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HIGH GREEN STRENGTH-LOW DENSITY COPPER POWDER AND PROCESS FOR PREPARING SAME

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ABSTRACT OF THE DISCLOSURE

Novel high green strength copper powders containing trace amounts of elemental selenium and/or tellurium and certain refractory metal oxides have been prepared. An improved process for preparing high green strength copper powder wherein selenium and/or tellurium and certain refractory metal oxides are incorporated in copper oxide powder, and the copper oxide powder is reduced to form low density-high green strength copper powder, is described.

The present invention relates to low density-high green strength copper powder and to processes for preparing the powder.

The invention is advantageous in that it provides copper powders having a low apparent density and is further advantageous in that the copper powders, when compacted, have a higher fresh green strength than that heretofore obtainable in copper powders obtained using gaseous reduction techniques.

Copper powders of low apparent density find application in the production of sintered articles. The low density permits considerable pressing of the powder as it is filled into a mold and is usually accompanied by the development of sufficient green strength in the copper compact to enable it to be handled between the press and the sintering furnace.

The present invention provides an improvement in a conventional process for making copper powder by reducing finely divided copper oxide with a reducing gas in a reduction zone at elevated temperature. The improvement is for making copper powder having a low apparent density and high green strength and comprises the steps of:

(a) Forming a uniform mixture of fine (325 mesh) copper oxide and from about 0.05 to about 0.5 weight percent of at least one finely divided metal selected from the group consisting of selenium and tellurium and from about 0.05 to about 0.5 weight percent of a refractory metal oxide, or a compound which is converted to oxide on heating at 900–1200° F., of Groups III, IV, V and VI of the Periodic Chart, and

(b) Reducing said mixture with a reducing gas in said zone at a temperature of between about 900 and 1200° F.

By so proceeding, a novel finely divided porous copper powder is obtained having particles substantially all of which are finer than 200 mesh and at least 80 percent of which are finer than 325 mesh (e.g. substantially all of the particles pass through a No. 200 mesh U.S. Standard screen and 80 percent or more pass through a No. 325 mesh U.S. Standard screen). The copper powder has an apparent density below 2 grams per cubic centimeter and a green strength usually above 3500 p.s.i. when pressed (i.e. compacted) at 12 t.s.i. using die wall lubricant only according to the standard ASTM testing procedure.

The term "finely divided copper oxide" as used herein is intended to mean and to include finely divided or powdered cuprous and cupric oxides or mixtures thereof. As

will be hereinafter evident from the specific examples, finely divided copper oxide which has been found to be particularly suitable for use in processes of the present invention is preponderantly cuprous oxide (containing 85 percent or more of Cu_2O) because such material is more readily and economically reduced to elemental copper than is cupric oxide.

The term "finely divided metal" or "finely divided elemental metal" as used herein is intended to mean and to refer to finely divided elemental selenium, tellurium or mixtures thereof.

The term "green strength" as herein used is intended to mean and to refer to the modulus of rupture (in p.s.i.) of a 15 gram sample of freshly prepared copper powder freshly compacted in a press employing a standard mold at a pressure of 12 t.s.i. with a die wall lubricant. It is a standard ASTM test method in powder metallurgy.

The substantially uniform mixture of finely divided copper oxide, finely divided metal and finely divided refractory metal oxide employed in the process of this invention can be readily formed by conventional mixing methods such as tumbling, ball milling, or mixing the ingredients in a mechanical mixer. Because of the small quantities of finely divided metal (e.g. from about 0.05 to about 0.5 weight percent) and finely divided refractory metal oxide (employed in substantially the same weight perecntage range as the elemental metal), it is usually desirable to first form a pre-mix composition containing between about 5 and about 15 weight percent, respectively, of the finely divided metal and the finely divided refractory metal oxide with the balance of the pre-mix consisting essentially of finely divided copper oxide. The pre-mix composition, which is formed by conventional mixing techniques, is then mixed with additional finely divided copper oxide in an amount sufficient to obtain a substantially uniform mixture containing the desired quantities of metal and refractory metal oxide.

If the powdered copper oxide mixture contains less than about 0.05 weight percent of finely divided metal (e.g. selenium or tellurium, the copper powder obtained upon reduction of the copper oxide will usually have an undesirably low green strength. Although more than about 0.5 percent of the finely divided metal can sometimes be employed, the use of large quantities of the metal is economically disadvantageous and the copper powder may sometimes have a green strength below that maximally obtainable. Generally, mixtures containing from 0.1 to about 0.3 weight percent of finely divided metal are preferred since such mixtures usually provide copper powders having green strength above 3500 and often above 4000 p.s.i. when pressed at 12 t.s.i.

If the copper oxide mixture contains less than 0.05 percent of refractory metal oxides, the copper powder obtained from such mixtures will often have an undesirably low green strength (e.g. a green strength below 3500 p.s.i.). Although more than 0.5 weight percent of refractory metal oxide may sometimes be employed in the mixtures, there is usually no advantage and, although high green strength copper powders having a green strength above 3000 will generally be obtained, copper powders having maximum green strength (e.g. a green strength above 4000 p.s.i.) will sometimes not be obtained. Preferred concentrations of refractory metal oxide in the powdered copper oxide mixture are from about 0.1 to about 0.3 weight percent since such concentrations provide copper powders which usually have a green strength above 4000 p.s.i. when pressed at 12 t.s.i.

A wide variety of refractory metal oxides may be employed in the compositions of this invention provided they are refractory oxides of a metal of Groups III, IV, V and VI of the Periodic Chart. Examples of refractory

metal oxides which are useful in the compositions of this invention are refractory oxides of titanium, aluminum, zirconium, silicon, chromium, vanadium, tantalium and columbium. Refractory metal oxides which cannot be employed in the compositions of this invention include those of Group II metal such as barium, calcium, strontium, zinc and magnesium oxides.

Finely divided copper oxide particles are employed because the process of this invention involves contacting the solid coper oxide particles in the above defined mixture with reducing gases at elevated temperatures. Such particles are in the micron size range and advantageously at a particle size in the range from 5 to about 15 microns as measured by a Fisher Sub-Sieve Sizer. If the copper oxide particles have an average particle size below of about 5 microns, the powders reduced therefrom may sometimes have lowered green strength. On the other hand, if copper oxide particles have an average particle size above about 15 microns, reduction times will be unduly prolonged and the resultant copper powder may sometimes contain small amounts of unreduced copper oxide which can also have an adverse effect on the green strength of the copper powder.

Although a wide variety of finely divided copper oxide powders may be employed, finely divided copper oxides which have been found to be particularly advantageous for use in the process of this invention are obtained by mixing from about 40 to about 60 weight percent of a copper oxide powder whose particles have an average particle size of from about 2 to 5 microns (as measured by the Fisher Sub-Sieve Sizer), of from about 60 to about 40 weight percent of a copper oxide powder whose particles have an average particle size of from about 10–15 microns when measured as above-described. Such finely divided copper oxide mixtures have an average particle size with in the range of from about 5 to 15 microns and, when mixed with the hereinbefore defined finely divided metals, can be readily reduced to form the copper powder employed in the process of this invention. The particle size of the finely divided metal and refractory metal oxides is such that all are, or substantially all of the particles of each will pass through a No. 325 mesh U.S. Standard screen.

If metals and/or refractory metal oxides having a larger or coarser particle size are employed, copper powder having lower green strength will often be produced. Although the reasons for the criticality with respect to coarse particles of the additives is not known with certainty, it is believed that the coarse particles do not have sufficient surface area to effect the desired conversion of copper oxide to a copper powder having the properties desired. Finely divided selenium, tellurium or mixtures thereof whose particles pass through a No. 325 mesh U.S. Standard screen can be advantageously employed. Refractory metal oxides such as titania, alumina, silica, zirconia, vanadia, chromia, etc., whose particles pass through a No. 325 mesh U.S. Standard screen can also be employed.

As previously noted, the finely divided copper oxide mixture is reduced with reducing gas in a reduction zone at a temperature of at least about 900° F. If zone temperatures below 900° F. are employed, the copper powder obtained will not have the desired high green strength properties hereinbefore described. The low temperature criticality is surprising since past attempts to produce low density-high green strength copper powder have employed reduction temperatures in the range of from between 500 and 700° F. to produce copper powders having only slightly lower apparent density and slightly higher green strength. Although reduction zone temperatures above 1500° F. or higher may be employed in the process, it has been found generally preferable to maintain the reduction zone at a temperature between about 900° F. and 1200° F. Zone temperatures of 1000° to about 1100° F. are particularly preferred for reasons of economy. The use of temperatures within the particularly preferred ranges also results in maximum uniformity of the copper powder produced. As will be evident hereinafter from the specific examples, the temperature of the reduction zone is obtained by conventional gas fire or electrical heating means.

The reducing gas employed can be any reducing gas conventionally used for the reduction of finely divided metal oxides and can include, for example, gaseous carbon monoxide, hydrogen, dissociated ammonia, steam reformed natural gas, rich endothermic gas, and the like, and mixtures thereof. The quantity of reducing gas employed will depend upon the reducing capacity of the gas and the amount of copper oxide mixture which it is desired to reduce. Generally, the amount of reducing gas employed can vary within the range of from about 10 to about 20 standard cubic feet of gas per pound of copper powder produced. The lower quantity of gas employed corresponding to the higher reducing capacity of the gas and whether or not cuprous instead of cupric oxide is used.

The finely divided copper oxide mixture containing selenium and/or tellurium and the above refractory metal oxide can be reduced in a conventional reduction zone (e.g. reduction furnace using well-known batch or continuous procedures wherein the mixture is contacted with a reducing gas stream within the temperature range hereinbefore defined). The contact of the copper oxide mixture with the reducing gas may be effected by a variety of conventional ways such as, for example, by fluidizing the powdered copper oxide mixture by the gas which is introduced to the reaction zone as a flowing stream. Alternatively and preferably, the reduction is performed on a bed, preferably a thin bed of the mixture and can be suitably accomplished by placing a thin layer (e.g. a layer of about ⅛ to ¾ inch thick) of a copper oxide mixture on a movable metal belt and contacting the layer with a stream of reducing gas in the reduction zone by moving the belt through the zone. A layer of ¾ inch or less in depth is important in achieving total reduction of the copper oxide to copper. The flow of reducing gas through the zone may be cross-current, concurrent, or counter-current to the movement of the thin bed of the mixture through the zone. However, more efficient contact of the reducing gas and the mixture in the zone is obtained when the bed of the mixture is moving in counter-current contact with the flow of the reducing gas stream. Although beds thinner than ⅛ inch can be employed, there is no advantage gained and the use of the reducing gas is inefficient under such circumstances.

The rate of gas flow through the zone is directly proportional to the amount of finely divided copper oxide mixture to be reduced and has been found to be at least 10 standard cubic feet per hour per pound of reduced copper powder product when produced at temperatures within the afore-defined ranges and when the contact time in the reaction zone is at least 20 minutes using a finely divided copper oxide mixture which is preponderantly cuprous oxide.

The rate at which the reducing gas flows through the reduction zone must be increased by a factor greater than two (2) if the mixture is preponderantly cupric oxide. Using preferred mixtures, for example, mixtures in which the copper oxide is preponderantly cuprous oxide and a reducing gas such as hydrogen endothermic or steam reformed natural gas, the flow through the reduction zone will be at the rate of from about 10 to 20 cubic feet per hour per pound of copper powder produced when the contact time at temperature with the powders of the gas stream is from about 20 to about 40 minutes. By so proceeding, it is possible to obtain substantially complete reduction of the copper oxide. The moving belt passes the thin layer of mixture through the reduction zone and the mixture emerges from the zone as a layer of a friable agglomerated mass consisting substantially of elemental porous copper powder containing trace amounts of selen-

ium and/or tellurium and refractory metal oxide. The reduced mass is deagglomerated by comminution, the particles having the aforedescribed particle size and low apparent density.

The low density-high green strength porous copper powders of this invention contain residues consisting of trace amounts of selenium or tellurium or mixtures thereof and residues of the refractory metal oxides hereinbefore described.

The amount of selenium and/or tellurium incorporated in the copper oxide mixture is in the range of from about 0.05 to about 0.5 weight percent and the copper powder obtained from such mixtures would be expected to contain 0.055 to 0.6 weight percent of elemental metal (e.g. elemental selenium and/or tellurium) due to the oxygen loss during reduction of copper oxide to copper, depending upon whether the copper oxide powder consisted of cuprus or cupric oxide. However, the copper powders of this invention often contain somewhat less of the elemental indicating some loss of metal during the reduction process. The amount of selenium and/or tellurium in the powdered copper is usually from about 500 to about 3000 parts per million parts of copper powder, the higher quantities of metal residue in the copper powder generally corresponding to higher quantities of metal initially used in the copper oxide mixture.

When senenium is added to the copper oxide mixture, the residue in the copper powder is selenium. When tellurium is used in the copper oxide powder, the residue in the resulting copper powder is tellurium and when selenium and tellurium are both present in the copper oxide mixture, the copper powder obtained will contain a mixture of selenium and tellurium residues. The exact nature of the selenium and/or tellurium residue in the copper powder is not known with certainty but it is believed, in view of the reducing conditions to which the copper oxide is subjected, to be in the form of copper selenide or telluride.

The refractory metal oxide in the copper powder compositions falling within the scope of this invention is a refractory oxide of a metal falling within Groups III through VI of the Periodic Chart. Any metal within these groups which forms refractory oxides may be employed in the processes of this invention and such refractory metal oxides have been described hereinbefore. The refractory metal oxide in the copper oxide mixture which is passed through the reduction zone is not reduced to any measurable extent and is present in the finely divided porous copper powder in an amount of from about 0.055 to about 0.6 weight percent depending upon the amount of refractory metal oxide employed in the copper oxide powder mixture and whether cuprous or cupric oxide was employed in the copper oxide powder mixture. The increase in refractory metal oxide in the porous copper powder over that initially employed in the powdered copper oxide mixture is due to the loss of oxygen during reduction. Whereas some elemental metal (i.e. selenium or tellurium) is lost during reduction, no loss of refractory metal oxide occurs during the reduction process.

The high green strength copper powders of this invention consist essentially of particles substantially all of which are finer than 200 mesh and at least 80 percent of which are finer than 325 mesh. The copper powders have an apparent density of between about 1.4 to about 1.8 grams per cubic centimeter and a green strength between about 3300 to about 4200 p.s.i. when pressed at 12 t.s.i. Preferred copper powder compositions are those containing selenium and titania, selenium and alumina, tellurium and titania, and tellurium and alumina, within the range hereinbefore described. Particularly preferred copper powder compositions are those containing selenium and titania or selenium and alumina.

The following specific examples are intended to illustrate the invention but not to limit the scope thereof, parts and percentages being by weight unless otherwise specified.

Example 1

Two thousand (2000) grams of copper oxide powder were shown, upon analysis, to have the following composition and characteristics:

Free copper (Cu), percent	2.72
Cuprous oxide (Cu_2O), percent	96.10
Cupric oxide (CuO), percent	1.05
Screen analysis, percent:	
+100	.30
+150	Tr.
+200	Tr.
+250	Tr.
+325	.40
−325	99.30
Average particle size determined by Fisher Sub-Sieve Sizer, microns	14.0

A pre-mix containing 80 percent of the above copper oxide powder and 10 percent each of powdered (325 mesh) selenium and pigment grade titanium dioxide was prepared by mixing and tumbling 32 grams of the copper powder and 4 grams each of the selenium and titanium dioxide described above. The mixing was accomplished by tumbling the components in a jar for 15 minutes.

Twenty-four (24) grams of the pre-mix were mixed with 1176 grams of the copper oxide powder in a twin shell laboratory mixer to form 1200 grams of a homogeneous mixture comprising copper oxide powder which contained 0.2 weight percent of powdered elemental selenium and 0.2 weight percent of finely divided titanium dioxide.

The mixture was reduced by charging it into trays 4 inches wide, 12 inches long and ½ inch deep, which were placed on a moving endless mesh belt of a pilot plant reduction furnace which was operated under the following conditions:

Furnace preheat	1000° F.
Furnace high temperature	1075° F.
Belt speed	1 inch per minute to give approximately 30 minutes at 1000 to 1075° F.
Reducing gas	Endothermic with 30–40° F. dew point and approximate composition of: CO, 20%; H_2, 40%; N_2, 35–40%; CH_4, 0.40%; CO_2, 0.0%.
Reducing gas flow	Approximately 150 cubic feet per hour into heating zone.

After the reduced charge had passed through the cooling zone in the furnace, it was inspected and found to be a "puffed" light friable cake which was ground in a hand mortar to provide a powder, all of which passed through a 200 mesh screen, 90 percent of which passed through 325 mesh screen. The powder was tested for green strength (modulus of rupture of green bar in terms of p.s.i.) and apparent density. The green strength measurement was determined using the ASTM Standard B312–58T using a 15.00 gram transverse bar, 1¼ inch long by ½ inch wide and approximately ¼ inch thick pressed at 12 t.s.i. using a small amount of lubricant on the die wall in which the powder was pressed. The apparent density was determined by the use of a Hall flowmeter as per ASTM Standard B212–48. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are set forth in Table I below immediately following Example 4.

Example 2

The reduction procedure of Example 1 was repeated except that the copper oxide powder described in Example 1 was reduced per se without additives. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are shown in Table I.

Example 3

The reduction procedure of Example 1 was repeated except that the copper oxide powder described in Example 1, to which 0.2 percent selenium had been added, was reduced. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are shown in Table I.

Example 4

The reduction procedure of Example 1 was repeated except that the copper oxide powder of that example contained 0.2 percent TiO_2 (in place of the selenium TiO_2 additives employed in Example 1). The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are shown in Table I.

TABLE I

Reduction Mixture	Copper powder properties: Green strength, p.s.i. (modulus of rupture of green bar)	Apparent density, gms./cc.	Puffing
Copper oxide powder +0.2% Se +0.2% TiO_2 (Example 1).	3,860	1.55	Marked.
Copper oxide powder only (Example 2).	2,295	2.26	None.
Copper oxide powder +0.2% Se (Example 3).	2,915	2.06	Slight.
Copper oxide powder +0.2% TiO_2 (Example 4).	2,190	2.28	None.

Example 5

Two thousand (2000) grams of a copper oxide different than that employed in Example 1 (hereinafter designated powdered copper oxide B) were shown, upon analysis, to have the following composition and characteristics:

Free copper (Cu), percent	.22
Cuprous oxide (Cu_2O), percent	98.50
Cupric oxide (CuO), percent	1.10
Screen analysis, percent:	
+100	Tr.
+150	Tr.
+200	Tr.
+250	Tr.
+325	.10
−325	99.90
Average particle size as determined by Fisher Sub-Sieve Sizer, microns	6.3

A pre-mix containing 80 percent of the above copper oxide powder and 10 percent each of powdered 325 mesh selenium and pigment grade titanium dioxide was prepared by tumbling 32 grams of copper powder and 4 grams each of the selenium and titanium dioxide described above. The mixing was accomplished by tumbling the components in a jar for 15 minutes. Twenty-four (24) grams of the pre-mix were mixed with 1176 grams of the copper oxide powder in a twin shell laboratory mixer to form 1200 grams of a homogenous mixture comprising copper oxide powder B which contained 0.2 percent of powdered elemental selenium and 0.2 weight percent of finely divided titanium dioxide. The mixture was reduced using a procedure substantially identical to that described in Example 1. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are set forth in Table II immediately following Example 8.

Example 6

The reduction procedure of Example 1 was repeated, employing the copper oxide powder described in Example 5, except that this powder was reduced per se (i.e. without the addition of selenium or titania). The resultant copper powder product including green strength, apparent density and "puffing" characteristics and are shown in Table II.

Example 7

The reduction procedure of Example 1 was repeated except that the copper oxide powder described in Example 5, to which 0.2 percent selenium had been added (in place of the titania selenium additive of Example 5), was reduced. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are shown in Table II.

Example 8

The reduction procedure of Example 1 was repeated except that the copper oxide powder described in Example 5, to which 0.2 percent TiO_2 was added (in place of the selenium TiO_2 mixture employed in Example 5), was reduced. The properties of the resultant copper powder product including green strength, apparent density and "puffing" characteristics are shown in Table II.

TABLE II

Reduction mixture	Copper powder properties: Green strength, p.s.i.	Apparent density, gms./cc.	Puffing
Copper Oxide B+no additions (Example 6).	2,820	2.19	None.
Copper Oxide B+.20% Se (Example 7).	3,330	1.90	Noticeable puffing.
Copper Oxide B+.20% TiO_2 (Example 8).	2,760	2.11	None.
Copper Oxide B+.20% TiO_2+.20% Se (Example 5).	4,205	1.45	Marked.

The results in Tables I and II distinctly show that copper oxide powder containing the above indicated amounts of selenium and titania, upon reduction, produce copper powder having superior green strength.

In the preceding examples, zirconia, silica, vanadia or chromia can be substituted in the same weight percentages for the titania or alumina, when employed in those examples, to significantly increase the green strength and decrease the apparent density of the copper powders produced, when such powders are compared with controls which do not contain the refractory metal oxide or the elemental selenium or tellurium in the above examples. Tellurium can also be used in the same weight percentage to replace the selenium employed in the above examples to materially increase the green strength and decrease the apparent density of the reduced copper powder products.

Example 9

The reduction procedure of Example 1 was repeated employing the copper oxide powder described in Example 5, to which had been added 0.2 percent alumnia in place of the 0.2 percent titania employed in Example 5. The green strength and apparent density of the resultant copper powder are as follows:

Green strength, p.s.i.	4,181
Apparent density, gms./cc.	1.61

Example 10

The reduction procedure of Example 1 was repeated employing the copper powder of Example 5, to which had been added 0.1 percent powdered selenium and 0.2 percent 325 mesh powdered alumina in place of the 0.2 percent selenium and 0.2 percent titania employed in

Example 5. The green strength and apparent density of the resultant copper powder product were as follows:

Green strength, p.s.i.	4,050
Apparent density, gms./cc.	1.59

The results of Tables I and II, covering Examples 1 through 8, and Examples 9 and 10, show that the addition of selenium to copper powder increases the green strength of the copper powder. The addition of TiO_2 alone to copper powder does not effect the green strength. However, the addition of TiO_2 and selenium to the copper powder markedly increases the green strength indicating that TiO_2 significantly synergizes the effect of selenium in increasing the green strength of copper powder. Marked lowering of the apparent density of selenium (or tellurium) refractory metal oxide containing powders is also observed.

In the foregoing examples where the copper oxide powder contained 0.2 weight percent of selenium and 0.2 weight percent of titania, the reduced copper powder contained 1200 parts per million (0.12 weight percent of selenium) and 0.22 weight percent of titanium dioxide. Since the relative percentages of selenium and titania should be increased in the copper powder (due to the removal of oxygen from the copper oxide), the results show that some selenium is removed during reduction but that very little, if any, of the titania is removed.

It is not known with certainty whether selenium (or tellurium) and the refractory metal oxide function, during reduction of the copper oxide, to form copper powder products having high green strength and low apparent density or whether the presence of the trace quantities of selenium and titania in the copper powder products causes the increase in green strength of the pressed copper powder product. However, the net result is unexpected and valuable in the powder metallurgy of copper.

What is claimed is:

1. A composition consisting essentially of a finely divided porous copper powder from about 0.03 to about 0.5 weight percent of an elemental metal selected from the group consisting of selenium, tellurium and mixtures thereof and from about 0.05 to about 0.6 weight percent of a refractory metal oxide of a metal of Groups III, IV, V and VI of the Periodic Chart, said composition being characterized in having a high green strength when pressed.

2. The composition of claim **1** in which the copper powder consists essentially of particles substantially all of which are finer than 200 mesh and at least 80 percent of which are finer than 325 mesh, said powder having an apparent density between about 1.0 and 1.8 grams per cubic centimeter and a green strength of between about 3000 and about 4500 p.s.i. when pressed at 12 t.s.i.

3. The composition of claim **1** wherein the elemental metal is selenium.

4. The composition of claim **1** wherein the refractory metal oxide is titania.

5. The composition of claim **1** wherein the refractory metal oxide is alumina.

6. The composition of claim **1** wherein the elemental metal is selenium and the refractory metal oxide is titania.

7. The composition of claim **1** wherein elemental metal is selenium and the refractory metal oxide is alumina.

8. In a process for making copper powder by reducing finely divided copper oxide with a reducing gas in a reduction zone maintained at elevated temperature, the improvement for making copper powder having a low apparent density and high green strength which comprises the steps of:

(a) forming a substantially uniform mixture of said copper oxide and from about 0.05 to about 0.5 weight percent of at least one finely divided metal selected from the group consisting of selenium and tellurium and from about 0.05 to about 0.5 weight percent of a finely divided refractory metal oxide of a metal of Groups III, IV, V and VI of the Periodic Chart, and

(b) reducing said mixture with said reducing gas in said zone at a temperature of at least about 900° F.

9. The process of claim **8** wherein said copper oxide is preponderantly cuprous oxide.

10. The process of claim **8** wherein said reduction is performed in a thin bed of said mixture and the bed is maintained moving in counter-current contact with a flow of said reducing gas in said reduction zone.

11. The process of claim **10** wherein the reducing gas flow is maintained at a rate of at least about 10 standard cubic foot per hour per pound of reduced copper powder produced and the contact time in said reduction zone is at least about 20 minutes.

References Cited

UNITED STATES PATENTS

3,024,110	3/1962	Funkhouser et al.	75—206
3,026,200	3/1962	Gregory	75—206
3,143,789	8/1964	Iler et al.	75—206
3,383,198	5/1968	Shafer	75—.5

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