

June 2, 1959

H. EVANS ET AL

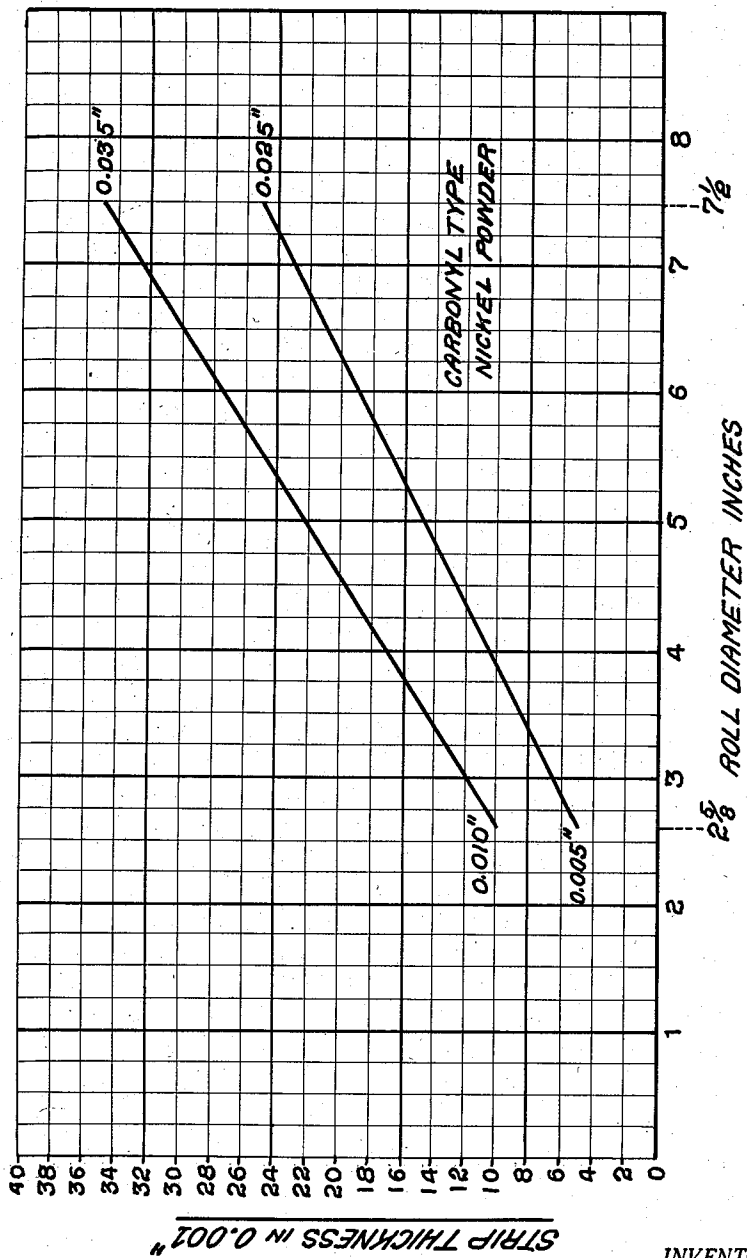
2,889,224

MANUFACTURE OF METAL STRIP FROM METAL POWDER

Filed July 18, 1956

2 Sheets-Sheet 1

Fig. 1.



INVENTORS
HOWARD EVANS
DAVID KENNETH WORN
BY
A. R. Keller
ATTORNEY

June 2, 1959

H. EVANS ET AL

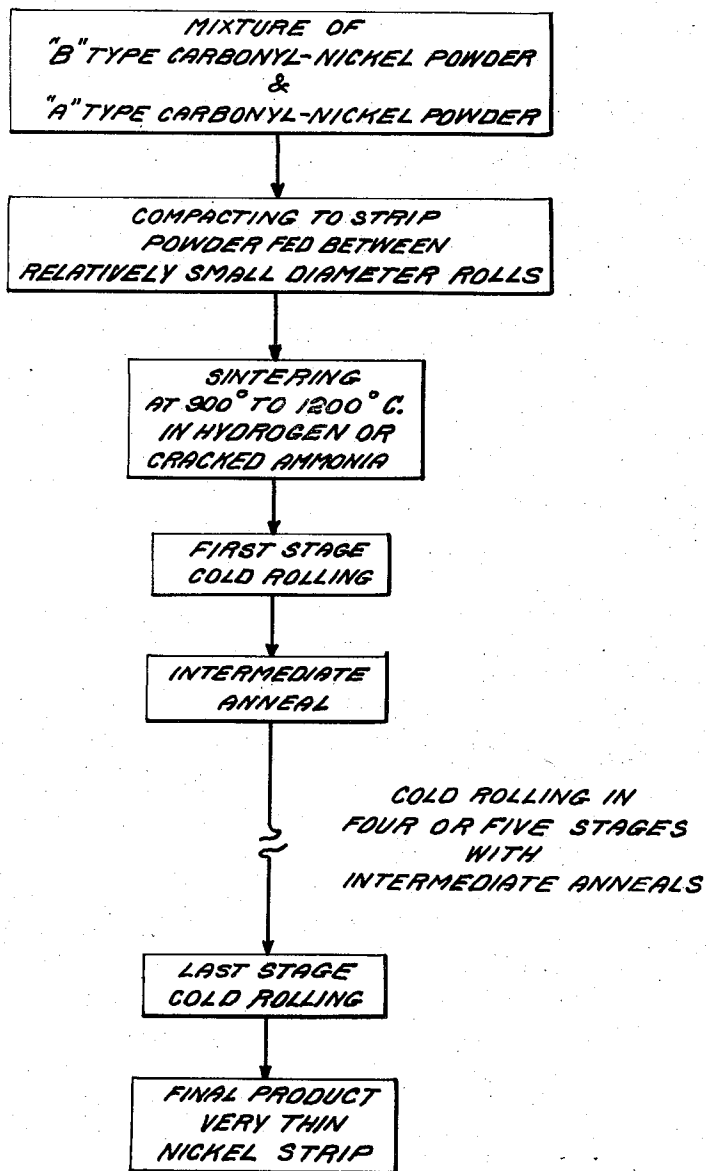
2,889,224

MANUFACTURE OF METAL STRIP FROM METAL POWDER

Filed July 18, 1956

2 Sheets-Sheet 2

Fig. 2.



INVENTORS
HOWARD EVANS
DAVID HENNETH WORN
BY
A. R. Heller
ATTORNEY

1

2,889,224

MANUFACTURE OF METAL STRIP FROM METAL POWDER

Howard Evans, deceased, late of Solihull, England, by Evelyn May Evans, Solihull, England, and Gwladys Maud Bishop, Penistone, near Sheffield, England, administrators, and David Kenneth Worn, Hall Green, Birmingham, England, assignors to The International Nickel Company Inc., New York, N.Y.

Application July 18, 1956, Serial No. 598,693

Claims priority, application Great Britain
July 20, 1955

2 Claims. (Cl. 75—214)

The present invention relates to a method for producing sintered metal strip and more particularly to a method for producing thin metal strip by direct rolling of metal powder and especially to the manufacture of thin strip material of nickel or of iron or of both by the direct rolling of the metal powder.

It is well known that metal strip can be made from metal powder by passing the powder between rolls arranged so as to compress the powder into a continuous compact and thereafter sintering the compact. It has been proposed to make metal strip from nickel powder produced by the thermal decomposition of nickel carbonyl. It is known that when nickel is thermally decomposed to yield the corresponding metal powder the kind of powder produced depends upon the operating conditions in the decomposer. Normally the powder is in the form of discrete particles, but if the throughput of the carbonyl or the heat input of the decomposer or both is or are increased the powder particles agglomerate and the structure of the product becomes fibrous, the bulk density of the powder being much less than that of the other kind of powder. These two powders are often known, as "A" type and "B" type, respectively. The "A" type metal powders have relatively free flowing discrete particles which do not readily combine together under compression. Although the interlocking aggregate structure of the "B" type powder particles enables them to matte together when the powder is compacted, this type of powder has poor flow properties. Powder consisting wholly or mainly of discrete particles and which will now be referred to as "A" powder has a bulk density of between 2 to 2.6 grams per cubic centimetre whereas powder wholly or mainly with the fibrous structure, which will now be referred to as "B" powder, has a bulk density of between 0.6 to 1.4 grams per cubic centimetre. It has been found that when compacting rolls are used of a large enough diameter to allow adequate feed of "B" type powder into the roll gap, for example, 8 inch diameter rolls, the relatively thick strip thus produced by the compacting rolls has excellent strength and resilience to withstand the mechanical stress of handling before and during its passage through the sintering furnace. However, when attempts have been made to produce a thin compact of about 0.005 inch thickness or even 0.01 inch thickness from the "B" type powder using smaller diameter compacting rolls such as about 2½ inches diameter, difficulties arose and adequate feed of the "B" type powder into the roll gap was not obtainable, the strip produced being of non-uniform density. Although attempts were made to overcome the foregoing difficulties by, e.g., roughening the rolls, none was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that thin metal strip made from carbonyl-nickel powder, by passing the carbonyl-

2

metal powder between rolls arranged to compress the powder into a continuous compact and thereafter sintering the compact, may be expeditiously and economically formed from a special mixture of two kinds of the particular carbonyl-metal whereby the strength of the strip of compacted material before sintering is greater than that of a strip formed of the "A" type powder alone.

It is an object of the present invention to provide an improved method for producing thin metal strip of compacted nickel-carbonyl powder, of iron carbonyl powder, or of both and having high strength before sintering.

Another object of the invention is to provide an improved method for producing thin metal strip from nickel-carbonyl powder, from iron carbonyl powder, and from both.

The invention also contemplates providing an improved method for producing thin metal strip from nickel-carbonyl powder, wherein the strength of the compacted metal strip before sintering is greater than that of a strip formed of the corresponding "A" type metal powder alone.

It is a further object of the invention to provide an improved thin metal strip made from nickel-carbonyl powder, wherein the strength of the compacted metal strip before sintering is greater than that of a strip formed of the corresponding "A" type metal powder alone.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a graphical representation showing the relation between the compacting roll diameter and the thickness of the strip before sintering; and

Figure 2 depicts a flow sheet of an embodiment of the invention.

Generally speaking, the present invention relates to an improved process for preparing thin metal strip comprising compacting and sintering carbonyl-nickel powder. The improved results of the invention are achieved when a special mixture of the "B" type powder and of the "A" type powder of the particular carbonyl-metal used is compacted between rolls into strip form. The mixture of these metal powders used according to the invention contains from about 25% to 95% "A" type powder by weight, the remainder being "B" type powder. For example, when preparing thin nickel strip from carbonyl-nickel powders the mixture of these powders should contain from about 5% to about 75% "B" type powder by weight. The strip is then compacted between relatively small diameter rolls say not less than 2 inches diameter up to about 4 inches diameter with a nominal gap width of 0.005 inch. The compacted strip is between 0.004 and 0.010 inch thick. In a mass of powder fed to the rolls there is a compacting zone above the bite of the said rolls and if it is shallow as is the case with small rolls, the powder tends to bridge over and not enter the bite but with a mixture as quoted above this problem is obviated. The compacted strip issues from the bite and passes into a sintering furnace and is subjected to a temperature of 900 to 1200° C. in a gas of hydrogen for ½ minute. It then passes to a first stage of cold rolling and is reduced to 0.004 inch. It is then annealed at a temperature of 900 to 1200° C. for ½ minute and further cold rolled to reduce it by 20%. Depending on the final strip thickness required, a plurality of annealing and cold rolling operations may be included. The final stage of cold rolling to give very thin strip say 0.001 inch thickness is effected in rolls of very small diameter say approximately ⅞ inch.

The proportion of "B" type powder in the mixture of carbonyl-metal powders affects the thickness of the compacted strip produced with a given gap setting, that is to say the distance apart of the compacting rolls, the

strength of the strip and the appearance of the strip. There is an optimum gap setting of the compacting rolls which depends on the roll diameter. For example, when using compacting rolls about 2½ inches in diameter the nominal gap setting should not exceed about 0.007 inch. With these rolls the maximum strength is obtained when the proportion of "B" type carbonyl-nickel powder is about 70% (30% "A"). At a proportion as high as this, however, the strip is distinctly mottled in appearance, indicating lack of uniformity which is itself the result of the comparatively poor flowing properties of the "B" type powder. It is preferred not to use the proportion of "B" type carbonyl-metal powder that provides maximum strength in the compacting strip, but rather to keep the "B" type powder at not more than about 50% of the mixture, for example, not more than about 50% of "B" type carbonyl-nickel powder when making nickel strip.

For a given setting of the roll gap and roll diameter, no more "A" type carbonyl-metal powder should be added than is sufficient to ensure adequate feed of the powder between the rolls, since further additions of "A" type powder progressively reduce the strength of the compacted strip before sintering.

It is more economical to produce very thin strip from a thin strip rather than a relatively thick one, for then the amount of subsequent working is much reduced. For example, it would be a decided advantage in the case of very thin strip of about 0.001 inch thickness to produce this with some working from a strip of say 0.005 inch thickness on relatively small diameter rolls rather than make it from strip of 0.020 inch made on relatively large diameter rolls. There is a direct relation between roll diameter and the thickness of strip which can be produced by direct rolling. This relationship is shown by the graph in Figure 1 of the drawing.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative example is given:

A very thin metal strip was produced by the novel method of this invention as outlined in the flow sheet depicted in Figure 2 of the drawing. This very thin metal strip was formed from a powder mixture consisting of 50% "A" type carbonyl-nickel powder and 50% "B" type carbonyl-nickel powder. The "A" type powder was of approximately 4 micron particle size as determined by the gas-permeability method and had a bulk density of 2.6 grams per cubic centimetre. The "B" type powder was of approximately 3 micron particle size and had a bulk density of 0.9 gram per cubic centimetre. The mixture of carbonyl-nickel powders was compacted between rolls 2½ inches in diameter to form a continuous strip 0.006 inch thick and 2 inches wide at a speed of 10 feet per minute. The strip of compacted material then was passed directly through a tube furnace having a hot zone 2 feet long maintained at a temperature of 900° C. to 1200° C. The protective atmosphere in the tube furnace was hydrogen. However, cracked ammonia may be used as the atmosphere in the furnace. The sintered strip leaving the furnace was found to be ductile. The sintered strip was cold-rolled in four or five stages with intermediate annealing treatments, each carried out by passage of the strip at a speed of 10 feet per minute through a furnace having a hot zone 2 feet long maintained at a temperature of 900° C. to 1200° C. in a protective atmosphere. The total reduction in thickness of the strip was 70%. The finished strip possessed a well-developed crystal structure and was free from porosity.

Although the invention has been described in detail with respect to the production of thin metal strip from carbonyl-nickel powder, similar considerations apply in the case of thin strip prepared from carbonyl-iron powder.

It will be appreciated that the invention has wide applicability. For illustrative purposes, it is noted that

the present invention is particularly applicable to powders of high and low bulk density. It is generally accepted that bulk density is a convenient criterion of the flow characteristic of a powder in that it is indicative of the surface structure of the particles comprising the powder. A low bulk density powder has a poor flow characteristic and it is possible to enhance the flow by adding a proportion of a powder of a higher bulk density. It has been found that powder other than carbonyl powder of low bulk density may be compacted with small rolls to give a strip of good green strength if a proportion of higher bulk density powder is added to enhance the flow. For example, electrolytic or hydrogen reduced copper powders have poor flow characteristics and good bonding properties and the flow can be enhanced using small rolls by adding a proportion of atomized copper powder which has a spherical particle and good flow characteristic.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. The method for producing by direct rolling a substantially non-porous thin metal strip from carbonyl nickel powder which comprises establishing a mixture containing about 5% to 75% by weight of a carbonyl nickel powder having a bulk density between about 0.6 and 1.4 grams per cubic centimeter and characterized by a fibrous structure and poor flow properties and about 95% to 25% by weight of a carbonyl nickel powder having a bulk density between about 2 and 2.6 grams per cubic centimeter and characterized by being in the form of discrete particles; passing said mixture of carbonyl nickel powder through compacting rolls having a diameter between about 2 inches and about 4 inches to produce a compacted metal strip of uniform structure and having a thickness of about 0.004 inch to 0.010 inch, said compacted strip having a greater strength than a similar strip made only from said carbonyl nickel powder having discrete particles and having greater uniformity than a similar strip made only from said nickel powder having a fibrous structure; sintering said compacted strip and reducing said sintered compacted strip to a ductile non-porous form by cold rolling and annealing.

2. The method for producing by direct rolling a substantially non-porous thin metal strip from carbonyl nickel powder which comprises establishing a mixture containing about 50% by weight of a carbonyl nickel powder having a particle size of approximately 4 microns and a bulk density of 2.6 grams per cubic centimeter and about 50% by weight of a carbonyl nickel powder having a particle size of approximately 3 microns and a bulk density of 0.9 gram per cubic centimeter; compacting said mixture of carbonyl nickel powder between rolls of about 2½ inches diameter to form a continuous strip about 0.006 inch thick; sintering said compacted strip and thereafter reducing said sintered compacted strip to a non-porous nickel strip by cold rolling and annealing.

References Cited in the file of this patent

UNITED STATES PATENTS

2,337,588	Calkins	Dec. 28, 1943
2,341,732	Marvin	Feb. 15, 1944
2,758,336	Franssen	Aug. 14, 1956
2,771,637	Silvasy et al.	Nov. 27, 1956

FOREIGN PATENTS

311,141	Great Britain	July 9, 1928
---------	---------------	--------------