HIGH FREQUENCY INDUCTOR FOR SMALL DIAMETER HOLES

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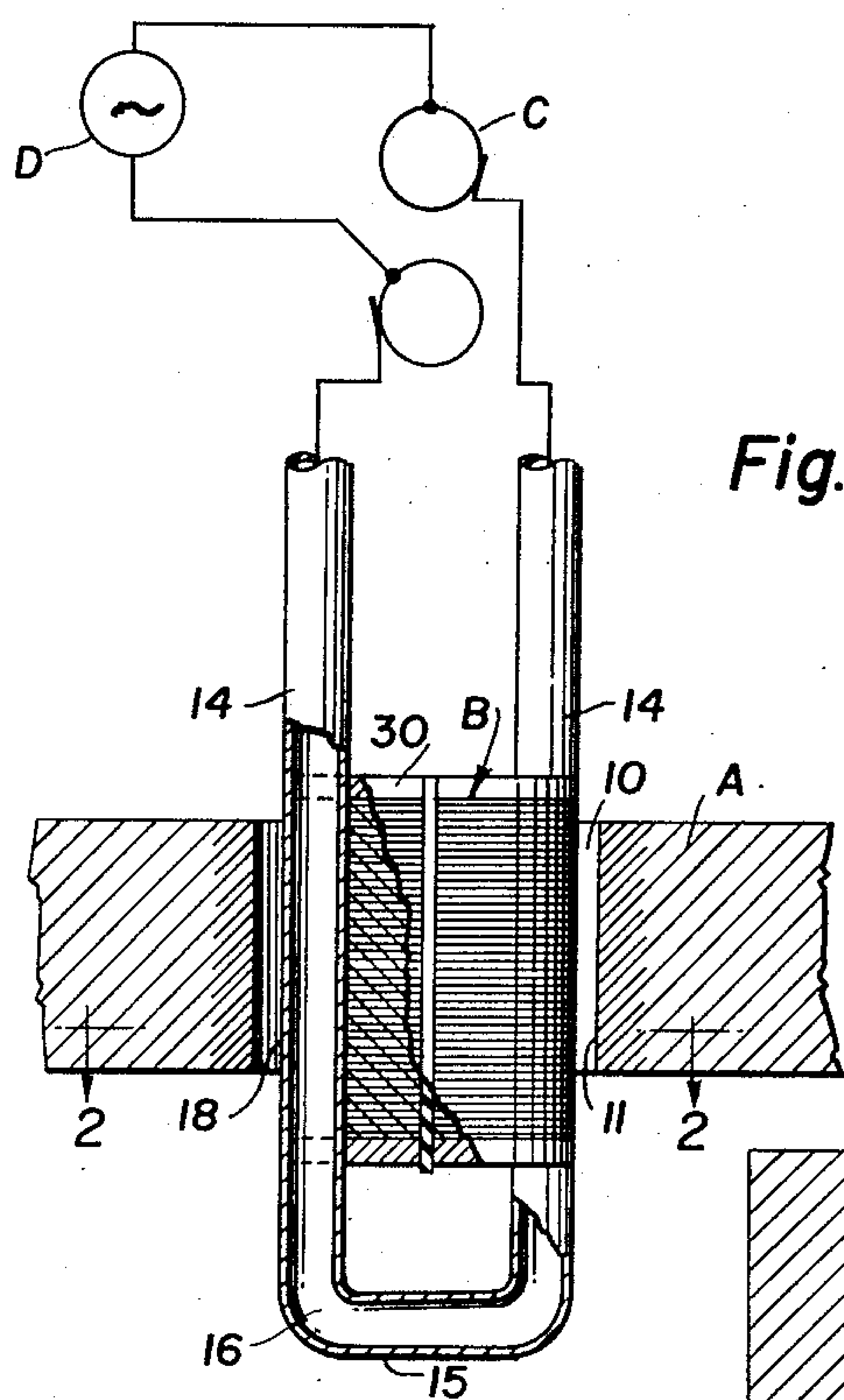


Fig. 1

Fig. 2

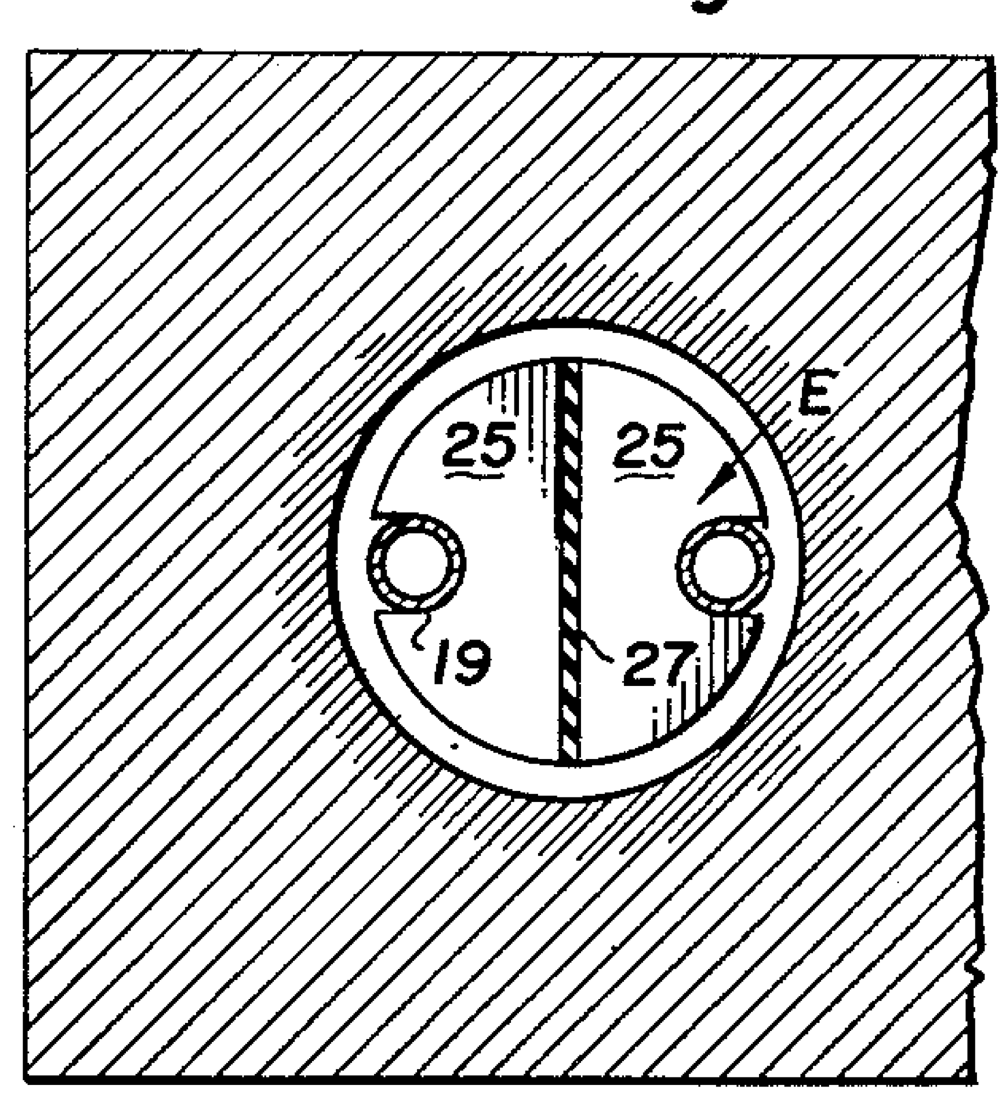
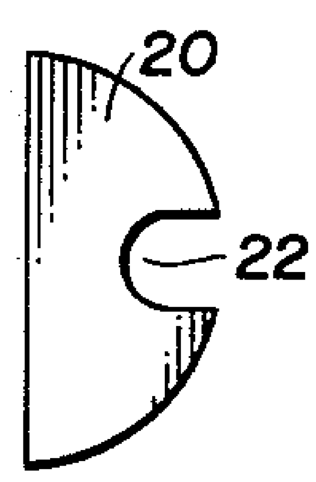


Fig. 3



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HIGH FREQUENCY INDUCTOR FOR SMALL DIAMETER HOLES

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This invention pertains to the art of high frequency induction heating and more particularly to an inductor for heating the surfaces of small diameter holes.

In the art of high frequency induction heating, difficulty has always been experienced in heating small diameter holes or openings. Heretofore it has been conventional to position an inductor in the hole having an external surface and current path concentric with the hole surface. As the hole gets smaller and smaller, however, the dimensions of the conductor forming the inductor becomes very appreciable in relation to the hole size and the heating becomes more and more difficult. Eventually a dimension is reached wherein no heating can be accomplished.

The present invention contemplates a high frequency inductor which overcomes these difficulties and successfully heats small diameter holes for various heat treating purposes.

In accordance with the invention, there is provided a high frequency inductor for heating the surfaces of holes, openings or bores in metallic workpieces comprising a pair of parallel extending spaced conductor legs, the remote surfaces of which are workpiece facing surfaces, and magnetically permeable material of a generally circular cross-section and diameter generally equal to the spacing of said surfaces, disposed between and encompassing the surfaces of the legs other than the workpiece facing surfaces. Means are provided for relatively rotating such inductor and the workpiece about the axis of the hole when the inductor is disposed in such hole.

The magnetically permeable material may be either of the powdered or laminated type. In the latter event, each lamination is generally in the shape of a semicircle with each semicircle being associated with one of the legs, and opposed semicircles being electrically insulated from each other.

The principal object of the invention is the provision of a new and improved high frequency inductor which will readily and efficiently heat small diameter holes, openings or bores.

Another object of the invention is the provision of a new and improved high frequency inductor comprised of a pair of parallel extending legs and magnetically permeable material disposed between the legs which will assist in the heating operation.

The invention may take physical form in a number of different appearing parts and arrangements of parts, a preferred embodiment of which will be described in this specification and illustrated in the accompanying drawing which is a part hereof and wherein:

Figure 1 is a side elevational view, partly in sections, of a high frequency inductor embodying the present invention in operative relationship in the hole of a workpiece.

Figure 2 is a cross-sectional view of Figure 1 taken approximately in the line 2—2 thereof.

Figure 3 is a top elevational view of a lamination employed in the preferred embodiment.

Referring now to the drawing wherein the showings are for the purposes of illustrating the invention only and not for the purposes of limiting same, Figure 1 shows a metallic workpiece A of substantial thickness having a hole **10**, the surfaces **11** of which are to be heated.

Disposed within the hole **10** is a high frequency inductor B connected through suitable rotating contacts C to a high frequency power source shown schematically at D.

The inductor B is comprised of a hairpin shaped conductor including a pair of spaced parallel extending legs **14** of electrically conductive material electrically connected at the lower ends by a base **15**. As shown, the conductors **14** and **15** have a hollow interior **16** through which a cooling medium such as water or the like may be flowed as is conventional in the high frequency induction heating art.

The legs **14** have remote surfaces **18** which form the workpiece facing surfaces of the inductor B. As shown, the legs **14**, **15** are so spaced as to position the surfaces **18** in close spaced relationship with the surfaces **11** of the hole **10**. The closer the spacing, the greater the electrical coupling to the workpiece A but such spacing must be limited in relation to the necessity that the indicator B should not touch the workpiece A during a heating operation, and this is so particularly in view of the fact that the inductor B will be rotated within the hole **10** during the heating operation.

The legs **14** and **15** may be of any desired electrically conductive material, copper being preferred.

Magnetically permeable material indicated generally at E is disposed between the legs **14** and has a generally circular cross-sectional shape such as to substantially fill the opening **10** and to partially surround the surfaces **19** of the legs **14** other than the workpiece facing surfaces **18**.

The magnetically permeable material may generally be of any desired magnetically permeable material but, as between the two legs **14**, must present either a high degree of electrical resistance or other means must be provided to provide electrical insulation between the two legs **14**.

The magnetically permeable material E in the preferred embodiment of the invention is comprised of a pair of stacks **25** of thin magnetic laminations **20**, each stack having a generally semi-circular cross section substantially as is shown in Figure 3. Centrally of the curved outer surface, a circular notch **22** is provided through which the legs **14** extend. It will be noted that in effect the magnetically permeable material surrounds the surfaces **19** of the legs **14** and is in close contact therewith.

The outer diameter of the laminations **20** is such as to substantially fill the diameter of the opening **10** while allowing sufficient mechanical clearance to permit rotation of the inductor B during a heating operation.

A sheet of electrical insulation **27** is positioned between the two stacks of the laminations. This sheet **27** should be kept as thin as possible so that the maximum amount of magnetic material may be disposed between the legs **14**. The laminations **20** are each made of as thin a magnetic material as is available and each lamination should be suitably varnished before assembling into the stack shown, to provide electrical insulation between laminations and reduce eddy currents.

At the end of the stack of laminations **20** is a similarly shaped lamination **30** of copper which is brazed to the the legs **14**. The copper lamination **30** serves to hold the magnetic laminations **20** in assembled relationship, and also to assist in cooling the lamination by conducting heat generated in the laminations to the water cooled legs **14**.

It will be noted that the axial length of the magnetically permeable material E is somewhat greater than the axial length of the hole **10**, that is to say, the thickness of the workpiece A.

In operation, the inductor B is positioned within the hole **10** as shown in Figure 1. The inductor is rotated by any suitable means not shown and at any desired rotational speed. High frequency currents are fed to the inductor from the power source D through the rotatable contact C. These high frequency currents create a magnetic flux field which induces high frequency currents to flow in the surface **11** of the hole **10**. These high frequency currents cause the surface **11** of the hole **10** to rapidly heat. When the heating operation has been completed, surfaces of the hole **11** may be quenched if desired or allowed to cool slowly, depending upon the characteristics desired for the surface of the hole **10**. The inductor B may be removed either before, during, or after this subsequent cooling treatment.

The present inductor has proven extremely satisfactory in heating small diameter holes in relatively long diameter openings which could not otherwise be heated by any known high frequency inducing coils. It has proven extremely practicable and durable in practice and relatively efficient electrically.

It will be appreciated that modifications and alterations of the invention will occur to others upon a reading and understanding of this specification, and it is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims.

Having thus described my invention, I claim:

1. A high frequency inductor for use in heating small diameter holes in metallic workpieces comprising in combination a U-shaped conductor having a pair of spaced parallel extending legs, the outer or remote surfaces of which form workpiece facing surfaces and are spaced to a distance approximately the diameter of the hole to be heated, said conductor having a portion electrically interconnecting the ends of said legs into a series circuit therewith, and a stack of magnetically permeable laminations having their plane perpendicular to the length of said legs and spaced from said portion and disposed between said legs, and means electrically insulating one leg from the other.

2. A high frequency inductor for use in heating small diameter holes in metallic workpieces comprising in combination a hairpin shaped conductor having a pair of spaced parallel extending legs, said conductor having a portion electrically interconnecting the ends of said legs, a stack of laminations of a diameter approximating the diameter of the hole to be heated, comprised of two semi-circular stacks one positioned along each leg and spaced from said portion with a layer of electrical insulation therebetween, said laminations having their plane perpendicular to the length of said legs, each stack having a notch along its outer edge to receive its respective leg.

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