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PROCESS OF HEATING OPPOSED METAL PARTS BY COMBINED  
INDUCED AND CONDUCTED ELECTRIC CURRENTS  
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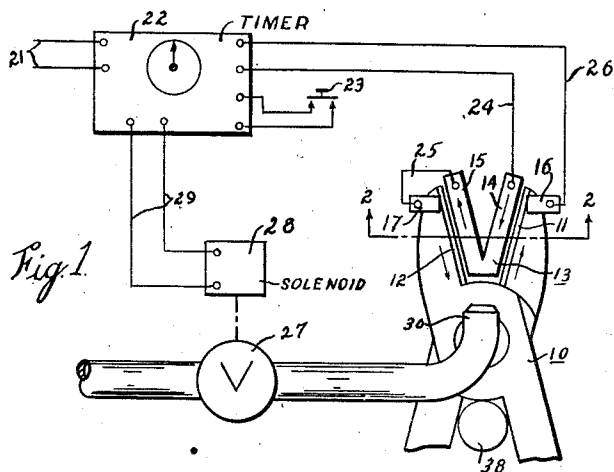


Fig. 1

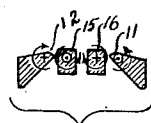


Fig. 2

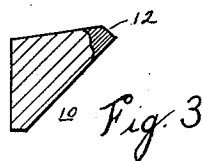


Fig. 3

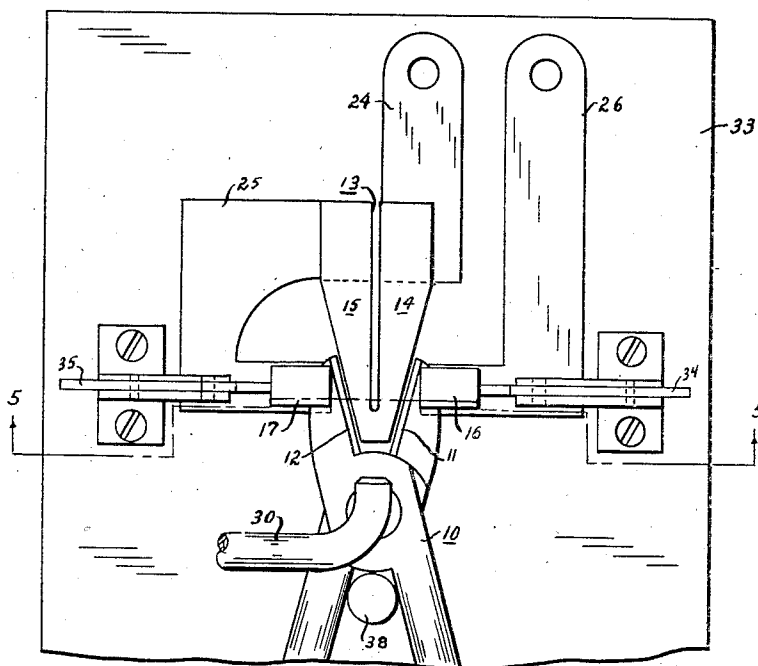


Fig. 4

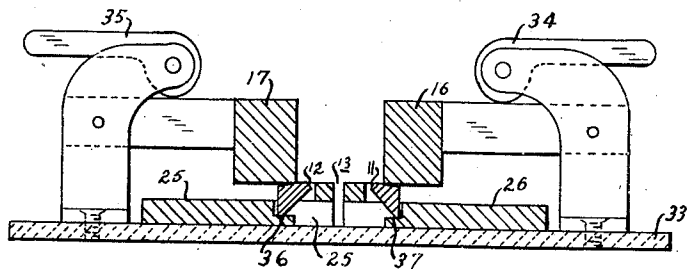


Fig. 5

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## UNITED STATES PATENT OFFICE

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## PROCESS OF HEATING OPPOSED METAL PARTS BY COMBINED INDUCED AND CONDUCTED ELECTRIC CURRENTS

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2 Claims. (Cl. 219—11)

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My invention relates in general to a process for heating the cutting edges of tools and other metal parts preparatory to hardening the same.

My invention is particularly adapted for heating the opposed cutting edges of cutting pliers and other related hand tools. Inasmuch as the opposed cutting edges of a pair of pliers are always opposed to each other, it is difficult to heat the cutting edges without heating all of the metal adjacent thereto.

An object of my invention is the process of heating only the opposed cutting edges without the heat penetrating the adjacent metal forming the jaws of the tool.

Another object of my invention is the provision of localizing the heating of an object or charge to a particular portion without materially heating the remaining portion of the object or charge.

Another object of my invention is the process of localizing the heating of a portion of an object or charge by passing a high frequency current through an inductor disposed close to the localized portion to inductively heat the localized portion as a secondary of the inductor and at the same time passing a high frequency current bodily through the localized portion in the opposite direction to that in which the current flows in the inductor to limit the depth to which the localized portion is heated.

Another object of my invention is to provide a flux condition which magnetically causes the heating current to flow through but a localized portion of the object or charge being heated and thereby prevent the current from flowing through the remaining portion of the article or charge.

Another object of my invention is the provision of connecting an inductor which is adapted to lie close to an object or charge to be heated in circuit relation with the object or charge to be heated whereby the circuit connection is such that the current which bodily flows through the article or charge is in the opposite direction to that in which the current flows in the inductor.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of an inductor heating device embodying the features of my invention;

Figure 2 is a cross-sectional view taken along the line 2—2 of Figure 1, and showing particularly the current and flux relationship existing

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between the inductor and the cutting edges of the cutting pliers;

Figure 3 is an enlarged view showing the depth to which the cutting edge of the cutting plier is hardened;

Figure 4 is a plan view of the inductor heating device shown in relation to a pair of cutting pliers; and

Figure 5 is a view taken along the line 5—5 of Figure 4.

With reference to Figure 1, my invention is shown as being applied to the process of hardening the cutting edges of a pair of cutting pliers indicated by the reference character 10. As shown, the pair of pliers 10 have opposing cutting edges 11 and 12 which are adapted to be hardened by my process. Between the opposed cutting edges 11 and 12 I provide an inductor 13 having two side legs 14 and 15 which form substantially a V-shaped construction. The tips of the cutting edges 11 and 12, respectively, are engaged by pressure contact clamps 16 and 17. In my invention, I provide for connecting the inductor 13 and the cutting edges 11 and 12 in circuit relation with a source of high frequency current indicated by the reference character 21. The high frequency current flows through a timer 22 which is initiated in operation by depressing a start push button 23. Upon operation of the timer 22, high frequency current flows through a conductor 24 to the inductor leg 14 whereupon the current flows down the inductor leg 14 as indicated by the arrow and then up the inductor leg 15 as indicated by the arrow. The current upon leaving the inductor leg 15 flows through a conductor 25 to the pressure contact clamp 17, whereupon the current flows down the cutting edge 12 as indicated by the arrow and then up the cutting edge 11 as indicated by the arrow to the pressure contact clamp 16, and thence through a conductor 26 back to the timer 22. The current flow through the inductor 13 and through the cutting edges 11 and 12 of the tool heats the cutting edges and after a predetermined length of time the heating circuit is deenergized by the operation of the timer 22. Substantially immediately upon the de-energization of the heating circuit the timer 22 provides for energizing a solenoid 28 for operating a valve 27 for squirting water or other coolant to quench the tool. The solenoid 28 may be energized by a pair of conductors 29 governed by the timer 22. Upon energization of the solenoid, water or other coolant flows through the valve 26 and through the spray jet 30 for directing the water or other coolant upon the cutting edges

of the tool. The spray jet remains in operation for a predetermined length of time after which the valve 27 is again closed upon operation of the solenoid 28 which is governed by the timer 22. After quenching of the tool, the tool may be removed from the heating circuit and a new tool inserted for hardening of the cutting edges.

The inductor 13 functions as a primary for establishing flux to inductively heat the cutting edges as a secondary of the inductor. It is noted in Figure 1 that the direction of the current flow in the cutting edges of the tool is in the opposite direction to that in which the current flows in the inductor legs. The Figure 2 shows the relationship of the flux created by the current flowing in the inductor leg and the current flowing in the cutting edges and it is noted that the relationship of the flux is such as to force the current toward the cutting edges of the tool and away from the main body portion of the jaws of the tool. The current which bodily flows through the cutting edges keeps the current from flowing in a skin effect manner completely around the jaws of the tool. The illustration in Figure 3 shows the hardness pattern of a cross-section of one of the jaws of the tool, and it is noted that the hardness is limited to the region of the cutting edges and does not extend in a skin effect manner around the entire peripheral marginal edge of the cross-section of the jaw. Accordingly, my invention provides for localized hardening of the cutting edges with the remaining part of the jaws substantially unaffected by the heating operation, with the result that the major portion of the jaws is tough and strong and will not crack as might be the case if the entire jaw were heated during the process of hardening the cutting edges.

As shown in Figures 4 and 5, the inductor 13 may be mounted upon an insulated base 33 whereby the tool may lie upon the base as the tips of the cutting edges are clamped by the pressure contact clamps 16 and 17. Any suitable means may be employed to press the pressure contact clamps 16 and 17 against the cutting tips of the tool and as illustrated I provide actuating cams 34 and 35, respectively, which when turned provide for firmly pressing the pressure contact clamps against the cutting tips of the tool. In Figures 4 and 5, which represent an actual construction of the inductor heating fixture, the conductor 25 is in the form of a connecting strap and is provided with a stepped shoulder 36 against which the cutting tip of the cutting edge 12 rests as it is clamped by the pressure contact clamp 17. The conductor 26 is also in the form of a strap and it is provided with a stepped shoulder 37 against which the cutting tip of the cutting edge 11 is pressed by the pressure contact clamp 16. The conductor 24 is likewise in the form of a strap with the lower end thereof suitably connected to the inductor leg 14. The upper ends of the conductor straps 24 and 26 are provided with openings for making attachment with the timer 22. The upper end of the inductor leg 15 and the conductor strap 25 are suitably connected together. A locating pin 38 is fastened to the insulated base 33 for aiding in positioning the tool with respect to the inductor legs 14 and 15. In placing the tool on the insulated base in preparation for heating operation, the handles of the tool straddle the locating pin 38 with the open jaws spaced whereby the cutting edges lie close to the inductor legs. The locating pin 38 provides a

guide to keep the clearance between the cutting edges and the inductor legs substantially the same for each tool that is inserted in the fixture for heating purposes.

For purposes of clarity, no means is shown for cooling the inductor 13 and the strap conductors, but it is clearly understood that any suitable means may be employed such, for example, as cooling tubes mounted in heat conducting relationship with the current carrying parts. Another alternative would be to construct the current carrying parts out of tubular members through which a coolant may be circulated.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

#### What is claimed is:

1. In the process of hardening the opposed surface portions of a device, said surface portions being composed of metal hardenable by heating and quenching, each surface portion having a first end and a second end, said device having movable joint means for connecting the second ends of the surface portions together with a metal-to-metal connection, said surface portions facing each other, the process of heating said opposed surface portions comprising, providing an inductor having leg portions with each leg portion having a first and a second end with the second ends connected together, operating the movable joint means to space the first ends of the surface portions from each other, closely aligning each surface portion to a respective leg portion of the inductor, connecting the first end of one leg portion to the first end of one surface portion thereby connecting the leg portions in series with the surface portions, connecting the first end of the other leg portion and the first end of the other surface portion respectively to a source of high frequency current, passing a high frequency current in series through the surface portions and the leg portions for heating the surface portions to hardening temperature, the current flowing in a surface portion being opposite in direction to the current flowing in the closely adjacent leg portion, the current flowing from the first end to the second end in one surface portion and from the second end to the first end in the other surface portion.

2. In the process of hardening the opposed surface portions of pliers, said surface portions being composed of metal hardenable by heating and quenching, each surface portion having a first end and a second end, said pliers having pivotal joint means for connecting the second ends of the surface portions together with a metal-to-metal connection, said surface portions facing each other, the process of heating said opposed surface portions comprising, providing an inductor having leg portions with each leg portion having a first and a second end with the second ends connected together, pivotally opening the pivotal joint means to space the first ends of the surface portions from each other, closely aligning each surface portion to a respective leg portion of the inductor, connecting the first end of one leg portion to the first end of one surface portion thereby connecting the leg portions in series with surface portions, con-

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necting the first end of the other leg portion and the first end of the other surface portion respectively to a source of high frequency current, passing a high frequency current in series through the surface portions and the leg portions for heating the surface portions to hardening temperature, the current flowing in a surface portion being opposite in direction to the current flowing in the closely adjacent leg portion, the current flowing from the first end to the second end in one surface portion and from the second end to the first end in the other surface portion.

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