June 27, 1950 H. GRUMEL 2,512,718

HIGH-FREQUENCY SURFACE HARDENING

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Fig. 1

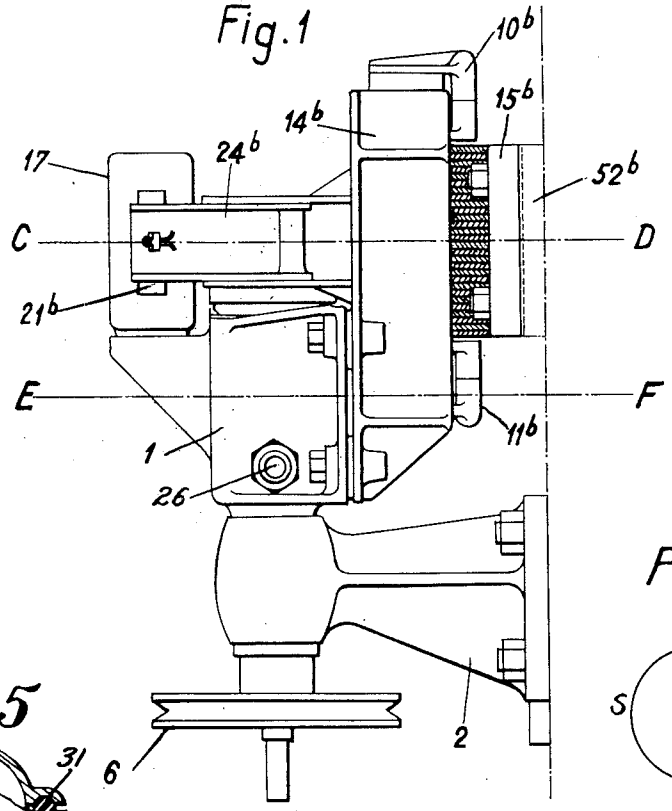

Fig. 5

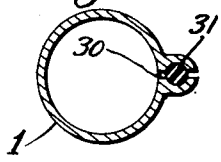

Fig. 6

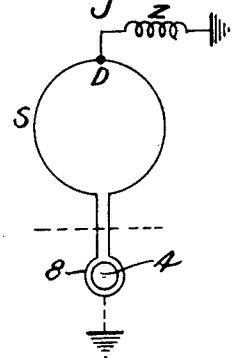

Fig. 2

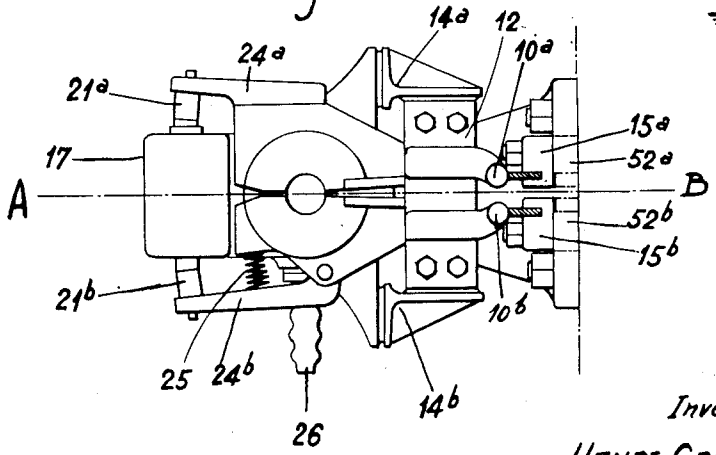

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Fig. 3

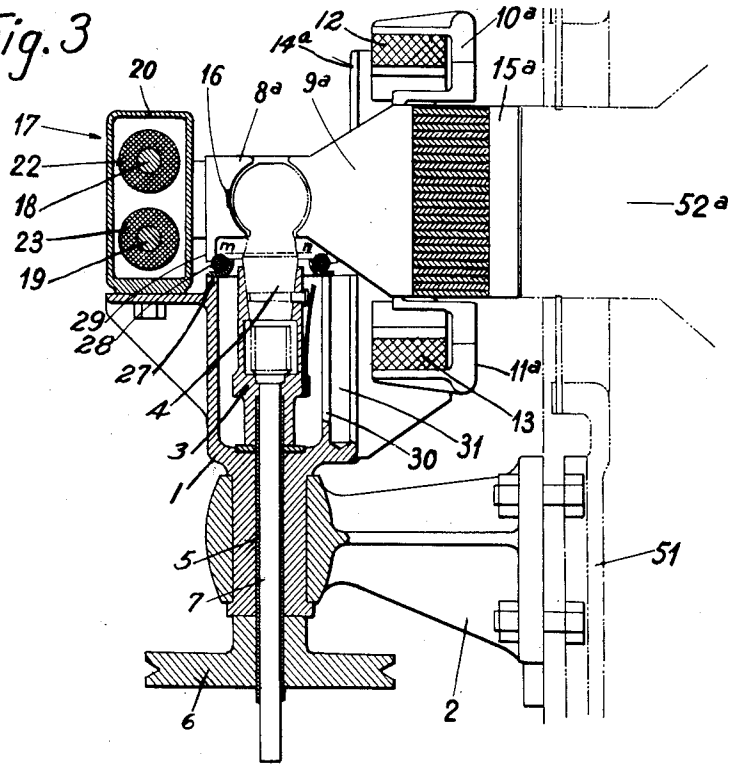


Fig. 4

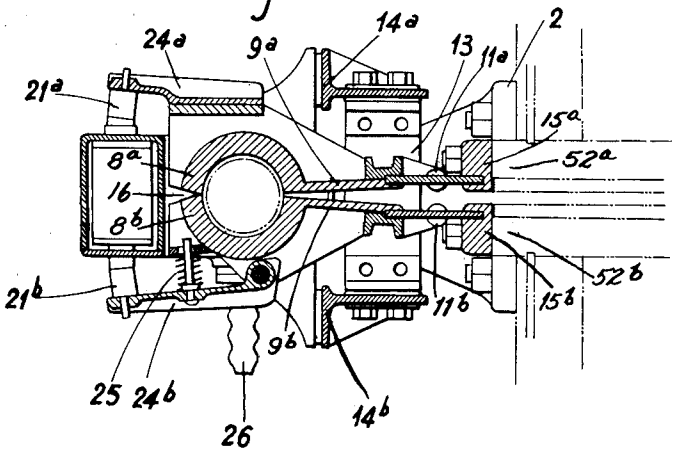
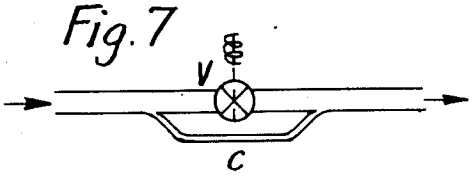


Fig. 7



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HIGH-FREQUENCY SURFACE HARDENING

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7 Claims. (Cl. 219—47)

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This invention relates to new and useful improvements in apparatus for high frequency induction surface hardening and more particularly for the mass production surface hardening of articles of small dimensions.

Objects and advantages of the invention will be set forth in part hereinafter and will in part be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the instrumentalities and combinations set out in the appended claims.

The invention consists in the novel parts, constructions, arrangements and combinations herein described and shown.

The annexed drawings, referred to herein and constituting a part hereof, illustrate an embodiment of the invention and, with the description, serve to explain the principles thereof.

In said drawings:

Figure 1 is a side elevation of the apparatus embodying the invention;

Figure 2 is a plan view;

Figure 3 is a sectional elevation on the line A—B of Figure 2 showing the apparatus mounted on a high frequency generator of the type above referred to;

Figure 4 is a sectional plan taken on line C—D of Figure 1;

Figure 5 is a detail section of the casing taken on line E—F of Figure 1;

Figure 6 is a diagram of the high frequency electric circuit; and

Figure 7 is a diagram of part of the quenching fluid circuit.

Surface hardening of articles of small dimension by induction, in the case of mass production, must be carried out, by reason of the capacity of production of the plant, at an extremely rapid rate, often much higher than the needs of the producer. Thus, in order to permit of a rational utilisation of the generators supplying the high frequency, it is necessary to operate on various different kinds of articles in alternate series.

It is an object of the invention, in order to reduce loss of time in changing from one kind of article to another, to provide tools adapted to the treatment of each of such articles and capable of being very rapidly mounted on the generator and without delicate mechanical adjustments being necessary.

To this end, according to the invention, there is provided for each type of article to be treated, a detachable monobloc or single piece mounting device comprising a support on which are directly mounted the heating inductor, the liquid spraying devices for surface hardening and possibly the mechanism for producing movement of the articles during the various stages of treatment, arrangements being provided to permit the convenient attachment of the fitment on the generator as well as the ready attachment of the electric connections, water pipes, and mechanical drive connections between the detachably mounted fitment and the elements which are permanently fixed on the generator.

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The high frequency generator described in the French Patent filed on December 1, 1942, for "Valve installation for the thermal treatment of metals by high frequency" is particularly adapted to supply such assemblies.

The embodiment of the single piece fitment thus defined may be very varied, depending on the shape of the article to be hardened. By way of non-restrictive example, there will now be described a fitment suitable for the heat treatment of articles of revolution of which the length of the part to be treated is not greater than the diameter, the article shown in the case of this example being a swivel joint.

Referring now specifically to the embodiment of the invention illustrated in the drawings and as specifically shown in Figures 1 to 4, 1 is a cylindrical casing forming the body of the apparatus, said casing being detachably fixed on the front plate 51 of a high frequency generator through the intermediary of a bracket 2. Within the casing there is arranged a mandrel 3 by which the article 4 to be treated is supported. The mandrel is mounted on a hollow shaft 5 adapted to be driven from any convenient source through a pulley wheel 6 or a corresponding sprocket wheel. This arrangement provides for rotation of the article during treatment in order that the profile of the part to be tempered may be accurately determined.

A rod 7 axially slidable within the interior of the hollow shaft 5 is provided to facilitate the removal of the articles after treatment.

The shape of the article to be heat treated as here shown makes it necessary to employ an inductor which opens to permit insertion and removal of the article. Accordingly, the inductor is formed of two semi-cylindrical members or half-shells 8a and 8b respectively carried by current supply arms 9a and 9b which are supported by pairs of upper and lower pivots 10a, 11a and 10b, 11b respectively. These pivots are carried by insulating transverse bars 12 and 13 which are in turn supported by uprights 14a and 14b rigid with the casing 1.

The electrical connection of the arms 9a and

9b to the fixed terminals 52a and 52b of the high frequency generator is effected by flexible conductors brazed at one end to the arms and at the other end to terminals 15a and 15b which are shown as being adjustably secured to the fixed terminals 52a, 52b by bolts.

With the use of an inductor of the kind described it is necessary to provide for electrical contact between the semi-cylindrical members or jaws 8a, 8b. It is very difficult, if not impossible, to provide a good contact over the whole height of the inductor. Consequently, a pair of silver contact points or pips 16 are provided on said jaws intermediate the upper and lower edges thereof, as shown in Figures 3 and 4, this arrangement permitting accurate closing of the electrical circuit and strictly identical operating conditions at all times. As with this arrangement the density of the current, however, is greatly increased in the central zone of the inductor, which might cause over-heating in the central part of the article being treated, the current supply arms 9a and 9b are of trapezoidal or equivalent form and constructed in such manner that at the point of attachment to the conductor, the current density is, on the contrary, much greater at the top and at the bottom than towards the centre. This condition, as will be easily understood, arises from the characteristic transmission of high frequency currents in conductors tending to become concentrated at surfaces and edges. This effect as produced in the arrangement of the invention can thus be compensated in conjunction with the rotation of the article during the treatment, which ensures heating over the whole of the surface being treated.

The two inductor jaws 8a and 8b are kept in contact, during the operations of heating and tempering, by a magnetic device generally indicated at 17. The magnetic circuit of this device is constituted by two cores 18 and 19 rigidly fixed on a casing 20 of non-magnetic metal and integral with the central case 1, and by two yokes 21a and 21b respectively integral with the jaws 8a and 8b of the inductors. The casing 20, in addition to supporting the cores, protects the coils 22 and 23 from the jets of water during the hardening operation.

The yokes 21a and 21b are fixed on arms 24a and 24b by means of hinged joints allowing them to align with the ends of the cores 18 and 19. The arm 24a is rigid with with the member 8a, which thus determines the correct closing position thereof. The arm 24b, however, is hingedly connected to the member 8b and controls the movement of said member to and from the closed position through a spring 25 which regulates the pressure at the contacts 16.

It will be seen from Figure 6 that the secondary S of the high frequency transformer supplying the heating inductor has its central point O connected to earth through an impedance Z the value of which is fairly considerable as compared with that of the secondary circuit. This impedance serves to determine the potential of the current with respect to earth when the heating inductor is not earthed; it is of sufficient value to ensure that if, on the contrary, it should be advantageous to earth the central point of the inductor, the circulation current which may result from lack of electrical symmetry in the system is of negligible value. This arrangement is employed in the construction here shown and described, no insulation being therefore necessary between the inductor member 8a, 8b and the control magnetic device 17. In this way, the central point of the inductor is earthed without inconvenience through the intermediary of the device 17 when the inductor is closed.

The hardening liquid is admitted to the casing 1 through a nozzle 26, whence it passes from the top to the bottom between the inductor members 8a and 8b and the part of the article 4 being treated. To ensure a good hydraulic joint between the inductor shells and the casing 1 the latter terminates in a metallic collar 27 in which there is provided a rubber ring 28 of circular cross-section. The inductor parts each have a projecting rim or lip 29 which engages this ring when the inductors are in the working position.

In order that when the heating operation ceases, a very rapid delivery of water is provided to the part being treated, the casing 1 is kept permanently full of water. To this end, an electrically operated valve V which controls the supply of water is by-passed, as shown in Figure 7, by a small gauge pipe C through which there continuously passes a stream of water to compensate for leakage. The water is thus maintained in the casing 1 to the level m—n, being the level of an over-flow port in the casing. In the normal delivery of hardening water, the leakage represented by this hole and by that of the gap between the inductor jaws, is absolutely negligible.

It will be noticed that in order to avoid induced circulation currents in the casing 1, the latter is split at 30 from the top to the bottom. A rubber joint 31 (see also Figure 5) ensures that this slit is tightly closed against the passage of water. Figure 5 giving a section of the casing, clearly shows this arangement.

It is to be understood that the foregoing description of an embodiment of apparatus according to this invention is purely exemplary thereof and numerous modifications may be made therein without departing from the spirit of the invention.

I claim:

1. In a high frequency induction current heating apparatus, an inductor composed of two solid half-shells similar and oppositely disposed separated by a small interval and together forming a cavity capable of receiving the piece to be heated, a contact in the form of a plug with a small predetermined surface being fixed between the edges of the half-shells at a mid-height of said half-shells, lead-in arms for high frequency current connected to said half-shells at the edges thereof opposite to those which have the aforesaid contact, said arm being of a substantially trapezoidal form and constructed and arranged so as to obtain a stronger current density toward the top and bottom of said shells than toward their mid-portion, means enabling the two half-shells to be firmly secured to each other in the zone of their contact, means enabling the separation of the two half-shells from each other or to be brought together in their normal working position, a support for holding the piece to be heated in the cavity of the inductor so that the axis of the piece and of the inductor coincide, and means for causing the said piece to rotate about said axis.

2. Heating apparatus according to claim 1, wherein the means for securing the half-shells opposite each other comprises an electromagnet and a compression spring.

3. Heating apparatus according to claim 1, wherein the means enabling the separation of the two half-shells or of bringing them together at

their normal working position comprises a pivoted support.

4. In an apparatus for heat treating small pieces by high frequency induction currents and having a generator and a transformer secondary, the combination of a heating unit having an attached supporting frame readily detachable from said generator and means thereon rotatable about an axis and carrying the piece to be heated, said heating unit comprising two opposed jaws carrying respective parts of an inductor and having in their opposed faces hollowed-out surfaces producing therebetween a substantially spherical cavity, and having upper and lower edges in planes normal to said axis, supporting and current supply means for said inductor comprising current-carrying arms, said arms at one end connected to said jaw and inductor parts respectively and at the other end mounted on pivots respectively extending substantially parallel to said axis, said arms having a progressively increasing dimension parallel to said axis from their ends joining the jaws to their pivots, said jaws having a pair of contact studs electrically connecting the same when in closed position at a point opposite to the pivoted ends of the jaws and in a plane perpendicular to said axis and medial of the jaws, means for clamping the jaws together, and means for rotating said piece whereby during heating and rotation the tendency of the heating currents due to said edges and said dimension to follow lines causing unequal density distribution is compensated.

5. In an apparatus for heat treating small pieces by high frequency induction currents and having a generator and a transformer secondary, the combination of a heating unit having an attached supporting frame readily detachable from said generator and means thereon rotatable about an axis and carrying the piece to be heated, said heating unit comprising two opposed jaws carrying respective parts of an inductor and having faces with shapes adapted to the form of the element to be heated, and having upper and lower edges in planes normal to said axis, supporting and current supply means for said inductor comprising current carrying arms, said arms at one end connected to said jaw and inductor parts respectively and at the other end mounted on pivots respectively extending substantially parallel to said axis, said arm having a progressively increasing dimension parallel to said axis from their ends joining the jaws to their pivots, said jaws having a pair of contact studs electrically connecting the same when in closed position at a point opposite to the pivoted ends of the jaws and in a plane perpendicular to said axis and medial of the jaws, means for clamping the jaws together, and means for rotating said piece whereby during heating and rotation the tendency of the heating currents due to said edges and said dimensions to follow lines causing unequal density distribution is compensated, said combination, including means for determining the potential of the heating current with respect to earth comprising an impedance of high value respecting that of the secondary circuit and connected between the center of the secondary circuit opposite the location of the inductor connection and ground.

6. The combination according to claim 5, in which the means for clamping the jaws together comprises an electromagnet and means for mounting it on said unit support without insulation therebetween and the inductor parts.

7. In an apparatus for heat treating small pieces by high frequency induction currents and having a generator and a transformer secondary, the combination of a heating unit having an attached supporting frame readily detachable from said generator and means thereon rotatable about an axis and carrying the piece to be heated, said heating unit comprising two opposed jaws carrying respective parts of an inductor and having faces with shapes adapted to the form of the element to be heated, and having upper and lower edges in planes normal to said axis, supporting and current supply means for said inductor comprising current carrying arms, said arms at one end connected to said jaw and inductor parts respectively and at the other end mounted on pivots respectively extending substantially parallel to said axis, said arm having a progressively increasing dimension parallel to said axis from their ends joining the jaws to their pivots, said jaws having a pair of contact studs electrically connecting the same when in closed position at a point opposite to the pivoted ends of the jaws and in a plane perpendicular to said axis and medial of the jaws, means for clamping the jaws together, and means for rotating said piece whereby during heating and rotation the tendency of the heating currents due to said edges and said dimensions to follow lines causing unequal density distribution is compensated, said combination, including means to reduce circulation currents arising from lack of electrical symmetry in the system when the jaw control point is grounded, comprising an impedance of high value respecting that of the secondary circuit and connected between the center of the secondary circuit opposite the location of the inductor connection and ground.

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