Aug. 1, 1950 H. GRUMEL 2,517,425

ARRANGEMENT OF ELECTRONIC DISCHARGE TUBE EQUIPMENT FOR THE THERMAL TREATMENT OF METALS BY HIGH-FREQUENCY CURRENTS

Filed Oct. 29, 1945 3 Sheets-Sheet 1

Fig.1

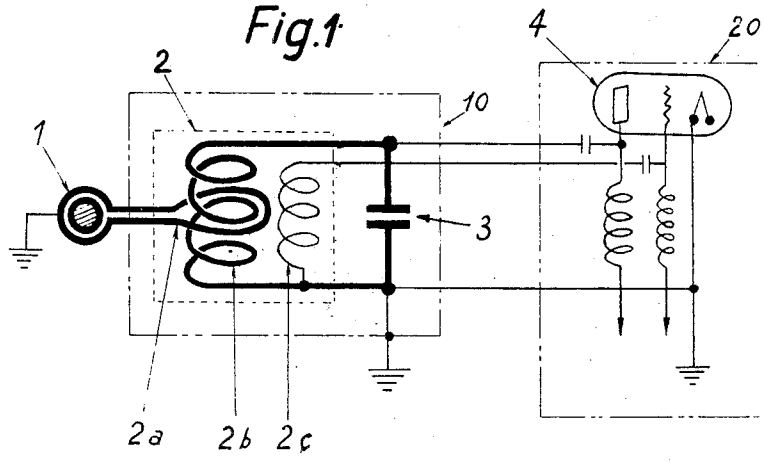
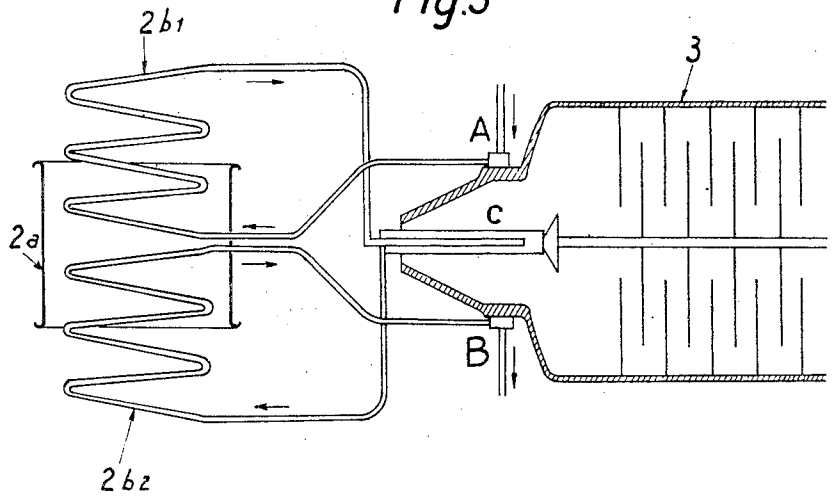


Fig.5



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Fig.2

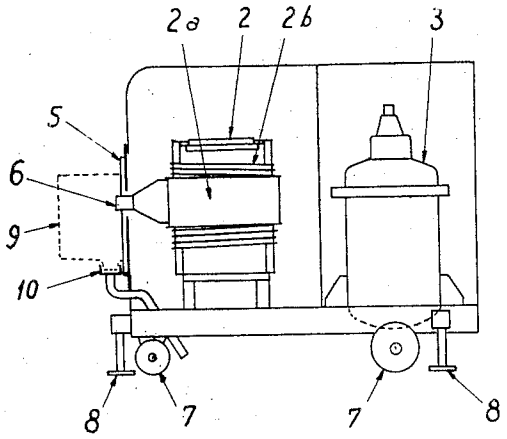


Fig.3

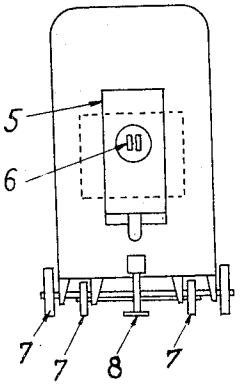
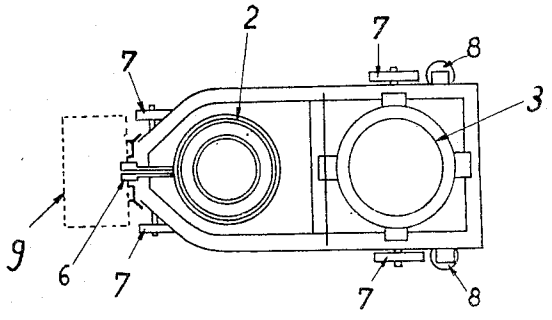


Fig.4



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Fig.6

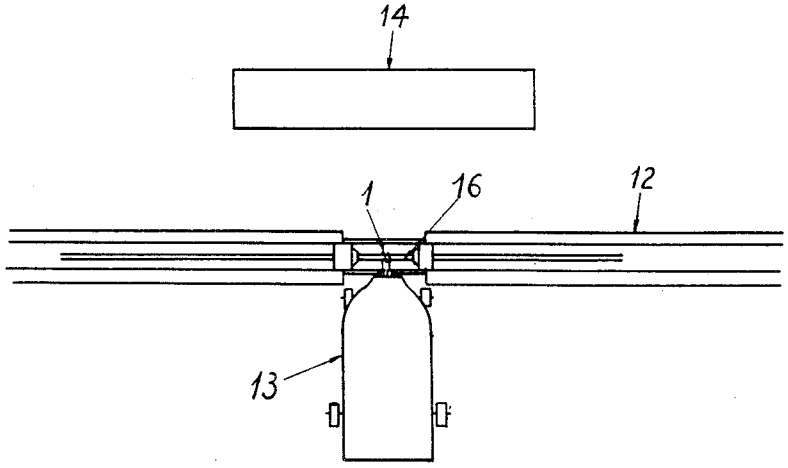
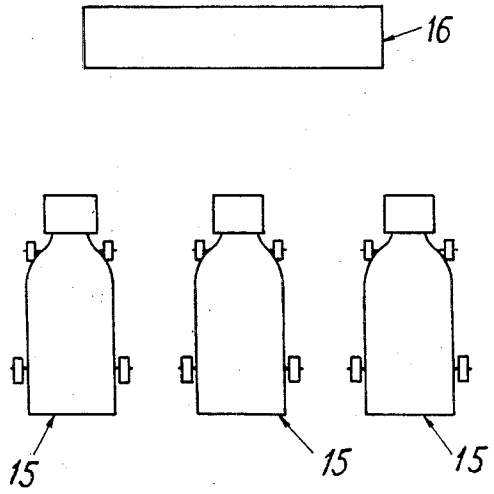


Fig.7



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2,517,425

ARRANGEMENT OF ELECTRONIC DISCHARGE TUBE EQUIPMENT FOR THE THERMAL TREATMENT OF METALS BY HIGH-FREQUENCY CURRENTS

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6 Claims. (Cl. 219—13)

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This invention relates to improved equipment for metallurgical treatments by high frequency currents.

It is known that the heating of a piece of metal by high frequency induction for the purpose of various treatments, such as tempering, welding, surface hardening, etc., is obtained by placing the part to be treated in an inductor or furnace under high frequency, the geometrical form of which depends upon the shape of the said part and of the effect which it is desired to obtain. The inductor coil must be traversed by a high frequency current of such an intensity that the field created is of sufficient magnitude to cause by induction the necessary losses in the piece or portion of a piece treated to attain the desired temperature.

For many reasons of a practical nature, both mechanical as well as electrical, it is advantageous to make heating inductors with a small number of turns and even quite often with a single turn. These inductors therefore have a very small reactance (quite often much less than a microhenry), they will give an actual load resistance also very small (from a tenth to a thousandth of an ohm according to the piece treated and the frequency used) and owing to this must be traversed by currents of very great intensity. The consequence is that in all cases it is necessary and essential to supply such inductors through the intermediary of a reducing transformer. The secondary of the transformer generally comprises only a single turn and must be connected to the inductor by extremely short connections in order to avoid losses due to induction and the Joule effect.

In the case of an electronic discharge tube generator, the primary of the transformer will generally constitute the self-induction of the tank circuit which will mostly be the seat of a very considerable apparent power relative to the useful power, so that the element of the tank circuit must also be grouped close to the piece treated.

If the matter is examined from the practical point of view, it will be observed that it is necessary to place close to the piece to be treated considerable and cumbersome material which may be very inconvenient where the thermal treatment is accompanied by mechanical operations necessitating the employment of equipment which also takes up space. The condition is further complicated by the fact that all the parts of the circuit carrying voltages which are dangerous for the personnel must be enclosed in a protective covering or casing. Finally, where the thermal treatment is interposed in a sequence of manufacturing operations, it is important that if any great damage takes place in the high frequency generator, the replacement of the defective elements can be very rapidly carried out in order that the sequence of operations is stopped for the shortest possible time.

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According to the present invention there is provided an arrangement for the thermal treatment of metal parts by high frequency currents induced in the interior of the part by a heating inductor supplied from a secondary circuit coupled inductively with the self-inductance of the tank circuit of a high frequency generator having electronic tubes wherein the self-inductance and the condenser of the said tank circuit, the reactance coil maintaining the oscillations of the oscillating circuit, the secondary circuit and the heating inductor are combined into the same working unit, whilst the tubes and accessories of the high frequency generator constitute a separate unit capable of being located at a distance from the working unit.

These various desiderata referred to above are satisfied by the arrangement according to the present invention which is characterised by the following points:

(1) The elements which it is indispensable to place in the immediate vicinity of the piece to be treated, that is to say, either the transformer itself or the transformer with the elements of the tank circuit, are arranged in a screened carriage of suitable form.

(2) The tubes supplying the oscillations and their auxiliary circuits are grouped in a receptacle which, at the frequencies generally employed for thermal treatments, may without inconvenience be located at a distance of several meters from the carriage, that is to say, totally independent of the mechanical installation.

The invention will be more particularly described with reference to the accompanying drawings, in which.

Figure 1 illustrates diagrammatically the high frequency circuits of an arrangement constructed according to the present invention.

Figures 2, 3 and 4 illustrate respectively a side and front elevation and a plan view of the carriage with the enclosing panels removed in Figures 2 and 4.

Figure 5 illustrates the manner in which the electric circuits are arranged;

Figure 6 illustrates diagrammatically an in-

stallation for the treatment of articles of considerable length in accordance with the present invention; and

Figure 7 illustrates diagrammatically a tempering installation operable in accordance with the present invention.

Referring to Figure 1 there is illustrated an inductor winding 1 constituting the high frequency furnace, a transformer 2, a secondary winding 2^a, a primary winding 2^b forming the self-inductance of the tank circuit, an auxiliary winding 2^c giving the potential, opposite in phase to the primary potential, necessary to maintain the oscillations, and a tank circuit condenser 3. The above arrangement is enclosed in a screened carriage 10.

A tube 4 operable to maintain the oscillations, is arranged with its auxiliary circuits in a separate receptacle 20.

The high frequency transformer 2 is without core and the condenser 3 of the compressed gas type. The front of the carriage may be equipped with a very rigid mounting panel 5 provided with grooves (in the same way as a milling machine plate for example) which permit the easy and rapid fitting up of the heating inductors and of the manipulating tools. In the centre of the panel 5 the terminals of the secondary of the transformer 2 are indicated by two studs or terminals 6.

From the plan view illustrated in Figure 4 it is easy to see clearly the particular shape of the carriage, the front of which is tapered to leave as free as possible the heating inductor part. The carriage is supported upon rollers 7. Jacks 8 permit the carriage to be immobilised and if necessary to have its height adjusted.

Electric and hydraulic connections between the carriage and the remainder of the installation are made by flexible conduits which are arranged according to circumstances, either above or below the carriage.

When the arrangement is used for tempering, the panel 5 is arranged to support a bath 9 into which the quenching liquid flows. The bath 9 which has no walls on the side of the carriage, is supported by its base resting upon a gutter 10 through which flows the liquid entering the bath. The bath 9 is fixed to the panel 5 by means of hooks, thus enabling it to be instantly removed and facilitating to the maximum the dismounting of the inductors and of the equipment. Lateral tightness of joint is simply obtained by vertical grooves forming baffles.

Certain peculiarities in the arrangement of the electric circuits are illustrated in Figure 5, wherein the primary $2b$ of the transformer is shown as composed of two cylindrical windings $2b_1$ and $2b_2$ arranged coaxially end to end and connected in parallel with the centre point being earthed.

The coil $2b_1$ is arranged right-handed and the coil $2b_2$ is left-handed, so that the fluxes produced are added together. Two principal advantages resulting from this arrangement are:

(1) It is at the centre of the winding, that is to say, in the region of the most intensive field, that the potential is lowest, which permits of a secondary single-turn coil 2^a being arranged at this point. The secondary winding 2^a consists of a longitudinally split copper sleeve connected with the inductor. Its height is less than that of the primary but very close thereto and thus effecting as large a coupling coefficient as possible.

(2) The circuits which are the seat of a considerable apparent current intensity having regard to their dimensions, must be entirely cooled by water circulation including the connections and the terminals. Consequently, the following arrangement is provided. The condenser 3 of the tank circuit 2 is formed with an arrangement of concentric plates (Figure 5) the outer one of which, connected to one condenser electrode, is earthed; the central plates connected to the other condenser electrode are carried to the high potential.

On the other hand, the winding of the primary of the transformer consists of tubes. These tubes are individually extended for each ½ primary up to their connection on the terminal of the condenser. The cooling is then ensured under the following conditions. Water enters at A (consequently at a point which is earthed), it cools the corresponding zone of the outer end of the condenser terminal, runs through one half of the primary, penetrates into the central part C of the terminal which is constituted by two concentric tubes, passes into the other half primary, comes back on the outer part of the terminal of which it cools the corresponding zone and leaves at B, that is to say, at a point which is earthed; thus, no insulation of water piping has to be provided.

Two examples, of particular cases of the installation or employment of the carriage above described, will be given.

(1) A bench for the treatment of articles of considerable length such as rails, tubes, etc. with a view to their surface hardening, welding, hot drawing, etc.

The installation is diagrammatically illustrated in Figure 6. The number 12 represents a manipulating or treating bench; 13 is the screened carriage, and 14 is the receptacle containing the tubes maintaining the oscillations, with their auxiliary circuits; 1 is the heating coil and 16 the piece undergoing treatment.

(2) Tempering installation. It is known that the time of heating a part to be tempered only represents a small portion of the total time necessary for the complete cycle of operations, the remainder of the time being employed in the tempering proper (quenching) and in the manipulations. In order to permit a better employment of the tubes, the wear of which depends essentially upon the total time their filament is alight, it is advantageous to be able to supply alternately several installations therewith. Such an installation is represented in Figure 7, in which there are illustrated a number of screened carriages 15 (three in the example illustrated) and a receptacle 16 containing the tubes. A general automatic switch (not shown) is operable to connect alternately the tubes to each of the carriages. As soon as the heating operation is terminated on one of them, the tubes are automatically connected on to the next succeeding one, whilst the quenching operations and manipulations are finished on the preceding carriages.

The cycle of the operations may be either entirely automatic or semi-automatic and subject to the control of the operator or operators, hence a signalling system is provided to indicate the state of the connection at each instant.

What I claim is:

1. In an arrangement for heating metallic pieces by induction currents at high frequency which comprises an electron tube oscillator and a heating inductor fed thereby, the combination of a metallic sleeve split longitudinally and connected to said inductor, a tank circuit of said os-

cillator magnetically coupled to said sleeve and comprising a condenser with variable surface and having electrodes respectively peripheral and central, the central ones being mounted on one and the same tube, a gas-tight metallic envelope surrounding the condenser, and connected to its peripheral electrodes and traversed by the said tube as far as an insulating and gas-tight joint there between, two coaxial electrically identical windings surrounded in parallel by said sleeve and symmetrically arranged with respect to its transverse medial plane, two connections coupling to the aforesaid envelope the ends of the windings in their plane of symmetry, two other connections coupling their two other ends to the tube of the condenser, and connections grounding the envelope of the condenser.

2. Arrangement according to claim 1, in which the connection of the secondary with the inductor has a very low resistance, so that the total resistance reflected to the terminals of the tank circuit is between one tenth and one-thousandth of an ohm.

3. Arrangement according to claim 1, in which the two windings are tubular and the four connections are tubular and connect said windings to the condenser, thereby enabling the same current of cooling fluid to traverse one after the other of said windings through the said tube of the condenser.

4. In an arangement for heating metallic pieces by induction currents at high frequency, which comprises an electron tube high frequency oscillator and a heating inductor fed thereby, the combination of a single turn winding in the form of a cylindrical sleeve split parallel to its axis and connected to said inductor, a tank circuit of said oscillator magnetically coupled to said single-turn winding, said circuit comprising two tubular windings developing a cylindrical surface within said sleeve, coaxial with the latter and very near thereto, said windings electrically identical being

positioned symmetrically respecting a plane of symmetry transverse to said sleeve, a condenser with variable capacitance and having electrodes respectively peripheral and central, the central ones being mounted on one and the same tube, a gas-tight metallic envelope surrounding the condenser, connected to its peripheral electrodes and traversed by said tube as far as an insulating and gas tight joint between said tube and envelope, two tubular connections coupling to the envelope aforesaid the ends of the windings nearest to their plane of symmetry, two other tubular connections coupling to the tube of the condenser their two other ends, and a connection grounding the envelope of the condenser.

5. Arrangement according to claim 4, including a circuit for cooling said tube winding constituted by said windings connected in series by means of the said tube of the condenser.

6. Arrangement according to claim 4, in which the connection of the secondary with the inductor has a very low resistance, so that the total resistance reflected to the terminals of the tank circuit is comprised between one-tenth and one-thousandth of an ohm.

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