



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.06.2013 Bulletin 2013/26

(51) Int Cl.:
H05B 6/10 (2006.01)

(21) Application number: **11195710.6**

(22) Date of filing: **23.12.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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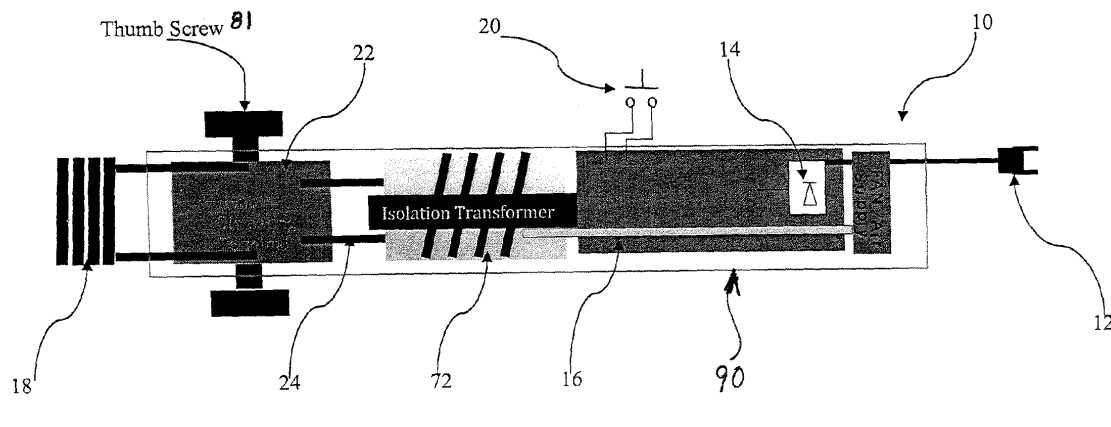
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(54) **Induction heater for automotive applications**

(57) A heater apparatus 10 used for automotive repair, which may be powered by a 240-volt AC power source, and which may utilize a frequency in a range of 15-50 KHz. Apparatus 10 may include an eddy current/

hysteretic circuit and a plurality of hand-held, manipulable applicators 18, which may be functionally engaged to the circuit for use in applying heat generated by the circuit to desired areas of automotive vehicles.

FIGURE 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to induction heaters used for removing fasteners and other automotive repair applications requiring the release of hardware from corrosion/thread lock compounds, or involving the need for thermal expansion in order to remove mechanical components, including but not limited to the following applications: bearings races, brake and transmission lines, zirk fittings, manifold bolts, crank shaft bolts, in-line connectors, removal of objects bonded to metal, hail dent removal, metal shrinking, fabrication and decal and body trim removal. More specifically, the invention relates to an eddy current/hysteretic heater apparatus and its method of use for such applications in the automotive field.

[0002] U.S. Patent Nos. 6,563,096 and 6,670,590, each of which are incorporated by reference in their entirety into this application, describe embodiments of eddy current/hysteretic heater apparatus and methods of use. Using the inventions of these patents, automotive repair personnel may quickly heat metallic elements such as fasteners, enabling their removal from automotive parts, for example.

[0003] While the inventions of the '096 and '590 have proven useful and commercially successful, a new design that would allow induction heaters to function successfully at, for example, 240V, 50 Hz input power supplies would be advantageous. In order to accomplish this, several design changes were required, including: redesigning the transformer to properly transfer inductive energy to the output load; changing transistor values (Q1, Q2) which would not otherwise survive higher voltages present as a result of the higher operating voltage; redesigning the circuit to ensure that integrated circuit U1 and transistors Q1 and Q2 are not destroyed by voltage transients whose amplitude increases with the increased input supply voltage; and redesigning the feedback circuit so that it will function properly with the new transformer and new operating voltage, under various applicable load conditions. These changes are described below.

SUMMARY OF THE INVENTION

[0004] According to an aspect of the present invention, there is provided a heater apparatus as specified in claim 1.

[0005] The invention is also directed to a method by which the described apparatus operates and including method steps for carrying out every function of the apparatus.

[0006] The objects mentioned above, as well as other objects, are solved by the present invention, which overcomes disadvantages of prior automotive induction heaters and methods of using them, while providing new advantages not believed associated with such heaters and

methods.

[0007] In general, those of ordinary skill in the art will appreciate that, with respect to the heater apparatus described in U.S. Patent Nos. 6,563,096 and 6,670,590, the transformer "turns-ratio" was redesigned to account for the higher input voltage while keeping the output voltage the same, and that the C3 value was changed to keep the LC resonance at the same frequency. (The optimum turns-ratio was found to be 15:1 (e.g., 60 turns on the primary winding and 4 turns on the secondary winding)). Additionally, diodes D11 A, B and C were added to clamp the Q1, Q2 collector voltage swing to a safe level. (The voltage rating on the transistors was also changed.) Further, D3 and D4 were moved to provide a new configuration in order to clamp the negative-going voltage transients of the Q1 and Q2 gates to ground. Diodes D13, D14 were also added in order to clamp the positive-going transients on the U1 outputs to a voltage power source Vcc.

[0008] Finally, the "base" operating frequency of the oscillator, comprised of components U1, R3, R4, R5, C5, R6, & C6, was lowered by changing R3, R4 and C5, C6 values. This increases the dynamic range of the feedback circuits R13/R15, R14/R16, Q3, Q4, Q6, Q7 and their surrounding bias control and coupling components. The increased dynamic range helps to maintain the zero-voltage switching condition of Q1 and Q2 during output open circuit conditions, keeping Q1 and Q2 heat dissipation to a minimum.

[0009] Various other components and/or their values were also changed from the circuit used in the embodiments disclosed in the '096 and '590 patents to properly rate the components and to reduce heat dissipation that may occur at the higher input voltage.

[0010] In a particularly preferred embodiment, a heater apparatus 10 is provided and may be used for automotive repair. Apparatus 10 may be powered by a 240-volt AC power source, and may utilize a frequency in a range of 15-50 KHz. Apparatus 10 may include an eddy current/hysteretic circuit with an induction work coil 19. The circuit may be engaged to the power source. A plurality of handheld, manipulable applicators 18 may also be provided, and may be functionally engaged to the circuit for use in applying heat generated by the circuit to desired areas of automotive vehicles.

[0011] In another embodiment, a controller may be provided for allowing only one of the applicators 18 to be in use at a time. The applicators 18 may be interchangeable in the connection of each to the eddy current/hysteretic circuit. The applicators 18 may be simultaneously engaged to the eddy current/hysteretic circuit. At least one of the applicators 18 may include a flexible pad 18 (e.g., FIGURE 3) for accommodating substantially all configurations of automotive vehicle body areas. Alternatively, or in addition, at least one of the applicators 18 (e.g., FIGURE 4) may include a magnetic ferrite structure 23 having an air gap 21 for delivering a concentrated level of heat to a mechanical part of an automotive vehicle.

Each applicator 18 may also include indicia 32 for indicating an on-condition of the applicator 18. Heater apparatus 10 may also include a sensor which turns an applicator 18 off when no motion is sensed over a predetermined period of time. A housing 90 may be used to contain the eddy current/hysteretic circuit and the plurality of applicators 18 when the heater structures are not in use.

[0012] Heater apparatus 10 may also include a high-frequency isolation transformer 72 functionally engaged between the eddy current/hysteretic circuit and the plurality of applicators 18. Transformer 72 may have a turns-ratio, as a preferred example, in the 15:1 range. The eddy current/hysteretic circuit may include insulated gate bipolar transistors (IGBTs, Q1, Q2). The IGBTs (Q1, Q2) may be protected from suffering collector overvoltage failure, and also may be protected from suffering negative-going voltage transient failure. The circuit may also include an oscillator for driving the IGBTs (Q1, Q2). The oscillator may have a base operating frequency in the range of 15-20 kHz, and positive-going transients on an output of the oscillator may be clamped to a voltage power source.

[0013] The eddy current/hysteretic circuit may include a drive circuit, a feedback circuit for protecting the drive circuit, and an LC circuit for generating power.

DEFINITION OF CLAIM TERMS

[0014] The terms used in the claims of the patent as filed and are intended to have their broadest meaning consistent with the requirements of law. Where alternative meanings are possible, the broadest meaning is intended. All words used in the claims are intended to be used in the normal, customary usage of grammar and the English language.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The novel features which are characteristic of the invention are set forth in the appended claims. The invention itself, however, together with further objects and attendant advantages thereof, can be better understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of an embodiment of the eddy current/hysteretic heater apparatus of the present invention;

FIGURES 2A and 2B are top and cross-sectional views, respectively, of the applicator shown in FIGURE 1;

FIGURE 3 is an enlarged view of one applicator of the eddy current/hysteretic heater apparatus, in which the applicator includes a flexible pad;

FIGURE 4 is an enlarged view of an applicator, including a magnetic ferrite structure having an air gap for delivering a concentrated level of heat, which may

be electrically connected to the heat dissipating terminal shown in FIGURE 1, for example;

FIGURE 5 is a schematic view of a preferred embodiment of the power supply of the induction heating mechanism of the present invention; and

FIGURE 6 is a schematic view of an inverter useful with the induction heating mechanism of the present invention.

[0016] The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. In the drawings, like reference numerals designate corresponding parts throughout the several views.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Set forth below is a description of what are believed to be the preferred embodiments and/or best examples of the invention claimed. Future and present alternatives and modifications to this preferred embodiment are contemplated. Any alternatives or modifications which make insubstantial changes in function, in purpose, in structure, or in result are intended to be covered by the claims of this patent.

[0018] Referring now to the drawings in greater detail, and more specifically to FIGURES 1-4, an eddy current/hysteretic heater apparatus is shown, made in accordance with the teachings of the present invention, and generally identified by the reference numeral 10. Heater apparatus 10 includes structure 12, such as a plug 12, for engaging apparatus 10 to a source of electrical power (not shown), preferably ordinary AC line power. A rectifier 14 may be provided for converting the AC power from the source into DC power. The DC power may contain a natural ripple frequency at twice the line frequency rate, or may be filtered to remove some or all of the ripple. A high-frequency inverter 16 of push-pull, half-bridge, full bridge or single-ended variety, either resonant or not, may also be provided. An applicator 18 may be functionally engaged to inverter 16 for applying a high-frequency magnetic field to any metallic automotive/mechanical structure to be heated for obtaining a desired result, as further described below. Switch 20 may be provided for use in activating apparatus 10.

[0019] Those of ordinary skill in the art will understand that, for example, bidirectional, high-speed switching devices and inverters exist which would eliminate the need for a separate rectifier. Accordingly, the use of same as a modification to the above-described circuitry should be regarded as falling within the scope of the present invention.

[0020] Referring now to FIGURE 1, in operation of apparatus 10, AC power may be delivered through plug 12 to rectifier 14, where it is converted to DC power of a similar or higher voltage. The DC voltage may, but need not, be filtered to remove ripple components. This DC

power may then be delivered to high-frequency inverter 16, where the power may be converted to a high frequency, such as in the range of 5-500 kHz, and most preferably for the currently described application in the range of 15-50 KHz, depending on load. This high frequency may then be run through isolation transformer 72 and heat dissipating terminals 22 (via wire 24), and then delivered to a selected applicator 18, wherein it may be transformed into a high-frequency magnetic field. Thumb screw 81 may be used to tighten and secure applicator 18 to heat dissipating terminal 22.

[0021] When applicator 18 is brought into close proximity with a non-magnetic metallic object (not shown), a similar, but opposing, high-frequency current may be developed within the object through known transformer action and a current may be caused to flow within and through the metallic object, generating heat within the object through its natural resistance. If the metallic object is of magnetic or ferrous nature, an additional action of heating, known as magnetic hysteresis heating, may occur in which rapidly changing high frequency flux causes magnetic domains within the metal to "rub" against each other, generating heat in a manner analogous to that caused by friction.

[0022] Applicators 18 may be of several differently shaped or sized handheld, manipulable or rigid elements. One embodiment may include a cylindrical coil of solid and/or stranded or a combination of both solid/stranded copper wire (FIGURE 2), with an air gap in the center of the coil where the magnetic field is concentrated to heat metallic objects placed within this field.

[0023] A second embodiment of applicator 18 may be planar, flexible or rigid structures in the form of pad 18 (FIGURE 3), for heating relatively small or large areas of (e.g.) sheet metal with flat or compound-curved surfaces.

[0024] Referring now to FIGURES 2 and 4, a third embodiment of applicator 18 may include flux-concentrator work coils 19 (FIGURE 4) employing a ferrite, or other suitable magnetic material having a magnetic permeability substantially greater than air, and having an air gap 21 (see FIGURE 4, showing an applicator 18 which be electrically connected, e.g., plugged into, heat dissipating terminal 22 shown in FIGURE 1) in the magnetic circuit, with the flux density being greater than if the same coil 19 were similarly energized but without core 23. This latter coil 19 may be used for intense heating of rusted nuts and bolts and the like (not shown) to facilitate their disassembly, and to locally heat small areas of sheet metal in certain body-work operations, such as in hail dent removal.

[0025] A fourth embodiment of applicator 18 may include a stranded litz wire of any predetermined length to wrap around symmetrical as well as asymmetrical metallic objects of any size or shape for the purpose of releasing such items from corrosion or for thermally expanding items, such as bearings, races, O-2 sensors, tie rods/tie rod ends, or other automotive parts, in order to free/release a desired metallic object.

[0026] In a preferred embodiment of apparatus 10, connectors (heat dissipating terminals) 22 (FIGURE 1) may be inserted in cable 24 between inverter 16 and work coil 19, to allow for exchanging of one applicator 18 for another. A custom connector/heat dissipating terminal 22 may be used to prevent the conductive heat created from transferring back through the apparatus, from damaging other components.

[0027] Referring to FIGURES 3-4, it may be seen that a single loop of wire 30 may be incorporated into either pad 18 or concentrator tip 18 to deliver a small, high frequency voltage by known transformer action for the illumination of an electric lamp 32, or other indicia for indicating an "on" or energized condition for applicator 18. A small lamp 32 may serve only to indicate that the applicator 18 is energized, while a larger lamp 32 may serve not only to indicate activation, but also to serve as a light source to illuminate the work area.

[0028] Referring to FIGURE 4, a voltage regulator 33 may be inserted between leads 40 of the applicator and the lamp loop 30 to maintain light output substantially constant while drive frequency is varied to change the power level, if such capability is incorporated into apparatus 10, and/or loading on applicator 18 is varied.

[0029] Referring now to FIGURE 5, a preferred embodiment of a power supply useful with the induction heating mechanism of the present invention is shown. The isolation step-down transformer, not shown in FIGURE 5, but indicated by T1-C, and by T1-2 and T1-2 in FIGURE 6, may be a center-tapped inductor. For the purpose of this description, this will be referred to as the isolation step-down transformer, which has three terminals: a center tap, and the two ends.

[0030] In a particularly preferred embodiment, commercially known as the "Miniductor," used primarily for loosening rusty and stuck bolts, an externally-connected, two-leaded work coil may be placed over or wrapped around the stuck nut or bolt. The Miniductor is activated to cause heavy high-frequency current to flow through the work coil which, in turn, inductively heats the target nut or bolt. Thermal expansion resulting from the high heat causes the nut/bolt to break free.

[0031] Still referring to FIGURE 5, power rectifier BR1 may provide DC power for the unit. Inductor L1 may be used to feed rectified power to the center tap of the isolation transformer, effectively making the power appear as a current source. D11A-C may provide transient over voltage protection to inverter power transistors Q1 and Q2. Transistors Q5, Q8, Q9 and Q11 may function as the inverter turn-on/off circuit. This type of inverter should be turned on only when the power supply voltage is at a low point (to prevent failure due to overvoltage transients) and, more specifically, at or near the zero crossings of the power line, when the lightly filtered rectified power is also at a low point. The inverter may be turned on by a contact closure between S1-1 and S1-2. Resistors R17, R18 and R24 may be used to feed current to zener diodes D9 and D10 to provide a 14-volt power source Vcc, fil-

tered by capacitor C10. When the rectified power supply voltage is well above 14 volts, the current through R18 and R24 turns on Q11, which inhibits a closure of S1-1 and S1-2 from turning on the inverter. When the voltage is low enough, Q11 turns off, and a closure will turn on silicon-controlled rectifier Q9 and transistors Q5 and Q8, providing the inverter turn-on voltage of about 14 volts to terminal THSW. When the power supply voltage rises again above 14 volts, SCR Q9 will turn off and turn off the inverter. Overall, this provides for the turning on and off of the inverter near the zero crossings of the power supply.

[0032] Referring now to FIGURE 6, a preferred embodiment of the power circuit of the inverter including parallel resonant circuit C3 and the isolation transformer, and power transistors Q1 and Q2. In normal operation, transistors Q1 and Q2 may be turned on and off alternately, supplying power to the isolation transformer. Gate driver U1 may be employed to turn on Q1 and Q2 alternately. The collector voltages of transistors Q1 and Q2 may be sampled by R15 and R16 and attenuated by the voltage divider components R13 and R9 (working in conjunction with R15) and R14 and R10 (working in conjunction with R16). The attenuated signals may then be applied to transistors Q3 and Q4. Transistors Q3 and Q4 may act as comparators that, via C8 and C9, provide pulses to Q6 and Q7 when the collectors of Q1 and Q2 approach zero volts. This, in turn, alternately switches the states of the two gate drivers when the collectors of Q1 and alternately Q2 are at or close to zero volts. Therefore the on/off transitions of Q1 and Q2 occur at or near when their collector voltages are at zero volts, minimizing wasted power dissipation. Feedback from R15 and R16 along with their associated feedback circuits as described earlier, operate on the diminishing Q1 and Q2 collector voltages, whose rate is determined by the LC resonance presented earlier but influenced strongly by the load characteristics of the external work coil and its target metal piece. This action causes the transitions of Q1 and Q2, the periods of maximum potential wasted heat dissipation, as they transfer high power pulses from the input power source to the output of the isolation step-down transformer, to always tend to occur near or at zero collector voltage, greatly minimizing the wasted heat losses.

[0033] Additionally, C5, C6, R5, and R6 may create a cross-coupled oscillation circuit for the two gate drivers when the power stage is not yet operating, such that the inverter will start up properly. The self-oscillation frequency is preferably deliberately chosen to be below the natural resonant frequency of the power circuit, so that when the power circuit begins to operate, it will pre-empt the self-oscillation of the gate driver circuit.

[0034] The values of R15, R13, and R9, and R16, R14, R10 are preferably chosen such that the switching of Q1 and Q2 occurs as close as possible to the zero voltage point of the collectors, to optimize inverter efficiency, while ensuring reliable switching.

[0035] It will be understood by those of ordinary skill in the art that D5, D6, D7, and D8 switch R15 and R16 out of the circuit below about 14 volts, which then allows the bias circuitry for Q3 and Q4 to function properly in switching the state of U1 output drivers at the proper timing to keep Q1 and Q2 heat dissipation low. R1 & R2 have been selected to optimize transition time and energy losses and the efficiency of the drive circuit device U1. Insulated gate bipolar transistors Q1 and Q2 minimize drive power requirements (high input impedance) and low output on resistance, providing minimal collector losses during operation.

[0036] The unit values shown in the drawings have been selected in order to provide an induction heater capable of being powered by 240 volts (typical European voltage transmission) and a 50 Hz input power supply.

[0037] Those of ordinary skill in the art will appreciate from the above disclosure that user-operated power may control the average power delivered to applicator 18 by varying the drive frequency for a resonant inverter 16, with power reduction being accomplished by a progressively increasing (preferred) or decreasing the drive frequency away from resonance. In the case of a non-resonant inverter 16, frequency may be similarly varied to control power instead. In either case, power may be controlled by changing the inverter drive waveform from a symmetrical 50/50% duty cycle (if the inverter 16 topology chosen uses more than one switching device (not shown)) where maximum power is delivered, to a progressively asymmetrical drive waveform where very little power delivery occurs (e.g., with one transistor conducting 95% of the time, and the other transistor conducting 5% of the time, with a half-bridge resonant converter delivering only 3-5% of full power).

[0038] In a typical body shop/garage environment, damp to wet concrete floors and grounded metallic objects such as automotive vehicles on lifts are commonplace. While applicators 18 and cables 24 are insulated, insulation may fail as is known, potentially creating an electric shock risk. There are two methods for preventing such an occurrence. One method involves using a standard ground fault interrupter module between the AC source and input rectifier 14 of apparatus 10.

[0039] Another method involves using a high frequency isolation transformer located between inverter 16 and each applicator 18.

[0040] Referring again to FIGURES 5-6, those of ordinary skill in the art will recognize that in the preferred embodiment of the circuits disclosed there and described above, the following circuits consist of the following components:

- the drive circuit consists of U1 (output driver transistor located internally), R1, R2, D3 and D4
- The feedback circuit consists of R15, D5, D6, R13, R9, Q3, R11, C8, R7, Q6, on Q1 side, and R16, D7, D8, R14, R10, Q4, R12, C9, R8, and Q7
- The LC circuit consists of center-tapped, isolation

transformer, L1, and C3.

-- The oscillator circuit consists of U1, R3, C5, R5, and R4, C6, R6, and D13, D14

[0041] The above description is not intended to limit the meaning of the words used in the following claims that define the invention. Persons of ordinary skill in the art will understand that a variety of other designs still falling within the scope of the following claims may be envisioned and used. It is contemplated that future modifications in structure, function, or result will exist that are not substantial changes and that all such insubstantial changes in what is claimed are intended to be covered by the claims.

Claims

1. A heater apparatus (10) used for automotive repair, powered by a 240-volt AC power source, and utilizing frequency in a range of 15-50 KHz, comprising:

an eddy current/hysteretic circuit designed to provide induction heating, the circuit engaged to the power source; and
a plurality of hand-held, manipulable applicators (18) functionally engaged to the circuit for use in applying induction heating generated by the circuit to desired areas of automotive vehicles.

2. The heater apparatus (10) of Claim 1, further comprising a controller for allowing only one of the applicators (18) to be in use at a time.
3. The heater apparatus (10) of Claim 1 or claim 2, wherein the applicators (18) are interchangeable in the connection of each to the eddy current/hysteretic circuit.
4. The heater apparatus (10) of Claim 2, wherein the applicators (18) are simultaneously engaged to the eddy current/hysteretic circuit. The heater apparatus (10) of Claim 1, wherein at least one of the applicators (18) comprises a flexible pad (18) for accommodating substantially all configurations of automotive vehicle body areas.
5. The heater apparatus (10) as claimed in any of claims 1-4, wherein at least one of the applicators (18) comprises a structure (23) having an air gap (21) for delivering a concentrated level of heat to a mechanical part of an automotive vehicle.
6. The heater apparatus (10) as claimed in any of claims 1-5, wherein each applicator (18) includes indicia (32) for indicating an on-condition of the applicator (18).

7. The heater apparatus (10) as claimed in any of claims 1-6, further comprising a sensor which turns an applicator (18) off when no motion is sensed over a predetermined period of time.

8. The heater apparatus (10) as claimed in any of claims 1-7, further comprising a high-frequency isolation transformer (72) functionally engaged between the eddy current/hysteretic circuit and the plurality of applicators (18).

9. The heater apparatus (10) of Claim 8, wherein the transformer (72) has a turns-ratio in the range of 15:1.

10. The heater apparatus (10) as claimed in any of claims 1-9, further comprising a housing (90) containing the eddy current/hysteretic circuit and the plurality of applicators (18) when the heater structures are not in use. The heater apparatus (10) of Claim 1, wherein the circuit includes insulated gate bipolar transistors (IGBTs, Q1, Q2), and wherein the IGBTs are protected from suffering collector overvoltage failure.

11. The heater apparatus (10) as claimed in any of claims 1-10, wherein the circuit includes IGBTs (Q1, Q2), and wherein the IGBTs (Q1, Q2) are protected from suffering negative-going voltage transient failure.

12. The heater apparatus (10) as claimed in any of claims 1-10, wherein the circuit includes IGBTs (Q1, Q2) and an oscillator for driving the IGBTs (Q1, Q2).

13. The heater apparatus (10) of Claim 12, wherein the oscillator has a base operating frequency in the range of 15-20 kHz.

14. The heater apparatus (10) of Claim 12, wherein positive-going transients on an output of the oscillator are clamped to a voltage power source.

15. The heater apparatus (10) of Claim 14, wherein the eddy current/hysteretic circuit includes a drive circuit and a feedback circuit for protecting the drive circuit and, optionally, wherein the circuit includes an LC circuit (L1, C3) for generating power

FIGURE 1

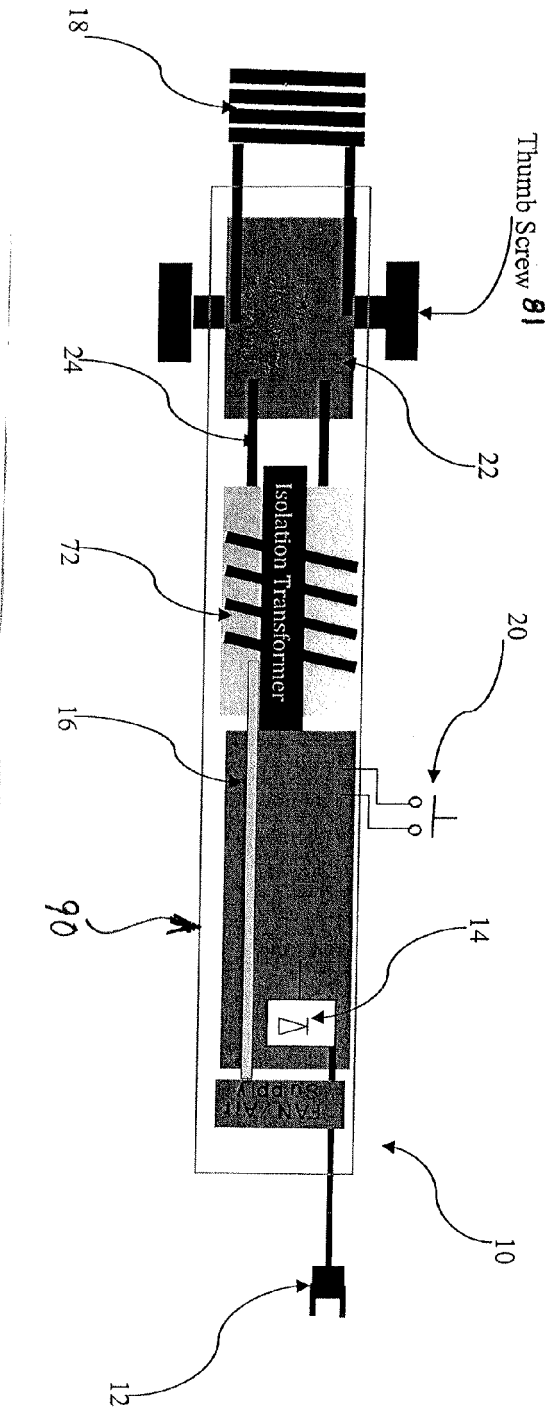


FIGURE 2A

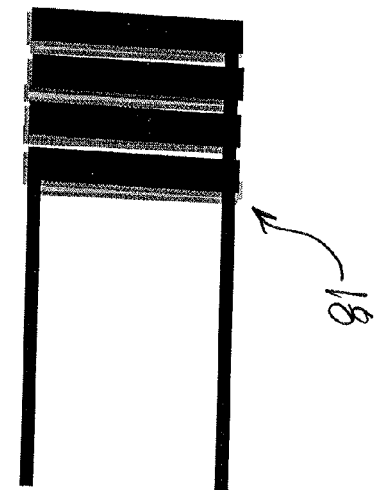


FIGURE 2B

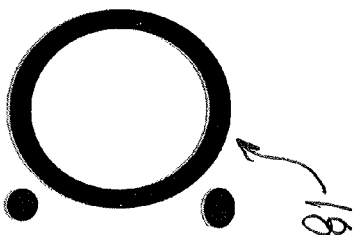


FIGURE 3

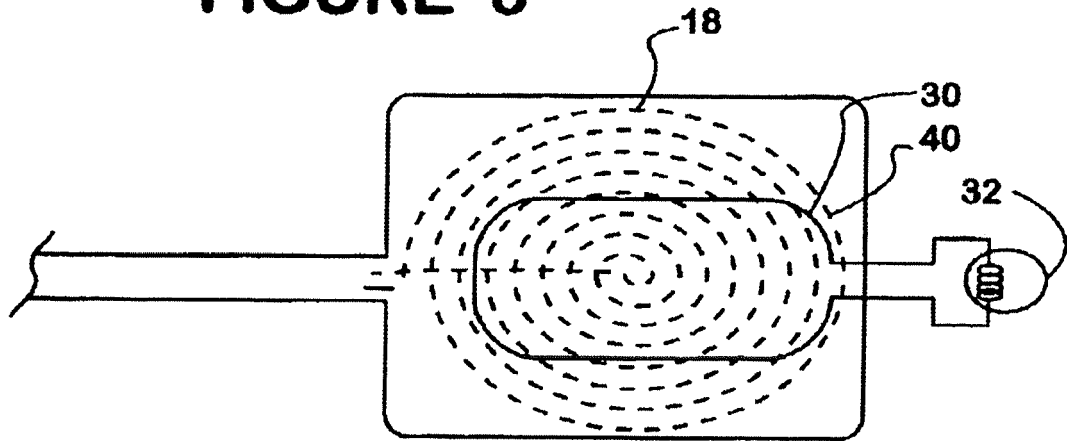


FIGURE 4

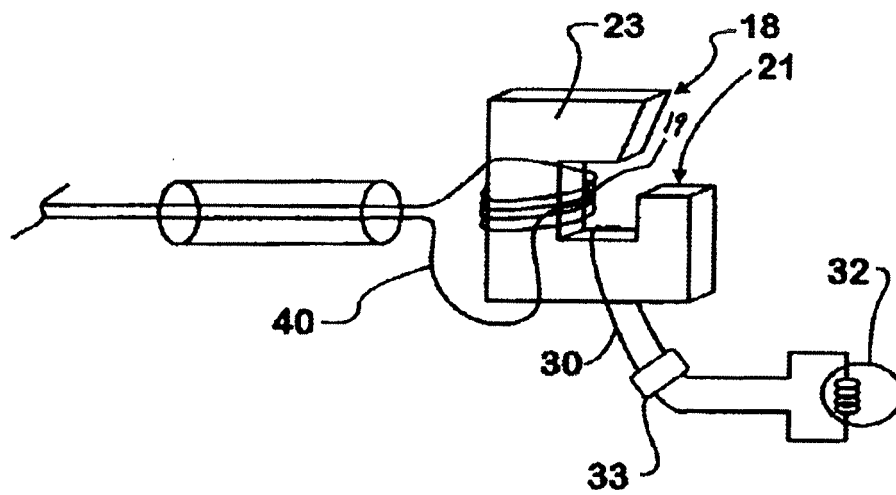
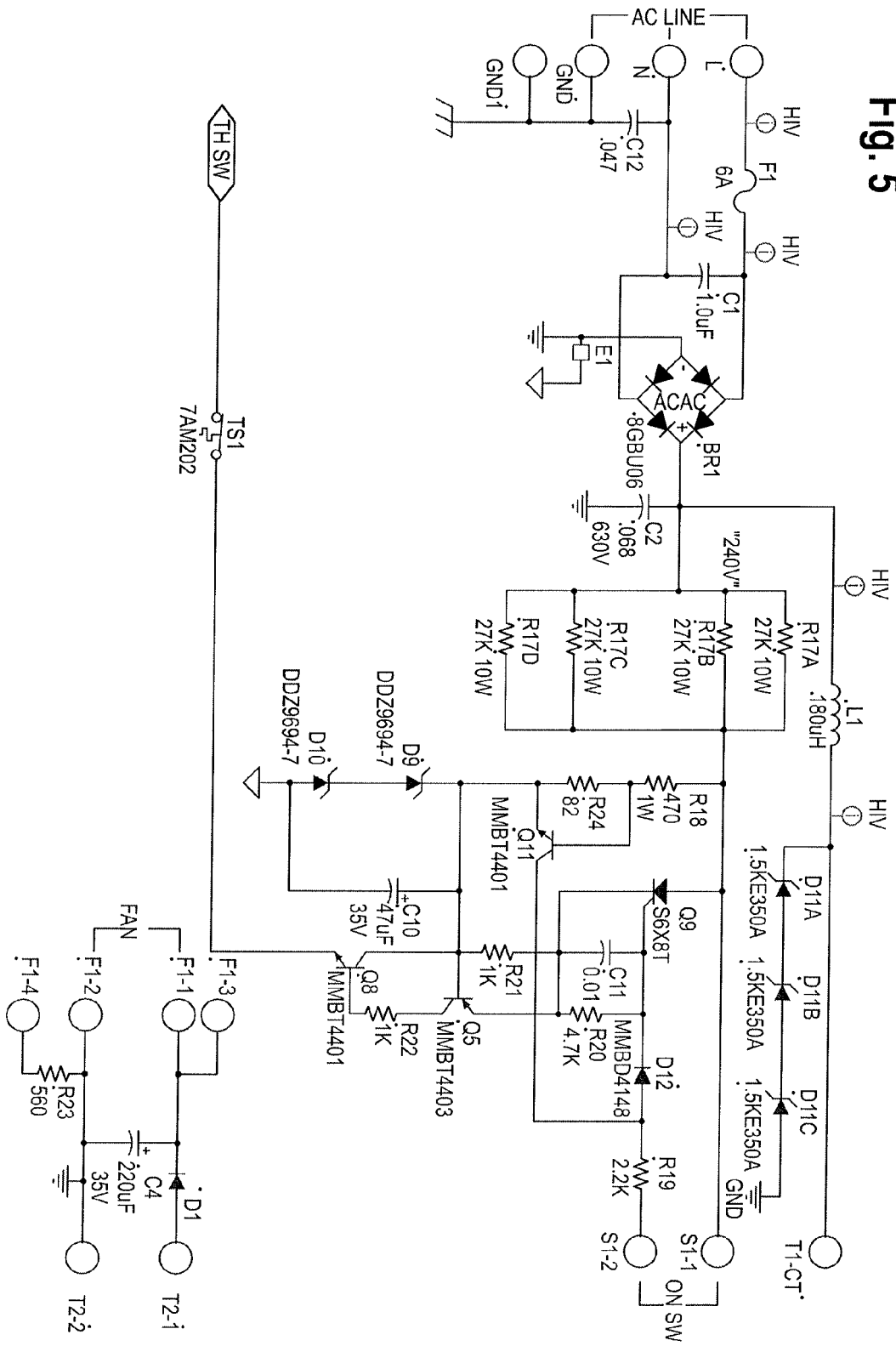


Fig. 5



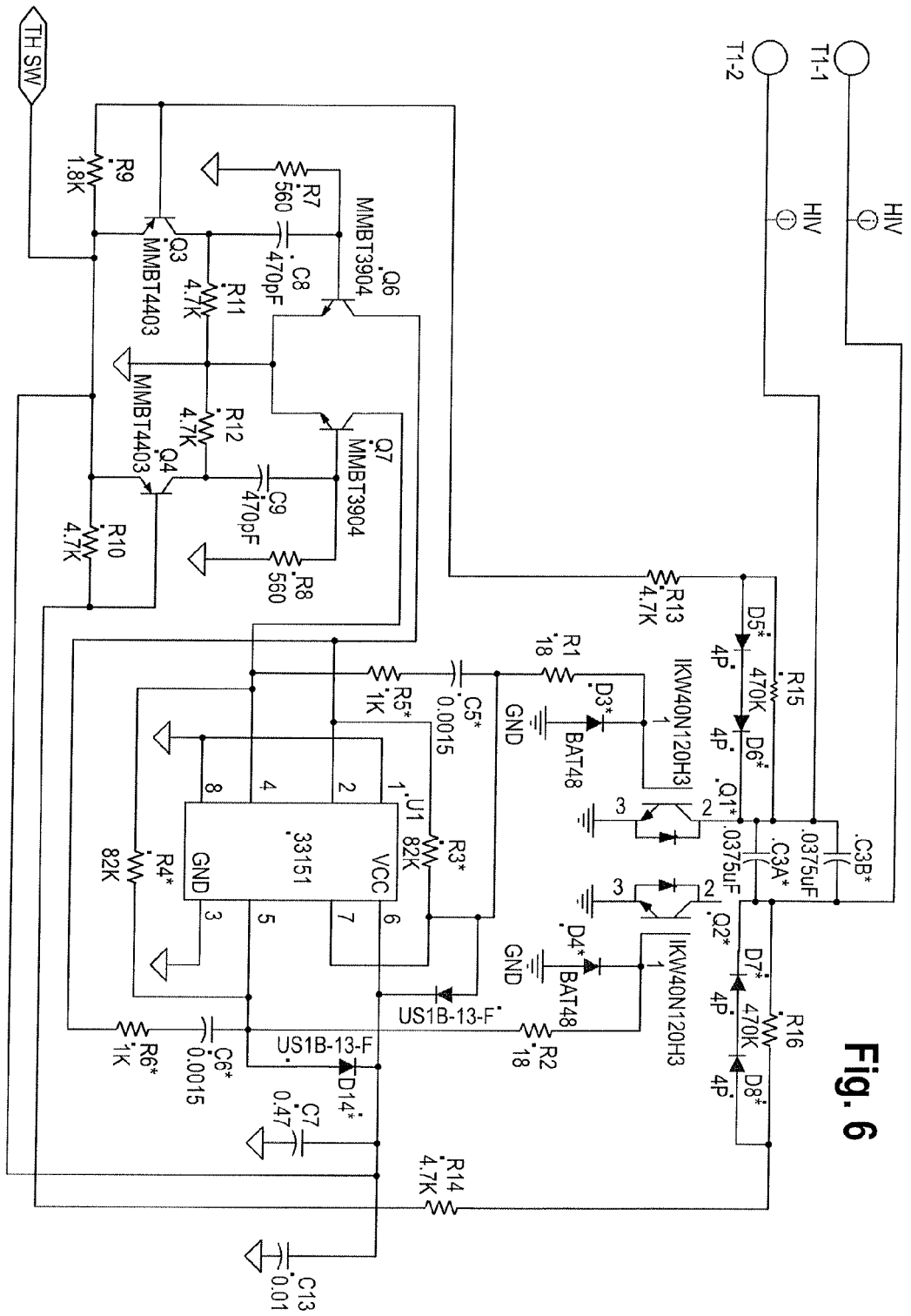


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 11 19 5710

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X	US 6 563 096 B1 (PACHOLOK DAVID R [US] ET AL) 13 May 2003 (2003-05-13) * abstract * * figures 1-6 * * column 2, line 22 - column 5, line 17 * -----	1-15	INV. H05B6/10
A	WO 2005/062448 A2 (EMA INDUTEC GMBH [DE]; WEBER SIEGFRIED [DE]) 7 July 2005 (2005-07-07) * abstract * * page 1, line 24 - page 2, line 31 * * page 12, line 27 - page 13, line 16 * * figure 4 *	1-15	
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) H05B
Place of search Munich		Date of completion of the search 16 May 2012	Examiner de la Tassa Laforgue
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03 82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 19 5710

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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