

Oct. 20, 1931.

E. E. ARNOLD

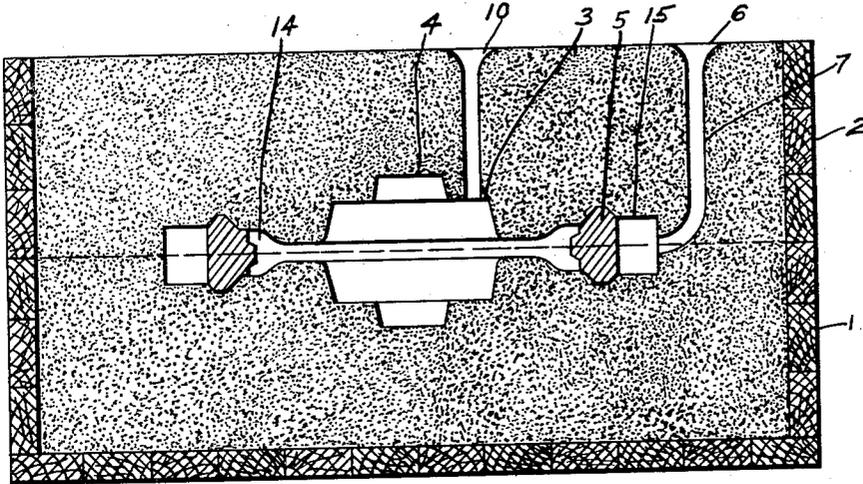
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METHOD OF MAKING GEARS

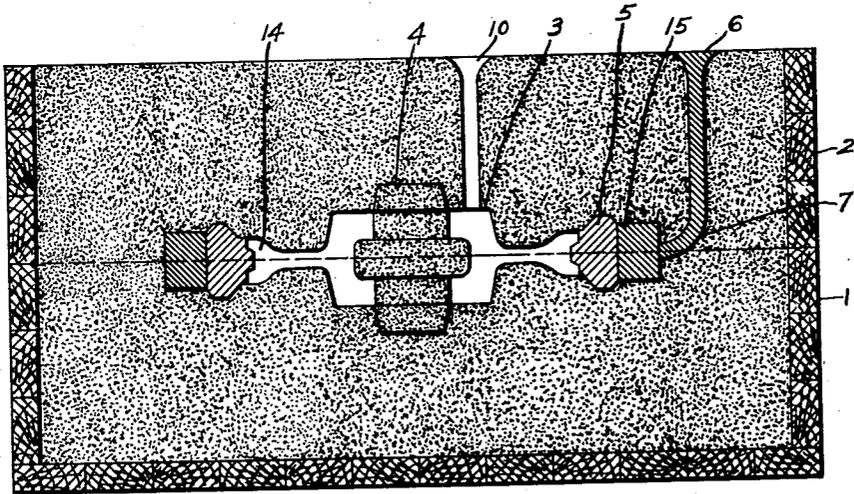
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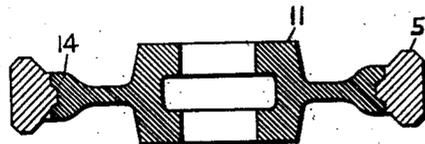
*Fig. 1.*



*Fig. 2.*



*Fig. 3.*



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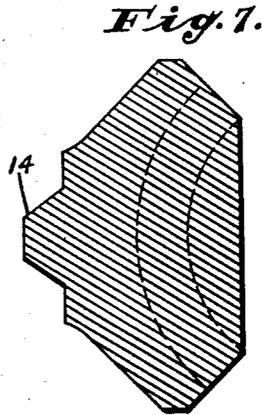
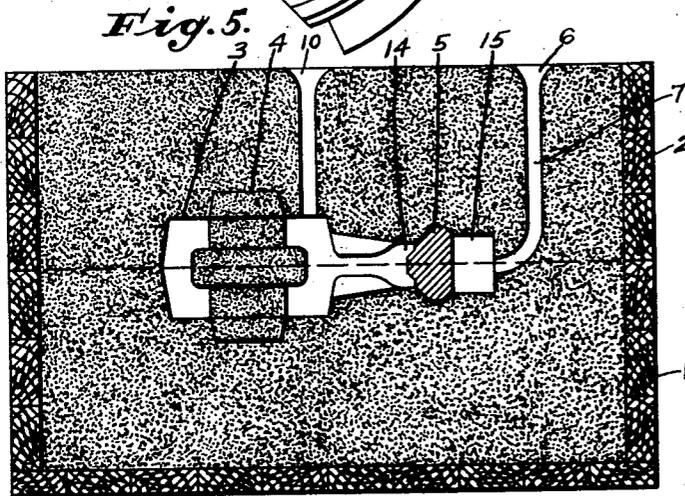
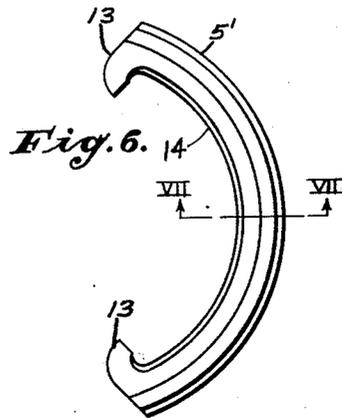
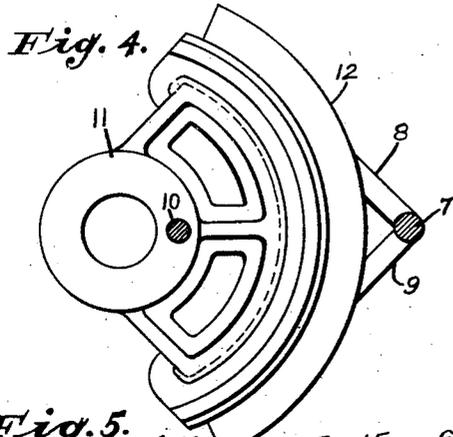
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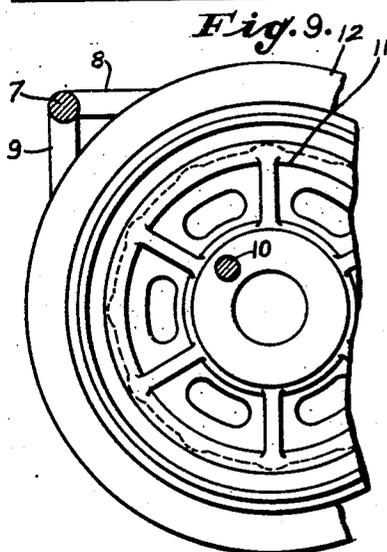
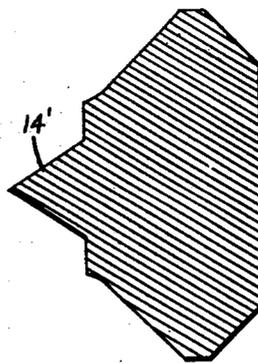
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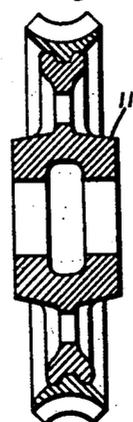
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*Fig. 8.*



*Fig. 10.*



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# UNITED STATES PATENT OFFICE

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## METHOD OF MAKING GEARS

Application filed April 11, 1929. Serial No. 354,302.

My invention relates to machine elements and more particularly to gears or pulleys having inner hubs or webs and outer rims composed of metals or alloys having different coefficients of expansion.

The principal object of my invention is to provide a blank from which a gear or pulley may be produced that has an outer rim or segment composed of a metal or alloy having a relatively high coefficient of expansion united, by a casting or molding operation, to an inner web or hub formed of a metal or alloy having a relatively low coefficient of expansion.

Another object of my invention is to provide a method of uniting an outer rim or segment of a machine element to an inner web or hub by a casting or molding operation.

A further object of my invention is to provide a method of integrally uniting an outer rim composed of a relatively expensive metal or alloy having a comparatively high coefficient of expansion, such as bronze, to a central web or hub composed of a satisfactory metal or alloy, having a comparatively low coefficient of expansion which is inexpensive, such as cast iron, by a casting or molding operation which comprises heating the bronze rim in a mold and then pouring sufficient molten iron to form the central hub and web internally of the rim, the heat imparted to the rim expanding it to such extent that, during the contraction of the parts, the outer rim, because of its greater rate of contraction, will be shrunk, in a tight engaging fit, upon the central portion.

It is customary, in making gears or gear segments which are subjected to pressure in service, such as worm gears utilized in elevators, to form the central portion of the gear of an inexpensive metal, such as cast iron, and the outer portion or rim of a copper-base alloy having bearing qualities to reduce friction and of sufficient strength to resist the stresses to which the gear is subjected in service. Heretofore, in making gears of this type, it has been the practice to first form the central portion of the gear of cast iron and machine its outer surface. The inner surface of a bronze rim is next ma-

chined to fit the machined surface of the cast-iron center, after which it is placed over, and bolted to, the cast-iron central portion. The outer surface of the bronze ring is then machined, and the teeth are cut by a hobbing tool, in the usual manner.

This process of securing the bronze ring to the cast-iron center is expensive because of the many machining operations required. In view of this expensive procedure, it has been proposed to unite the cast-iron center to the bronze ring by a welding operation but such process also requires some machining to which is added the expense of welding.

In making machine element of the type specified, I have made the discovery that the expensive machining operations may be avoided by casting the central portion interiorly of a bronze rim which has been so expanded by a previous heat application, that, during the subsequent cooling of the cast center and the rim, the rate of contraction of the rim will exceed the rate of contraction of the central portion by a sufficient degree to ensure a tight engaging fit between the two members.

My invention will be better understood by reference to the accompanying drawings in which:

Figure 1 is a cross sectional view of a sand mold showing a previously prepared bronze rim in cross section and gates through which molten metal for forming the cast-iron center and the outer heating ring may be poured;

Fig. 2 is a similar view showing the bronze rim and the outer heating ring in cross section;

Fig. 3 is a cross sectional view of a complete gear or pulley blank made in accordance with my improved process, the outer heating ring having been removed;

Fig. 4 is a plan view of a segmental gear blank, with the outer heating ring in place and showing a passageway leading to the center and a plurality of passageways leading from the gate to the heating ring;

Fig. 5 is a cross-sectional view of a sand mold in which the segmental gear shown in Fig. 4 may be formed;

Fig. 6 is a plan view of the bronze rim em-

ployed in making the segmental gear shown in Fig. 4;

Fig. 7 is a detail cross-sectional view of a typical bronze ring or segment;

Fig. 8 is a similar view showing a modified cross section of a bronze ring;

Fig. 9 is a plan view of the gear blank shown in Fig. 3, with the heating ring in place; and

Fig. 10 is a cross-sectional view of the complete gear having machined teeth.

Referring to Figs. 1 and 2 of the drawings, the sand mold consists of the usual drag 1 and cope 2 in which a mold cavity 3 is formed having the shape of the complete gear blank and outside heating ring, a core 4 being inserted in the central portion to form the axial opening for a suitable bearing.

In practicing my invention, a previously prepared bronze ring 5 is first placed in the mold. Molten iron is then poured through the gate 6 and flows through the conduit 7 into the chamber 15, which extends around the exterior surface of the bronze ring 5. It is sometimes desirable to provide conduit 7 with branches 8 and 9, as shown in Figs. 4 and 9, thereby permitting the molten metal to flow simultaneously into different portions of the annular chamber. Although either method may be utilized, the latter is preferred because it prevents undue heating or local melting of the bronze ring. After a short interval of time, say from 3 to 15 minutes, according to the size of the bronze ring and the volume of the chamber, molten iron is poured through gate 10 to form the metal center 11 which may consist only of a hub, or of a hub and a web, as shown in the drawings.

The interval of time between which the molten metal is poured into the different portions of the mold permits the metal in chamber 15 to form a heating ring 12 which transfers a portion of its heat to the bronze ring 5. Heat is also transferred to the bronze ring from the metal which forms the cast central portion of the gear blank. The heat thus imparted to the bronze ring causes it to expand and enlarges the portion of the mold in which the central portion is formed.

The metal portions of the gear blank and the heating ring are then permitted to cool, during which period a contraction of the elements takes place. The bronze ring, however, has a higher rate of contraction than the cast central portion so that, during the cooling process, it is shrunk to form a tight engaging fit on the cast-metal center. The heating ring 12, having a slower rate of contraction than the bronze ring 5, may be easily removed from the latter, and a blank is thus produced from which gears or pulleys may be formed.

In my early experimental work, it was thought that the metal which was poured into

the mold to form the cast center would supply enough heat to the bronze ring so that, during the subsequent cooling of the center and rim, there would be sufficient contraction of the ring, in excess of the contraction of the central portion, to cause a tight fit between the two elements. In practice, however, it was found that such method did not supply sufficient heat to the bronze ring so that, in the subsequent cooling process, a tight fit between these two members was not obtained. I then conceived the idea of supplying additional heat to the bronze ring. This was accomplished by providing the exterior chamber 15 in the mold into which molten iron is poured through the gate 6. Initial heat was thus supplied to the bronze ring which started its expansion prior to the pouring of the center hub portion so that, during subsequent cooling of the cast-iron center and bronze ring, a tight engaging fit between the two elements was ensured.

The following specific example will serve to illustrate and explain my invention, although it will be understood that I do not desire to limit myself to the particular features described therein. A previously prepared bronze ring, provided with an interior anchoring fin 14, and having an exterior diameter of approximately  $14\frac{3}{4}$  inches and an approximate cross section of  $2\frac{1}{2}$  square inches, was placed in a properly shaped mold cavity having an exterior annular chamber 15, as shown in Fig. 1. The chamber 15 had a depth of 2 inches and a radial diameter of  $1\frac{3}{8}$  inches. During various trials with molds of the description specified, molten iron was poured through gate 6 into chamber 15 at a temperature of 2300 to 2350° F. and, after an interval of from 10 to 11 minutes, iron for the central portion was poured through gate 10 at a temperature of 2370 to 2380° F. The entire structure was then permitted to cool and, in each case, upon removing the casting from the mold, it was found that the heating ring 12 had cracked and could be easily removed and that the bronze ring had contracted sufficiently during the cooling process, to make a strong fitting engagement with the cast-metal center and, to all intents and purposes, formed an integral part thereof.

The above example indicates that reasonable latitude may be permitted in commercial operations. There are three factors, however, that must be taken into consideration; namely, the volume of the heating ring, the temperature at which the metal is poured and the time which is permitted to elapse between the pouring of the heating ring and the pouring of the central portion. Complete control of the process may be obtained by a proper regulation of these variables so that a product of any desired size may be produced. My invention may also be utilized in mak-

ing segmental gears, as shown in Figs. 4, 5, and 6. In such cases, a bronze ring 5' having hook-shape flanges 13 at each end is first placed in a mold cavity having the shape and size of the completed segment and heating ring. The iron for the heating ring is then poured, in the same manner as previously described, and, after sufficient heat has been imparted to the bronze ring, the metal for the center portion is poured. As in the previous example, it is necessary that the amount of heat imparted to the bronze ring by the heating ring and by the cast-metal portion shall be such that, during the subsequent cooling of these elements, the contraction of the bronze ring shall be sufficiently in excess of the contraction of the cast-metal center to make a tight engaging fit therewith.

After the blank has been formed, teeth may be cut therein to form a gear, as shown in Fig. 10 or it may be otherwise machined to form the desired machine element.

While I have described my invention in considerable detail, it will be understood that various modifications may be made therein without departing from the spirit of my invention and this is especially true with respect to the volume of the heating ring, the temperature at which the metal for the heating ring and that for the central portion are poured, and the time which is permitted to elapse between the pouring of the heating ring and the central portion, as these factors are dependent upon each other. For example, more heat will be imparted to the bronze rim by a heating ring having a greater volume and the same is true if the metal for this ring is poured at a higher temperature. It is, therefore, apparent that, if the metal for the heating ring is poured at a higher temperature, the volume of the ring need not be so great. It will also be understood that, if a larger heating ring is utilized and the metal therefor is poured at a high temperature, it will not require as much time to impart a given amount of heat to the bronze ring as if either one or both of these factors are decreased. Since the metal for the cast center also imparts some heat to the bronze ring, the temperature at which the metal for this portion of a gear blank is poured, must also be taken into consideration in the process. I have found, however, that under ordinary grey-iron-foundry conditions, good results may be obtained when the heating ring is of substantially the same section as the bronze rim and an interval of approximately 8 to 11 minutes is permitted to elapse between the pouring of the metal for the heating ring and the pouring of the metal for the cast center.

Other modifications of my invention will also be apparent to those skilled in the art. For example, the fin 10 of the bronze ring may be made in any one of various shapes, an

illustration being shown at 14' in Fig. 8. The bronze ring may also be provided with notches, as shown at 12 in Fig. 9, to insure a perfect junction between the cast iron center and the rim. I desire, therefore, that only such limitations shall be imposed upon my invention as are required by the prior art and the appended claims.

I claim as my invention:

1. The method of manufacturing gear blanks which comprises placing a rim composed of an alloy having a comparatively high coefficient of expansion in a mold to divide the cavity of the mold into an outer annular chamber and an inner chamber, causing said rim to expand by means of molten metal supplied to said outer chamber, pouring molten metal having a comparatively low coefficient of expansion into the central chamber, such heat being supplied to said rim by means of the molten metal that, during the cooling of the blank, there will be a sufficient contraction of the rim in excess of the contraction of the central portion to insure a tight engaging fit between the two members.

2. The method of manufacturing gear blanks which comprises placing a bronze rim having an inwardly extending annular fin in a mold to divide the mold cavity into an outer annular chamber and an inner chamber, expanding said rim by means of heat imparted to it by pouring molten metal into the outer chamber, pouring molten metal having a comparatively low coefficient of expansion into the inner chamber, said metal making contact with, and imparting additional heat to, said rim, the total amount of heat supplied to said rim being sufficient to cause it to expand while hot so that it will have such contraction during the cooling in excess of the contraction of the central portion as to form a tight engaging fit between the two members.

3. The method of producing a machine element comprising a rim having a relatively high coefficient of expansion and a cast metal center having a comparatively low coefficient of expansion which comprises placing the rim in a mold, heating said rim, and pouring molten metal interiorly of the rim, thereby supplying additional heat to the rim, the total amount of heat supplied to the rim being such that, during the cooling of the element, the rim will contract sufficiently to form a tight engaging fit with the inner cast-metal portion.

4. The method of producing a machine element comprising two metallic portions having different coefficients of expansion which comprises placing the metal or alloy having the greater coefficient of expansion in a mold, heating the same and then pouring the molten metal forming the portion having the lower coefficient of expansion into the mold so as to make contact with, and supply additional heat to, the first mentioned metal,

the total amount of heat supplied to the metal having the high coefficient of expansion being such that it will shrink into a tight engaging fit upon the metal having the lower coefficient of expansion during the cooling of the two portions.

5. The method of producing gear blanks which comprises placing a rim composed of a metal or an alloy having a comparatively high coefficient of expansion in a mold, heating the rim after it has been placed in the mold, pouring a metal or alloy having a lower coefficient of expansion interiorly of the rim so that it will flow in contact with the rim and supply additional heat thereto, the total amount of heat supplied to the rim being such that, upon cooling of the rim and cast-metal center, the higher rate of contraction of the rim will cause it to make a tight engaging fit upon the cast-metal center.

6. The method of producing gear blanks which comprises placing a bronze rim in a mold, heating said rim after it has been placed in the mold, pouring a molten ferrous metal interiorly of the bronze rim so that it will come in contact with, and supply additional heat to the rim, the preliminary heat supplied to said rim, being such that, together with the additional heat supplied by the molten ferrous material, the rim will be expanded sufficiently so that, during the cooling of the blank, the rim will contract and make a tight engaging fit on the solidified ferrous central portion.

7. The process of producing gear blanks comprising a rim and a cast central portion which comprises heating the rim, pouring molten metal interiorly of the rim, thereby imparting additional heat to the rim, the total amount of heat supplied to the rim being such that, during the cooling of the blank, the rim will be shrunk into a tight engaging fit on the central portion.

8. In the process of producing machine elements comprising a rim and a central portion having different coefficients of expansion, the steps which comprise heating said rim by means of molten metal poured exteriorly of said rim and then casting molten metal interiorly of said rim.

In testimony whereof, I have hereunto subscribed my name this 28th day of March, 1929.

EDWIN E. ARNOLD.