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C. A. BIELAWSKI
METHODS AND APPARATUS FOR TREATING METALLIC
AND NON-METALLIC POWDERS

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3 Sheets-Sheet 1

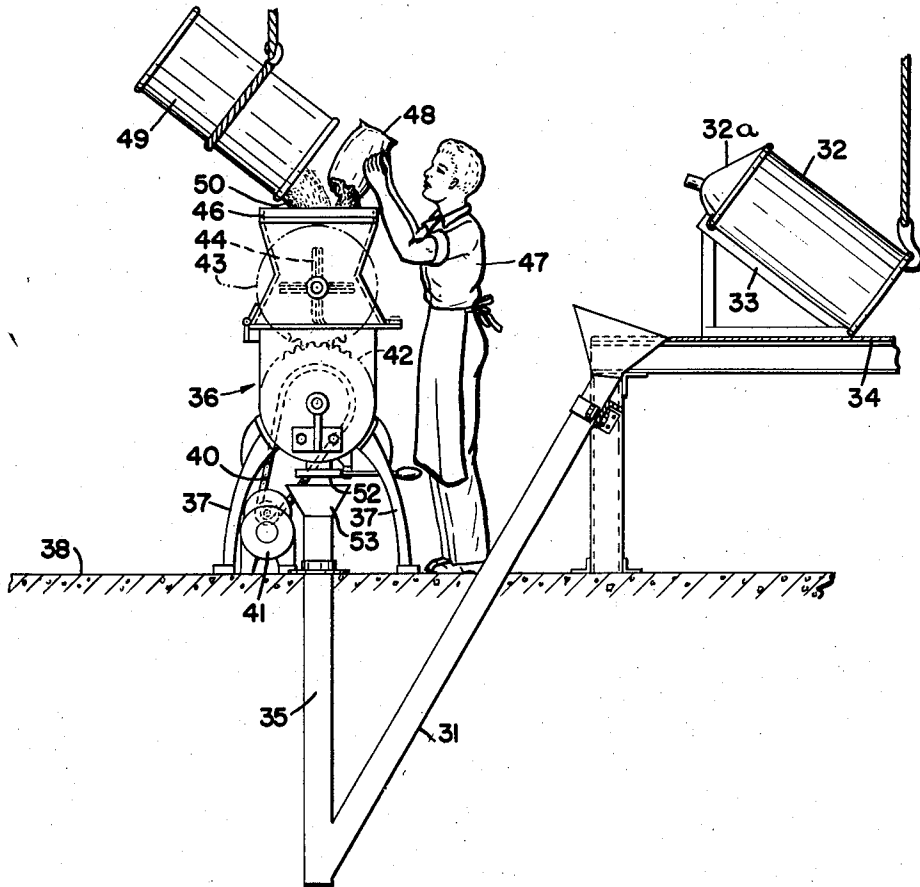
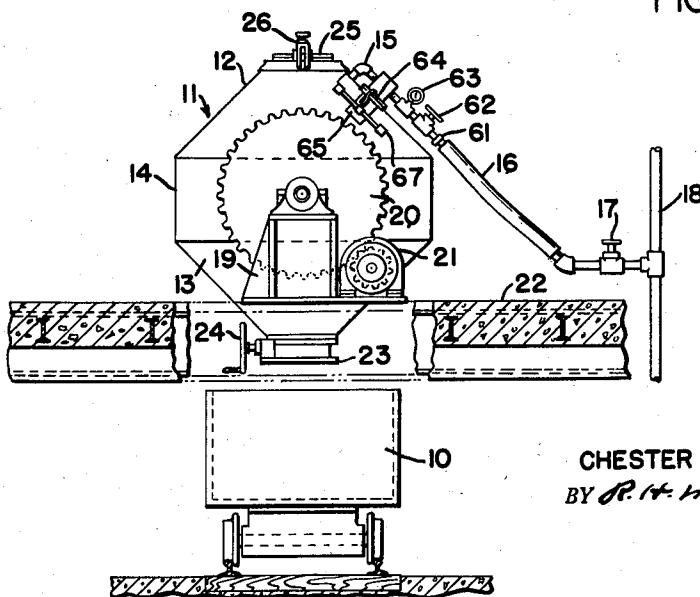


FIG. 1



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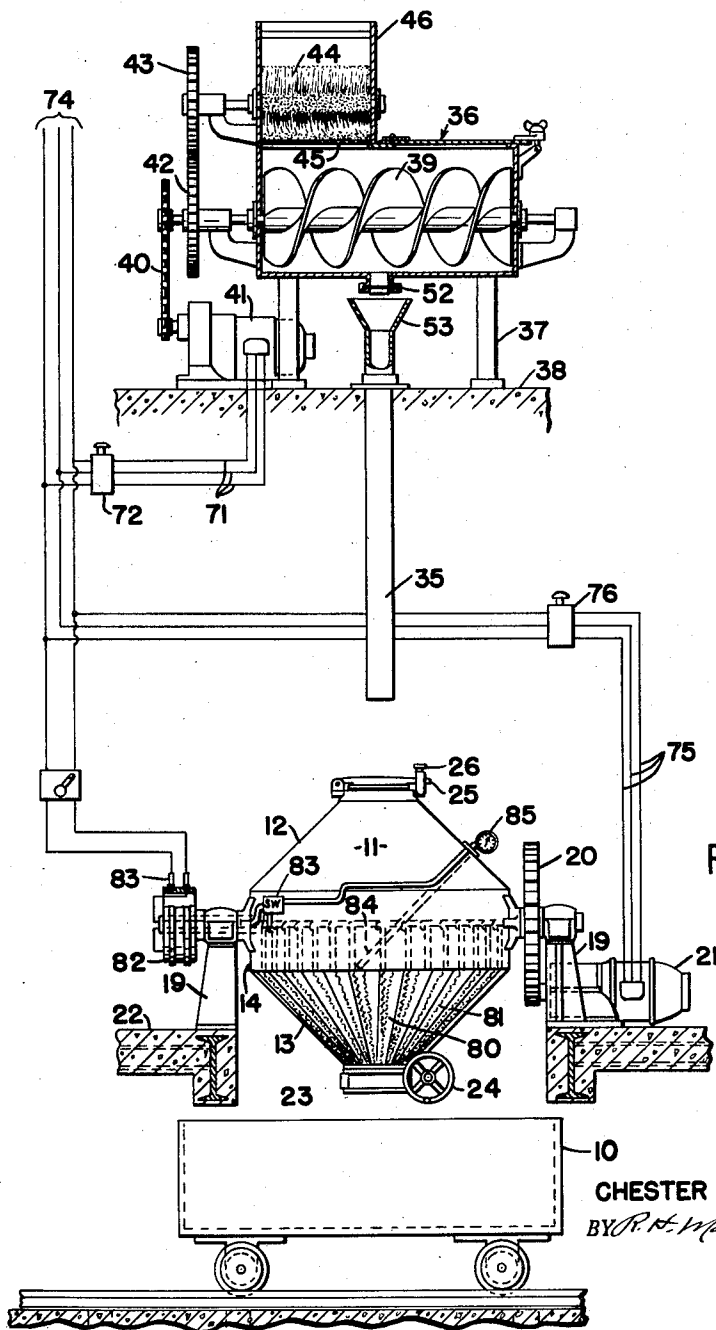
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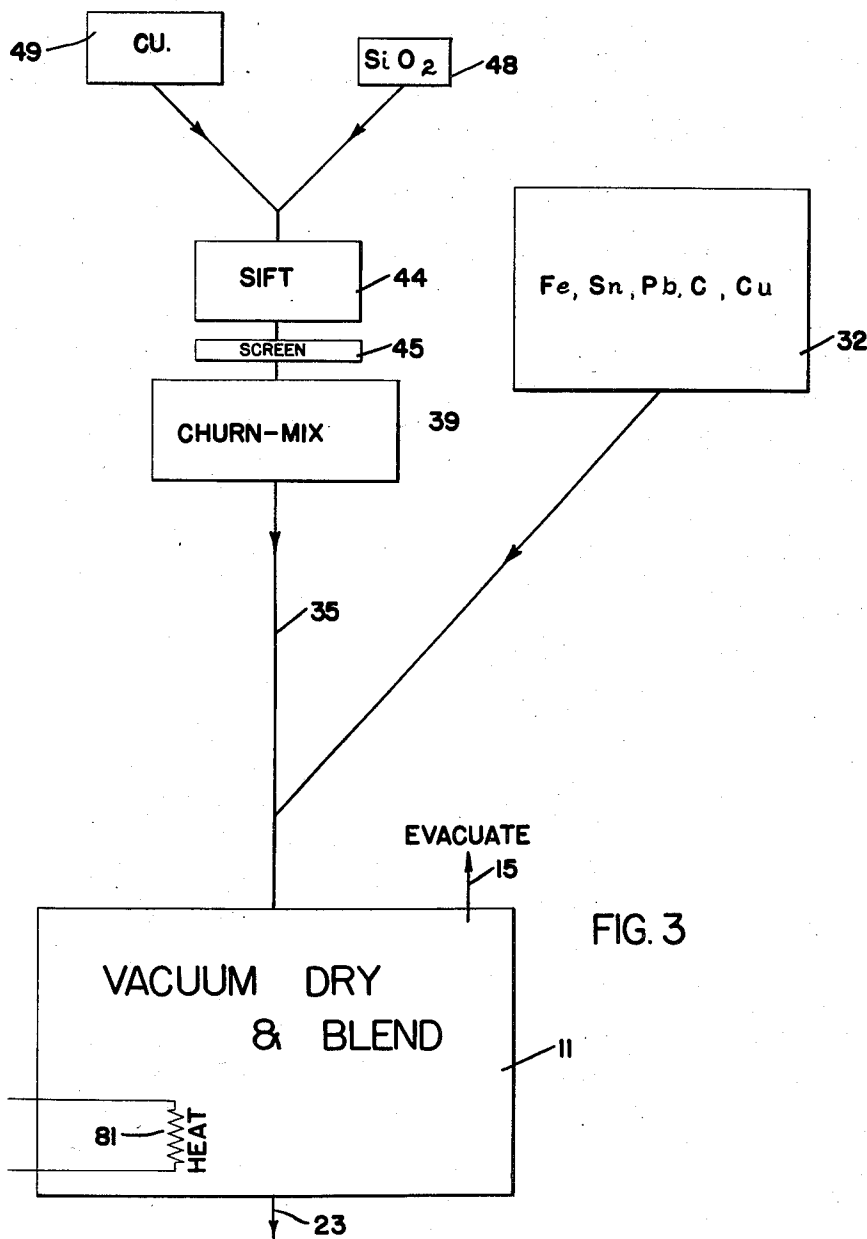


FIG. 3

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METHODS AND APPARATUS FOR TREATING METALLIC AND NON-METALLIC POWDERS

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5 Claims. (Cl. 75—5)

This invention relates to methods and apparatus for powder metallurgy and has particular significance in connection with the preparation and treatment of metallic and non-metallic powders as used, for example, for the ultimate manufacture of compressed and sintered friction products composed predominantly of comminuted metallic elements and a structural backing member, and useful as friction surfaces in clutches, brakes, and the like.

Friction articles such as are above referred to, and which are made by pressing and sintering mixtures of metallic and non-metallic powders usually against a copper plated metallic backing member, have numerous advantages over asbestos and other non-metallic materials in that the sintered articles are less susceptible to changes in temperature and atmospheric conditions, are less affected by extraneous oil, grease, and foreign matter, and show less wear with the same use. Because the sintered material is rather fragile, it is conventional to use a backing member or carrying plate of steel with the combined metallic and non-metallic mixture compressed and heated to affect sintering and simultaneous bonding to the carrier plate. U. S. Patent 2,178,527—Wellman and Reissue Patent 22,282—Swartz disclose examples of such sintered and bonded products.

In the preparation and treatment of such mixtures of metallic and non-metallic powders, drying of the powder becomes necessary. For one thing, compacts of the powdered material must be handled "green," that is before sintering in the "as molded" state, and it is found that reducing the moisture content of mixed powders increases the "green strength" of the molded powders and diminishes their breakage. Apparently because water is incompressible, its presence prevents proper compacting of the comminuted metallic or comminuted metallic and non-metallic materials. Also, it is necessary that certain powders have very low moisture content to prevent "balling" during mixing (as that would prevent procurement of a homogeneous mixture), to retard the oxidation of the powder mix during handling and storage, and to permit flow of the blended powder mix into the mold cavity. Furthermore, reducing the moisture content of the mixed powders avoids bonding troubles. As far as bonding is concerned, the above mentioned Wellman patent discloses a method depending upon treatment of the backing member to obtain chemically clean surfaces and then depending upon a controlled atmosphere, for example of "city" gas, nitrogen or the like, to assure a perfect bond between the compacted metallic and non-metallic materials and the surface of the backing member, but it has been found that these steps are not always practical or economical. The Swartz reissue patent discloses copper plating of cleaned surfaces of the steel carrier plate prior to bonding to protect the cleaned surfaces, and prevent formation of ferrous oxides and subsequent contamination of the bond, but I have found that during periods of relative humidity in excess of 40% even copper plating does not entirely cure the difficulty occasioned by the powders picking up moisture which leads

2

to a poor bond between the compacted powdered material and the plated steel backing and even to oxidation of the powdered materials themselves, moisture, in the presence of air, being a catalyst which promotes the oxidation of copper and other materials. Although the friction facing ultimately desired may be composed of any suitable metallic or combined metallic and non-metallic mixture having the requisite strength and frictional properties for the particular application involved, it has been found that a mixture with a high copper and some silica content, as given below, produces a desirable compound suitable for clutch or brake facings.

	Percent by weight
Copper	68.1
Tin	5.4
Lead	8.7
Iron	7.4
Graphite	6.0
Silica	4.4

Not only do most powders of the above materials if wet tend to "ball" but finely divided silica powder, whether wet or dry, tends to form into balls thereby preventing a thorough and uniform dispersion of one of the friction producing elements throughout the mix. During the numerous experiments that were conducted in an effort to discover a remedy for this situation, it was found that without some mechanical means to disperse or cause the silica powder to become adhered to some other ingredient or ingredients, the length of blending time required to produce a homogeneous mixture was abnormally long entailing consequent large operational expense in order to break up silica balls by attrition and cause the silica to be thoroughly dispersed throughout the mixture. That is, while progressive increases in blending time did tend to break up silica balls into smaller pellets or agglomerate sizes and eventually, by attrition, cause the disintegration of the agglomerate and promote uniform dispersion of the silica throughout the blended mixture, this was a process entailing such a great number of hours as to be quite disadvantageous from an economic standpoint.

It is an object of the present invention to provide simple and inexpensive means for overcoming the above mentioned difficulties.

Another object of the invention is to provide a method for treating metallic and non-metallic powders to assure that they will be dry and that they will not ball up due to the presence of non-metallic materials which act as agglomerates.

Another object is to provide an improved method of treating and combining metallic and non-metallic particles useful for the production of friction articles.

Another object is to provide apparatus for producing a homogeneous and dry mixture of various metallic and non-metallic powders, especially where powders of silica as well as of other materials are employed.

A further object of the invention is to provide means for producing a homogeneous mixture of metallic and non-metallic powders with a saving of time as contrasted with means heretofore known.

Other objects and advantages will become apparent and the invention will be better understood from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a front elevation showing apparatus constructed in accordance with the invention and found useful in performing the method of the invention;

Fig. 2 is a side elevational view of the principal apparatus shown in Fig. 1; and

Fig. 3 is a schematic representation of apparatus and steps of the invention.

As illustrative of all phases of the improved method and apparatus of the invention, reference is first made to Fig. 1. A receptacle in the form of a car 10 is adapted to receive a charge of finely mixed materials from a cone blender indicated generally at 11. This blender is of more or less conventional type having double cones 12 and 13 separated by an intermediate cylindrical portion 14 but, as is not so conventional, it is supplied with vacuum producing means including pipe connections 15 and a pipe coupling half adapted to be secured to a vacuum hose 16 when the cone blender is not in motion. The connecting vacuum hose 16 is in turn connected through a valve 17 to a "plant" vacuum line 18. The cone blender is provided with a pair of stub shafts each mounted in a bearing pedestal 19 (of which only one is shown in Fig. 1) and is also provided with a driving ring gear 20 arranged to be driven as by an electrical motor 21. The pedestals are supported as by a floor 22 and in operation the blender tumbles any material therein over and over with the material constantly falling into areas of decreasing diameter to thoroughly mix the materials in a manner too well known to require further description. The blender is provided with a bottom closure which may comprise a butterfly valve 23 operated as by a hand-wheel 24 and is provided with a top closure 25 which may be sealed by a hand clamp 26. The vacuum connections being provided for a purpose as hereinafter to be explained, it is of course desirable that the entire unit be capable of being hermetically sealed as by providing gaskets for the bottom valve and for the top cover 25 and making the entire blender gas tight as by means of a solidly welded construction.

When the top cover 25 is open, and the cone blender is in a stationary position with the axis of its cones substantially vertical as shown in the drawings, the blender is adapted to be fed from a hopper comprising a bifurcated structure having one arm 31 adapted to be fed as from a barrel 32 having a funnel like lid 32a and positioned on a stationary barrel dumper frame 33 located on a frame platform 34. The other arm 35 of the hopper feeding the blender is adapted to be fed from a churn or flour type rotary blade mixer 36.

I use such a bifurcated conveying means because I have found that it is uneconomic to churn everything which makes up the final mix when only two of the ingredients need be carefully mixed together in order to prevent balling due to the presence of an agglomerate material such as silica.

Churn mixer 36 comprises a frame having legs 37 resting on a floor 38, and, as is more or less conventional for such type mixers, it has a helical screw 39 (see Fig. 2) adapted to be driven through a chain 40 by a motor 41 which may be of the gear drive type. Motor 41 is also, through gears 42 and 43, adapted to drive a brush 44 which cooperates with a screen 45 (e. g., of eighty mesh) for brush screening material introduced through the churn mixer entry hopper at 46. Of course below the screen 45 the materials discharge into the screw 39 where they are churned and thoroughly mixed together after first having been screened to reduce the size of the particles.

In accordance with the present invention the combined power driven brush screener and churn mixer is provided as a mechanical means to cause powder containing silica to become dispersed throughout and adhered to some other ingredient of the mix prior to the addition of all the powders within the cone blender in order that the length of blending time required to produce a homogeneous mixture of the total batch will not need to be so abnormally long as the many hours required in order to break up silica balls which would otherwise exist, and whereby unduly prolonged mixing would tend to cause work-hardening or too fine a particle size through attrition of the metallic particles. I have found that it is only necessary to pre-screen and mix silica and copper together and that, for a mix of the type of the example described,

the iron, the tin, the lead and the graphite as well as a large proportion of the total copper can all be added separately without screen sifting and without churning and still silica balls will not form. In Fig. 1, I have shown a human operator 47 holding a bag of silica 48 and emptying the same into the sifter entry hopper 46 while simultaneously a crane hoisted barrel 49 is discharging a quantity of dry copper powder 50 into the same entry hopper. In practicing the present invention the copper powder need not be absolutely dry but is preferably so and it may readily be obtained in this condition either by purchase and proper storage or by proper treatment in the plant, for example as described and claimed in U. S. Patent 2,489,116—Young, relating to a method of treating moisture containing copper powders with sulphuric acid, washing with water, subjecting to passage of superheated steam while excluding air from contact with the powder, and replacing the steam with an atmosphere that is non-oxidizing while cooling the powder.

The bottom of the churn mixer is provided with a lever operated paddle valve 52, and when this valve is operated to its open position the contents of the churn mixer will discharge into a funnel 53 communicating with the bifurcated arm 35.

As will be seen from Figs. 1 and 2, the cone blender is provided with apparatus additional to that already described and for purposes which will hereafter become apparent. These may include, as seen in Fig. 1, a male-female disconnect coupling 61 for disconnecting the vacuum hose 16 when the blender is desired to be rotated, a manually operated shut-off valve 62 for preserving the vacuum within the blender when hose 16 is to be disconnected, a vacuum gauge 63 for indicating the amount of vacuum at any particular time; a vacuum line filter comprising a top portion 64 and a removable bottom portion 65, both inserted in series with the connections 15 from the blender, so that said connections will contain a filtering medium, and in series with the gauge 63, the valve 62, the coupling 61 and the hose 16. The bottom portion 65 is arranged to be removable so as to replace a dessicant therein, and is clamped by a plurality of clamps 66 to the top portion 64 and held against the blender frame as by a buckle strap 67 having metallic ends 68 welded to the outside of top cone 12.

Other additional apparatus more or less essential to the method of the invention is shown in Fig. 2 where the churn motor 41 is shown supplied with current through wires 71 fed from a control means 72 which in turn is connected to a source of power diagrammatically represented by the three phase lines 74. Similarly, the motor 21 is fed by a plurality of wires 75 connected through a control means 76 to the three-phase wires 74.

It is necessary that all of the materials have a low moisture content as has already been explained. But it is only necessary that the silica and the copper powder be provided dry in order to prevent balling. It is not always economically feasible to insure that each of the other added materials, such as the iron, tin (or zinc), lead, graphite and additional copper assumed supplied by container 32 (Fig. 1), will be initially dry at the time they are supplied through hopper 31 to cone blender 11, but dryness of these materials is not absolutely necessary because the screening and churning with the copper powder has already prevented balling of the agglomerate or aglutinant (silica in the case assumed) and further processing in the cone blender under vacuum and heat, as hereinafter described, desiccates all of the materials in the cone blender to remove the moisture and prevent oxidation of any of the materials.

I have found that depending upon vacuum alone is insufficient to dry the materials in the cone blender because the reduced evaporation or boiling point caused by the vacuum is not sufficient to dry them particularly since, as is well known, the presence of the vacuum

causes evaporative cooling which takes the temperature of the materials down well below room temperature. Therefore I prefer to use heating means such as strip heaters which may be conveniently powered by electricity and are preferably provided in at least one of the cones. As shown in Fig. 2, the one cone 13 comprises a plurality of wedge-shaped pieces 80, which may be of marinite or other insulating material just so the pieces or assemblies which contain them are capable of being joined edge to edge so as to provide a hermetic seal. These wedge-shaped pieces 80 each contain on their inner face a strip heater 81. The heaters are powered by any suitable means and while a disconnecting plug might be used to provide power to the heaters, but only when the cone blender is stationary, I have found that such an arrangement is not entirely satisfactory because too little of the powdered material is adjacent the heaters when the blender is stationary and thorough heating is not achieved by this expedient. Therefore, I prefer to power the heaters through rotating contact means such as that shown by slip rings 82 and brushes 83 connected to two of the lines 74 so that heating may be achieved at the same time that the material is tumbled by rotation of the cone blender to provide through heating of the contents of the latter. The heaters may be of any number and rating suitable to the particular size of the cone blender and I have found it desirable to use from eighteen to sixty pieces of marinite in the one cone each gored to receive and holding one strip heater, e. g., of Chromalox and having a rating in the neighborhood of from 500 to 1000 watts (each) and connected through a thermostatically operated control switch (indicated diagrammatically at 83) to the slip rings 82. Switch 83 is preferably of the relay type and arranged to operate responsive to temperature as of a thermocouple element 84 arranged in or near the center of the mass of powders and which may also actuate a temperature gauge 85.

In accordance with one aspect of the methods of the invention, and as may be most clear from reference to Fig. 3 in which like numbers refer to parts as in the other figures, containers 49, 48, of dry copper powder and of silica, respectively, are first brought up and emptied together into sifting-screening means (44-45) to effect brush screening and then these materials are subjected to churning means (39) and then discharged through conveying means (35) into a blending means, while at the same time a mixture of iron, tin, lead, carbon and copper (or other) powders is emptied through a conveying means (31) into the same blending means. In the blender, and because of the combination of slip rings and brushes shown in Fig. 2, the materials may first be tumbled and subjected to heat, or if desired they may be subjected to vacuum and simultaneously to heat, but at any event after they are first subjected to vacuum and heat, the cone blender is subsequently rotated to thoroughly blend the materials together with, of course, the vacuum hose 16 removed and the vacuum shut-off valve 62 on the cone blender closed to preserve the vacuum. I have found that the prior cone blending time of many hours, when some of the materials including the silica were not first mixed for a short time in a churn in which they are also brushed screened, can be reduced, by first so pre-sifting and churning silica and copper or other predominant component of the mix even for only a short period such as ten minutes, to a total cone blender rotation time of not more than ten or twenty minutes after which the materials are completely mixed and dried and (when cooled) ready to be removed. Still it is essential that at this point care be taken that there is not a sudden inrush of atmospheric, and usually moisture bearing, air into the cone blender to replace the vacuum. To take care of this problem I prefer to leave the blender under vacuum until it is cooled or at least until the blender outer shell is cooled to within 10 degrees F. of room temperature. Alternatively, determination of the proper degree

of cooling may be based on indication of gauge 85 operating responsive to temperature of the mix. If, at this time of cooling, there appears to be any leakage into the cone blender, as will be indicated by a change of reading on vacuum gauge 63 associated with the blender, it will be desirable to reconnect the vacuum line and start complete evacuation again and possibly continue it throughout the entire cooling cycle. When the blender and its contents are ultimately cooled the desired amount, the vacuum valve 62 may be closed, hose 16 removed and an inert gas, such as city gas or even air that has first been compressed and then cooled to remove its moisture, may be allowed to slowly pass into the double cone blender until the pressure in the blender is the same as that of surrounding atmospheric pressure. Then the bottom valve 23 is opened and the contents of the blender discharged into car or other container 10 in which it is rapidly transported to another part of the factory where it is further processed as soon as possible as by being pressed into compacts and sintered.

Instead of using an inert gas or pre-dried air, alternatively when breaking the vacuum and in order to prevent a rewetting of the dried material, reliance may be had upon the restricted passage of surrounding atmospheric air through a solid dessicant contained as in the filter container 65 prior to entrance of this atmosphere into the blender. Solid dessicants are well known and need not be described and it will be quite obvious to those skilled in the art that they can be regenerated or discarded and replaced in order to provide continued effective drying of atmospheric air thus introduced into the blender at the time that the vacuum is broken after cooling.

The pieces of apparatus shown in the various figures of the drawings need not be considered as exactly to scale and it will usually be desirable to have the cone blender of a size much larger than the comparative size of the brush screener and churn which processes only a fraction of the total material. This is particularly so since the churn may be completely filled and still be operative whereas the cone blender should, I have found, not be filled beyond the height of its circular or cylindrical portion 14 or 60% of its total volume. Insofar as rotational speeds are concerned, I have found that 60 R. P. M. is a desirable speed for operation of the screw 39 of the churn whereas 22 R. P. M. is a desirable speed for the cone blender. Roughly, this means that the cone blender may be twice as big as the churn and still require only the same horsepower motor to drive it.

Very little has thus far been said about the actual quantities of materials used. Of course such quantities will depend upon the ultimate mix desired, but for a mix as given by the example above, I have found it desirable to pre-sift and churn all of the silica with about three times as much by weight of copper. This will be much less than the total amount of copper in the mix, the remainder of which is included with the iron, tin, lead and carbon, as indicated by the symbols in the rectangle 32 of Fig. 3.

Usually the materials are measured to provide a final batch, i. e. as discharged from the blender, of a predetermined size. If it be assumed that the batch is to be about 3600 pounds, then the silica powder will account for about 150 pounds of the total and the copper powder to be mixed with the silica will amount to about 450 pounds. In order that an operator may readily handle the weights involved, this may mean that he uses three fifty pounds bags (48) of silica, mixing all of this with 450 pounds of copper powder supplied by the container 49. For the case assumed there will, after pre-sifting, churning of this mix of silica and copper, he added about 260 pounds of iron, 305 pounds of lead, 190 pounds of tin, 210 pounds of graphite and 1940 pounds of additional copper. Thus all of the material supplied from container 32 amounts to about 2905 pounds, so that it may be necessary to bring up five or six drums 32 if, for example,

the individual drums have a capacity of only five or six hundred pounds.

With the arrangements of the invention there is very little final moisture for the silica or copper or other materials to pick up, and very little tendency for the silica, or any other agglomerate material used in its place, to ball up whether wet or dry. This, I have found, very substantially reduces the processing time of powdered materials of the type described, resulting in great economies over prior art arrangements, as well as resulting in a superior product which will, when such powders are to be used to provide friction articles bonded to metallic plates, reduce bond trouble, and reduce "green" strength breakage. While the normal permissible water content of such powders may go as high as 30 hundredths of a percent, using the arrangements of the invention reduces the water content to less than .01 percent. Without the use of the mechanical means to disperse and cause the silica powder to become adhered to some other ingredient of the mix, such as the copper used, prior to addition of all the powders into apparatus such as the double cone blender, the length of blending time required to produce a homogeneous mixture was found to be ten to fifty times as great as that required according to the invention.

There is thus provided apparatus and methods of the character described capable of meeting the objects above set forth.

While particular embodiments of the invention have been illustrated and described, various modifications may obviously be made without departing from the true spirit and scope of the invention which is intended to be defined in the appended claims.

I claim:

1. The method of preparing powders for making friction bodies of sintered powdered metallic and non-metallic materials comprising a predominant component and an agglomerate in minor quantity, the said method comprising the steps of screening and pre-mixing a fraction of the predominant component with all of the agglomerate, adding the remainder of the materials, subjecting all of the materials to a vacuum and to heat, blending the materials together while maintaining said vacuum, and replacing said vacuum with a non-oxidizing atmosphere while allowing said materials to cool.

2. The method of claim 1 further characterized by the agglomerate being principally silica.

3. A method of preparing powders useful for the ultimate manufacture of compressed and sintered friction facings bonded to a metallic backing plate and where the powders comprise by weight more than 50% copper, less than 5% silica, and the remainder metallic and non-metallic elements comprising lead, iron and carbon, which method comprises the steps of screening the silica and a portion of the copper representing by weight substantially three to one of copper with respect to silica, churn mixing the same together, providing a rotatable blending

means adapted to be hermetically sealed, providing means for conveying the screened and churned mixture of copper and silica powders together with the remainder of the ultimate mix into said blending means, applying a vacuum and heat to the mixture within said blender, rotating said blender to thoroughly mix and blend the materials therein, and replacing said vacuum with a non-oxidizing atmosphere.

4. The method of reducing blending and drying time for a mixture of powders of copper, tin, lead, iron and a powdered silica of approximately one tenth the weight of the copper powder, which method comprises the steps of providing mechanical means to cause the silica to become dispersed in a portion of the copper powder, subsequently introducing all of the materials into a blender, subjecting said materials to heat and vacuum while within said blender, and rotating said blender.

5. Blender apparatus comprising double end cones and an intermediate cylindrical portion having its respective ends hermetically sealed to the open ends of the respective cones, stub shafts extending from opposite sides of the cylindrical portion for making the structure rotatable about an axis intermediate the cones, pedestal bearing means for said shafts, means for rotating the blender, removable closures at the apex ends of the cones and establishing for one position of the blender a top entry cover and a bottom discharge valve means, pipe connections leading from the interior of the blender for establishing a vacuum therein, a disconnect coupling for removably connecting a vacuum line to said connections, valve means associated with said connections for maintaining said vacuum when said vacuum line is disconnected for rotation of the blender, a removable filter associated with said connections and for filtering atmosphere introduced into the blender when the vacuum is broken, strip heaters of electrical resistance material located adjacent the inner side of the cones, and means including electrical connections and a thermostatic relay switch for energizing said strip heaters.

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