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PROCESS OF PRODUCING SINTERED METAL SHEETS

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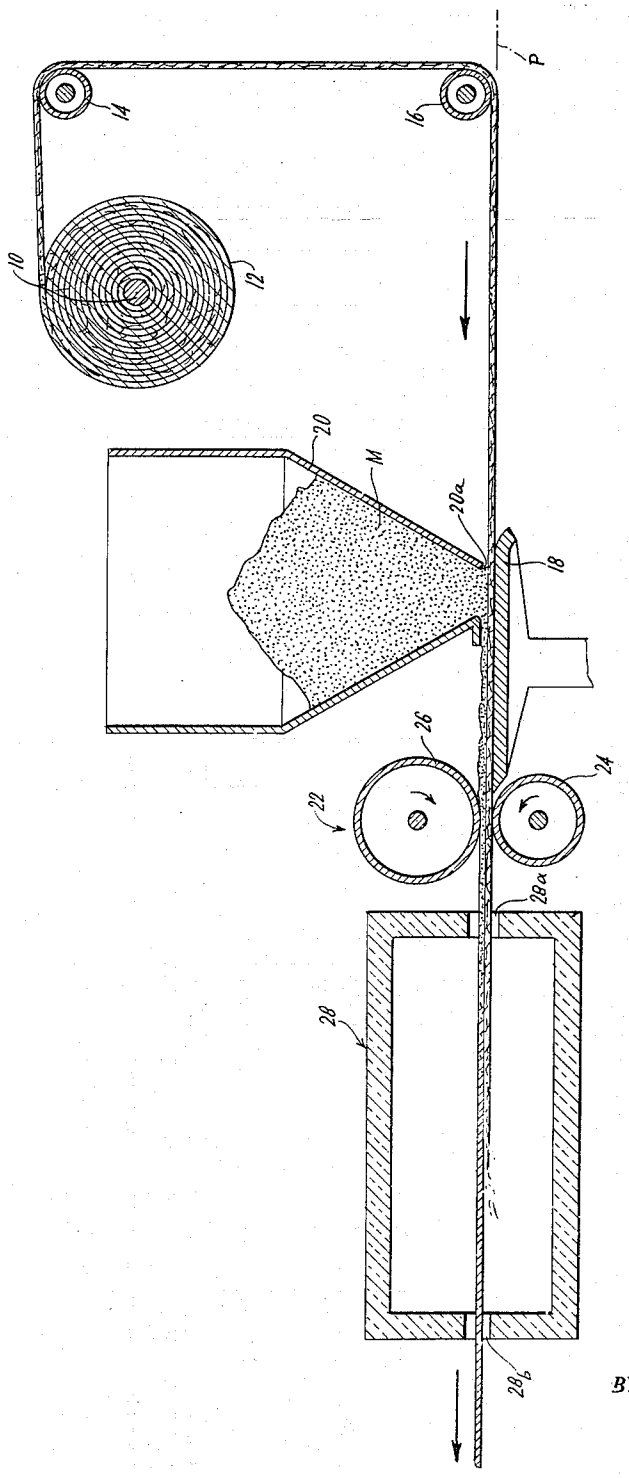

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PROCESS OF PRODUCING SINTERED METAL SHEETS

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The present invention relates to a method of manufacturing powdered metal sheets, and in particular is concerned with a continuous process for the rolling of non-compacted powdered metal into thin sintered sheets.

In the field of powdered metallurgy, it is known to roll metallic powders into a thin sheet or strip by feeding the metallic powder into a rolling mill, either vertically or horizontally. Following rolling, the metallic powder is compacted into a densified sheet or strip having sufficient green strength and rigidity to be self-supporting, which strip may be sintered in an appropriate non-oxidizing atmosphere, such as hydrogen or nitrogen. The compacted and sintered strip may be then further processed in accordance with well understood metallurgical techniques, such as by re-rolling and annealing, to produce metallic sheets of required density and strength.

For rolling mills having a vertical feed, precautions must be taken to achieve proper feed of the metallic powder to the rolling mill. Further such vertical feed requires reorientation of the rolls and mechanism of the conventional horizontally-fed rolling mill and fairly elaborate mechanisms to obtain delivery of powder to the mill for compacting into a green sheet. Still further, subsequent treatment, such as sintering, re-rolling and annealing, usually requires a change of direction of the compacted green sheet, with possible risk of fracture or bending of the green sheet.

Mills which employ horizontal feed or delivery of the powdered material usually incorporate a metal conveyor or metal carrier which extends between the rolls of the mill for introducing the metallic powder to the rolls. It has been found that such conveyor or carrier should be smooth and free from irregularities, and should be sufficiently hard to resist deformation as it passes through one or more pairs of rolls of the mill. A tempered steel has been found to possess the several properties for such carrier or conveyor. When using such tempered steel conveyors, it is frequently necessary to take precautions to avoid adherence of the compacted metal sheet to the conveyor proper. In this connection it is known in the art to employ a revolving brush which continuously cleans the surface of the metal conveyor and dusts the same with graphite or other material appropriate to prevent adherence of the powdered metal to the conveyor.

It is an object of the present invention to provide an improved method of forming sheets by powdered metallurgy techniques which obviates one or more of the aforesaid difficulties. Specifically it is within the contemplation of the present invention to provide an improved process for forming sheets or strips from metallic powders in which the several processing steps occur during feed of the powdered material to the rolls in a substantially horizontal plane. To advantage such horizontal feed of the powdered metal is highly compatible with known equipment for rolling, sintering, re-rolling and annealing of powdered metallic materials.

It is a still further object of the present invention to

provide an improved process for continuously fabricating thin sheets by powdered metallurgy techniques which minimizes the risk of introducing harmful stresses into the sheets during processing. Specifically the possibility of introducing stresses during processing and/or fracture or bending of a partially processed strip is substantially overcome by a process in which the non-compacted metallic mass of powder, the compacted sheet, and the sintered sheet is fed in a substantially continuous and horizontally extending feed path or plane.

In accordance with aspects of the present invention, a thin strip of metal is formed by applying a loose layer of metal powder on a horizontally-extending, heat-destroyable conveyor, carrier or base, feeding the conveyor supporting the loose layer of metal horizontally through a rolling mill to compact the loose layer of metal powder into a green sheet or strip, which is usually of sufficient density to be self-supporting, and thereafter sintering the green sheet or strip. Sintering causes the loose metallic particles to cohere thus making the sheet self-sustaining; at the same time sintering substantially destroys the conveyor which has lost its usefulness and as such is expendable.

Among the materials found suitable for the heat-destroyable or expendable conveyor are organic or cellulosic materials which are gasifiable or burn on being subjected to heat such as is encountered in sintering most metal powders. Paper of a composition leaving a low ash residue has been found suitable in supporting the powder for delivery to the rolling mill; the paper is substantially removed during the heating, and if necessary residues may be removed by directing air upon the under surface of the sintered sheet.

The above brief description, as well as further objects, features and advantages of the present invention will be best understood by reference to the following detailed description of a presently preferred process and illustrative apparatus, when taken in conjunction with the accompanying drawing, wherein:

The single figure is an elevational view, with parts broken away and sectioned for clarity, of illustrative apparatus for continuously processing non-compacted powdered metal into sintered sheets in accordance with the present invention.

Referring now specifically to the drawing, there is shown a supply roller or spindle **10** which carries thereon a conveyor **12** of heat-destroyable, non-metallic material, such as a low ash residue paper. Among the cellulosic materials suitable for the conveyor is a double washed filter paper of the type manufactured by Schleicher and Schull Co., and Whatman Paper Co. The ash remaining in a 7 cm. double washed paper of Schleicher and Schull Co. weighs approximately .000006 gram; the ash residue in a 7 cm. double washed paper of Whatman Paper Co. weighs approximately .00005 gram. Polystyrene films, such as manufactured under the trade marks Lustron and Styron are also suitable heat-destroyable conveyor materials. The conveyor, carrier or base **12**, is trained over idler rollers **14**, **16** and directed horizontally in the direction of the arrows along the feed plane P.

The conveyor **12** passes over a horizontally extending table or support **18** beneath the open mouth **20***a* of a feed hopper or bin **20** containing therein a mass of non-compacted metallic powder, designated generally by the letter M.

Following the support **18** and hopper **20**, is a rolling mill **22** which includes rolls **24**, **26** which cooperate in the feed plane P for compacting the metallic powder on the upper surface or run of the conveyor **12**.

Following the rolling mill **22** is a heat treatment chamber **28** which includes an entry opening **28***a* and an exit opening **28***b*, both disposed in the feed plane P such that

the assembly of the heat-destroyable conveyor **12** and the metallic material thereon may be passed through the chamber **28**.

A latitude of substitution is intended in the illustrative apparatus described aforesaid and many refinements and additions may be incorporated in a commercial installation. For example, a pre-tensioning system may be provided for the heat-destroyable conveyor **12** to assure a uniform feed rate along the feed plane P and relative to the hopper **20**; the feed hopper **20** may be adjustable up and down with respect to the feed plane and/or the size of the exit opening **20***a* adjusted such that varying quantities of material may be deposited on the conveyor **12** in a given time interval; the rollers **24**, **26** may be adjustable toward and away from each other such that the spacing between the rollers may be accurately predetermined for rolling varying thicknesses of sheet material; and the heat treatment chamber or furnace **28** may be divided into various sections and provisions made for heat regulation such that the time and temperature of sintering may be accurately controlled.

In accordance with the present process, the conveyor **12** in its traverse beneath the mouth **20***a* of the hopper **20** receives thereon a uniformly spread, loose and uncompacted layer of metal powder. The layer of powder on the conveyor **12** is then moved through the rolls **24**, **26** of the mill **22** where the non-compacted powder is compressed and emerge as green, compact sheet. This green, compact sheet is self-supporting and adheres to the underlying conveyor **12** and is advanced therewith into the heat treatment chamber **28** for sintering.

Sintering is accomplished in a hydrogen or nitrogen atmosphere; preferably provision is made in the chamber **28** for pre-heating, sintering and cooling of the sintered sheet. The heat in the sintering chamber **28** is usually sufficient to destroy the conveyor **12**; however, if any residues of the conveyor still adhere to the under surface of the sintered sheet, such residues may be readily detached by directing a blast of air against the undersurface of the sintered sheet, either in the cooling zone or externally of the chamber **28**. Following the sintering, which causes the compacted particles to cohere into a continuous sheet, the sintered sheet may be subjected to well-known metallurgical processing, such as re-rolling and annealing, to increase strength and density. Such processing may be repeated in one or more passes depending upon the desired final characteristics of the sheet material.

Illustrative of the many applications to which the present process may be applied is the fabrication of sheets of nickel powder. Using a rolling mill having rolls of 2.75 inch diameter and a 4 inch face and a paper conveyor, nickel powder may be fed onto the conveyor at the open mouth of the hopper **20**. Starting with carbonyl nickel of +100 mesh, a green compacted strip was attained having a thickness of .015 inch. The green, compacted strip was pre-sintered at 1000° C. in a hydrogen atmosphere for a period of approximately 10 minutes and thereafter re-rolled. Without intermediate annealing, the pre-sintered sheet was again sintered in a hydrogen atmosphere and at a temperature of 1000° C. for a period of approximately 90 minutes. The resulting nickel sheet had a density of approximately 3.7 grams per cubic centimeter and a thickness of .0065 inch. When subjected to physical tests, the sheet was found to have good bending ductility.

Among the advantages realized in accordance with the present method is the ability to operate with the mill in the usual upright position and having a horizontal feed. Still further, the formation of the sintered sheet is compatible with subsequent processing by conventional metallurgy techniques. The use of a non-metallic heat-destroyable conveyor carrying the powder to the rolling mill is exceptionally convenient, in that the requisite support is provided without the problems of adherence or alloying of the powdered mass to the conveyor.

Numerous modifications and substitutions in the present process may occur to those skilled in the art, and accordingly the appended claims should be given a latitude of interpretation consistent with the disclosure; at times certain features of the invention will be used without a corresponding use of other features.

What I claim is:

1. In the manufacture of a metallic sheet from metal powder, the steps including uniformly spreading a loose non-compacted layer of metal powder onto a horizontally movable sheet of a material which will be destroyed at temperatures which cause said metal to sinter and having rigidity and strength sufficient to support said non-compacted layer, compacting said layer whereby a composite of said layer and sheet is continuously formed which composite is self-sustaining, horizontally passing said composite through a heat-treatment apparatus to cause said layer to sinter and to burn off said heat-destroyable sheet, and removing any residues of said heat-destroyable sheet from the sintered layer.

2. In the manufacture of a metallic sheet from metal powder, the steps including uniformly spreading a loose non-compacted layer of metal powder onto a horizontally movable sheet of a material which will be destroyed at temperatures which cause said metal to sinter and having rigidity and strength sufficient to support said non-compacted layer, rolling said layer whereby a composite of said layer and sheet is continuously formed which composite is self-sustaining, and horizontally passing said composite through a heat-treatment apparatus to cause said layer to sinter and to burn said heat-destroyable sheet.

3. A method for producing sintered metal sheet from powder metal including the steps of uniformly spreading a loose and uncompacted powder metal in a layer onto a carrier which will be destroyed at temperatures which cause said powdered metal to sinter, compacting said layer into a green sheet adhered to said carrier, heat treating said sheet to sinter the same and to substantially destroy said carrier, and subjecting said sheet to further compacting and annealing to increase the strength and density of said sheet.

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