O. C. GILBERT.

METHOD OF WORKING METALS.

APPLICATION FILED JULY 1, 1918.

1,427,100. Patented Aug. 29, 1922.

2 SHEETS—SHEET 1.

Fig. 1

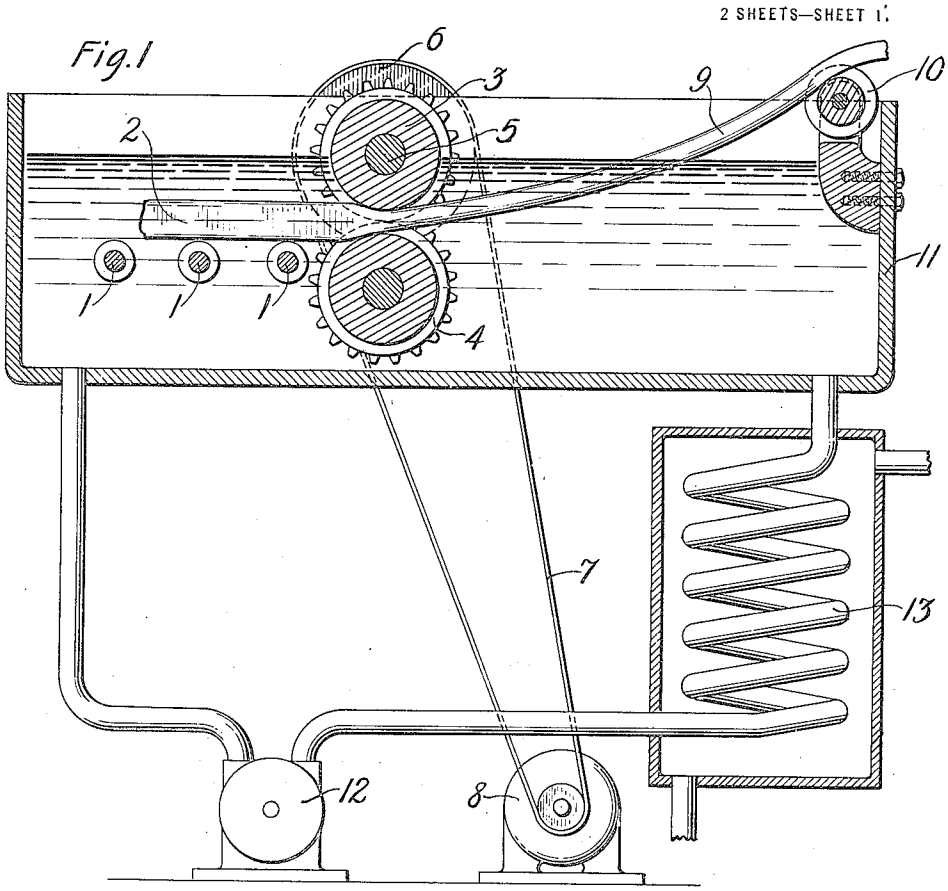
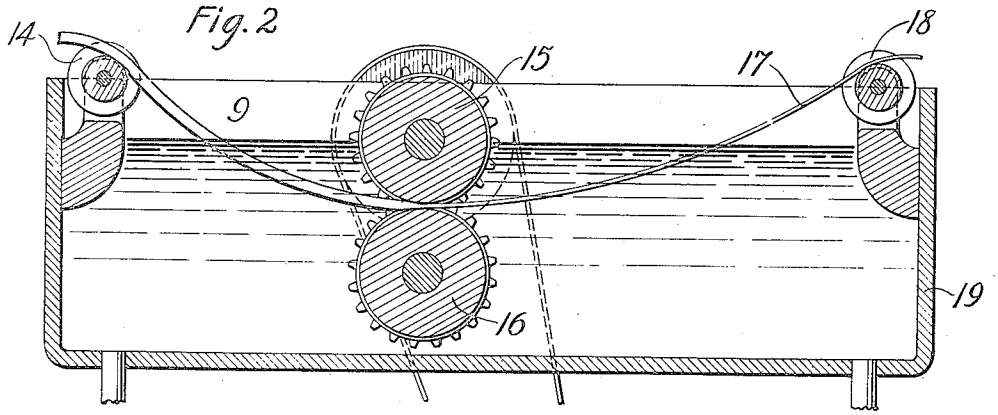


Fig. 2



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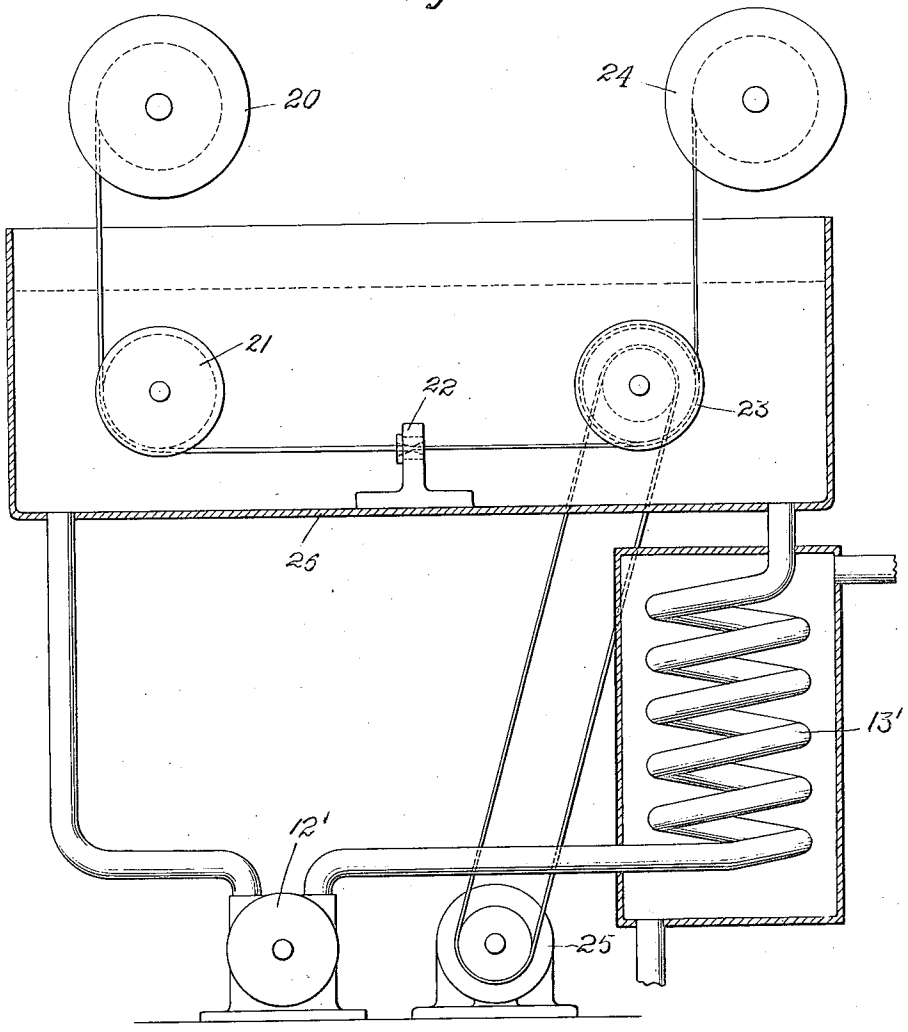
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2 SHEETS—SHEET 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

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METHOD OF WORKING METALS.

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Application filed July 1, 1916. Serial No. 242,811.

To all whom it may concern:

Be it known that I, OLIVER C. GILBERT, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of Working Metals, of which the following is a full, clear, concise, and exact description.

This invention relates to a process of working metals and their alloys to alter the physical form as well as certain physical qualities thereof. More particularly the invention relates to a process of working metal into wire form and simultaneously improving its tenacity and tensile strength.

The invention is particularly applicable to the metals and alloys used commercially in the production of wire and especially wire used as electrical conductors, since this wire is in use subjected to high tensile stresses. As an example copper may be mentioned since because of its high electrical conductivity it is extensively used in the electrical arts.

It is the usual practice to form wire by rolling and drawing a mass of the metal known as a "billet" until the desired cross section and elongation is attained. In the case of copper wire, for example, the billet is usually cast in metal molds or chills and has approximately the following dimensions 4″x4″x4½ to 7′. These billets when used for the production of wire are called "wire bars." These wire bars are heated in suitable furnaces to a red heat and passed through a succession of rolls until reduced to a diameter of about 5/16″. During the entire rolling process the bar is maintained at a temperature in excess of the annealing point, and consequently the process is known as "hot rolling." This hot rolled product, called "wire rod", is then reduced to the required diameter by drawing through suitable dies.

It is a well known fact to wire makers that the smaller sizes of wire are stronger than the larger sizes and this has been attributed to a greater hardness of an outside skin of the wire believed to be stronger than the center. Thus the belief has been prevalent that small wire being composed of a larger percent of hard skin was therefore of higher tensile strength per unit of cross section.

This belief has been further accentuated by the fact that when wire is cold drawn in the usual manner from hot rolled rod of very much larger sizes than the usual 5/16″ rod the tensile strength per unit cross section remains about the same as that of wire of the same size cold drawn from smaller hot rolled rod. Thus the opinion has developed among wire makers that cold drawn wire of a given size, say .104″ diameter, cannot be made to exceed a tensile strength of about 65,000 pounds per square inch, irrespective of the amount of cold work expended upon it.

The explanation of this belief lies in the fact that when copper wire of .104″ diameter or larger has been brought by cold working to a tensile strength of about 64,000 pounds per square inch the amount of heat generated by further cold work is sufficient to cause an annealing action under the ordinary conditions of wire drawing sufficient to neutralize the gain in strength inherent to the reduction in sectional area when the metal is kept below the annealing point. In the larger sizes of wire such as .225″ diameter, this annealing action in the case of pure copper is pronounced even at speeds as low as sixty feet per minute, a speed far below that to be encountered in any commercial wire plant.

In accordance with the process of the invention the so-called limit of tensile strength is largely exceeded since this improved process takes into account the annealing effect which is inherent to the reducing operation. Therefore, in accordance with a feature of the process of the invention, the metal is subjected to a cooling or refrigerating agent which maintains the metal during the entire reducing operation at a temperature below the annealing point of the metal.

The process of the invention will perhaps be best understood from a description of it when applied to some specific metal such as copper in the formation of copper wire. Since the tensile strength, provided the metal is maintained below the annealing point, is a function of the reduction in sec-

tion from the cast billet to the finished wire, the greater the difference in section is in any given case the greater the tensile strength of the resulting product. Therefore, it is of advantage to start with as large an initial section as is practicable. In practice the usual billet is approximately four inches square. Starting then with a billet of this section the billet is passed through a series of rolls and is reduced in section to about one quarter of an inch in diameter. The metal between the rolls and during the entire rolling operation is maintained at a temperature below the annealing point. If the billet at the start of the rolling operation is at approximately room temperature artificial cooling may not be essential during the initial stages of the reduction since the heat generated by the rolling operation in the early stages will not be sufficient to raise the copper to the annealing point which in the case of the ordinary grades of copper is about 400 degrees Fahrenheit. However, to insure that this temperature is not exceeded it is preferable that the metal be subjected to a refrigerating agent.

The particular refrigerating agent and the method of its application is not material to the process of the invention. However, in carrying out this process the rolls and metal passing between them are preferably flooded by a lubricant by means of a suitable circulating arrangement, such as a pump, which causes the lubricant to pass over the rolls, the metal and over refrigerating coils containing liquid ammonia. After the metal has been reduced to a section beyond which rolling is impracticable further reduction is accomplished by drawing through dies.

Since, when the drawing operation is started, the tensile strength has been increased to a comparatively high point, it is also necessary in accordance with the process of the invention to subject the metal during the drawing operation, to a refrigerating agent, and care must be exercised to carry the refrigeration to a point sufficiently low so that the increase in temperature due to the drawing operation is compensated for. Therefore the metal is subjected to a refrigerating lubricant at about the freezing point of water. Since the heat generated in the metal in any given case in passing through the die or rolls, is dependent upon the speed with which it passes through the die or rolls, the hardness of the metal and the degree of reduction, it may be desirable when working at high speeds to subject the metal to a much lower temperature than the freezing point of water. In any event the temperature of the lubricant must be lower than the annealing point of the metal by an amount sufficient to compensate for the heat generated in the metal in passing through the die or rolls. This is particularly necessary after a tensile strength in the neighborhood of 64,000 pounds per square inch is attained. It should be noted that this part of the process of the invention is materially different from the so-called cold drawing process as at present practised.

In the present drawing process, although the metal between passes and before entering the die is cooled by a blast of air or stream of water the resulting cooling is entirely inadequate to prevent annealing due to the passage through the die after a tensile strength of about 60,000 pounds per square inch is reached. Actual tests and curves plotted therefrom of the average value of tensile strength and reduction in section of wire formed by the usual cold drawing process, show that there is no corresponding increase in tensile strength above about 65,000 pounds per square inch in sizes above about .104″ diameter with further decrease in section to that size, in fact the annealing effect is so great that there is an actual decrease in tensile strength with a decrease in section.

In accordance with the process of the invention the metal before entering the die is refrigerated to such an extent that the increase in temperature due to the passage through the die is insufficient to raise the metal to a temperature beyond the annealing point. It has been demonstrated that copper wire can be produced by the improved process having a tensile strength of over 114,000 pounds per square inch.

The particular method and instrumentalities used in maintaining the metal at a temperature below the annealing point during the entire process is immaterial to the present invention and will be disclosed and claimed in another application.

The drawings however, illustrate, diagrammatically, conventional apparatus by which the steps of the process may be carried out and in which,

Fig. 1 illustrates a conventional apparatus by which the copper billet is reduced by passage through rolls to form copper rod, and also illustrating means for circulating a refrigerating agent around the billet during the rolling operation.

Fig. 2 illustrates diagramatically, a conventional apparatus for rolling the copper rod to form copper wire, the mechanism for circulating the cooling agent being broken away since it is identically like that illustrated in Fig. 1.

Fig. 3 illustrates a conventional apparatus for reducing the copper wire by drawing it through a die, and also illustrating means for circulating a refrigerating agent around the billet during the drawing operation.

Referring now to the drawings in de-

tail and particularly to Fig. 1, 1 represents a series of feed rolls which are designed to support a copper billet 2 while it is fed between a pair of reducing rolls 3 and 4 geared together. The reducing roll 3 is mounted upon a shaft 5 which also supports a pulley 6 which is driven through a belt 7 by any suitable source of power such as an electric motor 8. The rolls 3 and 4 serve to reduce the copper billet 2 into copper rod 9 which is passed over a discharge roll 10. The feed rolls 1 and the engaging portions of the reducing rolls 3 and 4 are located in a tank 11 and below the level of a cooling agent therein. Dolphin or porpoise oil may be used as the cooling agent and a pump 12 employed to continually circulate the oil, heated by the rolling process, from the tank through a refrigerating coil 13 and back into the tank.

The copper rod formed by the apparatus shown in Fig. 1 is passed through a second rolling apparatus of the type shown in Fig. 2; which comprises a feed roll 14 over which the copper rod 9 is passed and fed between reducing rolls 15 and 16 geared together and driven by an electric motor (not shown) similar to the electric motor 8 illustrated in Fig. 1. The wire rod 9 leaves the rolls 15 and 16 in the form of copper wire 17 which is fed over a discharge roll 18. The contacting portions of the rolls 15 and 16 are mounted within a tank 19 and below the level of a cooling agent therein. In this apparatus dolphin or porpoise oil may also be used as the cooling agent and be circulated and cooled by a mechanism like that illustrated in Fig. 1.

The copper wire formed by the apparatus shown in Fig. 2 is wound upon a supply roll 20 (Fig. 3) from which it is fed over an idler 21 through a reducing die 22, around a drawing roll 23, and thence wound upon a storage roll 24. An electric motor 25 or other suitable means may be employed to actuate the drawing roll 23 and to feed the wire as above described. The reducing die 22 and the rolls 21 and 23 are located in a tank 26 and below the level of a cooling agent therein. Dolphin or porpoise oil may also be used as the cooling agent in this apparatus and a pump 12′ employed to continually circulate the oil heated by the process from the tank through a refrigerating coil 13′ and back into the tank.

What is claimed is:

1. The process of increasing the tensile strength of a mass of non-ferrous metal which consists in changing the physical form of the metal by external stresses and in compensating for the heat generated by said stresses simultaneously with said changes in physical form to maintain the metal below the annealing point during such operations.

2. The process of increasing the tensile strength of a mass of non-ferrous metal which consists in changing the physical form of the metal by external stresses and subjecting the metal to a refrigerating agency simultaneously with said changes in physical form to compensate for the heat generated in the metal by said stresses.

3. The method of making copper wire which consists in reducing a mass of copper to wire form and maintaining the temperature of the copper below the annealing point during the entire reducing operation.

4. The method of making non-ferrous wire which consists in subjecting the metal to rolling and drawing operations, and maintaining the metal at a temperature below the annealing point during the entire rolling and drawing operations.

5. The process of making wire which consists in subjecting a mass of non-ferrous metal to the required rolling and drawing operations, and applying a refrigerated lubricant to the metal while it is being rolled and drawn to keep the temperature thereof below the annealing point during such operations.

6. The process of making wire which consists in subjecting a mass of non-ferrous metal to rolling and drawing instrumentalities and regulating the temperature of the metal simultaneously with the operation of such instrumentalities to compensate for the heat generated thereby to maintain the metal at a temperature below the annealing point.

7. The process of making wire which consists in subjecting a mass of non-ferrous metal to instrumentalities operating to reduce it in section and imparting to the metal a temperature which is lower than the annealing temperature of the metal by an amount at least equal to the temperature imparted to it by heat generated by the operation of the reducing instrumentalities.

8. The process of forming copper wire which consists in passing a mass of copper through dies to reduce it in section and submitting the copper just prior to its entrance to a die to a temperature approximating the freezing point of water so that while passing through the die, the temperature of the metal will be below the annealing point.

9. The process of forming copper wire of high tensile strength which consists in passing copper wire having a tensile strength in the neighborhood of 65,000 pounds per square inch through dies to further reduce the section of the wire, and reducing the temperature of the wire just prior to its entrance to a die to a temperature lower than the annealing point of copper by an amount equal to the heat generated in the copper in passing through the die.

10. The process of forming copper wire of high tensile strength which consists in passing copper wire having a tensile

strength of approximately 65,000 pounds per square inch through a die to further reduce the section of the wire, and maintaining such conditions in the wire during its passage through the die that its temperature is kept lower than the annealing point of copper.

11. The process of increasing the tensile strength of a mass of metal which consists in changing the physical form of the metal by external stresses and in compensating for the heat generated by said stresses to maintain the metal below the annealing point during such operation.

12. The method of making wire which consists in reducing a mass of metal to wire form and maintaining the temperature of the metal below the annealing point during the entire reducing operation.

13. Copper having a tensile strength in excess of 65,000 pounds per square inch.

14. Copper having a tensile strength in excess of 100,000 pounds per square inch.

15. Copper drawn into wire having a tensile strength in excess of 100,000 pounds per square inch.

16. Copper drawn into wire having a tensile strength of approximately 114,000 pounds per square inch.

In witness whereof, I hereunto subscribe my name this 26th day of June A. D., 1918.

OLIVER C. GILBERT.