet having carbon particles firmly retained therein, and to the process for its manufacture.

It is an object of the present invention to provide a novel fibrous sheet of high strength having carbon particles homogeneously distributed and firmly retained therein.

Another object is to provide a carbon-filled sheet characterized by substantial freedom from rub-off, flaking and smudging.

Still another object is to provide a novel sheet containing substantial quantities of activated carbon firmly retained therein and having highly absorptive properties and wherein the absorbent and/or adsorbent properties of the activated carbon incorporated therein are retained during the process of manufacture without the necessity for reactivation in the final sheet.

A further object is to provide a novel fibrous sheet having substantial amounts of graphite firmly and uniformly retained throughout and to such a sheet impregnated with a graphite-containing formulation to provide a sheet exhibiting good electrical conductivity.

A still further object is to provide a novel and highly efficient process for making a fibrous sheet having carbon particles firmly retained and uniformly distributed therein which is characterized by resistance to rub-off, flaking and cracking.

Other objects and advantages will be readily apparent from the following detailed description and claims.

Referring to the attached drawings:

FIG. 1 is a diagrammatic illustration of a process in accordance with the present invention; and

FIG. 2 is a diagrammatic illustration of a continuation of the process in FIG. 1 for production of conductive paper.

It has now been found that the foregoing and related objects can be attained by a process in which finely divided carbon particles are thoroughly admixed with fibers of papermaking length in water to provide a substantially homogeneous slurry and then the aqueous slurry is fed into the headbox of a papermaking machine while simultaneously introducing therewith a solution of non-interfering cationic agent, which slurry and solution then interact to deposit the fibers and carbon upon the wire of the papermaking machine in substantially uniform admixture to form a web, the cationic agent also being incorporated therein. The web is then dried and may be treated in accordance with conventional papermaking practice. For use as a conductive sheet, the web is further subjected to an impregnation treatment as will be described in detail hereinafter.

Referring to FIG. 1 of the attached drawings, a process embodying the invention is generally illustrated by the diagrammatic flow sheet. Here the fibers 2 and carbon particles 4, which may be activated carbon or graphite, are admixed thoroughly in water by a brushing operation in a conventional papermill beater 6 to form substantially homogeneous slurry. A dispersing agent 8 may be added to the beater 6 to aid in dispersing the fibers.

The aqueous slurry of fibers and carbon particles is

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then fed into the headbox of the papermaking machine 10 into which is being fed simultaneously therewith a solution or dispersion of cationic agent 12 so that the two feeds intermix but a very short time before the fibers and carbon particles deposit upon the wire of the papermaking machine to form the carbon-filled sheet product 14 of the present invention. Substantially all the cationic agent is also retained in the sheet. As will be brought out more in detail hereinafter, the pH of the headbox dispersion is maintained at about 3-6 and preferably about 4-5 by an acid agent 16 which may be admixed with the cationic agent solution 12 or fed in separately as shown in dotted line by a metering pump or other suitable control means.

The pH of the aqueous dispersion in the headbox must be maintained at about 3-6 and preferably at about 4-5. This is most conveniently done by use of an acid salt which will not materially affect the properties of the carbon, such as alum (potassium aluminum sulfate), although noninterfering mineral acids such as hydrochloric acid may also be employed, particularly in conjunction with a responsive metering device to control the addition of the acid in response to variations in the acidity of the headbox dispersion.

Various fibers and admixtures of fibers may be employed in the present invention including natural cellulosic fibers such as manila hemp, jute, bleached or unbleached kraft, carao, sisal, kozu; synthetic fibers such as viscose and acetate rayon, polyamide, vinyl acetate-vinyl chloride copolymer and polyester (Dacron, E. I. du Pont de Nemours & Company, Wilmington, Delaware); and inorganic fibers such as glass, quartz and ceramics including fused alumina-silica admixture.

Natural cellulosic fibers are preferable for most applications in that no binder is necessary to provide strength in the sheet. For the conductor sheet embodiment, they are additionally desirable because of the relatively low dielectric constant. If so desired, however, a small amount of an added binder material can also be incorporated to enhance the bond formed by the cellulosic material.

Synthetic organic fibers and inorganic fibers may be desirable for applications where resistance to high temperatures or corrosive conditions is necessary. The synthetic and inorganic fibers may also be admixed with each other, and may be used singly or jointly in combination with the natural cellulosic fibers to provide sheets incorporating advantageous features of the several fibers.

Generally, when the fibrous component of the sheet is comprised of synthetic and/or inorganic fibers, it is necessary to employ a binding agent such as highly beaten carao flock (described in United States Patent No. 2,477,000). When inorganic fibers are employed, colloidal silica may be employed as a binder as described in our co-pending application Inorganic Sheet and Method of Making Same, Serial No. 125,112, filed July 19, 1961.

The fibers are generally of papermaking length, i.e., predominately of about 1/32 inch to 3/8 inch and the synthetic or inorganic fibers may even be longer than 1 inch depending upon the dispersability of the fibers to provide an aqueous slurry. The synthetic and inorganic fibers are unhydrated but the natural cellulosic fibers may be beaten and hydrated, particularly for increasing the strength of the sheet.

For making an absorbent filter sheet, activated carbon is employed in amounts of from about 15.0-75.0 percent by weight of the finished sheet. Although activated carbon particles of up to 150 mesh may be utilized, a size less than 200 mesh and preferably less than 325 mesh is most desirably employed for optimum retention. Particular examples of activated carbon products which may be employed are LC-300 sold by National Carbon Com-

pany; Darco, KB, HDB, S-51, GFP and G-60 sold by Atlas Powder Company.

For the conductor sheet, graphite particles of less than 100 mesh and preferably less than 200 mesh are employed. It has been found that the process of the present invention permits use of larger size graphite particles than heretofore practicable consistent with good conductivity and retention. A specific example of a graphite which has proven highly satisfactory is Dixon 1176, sold by the Dixon Crucible Company.

The carbon content may be varied over a wide range and up to as much as about 75.0 percent by weight of the base sheet. Generally, amounts in excess of 75.0 percent by weight will tend to produce some rub-off. For the activated carbon absorbent sheet, the carbon content should be within the range of 15.0-75.0 percent by weight and preferably about 25.0-70.0 percent. For the conductor sheet, the graphite particles should be within the range of 30.0-75.0 percent by weight and preferably about 40.0-70.0 percent by weight of the base sheet.

The cationic or positively charged agent must not interfere with the ultimately desired properties of the carbon particles in the finished sheet as will be explained more fully hereinafter. It has been found that the cationic agent must be added to the headbox dispersion in the amount of about 0.21-10.0 percent by weight of the solids content of the fiber and carbon dispersion which is being fed thereto simultaneously. Amounts in excess of 10.0 percent by weight produce no significant additional benefit while providing a dilution of the essential fiber and carbon content of the sheet since a substantial portion of the cationic agent is retained in the sheet. The cationic agent is preferably employed in the range of about 1.0-7.0 percent by weight of the solids content in the fiber-carbon furnish for optimum strength and retention depending upon the percentage of carbon particles in the solids content. It has also been found that the cationic agent increases the bond between cellulosic fibers and certain of the synthetic fibers.

The cationic agent is added to the headbox in an aqueous solution (or colloidal dispersion) of about 1.0-5.0 percent by weight and preferably about 2.0-3.0 percent, and is dispensed into the headbox in a controlled amount by means of a metering pump or bucket system.

It has been found that amine-modified starches provide the desired cationic agent activity without interfering with the properties of the activated carbon so that there is no substantial reduction in the absorptive properties occasioned by the papermaking process. It has also been found that such amine-modified starches produce a superior conductor sheet by reason of their relatively low dielectric constant.

Exemplary of such amine-modified starches are: Cato 8 (a modified cornstarch) and Cato Amylon (a hybrid starch containing 55.0-60.0 percent amylose), both sold by National Starch and Chemical Corporation of Plainfield, New Jersey; Starbond W (a modified potato starch) sold by Morningstar-Paisley Corporation of New York, New York; Keotac 22-5 (a modified cornstarch) sold by Hubinger Company, Keokuk, Iowa. Generally, these cationic starch agents are considered to be starch ethers using an imino or amino group to provide a positive charge.

The cationic starch solution is readily prepared by mixing the starch in cold water, heating the mixture to a temperature of about 160-200° F., and continuing the agitation for about 10-30 minutes to effect the desired colloidal solution.

Although cylinder machines and conventional Fourdrinier machines may be employed, the sheet is most desirably formed in a papermaking machine using an inclined Fourdrinier wire since more dilute dispersions may be employed with greater uniformity in the sheet structure and greater control of the porosity in the final sheet. In such inclined Fourdrinier papermaking ma-

chines, the fiber-carbon slurry dispersion is maintained at 0.1-1.0 percent by weight solids and preferably at about 0.2-0.3 percent for optimum results. Higher consistencies may be readily employed on cylinder and conventional Fourdrinier machines.

It is imperative that the cationic agent be added to the fiber-carbon slurry but a very short time before the fibers start to deposit upon the wire. In a fluid system moving rapidly in the headbox, the two dispersions can be admixed by feeding thereinto at closely spaced points within the headbox or initially admixed by feeding jointly into the feed trough for the headbox so as to obtain optimum intermixing commensurate with almost instantaneous deposition of the fibers and carbon particles upon the wire after admixing.

Although the theory of the present operation is not fully understood, it is believed that the cationic agent, which forms a colloidal dispersion in which the particles carry a positive charge, develops a strong positive charge on the carbon particles in their aqueous slurry with the fibers, and the carbon particles then flock and are attracted to the surface of the fibers which act as if negatively charged. As a result, the carbon particles are firmly bonded to the surface of the fibers. Additionally, the cationic agent appears to function similarly with small cellulosic fiber particles to enhance the bond formed between the fibers.

The porosity of the carbon filter sheet may vary quite widely dependent upon the intended application, i.e. whether the air or fluid is to pass therethrough or across the surface and may readily vary from 10 c.f.m.-100 c.f.m. on the Frazier Permeometer, and even far higher on lightweight sheets. High porosity is best provided by use of long fibers which are relatively unbeaten and non-hydrated such as manila hemp and jute, or by use of a substantial percentage of unhydrated synthetic fibers such as rayon.

For the manufacture of conductor sheet, natural cellulosic fibers are preferred because of their relatively low dielectric constant. Low porosity and high density in such conductor sheets are also desired for optimum effectiveness.

Generally, the fibers and any bonding agent utilized should provide a sheet having a tensile strength of at least 500 grams per inch (machine direction). However, with the present invention, it is generally possible to obtain strengths well in excess of 1500 grams per inch even with as much as 75.0 percent by weight carbon, depending upon the fiber component selected, particularly since the cationic agent promotes the interfiber bonding of cellulosic fibers.

Subsequent to the preparation of the base conductor sheet utilizing graphite particles as the carbon component, the sheet is dried and subjected to further treatment as generally shown in the diagrammatic flow sheet of FIG. 2.

The sheet 14 is impregnated or saturated in a dispersion of graphite particles in a resin and the excess impregnant removed from the surfaces of the sheet, as indicated by the numeral 20, and is then dried. Subsequently, the dried sheet is subjected to a supercalendering operation as indicated by the numeral 22, wherein the sheet is compacted and the graphite particles crushed, as will be explained more fully hereinafter to form the finished conductor sheet 24. If so desired, a supercalendering operation may be included prior to the impregnation step 20, although this is not necessary to obtain a highly satisfactory product.

The graphite particles employed in the impregnant should be relatively fine and not greater than about 150 mesh, and preferably less than 325 mesh for optimum results. As stated above, the supercalendering of the dried and coated sheet will effect some reduction in particle size.

The resin formulation must be one having a relatively low dielectric constant and should provide a waterproof

coating which is resistant to acids and alkalis. It has been found that chlorinated natural rubbers and chlorinated resins are particularly advantageous for this purpose. Specific examples of such chlorinated materials are Parlon (a chlorinated natural rubber), sold by Hercules Powder Company, and Arochlor (a chlorinated biphenyl), sold by Monsanto Chemical Company.

The graphite should comprise 30.0–80.0 percent by weight of the solids in the impregnant formulation and preferably 50.0–80.0 percent so as to obtain maximum conductivity. The amount of impregnant taken up by the base sheet will be dependent in large part upon its initial porosity and fiber components.

The following is a specific example of an impregnant formulation which has proven highly satisfactory:

	Percent by weight
Chlorinated natural rubber (Parlon, Hercules Powder Company) -----	12.2
Plasticizer (Acryloid F-10, acrylic resin in toluene, Rohm & Haas) -----	4.8
Solvent—toluene -----	48.0
Graphite (Dixon 1176) -----	35.0
	100.0

In the supercalendering operation the sheet will be passed through at least two roll nips with slippage between the rolls to get the desired "ironing" and compacting of the sheet and graphite particles. The roll pressure employed should provide greater than about 100 pounds per linear inch and preferably greater than 200 pounds per linear inch.

The activated carbon sheet products have been found highly satisfactory for a number of uses. Among various applications for such sheet products are cigarette filters, air filters, gas filters, wrappers for fruit and other substances prone to discoloration or spoilage by gases in the atmosphere, deodorizer layers in a laminated sheet product for sanitary napkins and for surgical dressings for putrescent wounds, etc.

The conductor sheet utilizing the graphite particles may be used as a base sheet upon which a metal foil may be electroplated, a semi-conductive tape material for use in controlling corona effects, and electrosensitive recording paper for various types of recording apparatus.

Exemplary of the efficacy of the present invention are the following specific examples wherein various carbon-filled sheet products were produced in accordance with the present invention:

Example 1

To a conventional paper mill beater were furnished 35 pounds of kraft fibers, 10 pounds of abaca (hemp) fibers and 1200 gallons of water. The fibers were brushed hard for one hour.

At the end of the brushing operation, 55 pounds of activated carbon of —325 mesh size (National Carbon Company, LC-300) was added together with 10 pounds of abaca. This mixture was defibered for thirty minutes with the roll of the beater raised from the bed plate. To this mixture was then added 7 gallons of an aqueous dispersion containing 0.25 percent by weight karaya gum.

The resultant slurry was admixed with additional water to provide a consistency of about 0.25 percent solids and was fed into the headbox of a papermaking machine using an inclined Fourdrinier wire.

A separate solution was prepared in the following manner:

Ten pounds cationic starch (Cato 8, National Starch and Chemical Corporation), 5 pounds of alum and 30 gallons of cold water were mixed for five minutes and then heated to 180° F. with steam, and thereafter mixed for about fifteen minutes to form a colloidal solution. Additional water was added to make a total of 60 gallons of solution. This mixture was fed into the headbox at a

rate calculated to provide cationic starch in an amount equal to about 4 percent of the solids in the fiber furnish.

The resultant web was removed from the Fourdrinier and dried in accordance with conventional practice.

Upon testing, the sheet was found to contain about 50 percent carbon and to have a basis weight of 22 pounds (480 sheets—24" x 36"), and the thickness was determined at 6 mils. The tensile strength was 1294 grams in the machine direction and 438 grams in the cross direction. The porosity was 54 c.f.m. on the Frazier Permeometer; the density was 0.238 gram per cubic centimeter; and the Mullen was 3.2 pounds.

This sheet product has been subjected to extensive evaluation for cigarette filter purposes and has been found to be excellent and is currently being tested for other filter uses.

Example 2

A mixture of 1200 gallons of water, 36 pounds of abaca and 112.5 pounds of bleached kraft were defibered for fifteen minutes and brushed lightly for one and one-half hours in a papermill beater. To the mixture were then added 150 pounds of graphite of predominately 150–200 mesh (Dixon 1176, Dixon Crucible Company) and 0.8 pound karaya gum which were then thoroughly admixed with the fiber furnish.

A colloidal solution of cationic starch was prepared in a fashion similar to that in Example 1 and which contained 10 pounds of Cato 8 starch in 60 gallons of water. Still another solution consisting of 10 pounds of alum in 40 gallons of water was prepared.

The fiber-graphite dispersion was then fed into the headbox of an inclined Fourdrinier wire machine at a consistency of about 0.25 percent. Simultaneously there was being added to the headbox a controlled amount of cationic starch solution calculated to provide approximately 3 percent by weight of starch based upon the solids in the fiber-graphite furnish. The alum solution was metered into the headbox to maintain the pH at approximately 4.5. The resultant web was thereafter handled and dried in accordance with conventional papermaking practice.

The sheet was found to be 2.9 mils in thickness and to have a basis weight of 11.3 pounds (480 sheet—24" x 36"). The tensile strength was 1381 grams in the machine direction and 678 grams in the cross direction. The density was 0.260 gram per cubic centimeter, the porosity 159 c.f.m. on the Gurley Permeometer, and the Mullen 3.4 pounds.

An impregnant composition was prepared having the following formulation:

	Percent by weight
Toluene -----	48.0
Parlon (chlorinated natural rubber sold by Hercules Powder Company) -----	12.2
Acryloid F-10 plasticizer (acrylic resin in toluene sold by Rohm & Haas) -----	4.8
Graphite (Dixon 1176) -----	35.0
	100.0

The base sheet was dip impregnated in the above formulation, the excess being doctored off the sheet on both sides. The impregnated sheet was then dried and subjected to a supercalendering operation by passage through two roll nips at a pressure of approximately 150 pounds per linear inch.

Before impregnation, the graphite was 50 percent by weight of the base sheet and, after, 59 percent by weight. The final sheet product was found to have a basis weight of 27.2 pounds (480 sheets—24" x 36") and a thickness of 1.8 mils. The tensile strength in the machine direction was 3240 grams and in the cross direction 2240 grams. The density was 1.1 grams per cubic centimeter,

and the Mullen was 5.8 pounds. The porosity was determined to be 1371 second for 400 cc. of air in the Gurley Densometer test.¹ After soaking one hour in water, the average tensile strength was determined to be 2500 grams.

Example 3

A more highly porous carbon filter sheet was prepared in the following fashion. A mixture of 1200 gallons of water, 42 pounds of abaca and 16 pounds bleached kraft were defibered for twenty minutes in a paper mill beater and then lightly brushed for ten minutes. To this mixture was then added 50 pounds rayon of 1/4 inch length and 1 1/2 inch denier, and 143 pounds of -325 mesh activated carbon (LC-300, Nation Carbon). This mixture was then defibered for fifteen minutes in the beater and then mixed with an aqueous dispersion containing 1.5 pounds karaya gum.

The furnish was formed into a sheet in accordance with the remainder of the procedure set forth in Example 1.

The sheet was found to contain approximately 55 percent by weight carbon and to have a basis weight of 115 pounds (480 sheets—24" x 36"), the thickness being 31 mils. The tensile strength in the machine direction was 2288 grams and in the cross direction was 1975 grams. The density was 0.247 gram per cubic centimeter and the Mullen 8.4 pounds. The porosity was found to be 33.6 c.f.m. on the Frazier Permeometer.

This material has been most satisfactorily tested as an air-conditioning filter and is currently being evaluated for other uses where air or gas is passed through the sheet.

Example 4

A carbon filter sheet utilizing inorganic fibers was prepared in substantially the same fashion as outlined in Example 1, the distinctions being noted herein.

The base furnish comprised 35.4 percent of AAA (Grade 106) microglass fiber, 6.3 percent AA (Grade 110) microglass fiber, 4.2 percent colloidal silica sol (Ludox LS—a 30 percent solids aqueous sol sold by E. I. du Pont de Nemours & Company), and 54.1 percent activated carbon (LC-300, National Carbon). These components were thoroughly admixed in water and fed to the headbox at a consistency of about 0.25 percent by weight solids. The pH in the headbox was maintained at about 3.0 by means of hydrochloric acid.

The resultant sheet was found to be 10 mils in thickness and have a basis weight of 35 pounds (480 sheet—24" x 36"). The average tensile strength was 850 grams and the porosity was determined to be 6 c.f.m. on the Frazier Permeometer.

Example 5

A furnish consisting essentially of 1200 gallons of water, 16.5 pounds abaca and 65 pounds of bleached kraft was defibered for fifteen minutes and then brushed hard in the beater for 1 1/2 hours. To this mixture were added 200 pounds of activated carbon (LC-300, National Carbon) and 1 pound of karaya gum. The resultant dispersion was added to the headbox wherein the pH was buffered by the addition of alum and wherein the cationic starch was added at a rate approximating 4 percent of the solids content in the fiber-carbon furnish.

The dried sheet contained approximately 75 percent by weight carbon and had a basis weight of 20.6 pounds and a thickness of 5 mils. The tensile strength in the machine direction was 805 grams and in the cross direction, 204 grams. The density was determined to be 0.269 gram per cubic centimeter, and the Mullen, 1.2 pounds. The porosity was determined at 76 c.f.m. on the Gurley Permeometer.

It can be seen from the foregoing specification and specific examples that the present invention provides a

¹ Measured on Gurley Densometer in terms of number of seconds for 400 cc. of air to pass through sheet. TAPPI No. T460-M49 and ASTM No. D.726.

novel and highly desirable carbon-filled sheet product having the carbon particles retained firmly therein.

As will be readily apparent to persons skilled in the art, various modifications and adaptations may be effected without departing from the spirit and scope of the invention.

We claim:

1. In a method of forming a carbon-filled sheet comprising the steps of forming a substantially homogeneous aqueous slurry of fibers and carbon particles; feeding said slurry to the headbox of a papermaking machine and adding thereto a solution of cationic agent to form a mixture with said slurry; and causing said mixture to deposit upon the screen of the papermaking machine to form a web having the carbon particles distributed substantially uniformly throughout and retained firmly therein, the improvement wherein the cationic agent is added to the headbox just prior to sheet formation, the cationic agent is cationic starch and the carbon is activated carbon.

2. The method in accordance with claim 1 wherein said cationic starch is an amine-modified starch.

3. The method in accordance with claim 1 wherein said fibers are natural cellulosic fibers.

4. In a method of forming a carbon-filled sheet comprising the steps of forming a substantially homogeneous aqueous slurry of fibers and carbon particles; feeding said slurry to the headbox of a papermaking machine and adding thereto an acid agent to provide a headbox pH of about 3-6 and a solution of cationic agent to form a mixture with said slurry, said cationic agent being about 0.2-10.0 percent by weight of the solids in the slurry; and causing said mixture to deposit upon the screen of the papermaking machine to form a web having the carbon particles distributed substantially uniformly throughout and retained firmly therein, the improvement wherein the cationic agent is added to the headbox just prior to sheet formation, the cationic agent is cationic starch and the carbon is activated carbon.

5. In a method of forming a carbon-filled sheet comprising forming a substantially homogeneous aqueous slurry consisting essentially of fibers and carbon particles, said carbon particles comprising 15.0-75.0 percent by weight of the solids; feeding said slurry to the headbox of a papermaking machine and adding thereto a solution of cationic agent to form a mixture with said slurry, said cationic agent in said mixture being about 0.2-10.0 percent by weight of the solids in said slurry; and causing said mixture to deposit upon the screen of the papermaking machine to form a web having the carbon particles distributed substantially uniformly throughout and retained firmly therein, the improvement wherein the cationic agent is added to the headbox just prior to sheet formation, the cationic agent is cationic starch and the carbon is activated carbon.

6. A method in accordance with claim 5 wherein said cationic starch is an amine-modified starch.

7. The method of forming a conductive sheet comprising forming a substantially homogeneous aqueous slurry consisting essentially of gum, fibers and graphite particles, said gum comprising about 0.25-0.8 percent by weight of the solids and said graphite particles comprising 30.0-75.0 percent by weight of the solids; feeding said slurry to the headbox of a papermaking machine while simultaneously feeding therewith a solution of cationic starch to form a mixture with said slurry, said cationic agent being added to the headbox just prior to web formation and being about 0.2-10.0 percent by weight of the solids in said slurry; causing said mixture to deposit upon the screen of the papermaking machine to form a web having the graphite particles distributed substantially uniformly throughout and retained firmly therein; drying said web; impregnating said web with a dispersion of graphite particles in a resin binder having a relatively low dielectric constant; drying said impregnated web; and supercalen-

dering said dried impregnated web to form a conductive sheet.

8. A carbon-filled sheet consisting essentially of a substantially homogeneous mixture of fibers and activated carbon particles firmly bonded to said fibers, said activated carbon particles being present in an amount equal to at least 30.0 percent by weight of the sheet, said sheet additionally containing about 0.2–10.0 percent of a cationic starch and being characterized by substantial freedom from flaking, smudging and rub-off.

9. A carbon-filled sheet in accordance with claim 8 wherein said cationic starch is an amine-modified starch.

10. A carbon-filled sheet in accordance with claim 8 wherein said fibers include natural cellulosic fibers.

11. A carbon-filled sheet in accordance with claim 8 wherein said fibers include inorganic fibers.

12. A carbon-filled sheet consisting essentially of a substantially homogeneous mixture of fibers and about 15.0–75.0 percent by weight of activated carbon particles firmly bonded to said fibers, said sheet additionally containing a minor amount, less than 10.0 percent by weight, of a cationic starch and being characterized by substantial freedom from flaking, cracking and rub-off.

13. A conductor sheet consisting of a base sheet containing essentially a substantially homogeneous admixture of cellulosic fibers, 30.0–75.0 percent by weight of graph-

ite particles firmly bonded thereto and about 0.25–0.8 percent by weight of a natural gum, said base sheet additionally containing a minor amount, less than 10.0 percent by weight, of a cationic starch and being impregnated with a resin-graphite mixture, said resin having a relatively low dielectric constant.

14. A conductor sheet in accordance with claim 13 wherein said cationic starch is an amine-modified starch.

15. A conductor sheet in accordance with claim 13 wherein said resin is a chlorinated resin.

References Cited in the file of this patent

UNITED STATES PATENTS

2,328,198	Davenport	Aug. 31, 1943
2,559,220	Maxwell	July 3, 1951
2,694,633	Pattiloch	Nov. 16, 1954
2,730,446	Hutchins	Jan. 10, 1956
2,795,545	Gluesenkamp	June 11, 1957
2,935,436	Caldwell et al.	May 3, 1960
2,993,816	Blake	July 25, 1961
3,012,928	Whitman	Dec. 12, 1961
3,021,257	Stauffenberg	Feb. 13, 1962
3,022,213	Pattiloch et al.	Feb. 20, 1962
3,034,947	Conlisk et al.	May 15, 1962
3,039,914	Reiman	June 19, 1962