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G. W. SEULEN

INDUCTOR FOR THE HEAT TREATMENT OF WORKPIECES, ESPECIALLY CRANKSHAFTS

2,665,367

Filed June 8, 1949

3 Sheets-Sheet 1

Fig. 1.

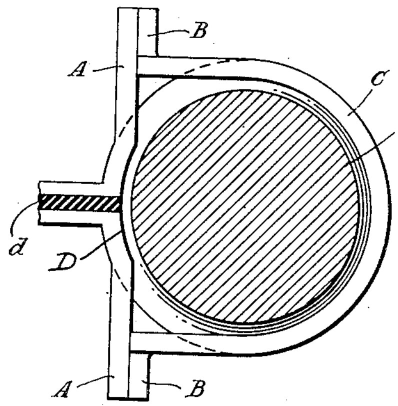

Fig. 2.

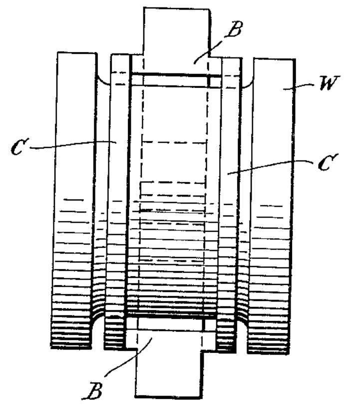

Fig. 3.

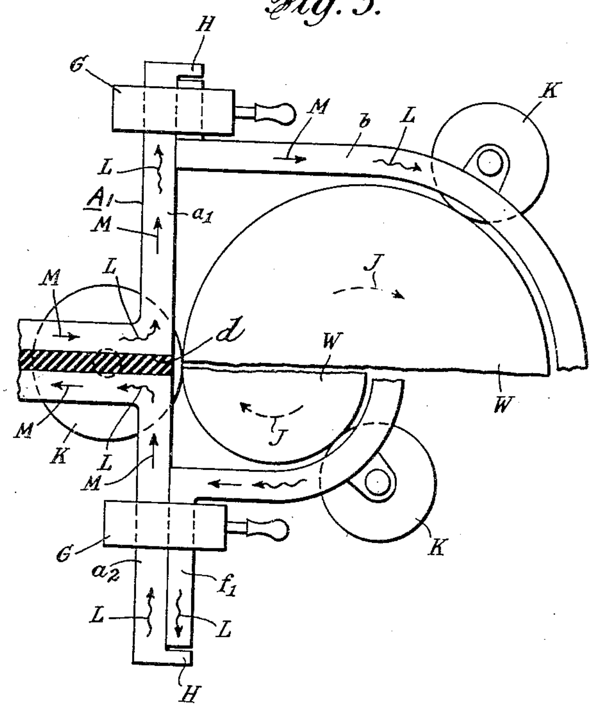

Fig. 4.

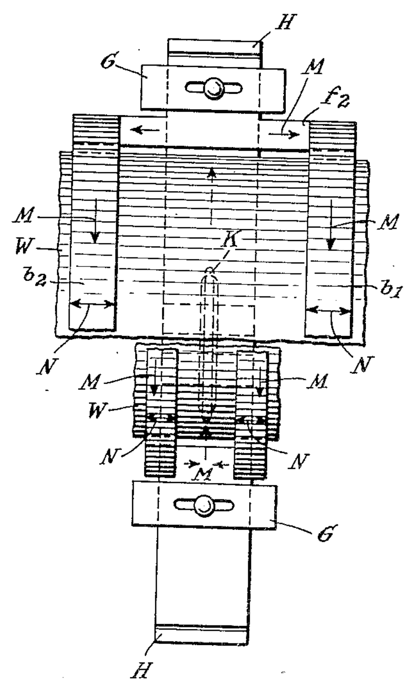

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Fig. 6.

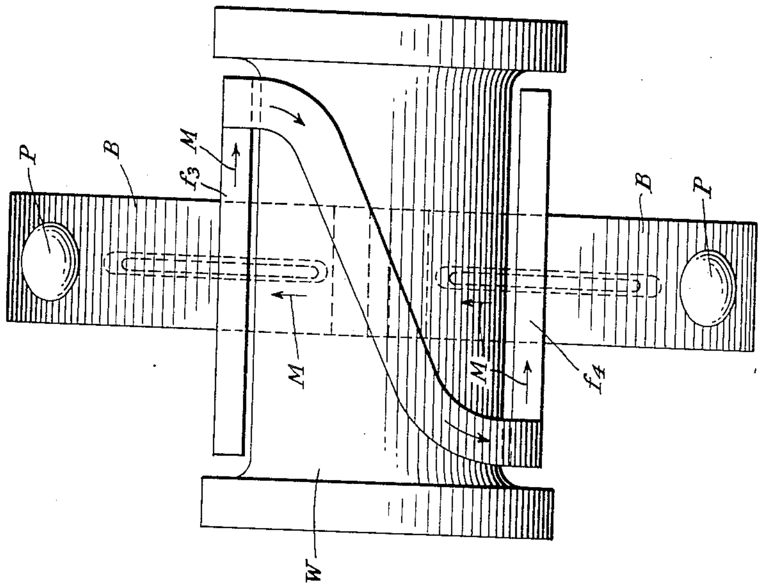

Fig. 5.

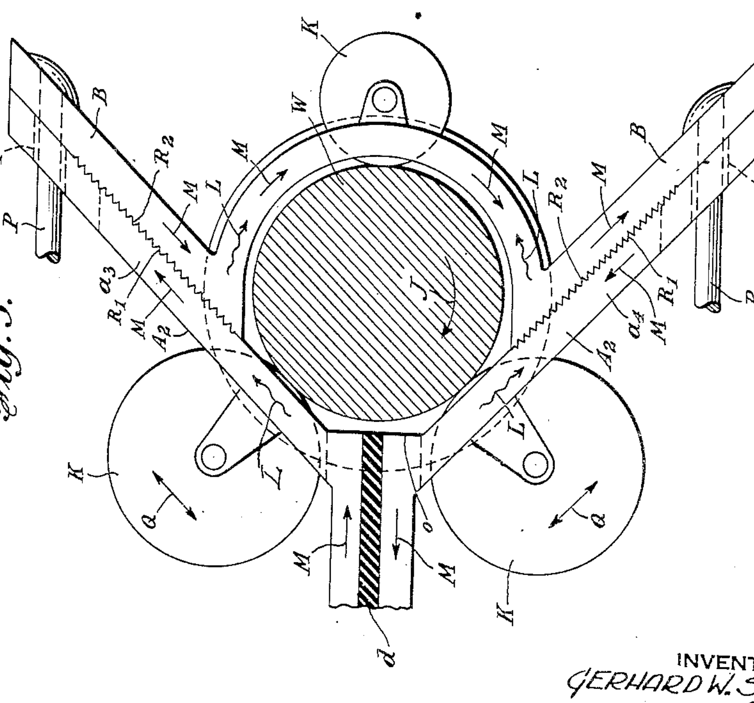

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Fig. 7.

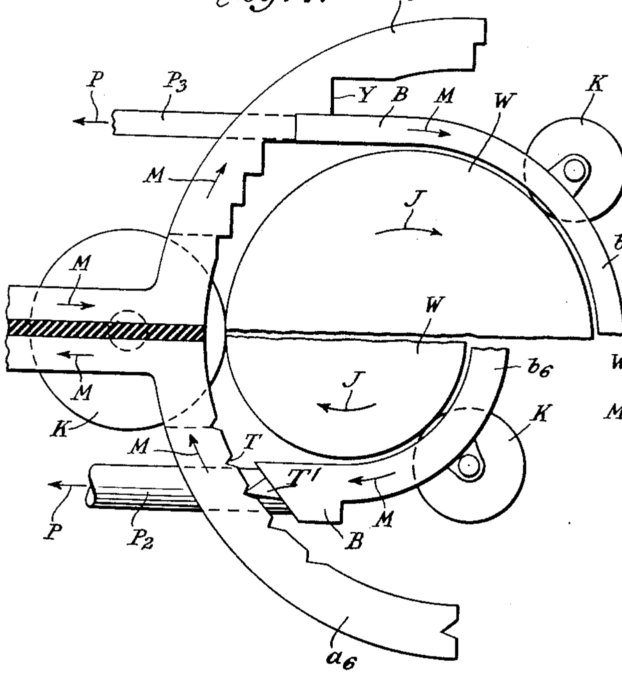


Fig. 8.

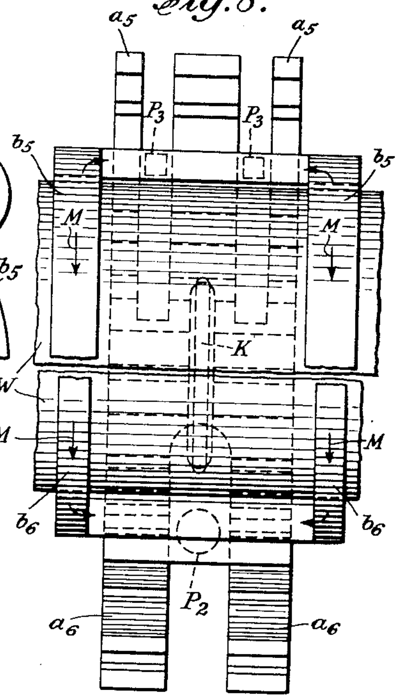


Fig. 9.

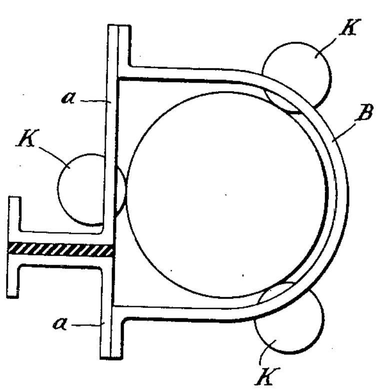
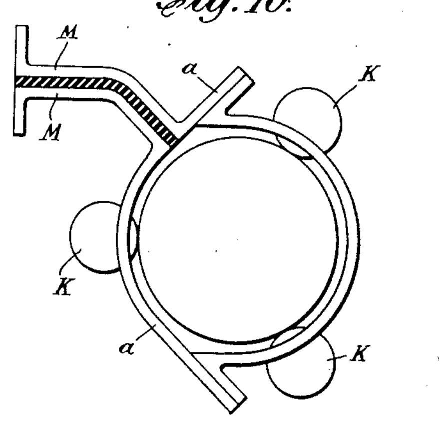


Fig. 10.



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UNITED STATES PATENT OFFICE

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INDUCTOR FOR THE HEAT TREATMENT OF WORKPIECES, ESPECIALLY CRANKSHAFTS

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10 Claims. (Cl. 219—47)

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The heat treatment of steel, for instance, for the purpose of surface hardening, is usually carried out by inductive devices whose loop conductors are connected to a transformer which supplies the required current of low tension and high current density. When such inductors are used for the heating of work pieces that are not bordered by shoulders or other projections, it is not necessary to subdivide the inductor because it can be placed onto the work piece without difficulty. However, if the work piece to be treated has shoulders or projecting portions of relatively large dimensions, the inductor must be subdivided in order to permit placing it onto the work piece portion to be treated. In this case, the inductor is generally composed of two half portions which during the treatment of the work piece are held together by suitable fastening means.

This, for instance, is the case when treating crank shafts, cam shafts, crank pins and similar parts which are to be hardened and whose pins to be treated are bordered by the hubs, bosses or cams of the shaft. As far as the heating performance is concerned, the just-mentioned subdivided inductors are well proven in practice. However, if work pieces or zones of different dimensions are to be treated, it is necessary to provide inductors of correspondingly different dimensions so that a special inductor of suitable shape and size is available for each of the zones of the work piece to be heated.

In order to treat the various parts of crank shafts, as many hardening stations must be provided as the crank shaft has pins of different dimensions. For instance, if a crank shaft for a diesel engine has six eccentrically located crank pins and seven centric bearing pins and if all of these pins are to be hardened, as much as five to seven treating stations are needed because the crank pins have dimensions different from those of the intermediately located bearing pins, and the various bearing pins may also have respectively different dimensions. After the six eccentric crank pins have been hardened in the first station, the first bearing pin is treated in the second station, the second to fifth bearing pins in the third station, the third bearing pin in the fourth station, and the fourth to seventh bearing pins in the fifth station, etc. The number of the required treating stations is determined by the number of the bearing and crank pins of respectively different dimensions.

Since the treating equipment must be designed for the most unfavorable case of application, it

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is generally necessary to provide seven treating stations. Each of these stations may be connected through a transformer and a suitable switch to a common generator, and suitable control devices may take care that only one of the stations is connected with the generator at a time.

As apparent from the foregoing, a rather large and intricate installation is necessary for this kind of heat treatment for the surface hardening of crank shaft pins and similar work pieces. The exchange of the various inductors is time-consuming and complicated so that, with the customary inductors, a considerable disadvantage must be put up with when using induction heating and hardening equipment.

It is an object of my invention to devise an inductor for application to work pieces of a large variety of diameters and widths which greatly reduces the just-mentioned disadvantages. Another, more specific, object of the invention is to reduce the number of the heat treating stations needed for complicated work pieces or even to permit operating with only one station, thus achieving a considerable reduction in the cost of the equipment and making it unnecessary to move the work piece from one hardening station to the other so that the time required for the complete hardening treatment is also reduced. It is also an object of the invention to make an inductive heating device applicable for work piece zones of different dimensions and shapes while using for the various zones a single inductor base member whose connections to the current supply circuit need not be changed when adapting the inductive device to the various zones or work pieces.

In order to achieve these objects, and in accordance with my invention, I provide a heating inductor which is composed of two members of respectively different widths which are connected with each other to form together a loop around the work piece. One of these members, hereinafter called the "base member," has two mutually insulated parts or rails to be connected to the respective two poles of the energizing transformer or other current source. The width of this base member in the axial direction of the work piece is adapted to the smallest width of the work piece portion to be treated. The second member of the inductor, hereinafter called the "cap member," is removably connected with the base member and has its width and diameter adapted to any other portion of the work piece to be treated.

According to another feature of the invention, a plurality of differently dimensioned cap members are provided adapted to the respectively different work pieces or zones to be treated; and any one of these cap members can be selected for attachment to a single base member.

These and other objects and features of the invention will be apparent from the following description in conjunction with the embodiments exemplified by the drawing, in which

Figure 1 is a schematic side view and Fig. 2 a front view of an inductor according to the invention;

Fig. 3 is a partially schematic side view and Fig. 4 a front view of another inductor according to the invention;

Figs. 5 and 6 represent schematically a side view and front view, respectively, of a third inductor according to the invention;

Figs. 7 and 8 are side and front views, respectively, of another embodiment, and

Figs. 9 and 10 are schematic illustrations of two respective other modifications of inductors according to the invention.

Figs. 1 and 2 elucidate schematically the design and operating principle of inductors according to the invention. A portion of a work piece W, for instance, a crank pin, is to be treated. The inductor for heating the crank pin is composed of a base member A and a cap member B. The width of base member A, measured in the axial direction of the shaft, is so chosen that it is not larger than the width of the shortest shaft portion or pin to be treated. Member A is composed of two conductive parts or rails that are rigidly interconnected but insulated from each other as is shown at d. The two rails are to be connected to the respective poles of a transformer or other source of alternating current of the suitable frequency, for instance, radio frequency. The cap member B is of arcuate shape and has two flange portions in engagement and electric contact with the two rails of the base member A to which it is removably attached. The inner diameter and the axial width of cap member B are in accordance with those areas of the work piece portion to be treated that are outside the effective range of member A. Generally, the base member A of the inductor acts on the center area and the cap member B on the adjacent outer areas of the work piece portion. For instance, when the crank pin to be treated has a diameter of 10 cm. and a width of about 10 cm., the same inductor base member A of about 5 cm. width can be used as for a pin of only 5 cm. diameter and 5 cm. width. Only the cap member B is different for crank pins of different dimensions. In the first-mentioned case, member B has an overall axial width of about 10 cm. and an inner diameter of about 10 cm., while in the second case member B of the inductor has a width of about 5 cm. and an inner diameter of about 5 cm. The just-mentioned numerical values are approximate because the necessary tolerances between the surfaces of the work piece and the surfaces of the heating inductor, of course, are to be considered. During the heating, the work piece W is kept revolving about the axis of the portion to be treated in order to secure an even distribution of the temperature.

It will be recognized that the flange portions of cap member B which contact the member A are interconnected by the heating conductors C proper. In the embodiment of Figs. 1 and 2, two such conductors C extend in parallel relation to each other on either side of the range of base member A. As a rule, the conductors are so disposed and dimensioned as to secure a desired heat distribution in the treated zone of the work piece, for instance, so that the temperature in the surface portion of the treated piece is distributed in a predetermined manner. To this end, the heating conductors may have different shapes and may extend at different or varying angles relative to the axial direction of the crank pin, as will be understood from the embodiment described in a later place with reference to Figs. 5 and 6.

It is generally desirable to keep the gap between the inductor and the surface of the work piece as narrow as possible. When using the same base member A for work pieces or zones of different diameters, the gap between base member and work pieces, of course, will differ. In order to reduce this difference, the surface area of the base member facing the work piece is preferably curved, for instance, in the manner shown at D in Fig. 1.

In the embodiment according to Figs. 3 and 4, the base member A_1 of the inductor is composed of two flat copper rails a_1 and a_2 which are insulated from each other at d for connection to the respective poles of the power transformer or other current source. The rails a_1 and a_2 are disposed at an angle of 180° relative to each other, i. e. their surfaces facing the work piece are aligned within a common plane.

The upper portion of Figs. 3 and 4 show the inductor equipped with a removable cap member b for the treatment of a crank pin of large diameter and large axial width, while the lower half of the same illustrations shows a cap member for treating a pin of smaller diameter and smaller width. Each cap member has two heating conductors b_1 and b_2 (Fig. 4) extending parallel to each other between flange portions f_1 and f_2. Clamping devices G connect the cap member with the base member under pressure applied, for instance by means of a clamping eccentric. In order to secure a proper position of the two inductor members relative to each other, the base member is equipped with guiding lugs H. During the treatment, the portions of the work piece to be treated revolve in the direction of the arrow J. The work piece portion is centered by means of guiding rollers K of non-magnetic material.

It is usually desirable to cool the inductor with water. To this end, the inductor members are preferably hollow and have ducts for the cooling water extending along the path apparent from the arrows L which indicate the flow direction of the water. As apparent from these arrows, the water enters into the rail a_1 and flows through the conductors b_1 and b_2 to the rail a_2. If an intensive cooling is required, a separate flow of water can be supplied through each of the copper rails a_1, a_2 whence it flows through only one-half of part b before it leaves the inductor. The connections through which the water flows from the base member to the cap member of the inductor is tightened by gaskets which are subjected to the high clamping pressure between the two inductor members.

The inductor current flows in the direction of the arrows M. The heat distribution is influenced simply by selecting the width N (Fig. 4) of the heating conductors b_1, b_2 of the cap member. A large width of these conductors produces an increased heat intensity in the middle area of the work piece, while a reduced width of the heating conductors increases the heat intensity in the outer sections of the work piece portion under treatment.

When using the inductor for the purpose of surface hardening, it is desirable to provide a suitable quenching device for quenching the surface after it has reached the hardening temperature. These quenching devices may be disposed at the side of inductor base member. However, these devices may be additionally or exclusively arranged at the cap member between the conductors b_1 and b_2. In this case, the cap member of the inductor is equipped with a supply line for the quenching water. However, the water may also be supplied through the base member and through openings in the contact surfaces between base member and cap member. The loop member is equipped with a handle (not shown) to facilitate exchanging it after each treatment.

In the embodiment shown in Figs. 5 and 6, the two copper rails a_3 and a_4 of the base member A_2 extend at an angle of 90° relative to each other. The corner portion, at o, of the angular design is shaped to reduce the air gap between work piece W and base member A_2. Two of the guide rollers K in this embodiment are journalled on the base member while only one of them is mounted on the removable loop member B. The two inductor members are joined together by means of bolts P which are rigidly secured to member B and traverse respective bores P_1 in member A_2 of the inductor. In the rear portion of the inductor, the bolts P are pulled magnetically, mechanically or hydraulically by suitable pressure means (not illustrated) in order to secure a satisfactory contact pressure. The guide rollers K of the base member are preferably displaceable in the direction of the arrows Q in order to adjust these rollers for different diameters of the work pieces to be treated. The contact surfaces of the inductor members may be serrated as shown at R_1, R_2, in order to improve the contact between members A_2 and B.

Instead of two parallel connected heating conductors as described previously, the part B of the inductor shown in Fig. 6 has only a single heating conductor which extends between terminal bars f_3 and f_4. The terminal bars are joined with the two respective flanges of cap member B. This design permits controlling and varying the heating zone as desired by a corresponding selection of the width and arrangement of the heating conductor.

In the embodiment according to Figs. 7 and 8, the base member of the inductor is substantially semi-circular and composed of two arcuate rails a_5 and a_6. This permits a considerable reduction of the air gap for all diameters of the work pieces to be treated. In order to secure a sufficient pressure at the electric contact surfaces and the connecting joints of the water ducts, the inner surfaces of parts a_5 and a_6 may have a stepped design as indicated at Y, or these surfaces may have grooves T engageable by a corresponding projection T' of member B.

The cap member B of the inductor is held under pressure against the steps or notches by means of bolts P_2 and P_3. A pulling force in the direction of the arrows P is applied to these bolts by suitable mechanical hydraulic or pneumatic means. It will be understood that the upper half of Figs. 7 and 8 shows the inductor applied to a work piece portion of large diameter, while the lower half of these figures shows the inductor applied to a work piece of small diameter.

Because of the electric or coolant supply lines, it is sometimes difficult to accommodate the guide rollers. It is, therefore, often desirable to depart from the substantially symmetric design of the inductors according to Figs. 1 through 8, while, of course, maintaining a symmetric triangular arrangement of the guide rollers. This is exemplified by the device shown in Fig. 9. In this device, two guide rollers K are mounted on the removable cap member B of the inductor, while the third roller K is mounted on the base member. The two rails a of the base member are aligned with each other but have different lengths, and the roller K is mounted on the longer one of the two rails. In the embodiment of Fig. 10, the rails a of the inductor base member are of arcuate shape. The appertaining terminal or bus portions M' for supplying current are bent, and one of the guide rollers K is disposed at about the center of one of the arcuate rails a, while the remaining two rollers K are mounted on the removable loop member of the inductor. It is also possible to have the rails a extend at a right angle to each other and to dispose the appertaining one roller K near the point of the angle. It is obvious that various other modifications of design and shape are applicable in order to secure a simple and favorable arrangement of the guide rollers.

The invention is not limited to the illustrated and specifically described embodiments. For instance, the efficiency can be improved by arranging magnetic yokes on the inductors or the appertaining heating conductors, and the various features of the invention can be combined with one another in a manner different from the specific embodiments here disclosed. The shape of the inductors may be changed in order to adapt them to work pieces different from those mentioned in the foregoing.

I claim:

1. An inductor device for heat treating work pieces, in particular crank shafts, comprising an inductor base member having two conductive rails rigidly joined with each other, each of said rails being of generally angular shape and having two angle legs of which one extends parallel and adjacent to the corresponding leg of the other rail, insulation disposed between said parallel legs for electrically insulating said rails from each other, said two other legs of said respective rails being serially arranged with respect to each other and forming together a substantially continuous surface facing the work piece when the device is in operative condition, and said other legs having respective end flanges remote from each other, an arcuate member having a heating conductor portion of substantially horseshoe-shaped axial elevation and having two ends angularly and outwardly projecting from said conductor portion in a plane parallel to that of the horseshoe shape, said ends being in contact engagement with said respective flanges when said device is in said condition, said arcuate member forming in series with said two other legs of said respective rails a closed loop around the work-piece axis in said condition, said loop having a loop opening of larger size than the cross section of the work piece to be treated and of an irregular shape compared with a circle, and releasable fastening means connecting said respective ends with said flanges to permit exchanging the arcuate member.

2. An inductor device for heat treating work pieces, in particular crank shafts, comprising an

inductor base member having two serially adjacent conductive rails rigidly joined with each other and electrically insulated from each other for connection to a current source, said rails having respective flange portions extending away from each other, a plurality of arcuate members each having a conductor portion of substantially horseshoe-shaped axial elevation and two end portions, said conductor portions of said respective arcuate members having different dimensions including different arcuate widths so that said two end portions of different respective arcuate members are differently spaced from each other, said two flange portions of said respective rails having respective seating surfaces each having a plurality of mutually adjacent seat areas engageable with the end portions of arcuate members of respectively different widths, whereby said different arcuate members are selectively joinable with said base member and to form together with said base member an inductive loop around the work-piece axis, said loop having a loop opening of larger size than the work-piece cross section to be treated and of a shape departing from a circle.

3. An inductor device for heat treating work pieces, in particular crank shafts, comprising an inductor base member having two serially adjacent conductive rails rigidly joined with each other and electrically insulated from each other for connection to a current source, an arcuate member exchangeably secured to said base member and having two flange portions and two substantially horseshoe-shaped heating conductors, said conductors being mutually spaced and extending parallel to each other between said two flange portions, said flange portions being in face-to-face engagement with said respective rails and said arcuate member forming together with said rails a loop around the work-piece axis when the device is in operation.

4. In a device according to claim 1, said two rails having respective current supply buses integral with said two parallel legs respectively, and said two other legs having different respective lengths so that said two supply buses lie out of center relation to said surface.

5. An inductor device for the heat treating of crankshafts and similar axially elongated work pieces, comprising an inductor base structure having two metal rails with respective electric terminal means for connection to a current source, said rails being insulatingly and rigidly joined with each other and extending in opposite directions away from their junction, said rails having respective longitudinal surfaces extending in said respective directions and forming each a continuation of the other, an arcuate conductor member removably mounted on said base and electrically interconnecting said rails, said member having transversely to said surfaces a larger width than said base structure and comprising a middle portion of partly semi-circular shape adapted to straddle the work piece and two end flanges integral with said middle portion, said flanges being seated on said respective surfaces on both sides respectively of said junction, said member forming together with the portion of said base structure between said two flanges a closed inductive loop within an elevation plane longitudinal of said rails and perpendicular to said surfaces so as to be capable of peripherally surrounding the work piece relative to a radial plane thereof, and said loop having an inner opening larger than the largest work-piece cross section to be treated and of a shape departing from a circle.

6. In a device according to claim 5, said rails having curved shape and forming together a substantially concave surface at the side of the work piece to be treated, and said arcuate member being curved away from said surface.

7. In a device according to claim 5, said rails having arcuate shape and forming together a substantially concave surface at the side of the work piece to be treated, said rail portions having stepped grooves disposed at said surface, and said arcuate member being engageable with said grooves of said respective rail portions.

8. In a device according to claim 5, said middle portion of said arcuate member consisting essentially of a single conductor having in a direction transverse to said surfaces a thickness smaller than the width of said member, said conductor extending from one transversal side of one of said end flanges to the opposite side of said other end flange.

9. An inductor device according to claim 2, comprising roller means engageable with the work piece to guide it for revolution during heating, part of said roller means being mounted on said base member, and part of said roller means being mounted on each of said arcuate members.

10. In a device according to claim 5, said two rail surfaces extending at an obtuse angle to each other, and said arcuate member being curved away from the point of said angle.

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