Dec. 17, 1957 J. B. BRENNAN 2,816,826

APPARATUS FOR AND METHOD OF PRODUCING METAL POWDERS AND METAL STRIPS

Filed Nov. 4, 1952 2 Sheets-Sheet 1

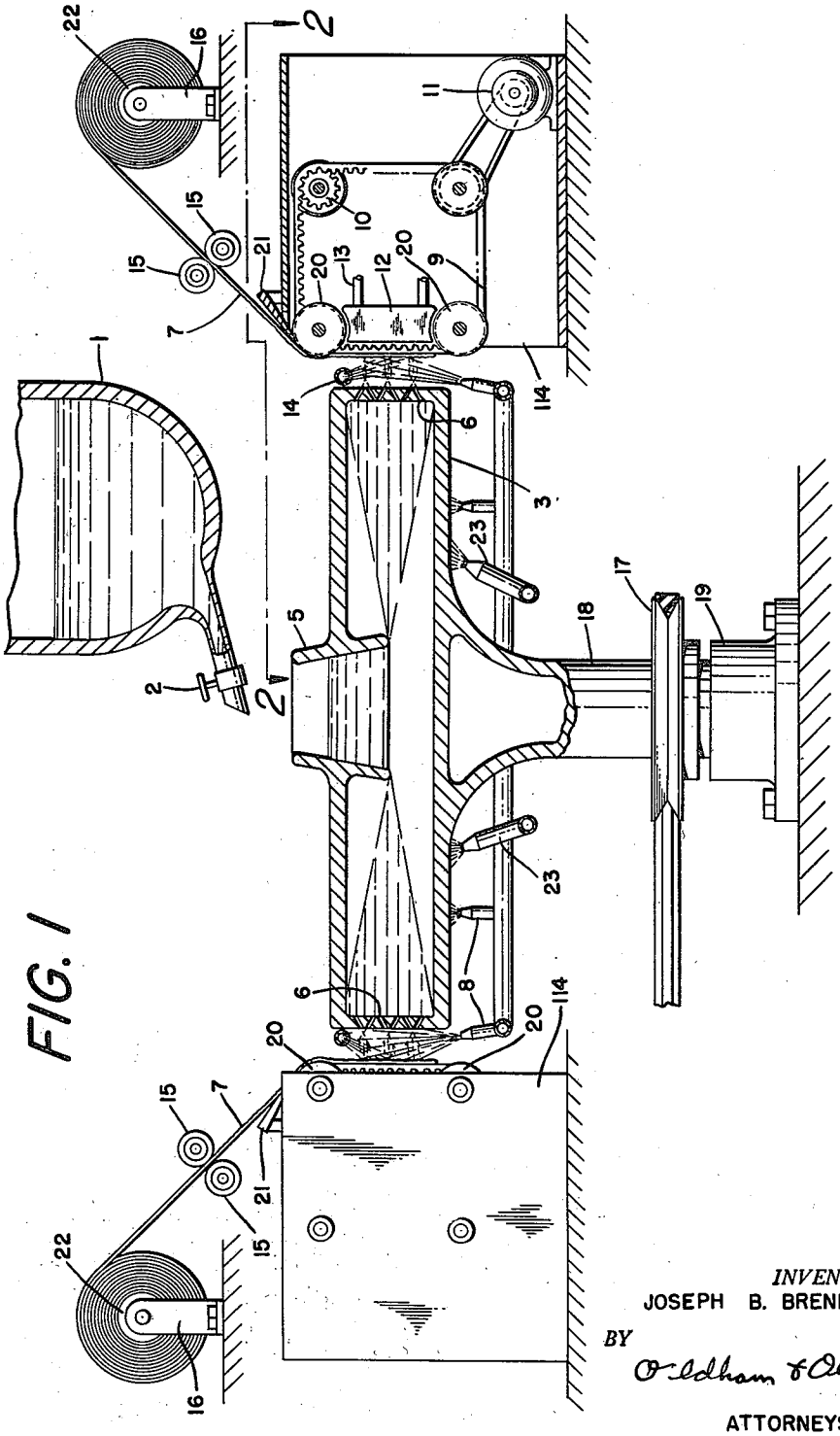


FIG. 1

INVENTOR.
JOSEPH B. BRENNAN

BY
Oldham & Oldham

ATTORNEYS

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FIG. 2

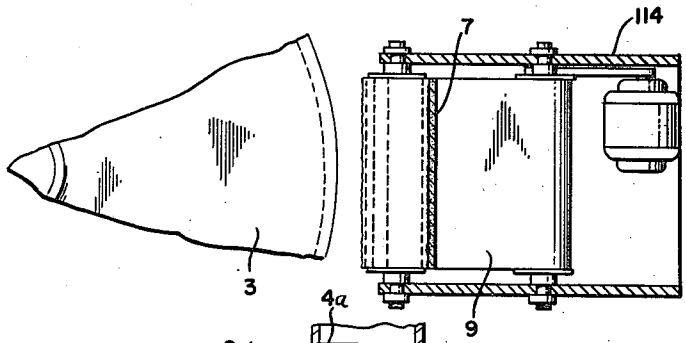


FIG. 4

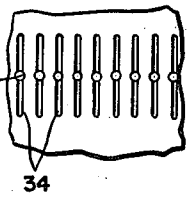
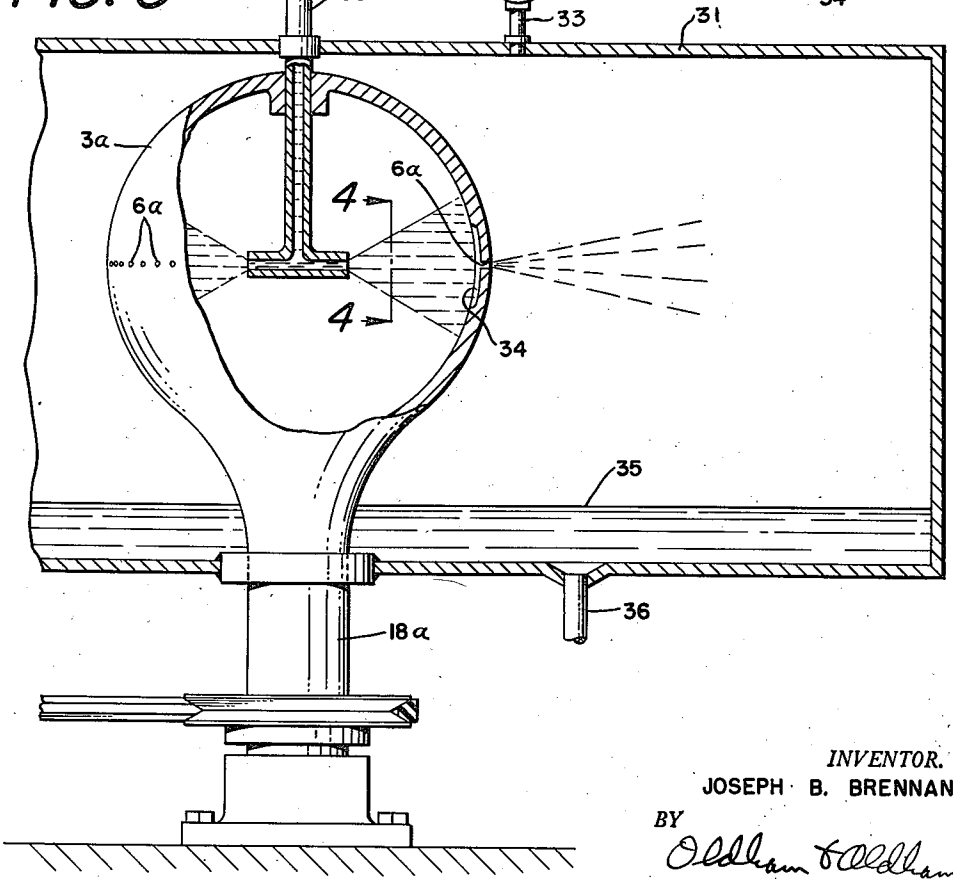


FIG. 3



INVENTOR.
JOSEPH B. BRENNAN
BY
Oldham & Oldham
ATTORNEYS

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2,816,826

APPARATUS FOR AND METHOD OF PRODUCING METAL POWDERS AND METAL STRIPS

Joseph B. Brennan, Cleveland, Ohio

Application November 4, 1952, Serial No. 318,616

13 Claims. (Cl. 75—0.5)

This invention relates to the production of metal powders and metal strips, especially to apparatus for and methods of production of iron and nickel powders and strips from their metal carbonyls, and to a process of precisely atomizing metallic substances and accurately, directionally projecting them by a centrifuge action.

This application is a continuation-in-part of my copending application Serial No. 722,829, now Patent No. 2,616,165, wherein I disclose that metal can be deposited on temperature controlled filaments when such filaments are exposed to vapors of metal carbonyls. The metal carbonyls decompose at relatively low temperatures and this facilitates obtaining metal deposits without the use of high temperatures as are required to produce metal deposits from molten metal.

This application is also a continuation-in-part of my earlier application Serial No. 43,881 filed August 12, 1948, now Patent No. 2,639,490 granted May 26, 1953.

Heretofore, efforts have been made to make use of metal carbonyls as sources for metal powders but the reaction apparatus has been clogged very rapidly by the metal particles produced, or the reaction has been a batch type of operation, or it has been objectionable for other reasons.

The present invention has as its general object the production of metal powders or metal strips from metals and metal carbonyls by a continuous, easily practiced method.

Another object of the invention is to avoid clogging of the apparatus when decomposing metal carbonyls to secure metal therefrom.

Another object of the invention is to obtain metal deposits in desired form at relatively low production temperatures and pressures.

Another of the objects of the invention is to provide novel apparatus by which metals, such as iron and nickel, can be atomized by the use of centrifuge means alone or in combination with gas blast means.

Another object of the invention is to provide centrifuge apparatus that can be used for continuously producing metal particles or which can be used to produce coherent particulate metal strips, which strips are of uniform size and gauge and exposed area.

Another object of the invention is to provide a method of continuously producing a metal strip from a metal carbonyl by an efficient, low cost, easily controlled method.

Yet another object of the invention is to obtain powdered metal from compounds or molten bodies thereof, while another object is to provide a new method of making metal carbonyls.

The foregoing and other objects and advantages of the invention will be made apparent as the specification proceeds.

For a better understanding of the invention, reference should be had to the accompanying drawings, wherein:

Fig. 1 is an elevation, partly shown in section, of apparatus for practicing the principles of the invention;

Fig. 2 is a fragmentary plan, partly shown in section, of the apparatus of Fig. 1;

Fig. 3 is an elevation, partly shown in section, of modified apparatus for use in performing the invention; and

Fig. 4 is an elevation on line 4—4 of Fig. 3.

The apparatus of the invention is particularly useful in the atomization of metallic materials for the production of powdered metal and the like when the particles are deposited on a temperature-controlled backing belt. For instance, a novel type of atomization of nickel, for example, or iron, for example, may be achieved by feeding the molten material into and through the centrifuge of the invention and through fine orifices of said centrifuge, and by gas blasting the molten metal particles being ejected from the centrifuge of the invention to break up and further atomize and react the metallic particles. As a further modification of this use of the apparatus, the molten material may be caused to react chemically with the gas used to effect the further atomization of the particles being discharged from the centrifuge. For example, carbon monoxide may be used as the atomization gas and it will chemically react with molten iron or nickel being ejected in particle form from a centrifuge to form the carbonyl of such metal which thereafter will be deposited in a precision manner upon the deposition means provided in the apparatus, or elsewhere, or collected as a powder. The gas blast to which the molten centrifuged particles is subjected not only helps to break up the metal into finer particles, but produces a finer and more uniform porosity in the deposited metal strip than would be attained by ordinary centrifuge action. In atomizing metal where a gas blast or pressure stream is used to assist in the atomization action, only relatively moderate centrifugal speeds are required to keep a constant feed of small molten metal particles passing through the orifices in the centrifuge member at a satisfactory discharge speed.

In practicing the process of the invention for the production of metal strips, it is necessary that a constant rate of atomization and deposit be achieved, so that a constant thickness of metal strip, as well as constant particle size, is produced. Thus, molten metal or other material being processed should be fed into the centrifuge at a uniform rate to maintain a uniform amount of metal therein, and the centrifuge should be operated at a uniform speed, to maintain uniform orifice pressure with a uniform gas blast being provided for processing the material ejected from the centrifuge. The rate of deposition is controlled both by the speed of movement of the centrifuge and temperatures at which the particles are deposited and also by orifice size and number in the centrifuge and the speed thereof when the inner openings of the orifices are kept covered with processing material. When metal powder is desired, the deposited particles should not contact previously deposited particles when any particles are still molten but if porous strips are to be produced, the newly deposited particles must overlap prior particles when at least the deposited particles are partially molten.

When feeding a liquid metal carbonyl to a centrifuge, the carbonyl is heated in the centrifuge preferably to below its decomposition temperature, and carbonyl particles are thrown from limited discharge orifices provided in the centrifuge, and the particles discharged are usually deposited as a thin layer upon continually presented temperature controlled surfaces that elevate the carbonyl particles to break down temperature so that metal particles, or metal strip is produced from the metal carbonyl.

Suitable apparatus for practicing the invention is shown in Fig. 1 and it includes a crucible or container 1, having

a discharge valve 2 provided in the lower portion thereof for controlled flow of a liquid metal, or metal carbonyl that is stored in the container 1, which may have a top provided therefor, if desired. A rotary type centrifuge 3 is positioned below the container 1 for receipt of liquid material therefrom and a receiving spout or opening 5 is provided in an upper portion of the centrifuge to receive material flowing from the container. The centrifuge 3 is provided with a plurality of small diameter discharge holes or orifices 6 in the periphery thereof so that the streams of particles of the metal and/or metal carbonyl can be discharged from the centrifuge through such discharge holes. Fig. 1 shows that the orifices 6 are inclined from the horizontal axis of the centrifuge 3 and adjacent orifices converge towards each other so that the materials ejected therefrom will collide to aid in breaking up the ejected material into fine particles. These discharge holes 6 may be used for discharge of the liquid carbonyl after it had been heated in the centrifuge to less than its decomposition temperature, so that the carbonyl can readily be decomposed after it has been thrown out of the centrifuge and contacts a receiving belt or strip which is maintained at a definite temperature.

The numeral 7 is used in the drawing for indicating a porous metal strip made from the metal particles continuously being produced by practice of the process of the invention in the embodiment illustrated in the drawings and where metal is deposited as a stream of particles, the individual particles of which contact a base in overlapping relationship to form the metal strip 7. Usually suitable heating means 8 are provided adjacent the discharge portions of the centrifuge 3 to aid in heating the material being discharged completely to its decomposition temperature so that a complete chemical reaction and break up of the carbonyl material is assured. When molten metal is being processed, the heating means 8 may or may not be used as desired, as heating the particles in transit maintains them at the desired degree of fluidity. The heating means 8 connect to a source of supply (not shown) of heating gas in a conventional manner. High frequency electrical energy may be supplied to suitable inductance coils lining the discharge path of the material, if desired for the transit heating.

In order to accumulate and collect the material being continuously discharged from the centrifuge 3, a plurality of relatively narrow, discharge receiving metal bands or tapes 9 may be provided around the periphery of the centrifuge. These bands 9 are positioned by a plurality of suitable rolls 20, and by sprockets 10 which engage positively with the inner portions of the bands 9 to drive and center the bands. These rolls 20 and sprocket 10 are so positioned that the endless bands 9 adjacent the centrifuge move in a direction normal to a plane defined by the centrifuge 3. The bands 9 are each provided with a flight or stretch of any desired length which is longer than the diameter of the spray field of the centrifuge 3, which flights combine to form a substantially continuous member around the centrifuge. The bands 9 may be positioned any desired distance from the centrifuge 3. Gas blast nozzle means 14 may be used to aid in breaking up or disrupting the molten particles in transit and the gas stream preferably is at a angle to the path of the discharged particles to effect a further break-up of the particles while they are in transit and moving across the space between the outer side wall of the centrifuge 3 and the receiving bands 9 and which intervening space can be conveniently referred to as a treating zone. These means connect to a suitable source (not shown) of a compressed gas, such as carbon monoxide when a metal carbonyl is to be produced, or an inert gas such as argon, when metal particles are to be produced.

Fig. 2 of the drawings clearly shows that a plurality of the metal receiving bands 9 are provided at different circumferentially adjacent portions of the centrifuge so that the lateral margins of the bands 9 substantially contact each other to insure that relatively little material discharged from the centrifuge will escape being deposited upon one of the bands 9.

Usually a motor 11 or other drive means is connected to each of the bands 9 by conventional means for driving these bands at desired and controllable constant linear speeds.

The provision of temperature control means for the particles deposited on the bands 9 is provided by use of a heating or cooling shoe 12 positioned behind each of the bands 9 in contact therewith adjacent the centrifuge 3 and suitable heating or cooling fluid is supplied thereto by pipes 13. If molten metal is being processed, the bands 9 are cooled for solidifying the deposited molten metal, but if a metal carbonyl is to be deposited and be decomposed as deposited, then the bands 9 are heated prior to receipt of the liquid particles, but the bands are temperature-controlled in any case. The flights of the bands 9 prior to passage past the centrifuge 3 may have supplemental temperature-control means for the bands 9 and material thereon provided therefor, as desired. Usually all of the positioning means associated with one band 9 are carried by a suitable frame 114. These frames may be of relatively narrow, elongate shape and may be provided with individual integral unitary supports for the different receiving units of the invention.

The deposited metal strip 7 may pass through a pair of rolls 15 prior to being stored on a wind-up roll 22 carried by a bracket 16. Usually the metal strips 7 are separated from the endless bands 9 on which they are deposited by a conventional member, such as knives 21. If metal particles are formed, they may be collected in any conventional manner as they are removed from the belts 9 by the knives 21, or they may be collected as powder, as hereinafter described. It will be appreciated that the relative speed or the movement of the endless bands 9 can be correlated with the rate at which metal particles are provided by metal deposition or by decomposition of the metal carbonyl being processed. Hence, a continuous metal strip can be produced, as is shown, or the metal powder may be collected in particle form, as explained in my co-pending application, Serial No. 40,610, depending upon the speeds of the bands 9 which are in relation to the amount of material being discharged from the centrifuge 3, both of which are constant for a given gauge of strip.

This centrifuge 3 can be rotated by any conventional means and a pulley 17 is shown engaged with a support shaft 18 provided on the centrifuge 3. This pulley 17 engages with suitable driven means (not shown) to rotate the centrifuge at a desired controllable rate. The centrifuge 3 is suitably journaled in a bearing member 19 by the hollow shaft 18, which may be temperature-controlled.

In order to heat the material in the centrifuge 3, suitable heater means, such as burners 23, are provided below the centrifuge and these burners 23, like the burners 8, may burn a suitable combustible gas or fluid therein, or high frequency electric heating coils may be used.

The material received in the centrifuge 3 is supplied to it at a controlled rate and the centrifuge will be partly filled with liquid material at all operating times, as shown in the drawing. Thus, the greater mass of material, and the greater volume of material in the centrifuge, will be positioned near the periphery thereof. Since some metal carbonyls, such as nickel, or iron, are decomposed at, or above, 180° C. into carbon monoxide and metal, the carbon monoxide at atomization passes from the apparatus as a gas which may be exhausted by conventional means, and the apparatus may be operated under a partial vacuum.

Somewhat similar apparatus to that shown in Figs. 1 and 2 is shown in Fig. 3, only in this instance a different shape of centrifuge is used and a container 1a is provided which has a control valve 2a for regulation of rate of

rial used for receiving liquid carbonyl thereon to decompose the carbonyl must be heated to a temperature above 180° C. and metal, glass fiber, or ceramic fiber or quartz or other materials used for receiving the hot liquid are inherently of such physical properties as to avoid injury by being heated to the temperatures required. The heating means used may be of any conventional type including high frequency heating members for use with glass or quartz filaments, for example.

The rolls 15 may be heated to aid in effecting a compression action of the metal strip or metal-coated fibers passed therebetween. High frequency electrical energy may be used to heat the strip and densify same in conjunction with rolls 15.

In some instances, it may be desirable to feed a carrier or atomizing gas into the centrifuges 3 and 3a to be ejected from the orifices in the centrifuges, with the material being processed.

Any foreign matter present in the metal being processed, such as metal oxides, will usually collect inside the center of the centrifuge, as they are lighter than the metals themselves, and such foreign matter can be removed from the centirfuge from time to time, as desired.

The openings 6 in the centrifuges of a size to pass only very fine streams of liquid therethrough, while the turbulence at openings 6a permits only particles of liquid to discharge therefrom.

When covering a plurality of filaments with a metallic cover, as disclosed in my patent application, Serial No. 722,829, the filaments may be passed, either singly or in groups, bundles, or yarns, through a bath composed of the metal to be coated thereon, the filaments preferably remaining in the bath long enough so that they reach substantially the temperature of the molten metal in the bath. In view of the fineness of the filaments, this requires a very short period of time, and thus the filaments may be moved continuously through the bath at a rapid rate of speed. As the filaments leave the bath, the excess metal is removed, for example, by blowing a blast of non-oxidizing gas over the filaments or by use of an electrostatic field.

Also, the excess metal may be scraped off the filaments or removed by centrifugal force. In any event, the filaments or fibers, when cool, are provided with adherent sheaths or casings which are substantially continuous throughout, are quite smooth and substantially impervious, and, preferably, are of a thickness of about .0001 to .005 inch, the thickness being controllable by varying the temperature of the bath, the length of time that the filaments are immersed therein, and other factors.

The coated filaments are then felted into mats which are preferably compressed to the desired thickness and subjected to heat during the pressing operation, thereby bonding the coated filaments together at their points of intersection. As noted above, the mats may be woven if desired, but this is more expensive than felting.

The mats are then cut to the desired size and shape to provide electrode and terminal assemblies, and may be incorporated in the electrolytic devices in the usual manner. For example, in the production of electrolytic condensers, two such electrode and terminal assemblies may be separated by insulating spacers composed of papers or other suitable material, rolled into cylindrical form and impregnated with a suitable film maintaining electrolyte. Prior to assembly, one or both of the electrodes may be subjected to a conventional electrolytic film-forming operation such as subjecting the mat to electrolysis as an anode in a solution of borax and boric acid until the leakage current is reduced to a desired low value at a voltage above the operating voltage for which the condenser is intended. The completed condenser may be encased in a tube in any conventional manner.

Alternatively, instead of coating the fibers and then felting them, the fibers may be felted together and then subjected to a coating operation, for example, by dipping as described above, or by depositing aluminum or other metallic vapor on the mats in a vacuum, the fibers preferably being heated to assure adherence of the metal sheaths. The coating may also be applied by a high pressure spray of aluminum in a chamber having a non-reactive atmosphere such as described in my application Serial No. 548,023, filed August 4, 1944, now abandoned, the mat preferably being maintained at a temperature at or near the melting point of the metal being deposited, thus insuring good adhesion of the molten metal and the production of substantially continuous sheaths on the filaments. Also, the heat results in the excess coating metal dropping off of the filaments while still in a fluid condition, and thus minimizes the accumulation of coatings of undue thickness and the formation of globules or beads of metal. When the coating is applied to the mats in molten form, the intersections of the filaments are bonded together during the coating operation; when lower temperatures are employed, it is preferable to subject the coated mat to heat and pressure to weld or sinter the intersection as previously described.

The method of depoisting metal on the filaments from metallic vapors may also be applied to filaments before they are made into mats, the vapor being deposited either on single filaments or on groups or bundles of several filaments. The vapor may be produced either by boiling the metal, preferably in a vacuum or by vaporizing the metal electrically in a vacuum, methods of this general type being well known and used in the production of mirrors. Other methods for coating separate filaments, groups or bundles of filaments, or mats composed of woven or felted filaments include coating the filaments with metal powder and subsequently fusing the powder to provide the adherent sheath, spraying the filaments or fibers with aluminum in accordance with the Schoop process and thereafter fusing the sprayed particles preferably by passing the coated filaments through a high frequency field, and drawing the filaments through a die filled with molten metal and removing the excess metal by blowing or by centrifugal force.

Where the metal is deposited in a molten state, it is preferable to heat the filaments substantially to the melting point of the metal to secure good adhesion of the sheath metal; for such methods, therefore, it is desirable to employ filaments composed of material which has a higher melting point than the metal to be coated.

It should be noted that the apparatus of the invention avoids any tendency to clog by the directionalized projection of the molten material released from the structure shown in Fig. 1, plus the fluid pressure exerted on the material in the centrifuge.

If desired, the filling spout 30 of Fig. 3 may be used with the centrifuge 5 to supply molten material continuously thereto by a conduit filled with the fluid being processed.

While several complete embodiments of the invention have been disclosed herein, it will be appreciated that modifications of these particular embodiments of the invention may be resorted to without departing from the scope of the invention as defined by the appended claims.

I claim:

1. That method of producing metal comprising the steps of centrifuging a body of liquid metal carbonyl, discharging liquid carbonyl particles from said body as a spray stream of said particles, and heating the discharged carbonyl particles while in said spray stream by directing a burner blast thereagainst to decompose the particles into metal and gas.

2. That method of producing porous metal strips comprising centrifuging a liquid metal carbonyl and discharging particles of the metal carbonyl as a spray stream of said particles, decomposing the discharged metal carbonyl particles by heating the same with a burner blast while in said stream to produce metal particles, and depositing the metal particles in overlapping relation to produce a porous metal strip.

flow of material 4a from the container. This material passes down through a bore 5a formed in an extension or discharge spout 30 of the container 1a, and extends into a centrifuge 3a on the rotating axis thereof. The discharge spout 30 is stationary and the centrifuge 3a revolves around such discharge spout. This centrifuge 3a has a plurality of small diameter discharge holes or orifices 6a provided in a diametrically disposed planar portion of the centrifuge positioned normal to the axis of rotation of such centrifuge. Any gases formed in the centrifuge 3a may exhaust therefrom through the discharge holes 6a.

As a feature of this type of apparatus, it is adapted to be operated under a vacuum and especially is useful for the recovery of metal powders or particles by ejection of the material being processed from the centrifuge 3a through the orifices 6a provided therein. Thus the centrifuge 3a is shown received in a suitable, relatively large chamber 31 which has a vacuum pump 32 connected thereto by a conduit 33 so that a desired amount of vacuum can be established within the chamber 31. Usually this vacuum would be about 30 inches of mercury.

Fig. 4 of the drawings shows that a plurality of recesses 34 may be provided in the form of channels in the inner surface of the centrifuge 3a and terminate at the orifices 6a. These recesses 34 have molten metal or other liquid being processed therein and flowing therethrough for discharge through the orifices 6a. Feed of such material from a plurality of recesses to one orifice produces a turbulence in the liquid and aids in breaking up the material being ejected from the centrifuge so that small droplets and particles are formed therefrom.

The body or mass of molten metal or other material being fed to the centrifuge normally will have a tapered or conical shape in the centrifuge, as indicated in the drawings, it is thought. Such liquid or molten metal within the centrifuge exerts a back pressure up through the spout 30 to the fluid material received in the container 1a. The back pressure is of such value that the specific pressure of liquid within the container 1a does not vary the deposit action of the centrifuge and constant operating conditions are maintained even though the level of liquid in the container 1a varies appreciably.

Material flows to the centrifuge 3a from the container 1a at substantially the same rate that it is discharged therefrom after uniform operating conditions are established in the apparatus. Usually the centrifuge 3a may be about 6 inches in diameter, for example, and it would be rotated at a speed from about 400 to 1800 R. P. M. for performing the operations of the invention.

Fig. 3 also shows that usually the floor of the chamber 31 has a suitable fluid 35, such as water or other material, thereover to aid in collecting the metal particles accumulating within the chamber 31. If desired, the fluid 35, which is inert to the materials being processed at the temperatures used, may be sprayed upon the inner surfaces of the walls of the chamber 31 to aid in washing material down from the walls to the floor where the material may be suitably collected and removed. The fluid 35 may be withdrawn from the container through a drain 36 and the metal particles may be separated from the fluid at any desired time. Of course, fluid may be continually supplied to the chamber in such instances.

The centrifuge 3a is rotated by conventional drive means positioned externally of the chamber 31 and engaging a support shaft 18a for the centrifuge. The shaft 18a and spout 30 are suitably sealed where they pass through walls of the chamber 31.

It will be realized that the apparatus of the invention as shown in the accompanying drawings may be used for building laminated metal strips, or laminations of metal on fibrous base materials, if the base strips used are made from metal, or fibrous material and are permanently bonded to the material deposited thereon.

In practicing the invention, metals from metal carbonyls can be deposited at relatively low temperatures so that rayon filaments, or cellulose threads, yarns, filaments, or fibers may be used in making the base strips, while other synthetic materials or fibers may likewise be used where the synthetic materials have appropriate chemical and physical properties for this use.

The invention, particularly as disclosed in Figs. 3 and 4, may be used for decomposing titanium iodide (TiI_4) and/or chloride, such as titanium chloride ($TiCl_4$), for obtaining titanium metal, and usually the discharged particles would be heated in transit to decompose the metal halide into metal and halide gas.

As has been indicated herein, the method of the invention is adaptable for use in decomposing any metal carbonyl but it is particularly suitable in decomposing nickel carbonyl ($Ni(CO)_4$) and iron pentacarbonyl ($Fe(CO)_5$).

It has been established that the carbonyls referred to can be decomposed at relatively low temperatures to secure metal therefrom. As in the apparatus shown in Figs. 1 and 2, the apparatus of Fig. 3 can use any desired type of heating means and an auxiliary heating of the material being processed may occur as the material is thrown from the centrifuge 3a in the form of rapidly moving fine particles, for example, by high frequency electric heating coils.

The metallic materials obtained by practice of the invention can be used as the porous strip of metal produced directly by practice of the invention, which porous strips could be used, for example, when made from nickel, as a storage battery electrode. The metal particles may be deposited in sufficiently continuous form to provide coherent but porous metal strips which have many desirable properties for use in condensers, storage batteries, or the like. The metal particles are preferably not over 8 microns in a particle's maximum dimension. Of course, where spaced metal particles are deposited on the base strips, suitable means may be used for recovering such metallic particles when separated from the endless bands on which they are deposited. The particles may be deposited in a temperature-controlled atmosphere or in a fluid chamber, as described in my application, Serial No. 722,829 and its predecessor, application Serial No. 548,023, filed August 4, 1944.

Other base strips or cords or filaments may be used, such as quartz fibers, cotton, woven or matted textile or glass or ceramic fibers, paper, or other similar materials, for the bands 9 and the deposited material will be retained thereon. The bands then usually would pass from a storage reel, past the centrifuge, and to the windup reel.

The apparatus may also be used to coat metal strips with deposited metal particles bonded thereto as a composite strip material.

Cooling means are used for the deposit belt of Fig. 1 when metal powder is to be deposited thereon, to aid in rapidly solidifying the metal on deposit.

The various deposition means disclosed for collecting material being ejected from the centrifuges, it will be seen, are suitably temperature-controlled.

When the apparatus of the invention is used to produce metal carbonyls, the apparatus generally would be enclosed so that a carbon monoxide blast gas used may be collected and be recirculated and the apparatus may be operated in a partial vacuum.

In feeding fluid materials from the crucible or storage containers used for retaining the liquids prior to passage to the centrifuge, it is necessary that the material be fed to the centrifuge rapidly enough to maintain the orifices in the centrifuge covered with liquid and constant uniform deposition action will be secured as long as such orifices of the centrifuge have complete liquid coverage. The back pressure in the spout 30 insures obtaining a proper rate of flow of material to the centrifuge in Fig. 3.

It will be appreciated that any deposition belt or mate-

3. That method of producing metal powders comprising the steps of centrifuging a body of liquid nickel carbonyl at a temperature and a pressure below its decomposition point, discharging heated carbonyl particles from said body as a spray stream, and breaking down the carbonyl particles into gas and metal particles by further heating such discharged particles with a burner blast while in said spray stream.

4. Apparatus of the class described comprising rotary centrifuge means having a centrifuge chamber for receiving molten metal, said centrifuge means having small openings in the periphery thereof for discharging molten particles of said metal, receiving means located substantially opposite and spaced from the openings in the periphery of said centrifuge means for adherent deposit of said particles thereon, and gas jet producing atomization means located outside of said chamber for causing gas jet contact with molten particles ejected from said centrifuge means, said jet producing means being disposed so as to direct gas jets into the intervening space between said periphery and said receiving means for disrupting impingement against said particles while the latter are traversing said space.

5. Apparatus of the class described comprising centrifuge means for receiving molten metal, said centrifuge means having a plurality of small openings in a portion of the periphery thereof for discharging molten particles of said metal, receiving means located substantially opposite and spaced from the openings in the periphery of said centrifuge means for adherent deposit of said particles thereon and forming a substantially continuous ring around the centrifuge means, means for moving said receiving means substantially parallel to the axis of rotation of said centrifuge means, gas jet means disposed so as to direct gas jets into the intervening space between said periphery and said receiving means for disrupting impingement against said particles while the latter are traversing said space, and means for cooling said receiving means.

6. Apparatus for atomizing metallic substances comprising centrifuge means having small openings in a portion of the periphery thereof defining a plane normal to the axis of rotation of such means, means for rotating said centrifuge means to throw out molten metallic particles from the openings in said centrifuge means, a plurality of deposit strips aggregating an annular group positioned at the periphery of said centrifuge means with deposit receiving strip portions substantially opposite said openings for the adherent deposit of said particles thereon as substantially flat product strips, means for moving said deposit strips substantially parallel to the rotational axis of said centrifuge means past the openings in said centrifuge means, and cooling means located substantially opposite the periphery of said centrifuge means and in cooling relation to said strip portions on the side of the latter remote from said openings.

7. In apparatus of the character described, a rotatable hollow centrifuge body having axially spaced wall portions and a peripheral wall portion connecting said spaced wall portions and defining therewith a concave internal annular pocket adapted to be supplied with fluid material, means for rotating said body, said peripheral wall portion having discharge orifice means therein comprising an annular group of small openings communicating with said pocket for discharge of said fluid material in particle form in response to rotation of said body, and fluid material supply means for feeding fluid material to said pocket, said supply means comprising a spout on one of said wall portions and rotatable with said body with the discharge end of said spout extending into said pocket substantially coaxially thereof beyond said one wall portion and substantially to the transverse mid-plane of said annular group of openings.

8. Apparatus as defined in claim 7 in which said orifice means comprises small openings distributed around the perimeter of said body and extending in an outwardly converging relation from said pocket whereby fluid streams being discharged will be broken up by impingement of the streams against each other.

9. Apparatus of the class described comprising rotary centrifuge means having a centrifuge chamber for receiving fluid material, said centrifuge means having small openings in the periphery thereof for discharging fluid particles of said material, different ones of said openings extending in a relatively converging relation outwardly of said centrifuge means whereby fluid material ejected from said converging openings will contact to break up the material into small particles.

10. The method of atomizing metal which comprises, rotating at a substantially constant speed a centrifuge having a chamber therein and orifice means in the peripheral wall of said chamber, supplying molten metal to said chamber at a rate to maintain a substantially constant-pressure annular fluid head of said molten metal therein adjacent said orifice means, ejecting streams of said molten metal from said orifice means, blasting said streams with gas while said streams are in transit in space for breaking the ejected metal into small particles, and collecting said particles by the adherent deposit thereof on a receiving means as a substantially flat metal sheet.

11. The method of atomizing metal which comprises, rotating at a substantially constant speed and in a substantially closed housing a centrifuge having a chamber therein and orifice means in the peripheral wall of said chamber, supplying molten metal to said chamber at a rate to maintain a substantially constant-pressure fluid head of said molten metal therein adjacent said orifice means, ejecting streams of particles of said molten metal from said orifice means, collecting said particles, and maintaining a vacuum condition in said housing.

12. The method of producing porous metal strip which comprises centrifugally discharging liquid metal carbonyl particles into and across a treating zone as a spray stream, decomposing said particles by impinging and heating the same with heated gas directed into said zone and against said particles while the latter are moving across said zone, and depositing said particles in an adherently contacting relation to form a substantially flat porous metal strip.

13. The method of producing porous metal strip which comprises the steps of causing a forced flow of a temperature controlled fluid metallic material through an orifice means for directionally projecting such material in an atomized stream into and across a treating zone, supplying heated gaseous reaction medium to said zone for a controlled heating thereof and for chemical reaction with the particles of said stream while said particles are in transit in said zone, and depositing the metallic product of the reaction to form a substantially flat coherent metallic strip.

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