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METHOD OF PROCESSING METAL POWDERS

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FIG. 1

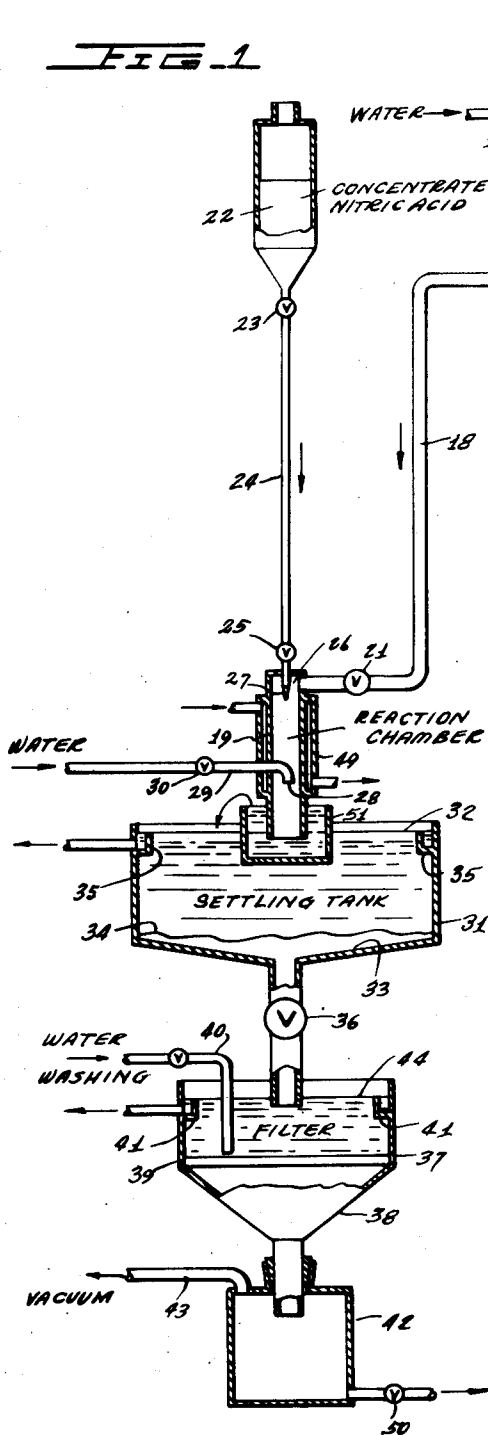
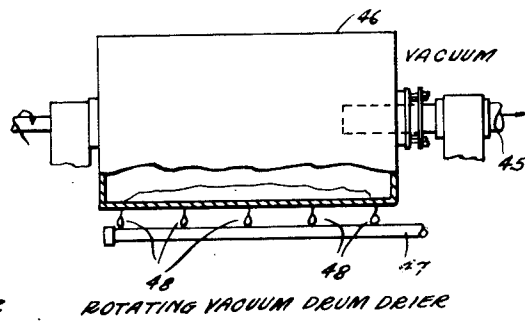


FIG. 2



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METHOD OF PROCESSING METAL POWDERS

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27 Claims. (Cl. 134—3)

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This invention relates to the processing of metal powders of aluminum or magnesium for any purpose and particularly for powder metallurgical purposes. Metal powders of aluminum or magnesium are obtained commercially by comminuting, such as machining or milling the respective metal, or by atomization or condensation processes. Their particles are usually oxidized or nitrided in surface layers exposed to the surrounding air, and mostly there is also a combustion or explosion hazard.

The films of stable compounds, such as oxides and nitrides, formed in the surface layers of the powdery metal particles are highly objectionable for many applications of the powders, in that the products made therefrom are heterogeneous due to the inclusion therein of those compounds. If the powders are used for powder metallurgical purposes, the films of the compounds stated render it difficult to obtain a coherent compacted body and to fully sinter it. The sintered bodies are heterogeneous, of insufficient density and consequently of inferior physical properties.

It is therefore an object of the invention to process metal powders of aluminum or magnesium, so as to remove surface films of objectionable compounds from their particles in an economical and effective manner.

It is another object of the invention to process powders of the kind herein concerned so as to remove from their particles superficial films of objectionable compounds, such as oxides and nitrides, and to immunize the surface layers of the cleaned particles against subsequent attacks by the oxygen or nitrogen contained in the surrounding air, at least for a limited period of time.

It is a further object of the invention to remove objectionable compounds, primarily oxides and nitrides, formed by contact with air in surface layers of powdery metal particles of aluminum or magnesium in an economical and effective process suited for mass production.

It is still a further object of the invention to reduce the surface layers of powdery particles of metals herein concerned to their metallic state by removing therefrom objectionable compounds previously formed therein by contact with air or otherwise, and to stabilize or immunize against subsequent attacks of air these surface layers at least for a limited period of time, in an effective and economical process suited for mass production.

These and other objects of the invention will be more clearly understood when the specification proceeds with reference to the drawings in which

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Fig. 1 illustrates schematically on hand of a flow sheet a preferred process according to the invention, suited for mass production, and Fig. 2 shows schematically and in cross-section a vacuum drying drum usable with the invention.

According to the invention, the powder of a metal, such as aluminum or magnesium, prepared in any known and suitable manner and the particles of which contain in their surface layers objectionable compounds, primarily oxides and/or nitrides, is subjected to a chemical treatment or washing process which removes the objectionable compounds from the particle surfaces and leaves the surfaces clean and resistant to corrosion and other chemical reaction with oxygen or nitrogen contained in the surrounding air, and at least for a limited period of time. To this end, according to the invention, the metal powder is treated with nitric acid (HNO_3) of suitable high concentration so as to remove from the powdery particles the objectionable oxide and/or nitride films rapidly; this effect manifests itself by a clean and metallic, shiny appearance of the treated particles. By the action of the highly concentrated nitric acid upon the surface layers of the particles from which those compounds are being removed, those layers are also cleaned in the aforementioned sense so that they stay immune against the attacks of oxygen or nitrogen such as contained in the surrounding air, or their chemical activity with respect to that oxygen or nitrogen is substantially reduced at least for a limited time period which suffices for manipulating or other subsequent treatment of the powder in powder metallurgical and other metallurgical processes.

After these effects of the invention are obtained, the reaction between the nitric acid and powdery metal particles is interrupted quickly in order to avoid losses of the metal substance by the continued attack thereon of the concentrated nitric acid. To this end the nitric acid can be removed immediately after the desired effect of the invention is obtained, for instance by separating the processed powder from the acid by decanting the latter or in a centrifuging process.

Another and more convenient way, particularly suitable for mass production, consists in diluting the acid with water immediately after the desired reaction has been completed, to such an extent that the diluted acid does not react any more with the metallic particles or at least the velocity of that reaction is very considerably reduced.

A preferred embodiment of the invention will

now be described with reference to Fig. 1 and in its application to magnesium powder of any origin, although it should be understood that the same process can be applied to powder of any other metal or to a mixture in desired and predetermined ratio of powders of different kinds of metals.

In a tank or container 10 a suspension of magnesium powder in any suitable vehicle or suspension medium is prepared. Water is preferred as such suspension medium. To this end, magnesium powder 14 is fed continuously from hopper 15 into tank 10 at a predeterminable rate or amount per unit of time, which can be adjusted for instance by regulating the speed of a rotating feeder 16 arranged near the bottom and outlet of hopper 15. Water is supplied to tank 10 through pipe 17 at a predeterminable rate per time unit adjusted by adjustable valve 20. Thereby any desired ratio of magnesium powder and water as suspension medium can be adjusted and maintained during operation, and a sufficient supply of that suspension provided. In order to suspend the magnesium powder in the water and maintain it suspended therein, air can be injected into the water within tank 10 as by an air supply line indicated by the dotted lines 13-1, or mechanical stirring means provided as indicated by stirrer 11 on shaft 12 of an electric motor 13.

The suspension or slurry thus formed is withdrawn from tank 10 through pipe 18 into reaction chamber 19 at a predeterminable rate which can be adjusted by any suitable means, such as adjustable valve 21.

Tank 10 is arranged at a suitable higher level than reaction chamber 19, so as to secure by action of gravity the desired flow of the suspension or slurry into the reaction chamber, and for other purposes to be explained hereinafter.

A supply of nitric acid of suitable high concentration is maintained in tank 22, and a measured quantity per time unit of the acid is withdrawn from tank 22 through valve 23, pipe 24 and another adjustable valve 25 into nozzle 26 arranged within reaction chamber 19 so that the discharge end 27 of nozzle 26 is at a lower level than the discharge aperture of pipe 18 into chamber 19. Nozzle 26 is of any suitable and known type and, if desired, it may be of a known type, not shown, arranged to impart to the jet or spray of acid a rotation movement. More than one nozzle or similar discharge devices can be used.

Upon proper adjustment of the adjustable valves 21 and 25 and after opening of valve 23, the suspension or slurry continuously formed in tank 10 and the highly concentrated nitric acid continuously supplied to tank 22 are discharged and injected, respectively, into chamber 19 at predeterminable and adjustable rates. The concentrated nitric acid injected into the chamber space admixes rapidly with the watery slurry or suspension of magnesium powder simultaneously discharged into chamber 19. The concentration of the injected acid is such that its slight dilution by the suspension-water does not inhibit or substantially reduce its instantaneous and vehement reaction with the magnesium powder. Nitrogen-oxide gases develop turbulently by this reaction but their escape through either pipe 18 or 24 is prevented by the sufficiently high pressure in the slurry and acid, respectively, flowing through those pipes and due to the arrangement of tanks 10 and 22 at suitable higher levels than that of reaction chamber 19.

Considerable heat may be developed by this

reaction, depending on the relative amounts of acid and magnesium powder, and cooling means can be provided in such case, such as a jacket 49 around chamber 19 through which cooling water is passed in the manner indicated in the drawing.

While the powdery particles and acid travel downwardly through the space of chamber 19, the turbulent nitrogen-oxide gases developing during the reaction secure the contact of all the particle surfaces by the acid, and the removal of oxide and nitride films in those surfaces and the cleaning of the latter is therefore completed after the particles and acid have travelled a certain path or distance downwardly below the discharge end 27 of nozzle 26. In order to interrupt the reaction at this point and to avoid losses of magnesium metal, the mixture of the powder and acid could be discharged into a relatively large pool of continuously replenished water which dilutes the acid sufficiently, or the powder and acid could be centrifugally separated in any known way. In Fig. 1, at the distance below nozzle 26 where the reaction according to the invention is completed, another nozzle 28 is arranged within chamber 19. Nozzle 28 discharges downwardly and is connected with pipe 29 passing through the wall of chamber 19 to the outside. Water is supplied through pipe 29 from a source not shown, of a predeterminable quantity per time unit adjusted by adjustable valve 30. Nozzle 28 can be of any suitable type and supplies water in sufficiently large quantity so that upon its rapid and intimate admixture with the nitric acid arriving below nozzle 26, the acid is diluted sufficiently so that its reaction with the magnesium powder is interrupted or at least the velocity of that reaction is reduced sufficiently so that no objectionable losses of magnesium occur thereafter.

It will be appreciated that the distance between nozzles 26 and 28 depends on the flow rate and concentration of the suspension or slurry of magnesium and on the flow rate and concentration of the nitric acid, all of which are adjustable at the start of and during operation in the manner hereinbefore described. The optimum distance between those nozzles is chosen so as to cause complete removal of objectionable surface films from the metal particles. No general rule can be given for this purpose because of the varying factors stated and the further fact that average particle size and kind of the metal powder or mixture of such powders comes into play too. However, after such optimum distance has once been established for a given kind of powder or mixture of powders, continuous operation in the chamber 19 in mass production can be maintained by adjusting the speed of feeder 16, the amount of water admixed thereby by means of adjustable valve 20, the amount of the suspension or slurry discharged into chamber 19 by means of adjustable valve 21, and the amount of concentrated nitric acid injected through nozzle 26 by means of adjustable valve 25. Thereby unavoidable variations of the average particle size and other properties of commercially obtainable metal powders can be taken care of during operation without changing the distance between nozzles 26 and 28 or of other dimensions and arrangements of the reaction chamber 19.

The rapid or almost instantaneous admixture of the diluting water and nitric acid is enhanced by the nitrogen-oxide gases previously developed within chamber 19 which are forced to escape

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through the lower open end of the chamber. This end is arranged within a pot 51 the bottom of which is at some distance below the open end of chamber 19 and the side wall of which is spaced from and extends considerably above that end. As a consequence, the mixture of cleaned magnesium powder and diluted nitric acid will collect in pot 51 to the level of its upper rim and thereby form a seal for the lower open end of the chamber. The nitrogen-oxide gases can penetrate that seal because the pressure in the liquid column between the upper end of the side wall of pot 51 and the lower end of chamber 19 is far smaller than the pressure in pipes 18 and 24, respectively. Pot 51 is filled almost immediately after operation has started, and the continuously supplied mixture of magnesium powder and diluted nitric acid flows over the upper rim of pot 51 into a settling tank 31. The cleaned magnesium powder in the overflowing mixture will always be covered fully by the liquid consisting of nitric acid and water, and detrimental access of air to those particles is thereby prevented.

The slurry of magnesium particles and highly diluted nitric acid collects in tank 31. Since the nitrogen gases escaped previously in the manner hereinbefore described, this mixture comes to a rest within tank 31 and segregates. The heavier magnesium powder sinks toward and accumulates upon the downwardly tapering bottom 33 of tank 31 up to level 34, whereas the diluted nitric acid forms a liquid layer on top of the settled magnesium powder to the level 32. Inside tank 31 and near its upper open end, a trough 35 is arranged acting as an overflow for the diluted nitric acid which is withdrawn from trough 35 in the manner shown.

The magnesium powder collected above bottom 33 forms a slurry still admixed with diluted nitric acid; it is withdrawn from tank 33 at proper time intervals, as explained later, through valve 36 into a vacuum filter, such as a washing and filtering vessel or tank 37 provided with a downwardly tapering bottom 38. A filter 39 is arranged in vessel 37 above and spaced from bottom 38. Clean washing water is poured or sprinkled through pipe 40 upon the slurry deposited on filter 39 and accumulates above the powder to the level 44 of an overflow (trough) 41 from which it is withdrawn in the manner shown. Vessel 37 communicates through an aperture in its bottom 38 and connecting pipe with another confined space 42 thereunder in which a vacuum is produced and maintained by pipe 43 connected with a vacuum pump (not shown). Thereby a great part of the liquid consisting of washing water, admixed with the magnesium powder above filter 39 is sucked away through filter 39 and the magnesium powder slurry more concentrated to form a cake which still contains but little liquid. Any access of air to powdery particles of the cake is prevented by the layer of washing water collected above it. Any liquid collecting in vessel 42 can be withdrawn therefrom through a pipe and valve 50. After a filter cake of sufficient height has been built up, the valve 36 is closed and the filter cake allowed to remain until the water entering through the pipe 40 has thoroughly cleaned the surfaces of the metal particles in the cake. The filter cake is then removed from vessel 37 and transferred into a dryer. The valve 36 may then be opened to allow another quantity of slurry to enter the vessel 37 to form a new filter cake. The extraction of

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the water still contained in the filter cake can be accomplished by treating it with a suitable extraction medium, such as acetone. The extraction of the water and the drying of the filter cake may be effected in a vacuum dryer of any known suitable type. Whichever kind of dryer and means for transferring the cake into it are used, it is essential that the magnesium particles of the cake are wet until they are placed into the dryer, so that access of air to the magnesium particles is prevented which, before the latter are completely dried, could react with the particle surfaces in spite of their thorough cleanliness.

Fig. 2 indicates, by way of example, one form of a vacuum dryer having a revolvable drum 46 in which vacuum is produced by means of pipe 45 projecting into the interior of the drum and connected with a vacuum pump (not shown). A mild heat, up to about 50° C., is produced within the drum, for instance, by means of gas flames 48 of a gas burner 47. Thereby the strong cooling effect resulting from the evaporation in vacuo of the liquid adhering to the magnesium powder can be compensated to desired extent. The vacuum produced within drum 46 should be of a pressure equalling or below 4 to 5 millimeters mercury column absolute. While the filter cake is being dried, it breaks up into powder; after the powder is completely dried, the vacuum can be released and the powder removed from the drum. The completely dry powder is clean and shiny, and its surface layers are resistant to contamination in the aforementioned sense for a limited period of time. The powder can therefore be manipulated, such as compacted for metallurgical purposes, without the danger of the formation of objectionable oxide or nitride films thereon.

If the dry powder is to be stored or shipped, an inert gas can be admitted into drum 46 immediately after the vacuum has been released, for instance, very dry hydrogen or an inert gas like helium, argon or neon. The inert gas may be supplied through the same tube 45 through which the drum 46 is evacuated. In certain cases and if the interior of the drum and the powder therein have been permitted to cool to room temperature while the vacuum is on, dry nitrogen can be used as protective gas and admitted into the drum after the vacuum has been released. The powder and inert gas of the types mentioned can be filled into containers or cans which are air-tightly sealed thereafter.

If an inert gas, such as helium, etc., has been admitted into the drum, a layer of that gas may be adsorbed by the dry powder particles which additionally protects the latter against oxidation for some time thereafter.

If the cleaned particles of metal are manipulated thereafter, for instance compacted into bodies of desired shape, the exposed surfaces of those compacts is far smaller than that of the particles comprised by the compact; therefore, if the resistance to contamination disappears during heat treatment of the compact, all that can happen is that the small exposed surface of the compact is oxidized or nitrified. By the use of a protective gas, such as very dry hydrogen of a dew point far below minus 40° C., or helium, argon or neon, even such superficial oxidation or nitrifying can be prevented. Since compacts of high density can be produced of the metals herein concerned by relatively low compaction pressures, no danger of undue ab-

sorption of the protective gas or penetration of oxygen or nitrogen into the interior of the compact exists. Hence the final product obtained by sintering will be of greatest purity, homogeneity and density and therefore exhibit unusual or heretofore unknown physical properties. The same advantages are obtained if the powder processed according to the invention is admixed with other clean powders in order to obtain from the powdery mixture a desired metal alloy, or if a mixture of those powders is processed, bodies or even ingots compacted and sintered therefrom will exhibit outstanding properties due to their homogeneity, density and purity. It is well known in the art that casting of magnesium, aluminum, or alloys of those metals requires a large riser because of the high shrinkage of those metals and alloys, and their production is therefore connected with extensive melting losses. The control of grain size is equally difficult in casting those metals and alloys, and the formation of blisters and blow holes therein is hard to avoid, if possible at all. The properties of the alloys depend greatly on the purity and exact ratio of the alloying constituents therein which to obtain is extremely difficult in casting processes. Therefore, if ready to use bodies, or ingots for further working and shaping are made by powder metallurgical processes from powder or powdery mixtures containing metal powder processed according to the invention, all these difficulties can be obviated. However, these aspects of the use of powders processed according to the invention do not form a subject matter thereof and are mentioned only to illustrate the high utility and novel effects of powders processed according to the invention.

It should be understood that the invention is not limited to any of the embodiments herein exemplified and illustrated. Thus, for instance, instead of single nozzles 26 and 28, any number of them can be arranged discharging at the same or slightly different levels, and the supply to them of the slurry and nitric acid, respectively, can be regulated simultaneously or independently. Instead of a vacuum filter as exemplified hereinbefore, any other type of filter can be used, such as a continuous working filter. Whatever the implements and equipment used for practicing the invention may be, their essential operation should consist in reacting upon the metal powder or mixture of such powders with nitric acid of sufficiently high concentration so as to rapidly remove from the powdery particles oxide and nitride films and also clean the surface layers of the particles; to interrupt this reaction immediately after these effects are obtained in order to avoid losses of metal substance; to wash the cleaned powdery particles and to dry them in the absence of air, i. e. in a sufficiently high vacuum and/or in the presence of dry and inert gas (e. g. helium), not shown; and to store the processed dry powder, if required, in air-tight containers and advantageously in the presence of an inert gas until the powder is further processed or used, particularly in a powder metallurgical process.

What I claim is:

1. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a fluid mixture containing water and said powdery particles with concentrated

nitric acid so as to remove metal compounds from the surfaces of said particles and thus produce on said particles cleaned surface layers, effectively interrupting immediately thereafter said reaction by effectively removing the powdery particles from the action of the concentrated acid, and thereafter separating said particles from the resulting mixture under conditions excluding the access of air.

2. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a fluid mixture containing water and the powdery particles with concentrated nitric acid so as to remove metal compounds from their surfaces and thus produce cleaned surface layers, and effectively interrupting immediately thereafter said reaction by diluting the acid and separating said particles from the resultant mixture under conditions excluding the access of air.

3. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a fluid mixture containing water and the powdery particles with concentrated nitric acid so as to remove metal compounds from their surfaces and thus produce cleaned surface layers, effectively interrupting immediately thereafter said reaction, thereafter adding water to the resulting mixture, and washing and drying the particles under conditions excluding the access of air.

4. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a mixture of water and the powdery particles with concentrated nitric acid so as to remove metal compounds from the surfaces and thus produce cleaned surface layers on said particles, effectively interrupting immediately thereafter said reaction, thereafter adding a washing agent to the resulting mixture and washing the particles with said washing agent so as to protect said particles against the access of air, and removing the washing agent and other mixture ingredients still adhering to the particles by treating them with a volatile solvent medium.

5. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a fluid mixture containing water and the powdery particles with concentrated nitric acid so as to remove metal compounds from their surfaces and thus produce cleaned surface layers, effectively interrupting thereafter said reaction, thereafter adding a washing agent to the resulting mixture and washing the particles under cover of a washing agent on a vacuum filter, and drying the wet filter cake in a non-oxidizing atmosphere.

6. In a method as set forth in claim 5, drying the wet filter cake in the presence of an inert gas.

7. In a method as set forth in claim 5, drying the wet filter cake in the presence of an inert

gas selected from the group consisting of helium, argon and neon.

8. In a method as set forth in claim 5, drying said filter cake in a vacuum the pressure of which does not exceed about 5 millimeters mercury column absolute.

9. In a method as set forth in claim 5, drying the filter cake at a temperature up to about 50° C.

10. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of suspending the metal powder in water so as to form a slurry, admixing with said slurry nitric acid of high concentration and in an amount sufficient to secure an intense reaction of said acid upon the metal particles and thereby to remove metal compound impurities on the surfaces of said particles and to thus produce cleaned surface layers on said particles, and effectively interrupting immediately thereafter said reaction by diluting said acid.

11. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of suspending the metal powder in water so as to form a slurry, admixing with said slurry nitric acid of high concentration and in an amount sufficient to secure an intense reaction of said acid upon the metal particles and thereby to remove metal compound impurities on the surfaces of said particles and to thus produce cleaned surface layers on said particles, effectively interrupting thereafter said reaction by effectively removing said particles from the action of said concentrated acid, substantially separating said acid and particles, washing the particles with and separating them thereafter from a washing agent, and drying the washed particles.

12. In a method as set forth in claim 11, substantially separating the acid and particles by allowing the latter to settle as slurry, washing the particles of said slurry with water and removing a substantial portion of said washing water by filtering, and thereafter drying the particles, said settling, washing, filtering and drying performed under conditions excluding the access of air to the particles until they are completely dry.

13. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises, in a continuous process, the steps of supplying continuously at predetermined rates and mixing metal powder and water so as to form a slurry thereof, discharging said slurry into confined space, admixing concentrated nitric acid with said slurry within said space so that the acid reacts upon the metal particles and removes from their surfaces metal compound impurities and thus produces cleaned surface layers while said particles and acid move downwardly through said space, discharging water into said space substantially at the place where said reaction has just been completed so as to dilute the acid and substantially reduce the velocity of said reaction, discharging the mixture of diluted acid and cleaned particles from said space under conditions per-

mitting gases developing during said reaction to escape, and thereafter subjecting the resulting mixture to a treatment including washing of said particles and separation of said particles from the resulting mixture under conditions excluding access of air to said particles.

14. In a method as set forth in claim 13, supplying said initial suspension or slurry and said concentrated nitric acid from levels considerably higher than the levels at which said suspension and acid are discharged into said confined space.

15. In a method as set forth in claim 13, adjusting independently the quantities per time unit of metal powder and suspension water to form said initial slurry and the quantity per time unit of said initial slurry fed into said confined space, and also adjusting independently the quantity per time unit of concentrated nitric acid supplied to said confined space so as to obtain and maintain a predetermined optimum ratio of said acid and powdery particles for said reaction.

16. In a method as set forth in claim 13, abstracting heat from said confined space while said reaction proceeds.

17. In a method as set forth in claim 13, admixing by injection under pressure said nitric acid with said initial suspension or slurry in said confined space.

18. In a method as set forth in claim 13, admixing by injection under pressure the diluting water with said mixture of acid and slurry within said confined space after said reaction has been completed.

19. In a method as set forth in claim 13, said treatment including collecting said mixture and allowing it to rest so that said particles separate substantially from the diluted acid and form an intermediate slurry, subjecting said intermediate slurry to a washing treatment, increasing the concentration of the washed slurry, and treating it to obtain clean dry metal powder, said treatment including withdrawing at predetermined intervals the settled intermediate slurry for subsequent washing and drying.

20. In a method as set forth in claim 13 said treatment including collecting said mixture and allowing it to rest so that said particles separate substantially from the diluted acid and form an intermediate slurry, subjecting said intermediate slurry to a washing treatment, increasing the concentration of the washed slurry, and treating it to obtain clean dry metal, said treatment also including, increasing the concentration of the withdrawn intermediate slurry by a vacuum filter treatment.

21. In a method as set forth in claim 13 said treatment including collecting said mixture and allowing it to rest so that said particles separate substantially from the diluted acid and form an intermediate slurry, subjecting said intermediate slurry to a washing treatment, increasing the concentration of the washed slurry, and treating it to obtain clean dry metal, said treatment also including filling the dried, clean metal powder immediately upon completion of said treatment into a container and thereafter sealing the latter air-tightly.

22. In a method as set forth in claim 13 said treatment including collecting said mixture and allowing it to rest so that said particles separate substantially from the diluted acid and form an intermediate slurry, subjecting said intermediate slurry to a washing treatment, increasing the concentration of the washed slurry, and

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treating it to obtain clean dry metal, said treatment also including filling the dried, clean metal powder immediately upon completion of said treatment into a container in the presence of an inert gas, and thereafter sealing said container air-tightly.

23. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of reacting upon a fluid mixture containing water and said powdery particles with concentrated nitric acid so as to remove metal compounds of the surfaces of said particles and thus produce on said particles cleaned surface layers, effectively interrupting immediately thereafter said reaction by centrifugally separating said particles from said acid, and thereafter separating said particles from the resulting mixture under conditions excluding the access of air.

24. In a method as set forth in claim 5, drying the wet filter cake under exclusion of air.

25. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of suspending the metal powder in water so as to form a slurry, admixing with said slurry nitric acid of high concentration and in an amount sufficient to secure an intense reaction of said acid upon the metal particles and thereby to remove metal compounds formed on the surfaces of said particles to thus produce cleaned surface layers on said particles, and effectively interrupting immediately thereafter said reaction by effectively removing the powdery particles from the action of the concentrated acid.

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26. The method of cleaning light powdery particles of metal selected from the class consisting of aluminum and magnesium and having metal compound surface impurities which are removable by nitric acid, which comprises the steps of suspending the metal powder in water so as to form a slurry, admixing with said slurry nitric acid of high concentration and in an amount sufficient to secure an intense reaction of said acid upon the metal particles and thereby to remove metal compounds formed on the surface of said particles for producing cleaned surface layers on said particles, and effectively interrupting immediately thereafter said reaction by centrifugally separating said particles from said acid.

27. In a method as set forth in claim 12, effectively interrupting said reaction by diluting said acid.

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