

Feb. 27, 1940.

F. V. LENEL

2,191,936

MANUFACTURE OF POROUS IRON ARTICLES

Filed March 10, 1938

2 Sheets-Sheet 1

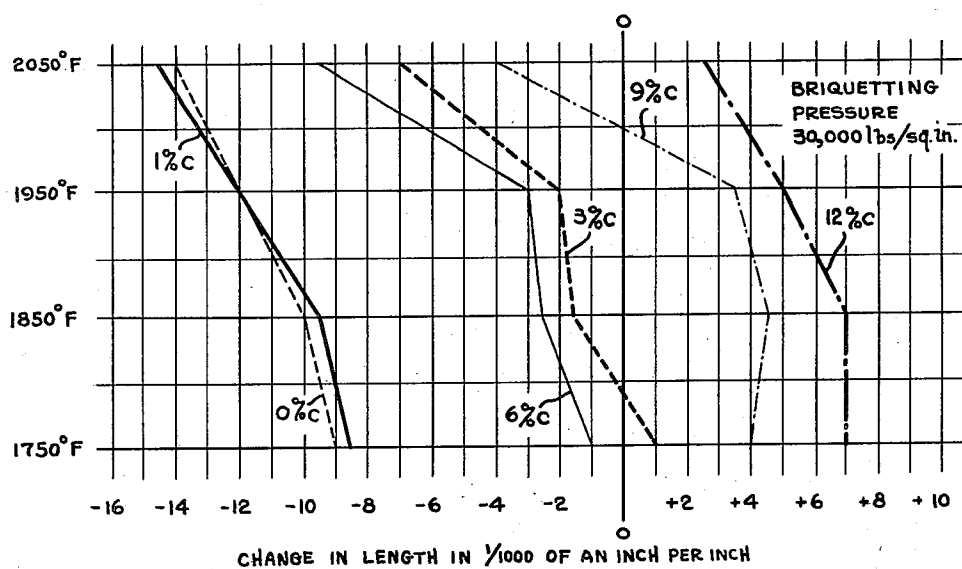


Fig. 1

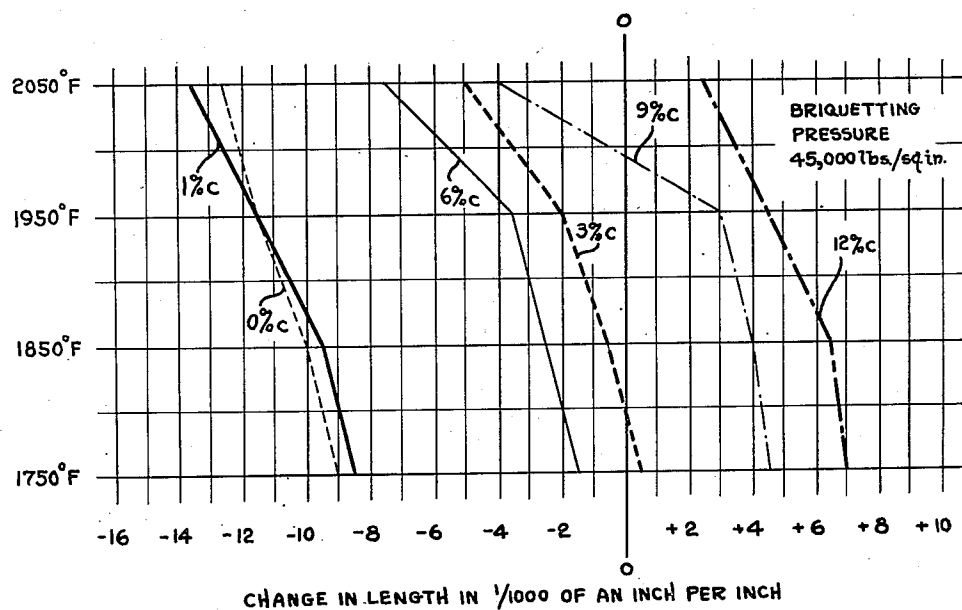


Fig. 2

INVENTOR
FRITZ V. LENEL

BY
Spencer Hardman & Fehr
ATTORNEY

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2 Sheets-Sheet 2

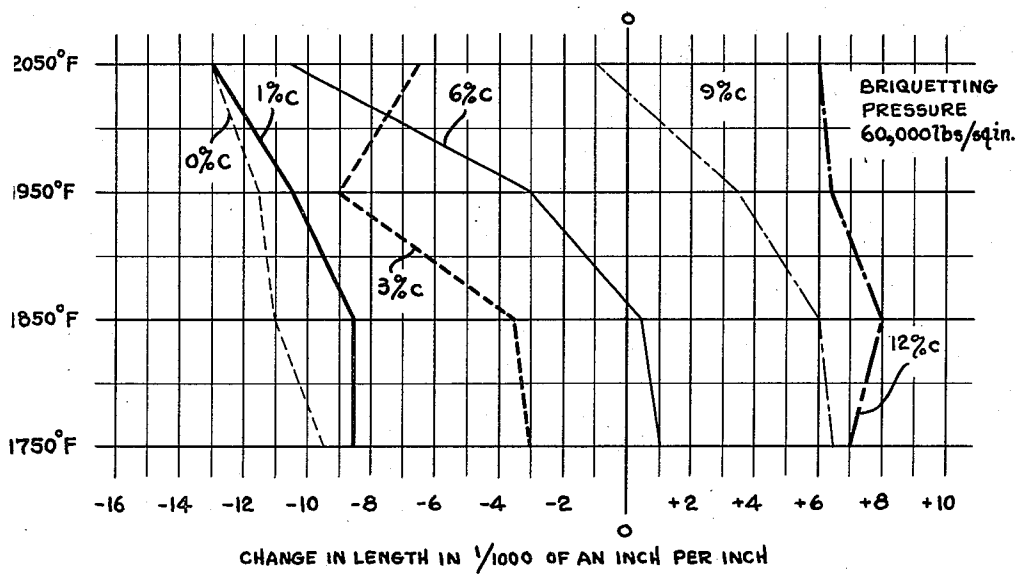


Fig. 3

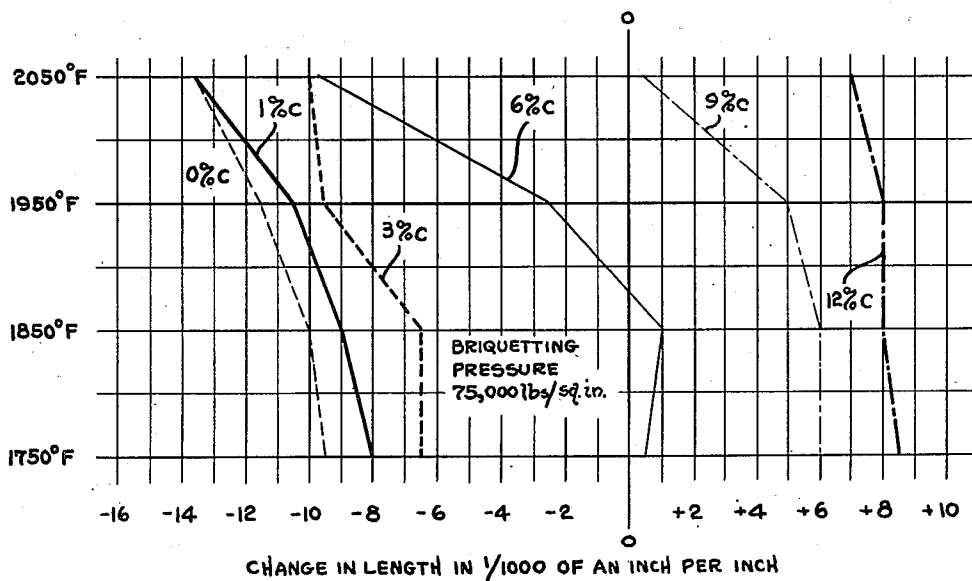


Fig. 4

INVENTOR
FRITZ V. LENEL
BY
Spencer Hardman & Feltz
ATTORNEY

UNITED STATES PATENT OFFICE

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MANUFACTURE OF POROUS IRON
ARTICLESFritz V. Lenel, Dayton, Ohio, assignor to General
Motors Corporation, Detroit, Mich., a corpora-
tion of Delaware

Application March 10, 1938, Serial No. 195,053

2 Claims. (Cl. 75-22)

This invention relates to a method of fabri-
cating ferrous articles from iron powder.

The primary object of the invention is to pro-
vide a method of fabricating an article from
iron powder and carbon so that the size of the
article after sintering thereof is predetermined,
the article being formed in an undersized con-
dition so that upon sintering thereof the in-
crease in size will cause the article to be sub-
stantially the size desired.

In carrying out the above object it is a further
object of the invention to accurately control the
percentage of carbon utilized, the briquetting
pressure and the sintering temperature in order
to obtain the results desired.

Further objects and advantages of the present
invention will be apparent from the following
description, reference being had to the accom-
panying drawings wherein a preferred embodi-
ment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a graphic representation of the change
in size of briquettes made from sponge iron and
carbon in varying percentages at increasing sin-
tering temperatures, all the briquettes being
compressed at a pressure of 30,000 lbs. per sq. in.

Fig. 2 is a chart similar to Fig. 1 with the ex-
ception that the briquettes were compressed at
a pressure of 45,000 lbs. per sq. in.

Fig. 3 is a chart similar to Fig. 1 in which the
briquettes were compressed at a pressure of
60,000 lbs. per sq. in., and

Fig. 4 is a chart similar to Fig. 1 in which the
briquettes were compressed at a pressure of
75,000 lbs. per sq. in.

Comminuted sponge iron, such as is obtained
by the reduction of iron ore or by reduction of
the oxides of iron is now being used in industry
in the fabrication of ferrous articles. In pro-
ceeding to make such articles, the sponge iron
powder is uniformly filled into a die cavity,
having an internal configuration corresponding
to the desired shape of the article and is then
briquetted under a high pressure to form the
iron powder into a self-sustaining mass having
the shape desired. The briquette so formed is
then sintered at a suitable high temperature,
under nonoxidizing conditions, for such a time
as to cause the particles of iron to sinter to-
gether and thereby form a porous ferrous article
having a high degree of mechanical strength and
of the desired configuration.

It has been found desirable to include carbon
in the preliminary mixture of iron powder so
that the final article, subsequent to the sintering

step is carburized, to some extent, and also in-
cludes some free carbon, mechanically held with-
in the pores of the article. The free carbon ad-
jacent the outer surface of the article aids in
lubricating the surface when the article is uti-
lized under any condition of frictional contact
with another surface. The carbon which is ab-
sorbed by the iron increases the hardness there-
of, thereby increasing the wear resistance of the
article. Carbon in the initial mixture is further
desired as it aids in the formation of the bri-
quette, acting as a lubricant in the briquetting
die.

I have found that when iron-carbon mixtures
are briquetted and sintered that the final size
of the sintered article does not correspond to the
size of the briquetted article. The present in-
vention is particularly concerned with this phase
in the manufacture of iron articles from pow-
dered iron and solves the problems of manufac-
turing ferrous bodies which include carbon in
appreciable percentages.

The inclusion of carbon in excessive quantities
tends to lower the mechanical strength of the
finished article. This is explained by the fact
that the free carbon, which is mechanically held
within the pores of the iron, reduces the area
of contact between the individual particles or
grains of iron and thereby reduces the strength
of the bond between the adjacent particles after
the sintering thereof. It has been proved by
test that carbon below 7% is most desirable
from a mechanical strength standpoint, although
articles having a carbon content in the order of
12% have sufficient mechanical strength for
many industrial and commercial uses.

The fabrication of ferrous articles from pow-
dered iron is most desirable from the aspect of
production and economy, since in many in-
stances it is possible to briquette irregularly
shaped articles having a plurality of apertures
therein and then sinter the same to form a rigid
ferrous article of substantially the size desired.
Many articles, that require a great number of
finishing operations when made by the usual
casting methods, may be fabricated by the pres-
ent method with sufficient accuracy to com-
pletely eliminate such machine work. When a
very high degree of accuracy is desired a final
machining operation may be utilized but such
a machining operation does not require any ap-
preciable time or labor since the body made from
powdered metal is so very close to the size re-
quired. In other words articles formed by bri-
quetting and subsequently sintering powdered

metal are initially fabricated with greater accuracy than is possible in the usual casting process. Furthermore, articles fabricated from powdered metals such as hereinbefore described have a porous structure and therefore are particularly adapted to impregnation with a lubricant material, such as oil. This oil slowly seeps to the surface of the article due to capillarity within the pores thereof and thereby provides a lubricating film at the surface of the article when the same is used under conditions of moving contact with another body.

I have discovered that the percentage of carbon initially mixed with the iron powder is one of the factors that controls the final size of the article to be produced or stated differently, it is one of the factors controlling the change in size of the briquette during sintering thereof. I have also found that the briquetting pressure and the sintering temperature are likewise of great importance in controlling the change in size of the briquette during sintering thereof.

Referring to the accompanying drawings it will be observed that articles having under 3% carbon in the initial mix always shrink upon sintering thereof regardless of the sintering temperature or briquetting pressure. It is also manifest that under certain conditions articles having 3% and over of carbon, in the initial mixture, can be caused to increase in size, or swell, during the sintering thereof by control of the pressure and temperatures. Thus a briquette having 3% carbon which has been briquetted between 30,000 and 40,000 lbs. per sq. in. will increase in size when sintered at a temperature of 1750° F. Articles having over 6% carbon therein and briquetted at pressures of 60,000 lbs. per sq. in. and over will increase in size when heated to temperatures approximating 1850° F. Likewise, articles that include 7½% carbon in the initial mix and briquetted at pressures of 30,000 lbs. per sq. in. and over will increase in size when heated to a temperature of not over 1950° F. Similarly articles including 11% or over of carbon and briquetted at 30,000 lbs. per sq. in. and above will increase in size when sintered at temperatures up to 2050° F.

From the foregoing it is manifest that by the proper choice of sintering temperature and briquetting pressure that articles may be formed including 3% or more of carbon which will increase in size a desired amount during sintering thereof. Therefore, it is possible to briquette the article to a predetermined smaller size in all directions than the size desired, so that upon sintering thereof the article will increase in size to substantially the size desired. A specific example, for illustrative purposes only, may be noted in the manufacture of a hollow cylindrical article having a closed end such as a piston. Such an article may be formed from sponge iron including carbon, in for example, 6 parts of carbon to 94 parts of iron. These ingredients are thoroughly mixed and then briquetted in a suitable die under a pressure of approximately 60,000 lbs. per sq. in. The briquette is then sintered under non-oxidizing, or reducing conditions for at least one-half an hour at a temperature approximating 1850° F. During this heating period it has been found that between 1 and 2% of the carbon is absorbed by the iron. The article according to my discovery will increase in size during the sintering step. Thus, when making ferrous articles having 6% carbon, the forming die should be of the shape desired but of slightly reduced dimensions

in all directions so as to allow for the increase in size during sintering. In this manner it is possible to briquette an article to a predetermined size, smaller than that desired, and then sinter, whereupon the article will increase in size to the size desired. Obviously when an article is formed by this process it is advisable to make a trial run on the iron-carbon mix contemplated, at a definite temperature and pressure so as to determine the exact increase in size per unit length that will occur. With this data available it is possible to design a briquetting die of the correct dimensions to produce articles which upon sintering will be the size ultimately desired.

One theory underlying the dimensional changes herein described is as follows: when carbon is heated with iron to a high temperature, such as the sintering temperature, there is a partial gasification of the carbon due to the combination of the carbon with the oxygen combined with the surface oxides on the iron, such gases being carbon monoxide and carbon dioxide. These gases escape from the briquette after the internal pressure of the gases is in excess of atmospheric pressures. This internal pressure causes a slight increase of size over the initial size thereof. When carbon in percentages of under 3% is utilized there is sufficient absorption thereof to substantially prevent such an evolution of gas. When using higher percentages of carbon at lower briquetting pressure the porosity of the briquette is sufficiently great to allow easy escape of the gases without the build-up of internal pressure.

It will be noted from the curves shown in the accompanying drawings that briquettes having 3% carbon therein do not follow any predetermined course in their action but are irregular and unpredictable. The nature of briquettes having 3% carbon therein cannot be explained other than it appears that 3% carbon is a critical percentage.

The points used in plotting the curves as shown in the accompanying drawings were obtained by actual tests in which small pellets or slugs approximately an inch long were briquetted with the required amount of carbon and under the pressures designated. These slugs were accurately measured as to the green length thereof and were then sintered at the temperatures indicated, cooled and remeasured. The increase or decrease in length was noted and these figures yield the basis for curves of the chart. In each case three slugs were utilized and an average of the dimensional change taken as the figure for the curve. It is interesting to observe that there was very little variance between the dimensional changes of the three check samples i. e. the thousandths of an inch increase or decrease was quite uniform in all cases, where samples were tested under similar conditions.

While sponge iron as herein defined is preferred in the fabrication of porous articles due to its low market price and to its purity and resultant constant reactant qualities, it is to be understood that substantially similar dimensional changes occur under like conditions when comminuted iron, electrolytic iron, iron from iron carbonyl, or any other form of iron powder is used.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. The method of fabricating articles from
sponge iron including carbon in percentages of
3% comprising the steps of: forming a briquette
of the desired shape out of intimately mixed finely
5 divided sponge iron and carbon under a pressure
of between 30,000 to 45,000 lbs. per sq. in. and of
a predetermined size which is slightly less in all
directions than the size ultimately desired, and
then sintering the briquette so formed in a non-
10 oxidizing atmosphere at a temperature of about
1750° F. for a time sufficient to cause the particles
of iron to sinter together and to absorb at least
a portion of the carbon and simultaneously cause
the sintered briquette to increase in size to sub-
15 stantially the size desired.

2. In the manufacture of a hollow cylindrical
porous ferrous body, the steps of cold molding
sponge iron with graphite in percentages of 3%
under pressures greater than 30,000 and less than
45,000 lbs. per sq. in. to form a cylindrical blank 5
of the shape desired but of predetermined di-
mensions which are less in all directions than the
dimensions ultimately desired and then heating
the blanks so formed at a temperature of about
1750° F. for causing the particles of iron to sinter 10
together and to absorb at least a portion of the
graphite and simultaneously cause the sintered
body to increase in size to substantially the size
desired.

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