

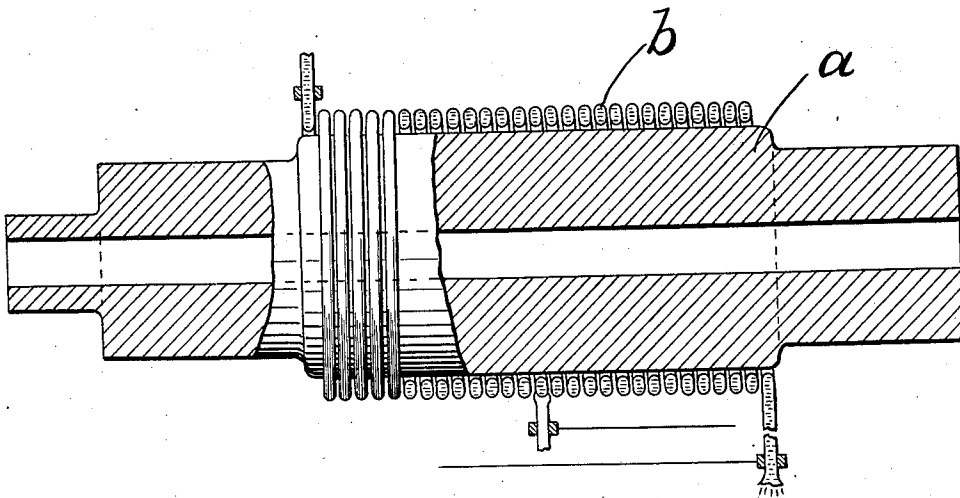
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PROCESS OF ZONE HARDENING STEEL ARTICLES

Filed June 12, 1929



WITNESS:

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PROCESS OF ZONE HARDENING STEEL ARTICLES

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My invention relates to the zone-hardening of rolls and other articles of steel and hardenable alloy steel.

In the heating of rolls for hardening, it has long been recognized as desirable to heat the periphery of the roll to a given depth above the hardening point of the particular material of which the rolls are made without raising the remainder of the roll above the hardening point of that material. In fact, it is usually desirable to keep the temperature of the interior of the roll as low as possible.

In the process as heretofore practiced, heat is applied to the exterior of the roll. Such heat may be and has been applied in oil-fired furnaces, in gas-fired furnaces and in electric furnaces. The firing is done as rapidly as practicable with the object of raising the outside zone to above the critical temperature of the steel before the interior attains such temperature. In all of these processes, all the heat is supplied from the outside, either by conduction from the hot gases within the furnace, or by radiation from the furnace walls or heating elements of an electric furnace. It is necessary not only to heat the outer face of the steel substantially above the hardening point, but it is also necessary to hold the face at that temperature for the time required to enable sufficient heat to penetrate the roll until a layer of desired depth is heated to such temperature. In the process, several difficulties are experienced. It is difficult or impossible to build up the desired heat quickly throughout this layer without overheating the surface. It is difficult or impossible more slowly to build up the desired heat throughout this layer without causing the interior to heat up by conduction to above the hardening temperature. Approximate success depends upon a nice control of the initial temperature of the walls of the furnace and of the amount of heat supplied to the furnace per unit of time, while the particular heat conductivity of the material used is a factor involved in the rate of heat penetration which makes certain control and uniformity of product extremely difficult. This varying heat conductivity tends in varying degree to heat the interior of the roll to a hardening

temperature by conveying heat away from the surface. In these furnaces, also, the material is heated in an atmosphere which tends to produce surface oxidation, while the high initial wall temperature necessary is very severe upon the refractories.

The object of this invention is so to heat the roll or other article to be zone-hardened that the roll may be heated at and near its surface above the hardening temperature while the interior of the roll remains relatively cold, to accurately and certainly predetermine the depth of the outer zone to be hardened, to increase the speed of the application of heat, to avoid overheating of the surface or the withdrawal of substantial heat from the zone being heated by conduction, and to carry on the process in an atmosphere adapted to prevent oxidation.

To aid in an understanding of the process, it is described in connection with the accompanying drawing, which shows, in longitudinal cross-section, a roll enclosed in a high frequency electric induction coil.

The roll *a*, which is to be zone-hardened, is peripherally surrounded by any convenient type of coil for electric inductive heating, such as a helical coil *b* connected with a source of high frequency electric current supply. Preferably the coil is artificially cooled by being made hollow to receive a cooling medium. A high frequency coil of this character is set forth in the Northrup Patent No. 1,328,336, January 20, 1920. It will be understood, however, that the practice of the process is not limited to the use of a high frequency electric inductive heater of any particular type.

A current of a power and frequency which should vary dependent on the depth of the outside layer which it is desired to heat to a hardening temperature and the rate at which the heating is to be done, as hereinafter explained, is passed through the coil. Heat is generated in an outside layer of predetermined thickness until its temperature is raised above the hardening point, while the interior of the roll is not raised above a comparatively low, non-hardening temperature. The production of this desirable effect is explained in part by the fact that when heat is

thus generated within the outside layer that it is desired to harden the heating time is so much reduced that the conductivity of the material is much less operative to transmit heat to the interior than in any process in which heat is supplied from the outside; also by the fact that the metal of the zone to be hardened is heated nearly or quite simultaneously and uniformly, instead of gradually from the surface inward and hence non-uniformly.

It is not only possible to more readily and accurately control the heat of the roll when all the heating is done within the roll itself, but it is entirely practicable to quite definitely predetermine the depth of the layer to be heated to the hardening temperature by adjusting the frequency of the current. For example, with a given current frequency of any definite number of cycles per second, the hardening heat will penetrate to a given depth within a time varying with the amount of power used. If the current frequency be increased, then the depth of penetration of the hardening heat will be less. If the current frequency be decreased, then the depth of penetration of the hardening heat will be greater. By increasing or decreasing the amount of power used the speed with which the exterior layer can be raised to the desired temperature will be respectively increased or decreased.

It will, therefore, be understood that a layer of any desired depth can be heated at such a rate that this layer will be above the critical temperature of the steel and at a predetermined hardening temperature long before the center of the roll will be even warm.

A typical temperature to which an outside layer of predetermined depth may be heated in a roll made of chromium steel is 1500° F. or more, or approximately 100° or more above the critical temperature of the steel. It is frequently desirable, before the zone-heating operation, to preheat the whole roll to a relatively low temperature.

While the chief advantage of the process is the production of a roll having an exteriorly hardened zone of limited and fairly definite depth without the production of a hardened interior, there are other pronounced advantages, namely, the speed of the operation, the control of the factors which determine and limit the depth of the hardened zone, the possibility of application of automatic control, the possibility of carrying on the process in any kind of atmosphere so as to prevent scaling, and the cleanliness of the process.

It will be understood that the roll, after being superficially heated, as described, above the critical temperature, is superficially cooled suddenly, as by immersion in or spraying with liquid, to produce permanent hardening of the heated surface.

While the process has been described as applied to the superficial heating of rolls, its possible applications cover a wider field; and it is intended to claim the process for all uses to which it is found applicable. Among other uses to which the process may be applied with special advantage are the hardening of mandrel bars for the cold drawing of copper, brass and steel tubing, pipe, etc., the heat treatment of mandrel bars for cold and hot forging or drawing of brass, copper, nickel and steel tubing, pipe, etc., the hardening and heat treatment of the periphery of discs, cutters, etc., and the heat treatment of wire by the continuous process.

While the thickness of the zone which is raised to the hardening heat is primarily governed by the current frequency, should the optimum frequency for a zone of desired thickness not be available the effects of conduction may be used to increase the thickness of the zone by decreasing the power input and increasing the time of holding.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

The process of heating steel articles as a step in the operation of zone-hardening, which comprises generating the major portion of the heat within an outer zone of metal by a high frequency electric induced current adapted to heat said zone to a hardening temperature, regulating the speed of the heating operation by the rate of the power input, and regulating the depth of penetration of the hardening heat by the frequency of the current and the rate of power input.

In testimony of which invention, I have hereunto set my hand at Philadelphia, Pennsylvania, on this 7th day of June, 1929.

JAMES R. ADAMS.