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D E C I S I O N
of 13 March 2006

Case Number: T 0350/04 - 3.2.06

Application Number: 95303563.1

Publication Number: 0688626

IPC: B23K 11/24

Language of the proceedings: EN

Title of invention:
Control equipment for resistance welding machine

Patentee:
KABUSHIKI KAISHA TOSHIBA

Opponent:
Robert Bosch GmbH

Headword:
Resistance Welding Machine/TOSHIBA

Relevant legal provisions:
EPC Art. 56, 113, 116

Keyword:
"Selection of closest prior art"
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0350/04 - 3.2.06

D E C I S I O N
of the Technical Board of Appeal 3.2.06
of 13 March 2006

Appellant: (Opponent)
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Decision under appeal:
Interlocutory decision of the Opposition Division of the European Patent Office posted 22 December 2003 concerning maintenance of European patent No. 0688626 in amended form.

Composition of the Board:

Chairman: P. Alting van Geusau
Members: M. Harrison
R. Menapace

Summary of Facts and Submissions

I. In the Opposition Division's interlocutory decision dated 22 December 2003, the European patent EP-B-0 688 626 (based on application number 95303563.1) in its amended form according to the proprietor's main request was found to meet the requirements of the European Patent Convention.

II. The amended form of the patent contains six independent claims; claims 1, 4, 13, 16, 19 and 21. The text of these claims reads as follows:

Claim 1:
"A resistance welding machine for welding a material by the Joule's heat generated by applying an electric power to said material via welding electrodes (1), comprising:
an inverter (7) for converting a first DC supply voltage to a first AC voltage; and
a transformer (8) for transforming said first AC voltage at a primary winding to a second AC voltage at a secondary winding; characterised by:
control means (12-31) for converting said second AC voltage to an waveform which alternates between (a) a first DC current composed of a series of positive-going pulses and (b) a second DC current composed of a series of negative-going pulses and for applying said waveform to said welding electrodes (11)."

Claim 4:
"A resistance welding machine for welding a material by the Joule's heat generated in said material by applying an electric power to said material, comprising:

an inverter (204) for converting a DC voltage to an AC voltage by pulse width modulation control;
a transformer (205) having a primary winding to which said AC voltage is applied and having a secondary winding which supplies an AC current; and
PWM control means for generating a DC current reference (I_1*) and for PWM controlling said inverter (204) based on a PWM signal composed of an "ON" PWM signal (h) and an "OFF" PWM signal (l, k), so that an error between an output (i1) of said inverter and said DC current reference (I_1*) becomes zero,
characterized in that said PWM control means includes,
reference control means for generating a reference control signal (i) based on said DC current reference,
pulse width modulating means for generating said ON PWM signal at a constant modulation cycle and for generating said OFF PWM signal based on a result of comparing said reference control signal (i) and said output current of said inverter,
square wave generating means for generating a square wave signal for determining a polarity and frequency of said AC voltage outputted from said inverter;
driving means (240, 241) for controlling said inverter in response to said PWM signal and said square wave signal; and
means for supplying said AC current to said material."

Claim 13:
"A resistance welding machine for welding a material by Joule's heat generated by applying an electric power to said material, comprising:
a power converter for converting a DC voltage to an AC voltage by pulse width modulation control, said AC

voltage being applied to said material to generate a load current (Id); and
PWM control means for generating a current reference (I*) and for PWM controlling said converter based on a PWM signal composed of an ON PWM signal and OFF PWM signal, so that an error between said current reference (I* and said load current (i1) becomes zero;
said PWM control means including,
reference control means for generating a reference control signal based on said current reference (I*),
pulse width modulating means for generating said ON PWM signal at a constant modulation cycle and generating said OFF PWM signal based on a result of comparing said reference control signal and said load current;
means (328) for generating, synchronised with said modulation cycle, a dither signal which gradually increases or decreases and for adding said dither signal to one of said current reference and said load current; and
correction means for correcting one of said current reference and said load current by one of a modulation factor obtained from said PWM signal and an output of a function generator (333) to which said modulation factor is applied."

Claim 16:
"A resistance welding machine for welding a material by the Joule's heat generated in said material by applying an electric power to said material, comprising:
an inverter (304) for converting a DC voltage to an AC voltage by pulse width modulation control;
a transformer (305) having a primary winding to which said AC voltage is applied and having a secondary

winding which supplies an AC current to said material; and
PWM control means (313, 314, 315) for generating a current reference (I*) and for PWM controlling said inverter based on a PWM signal so that an error between an output current of said inverter and said current reference becomes zero;
said PWM control means including;
control means (326) for controlling an output current of said inverter by a PWM signal based on a comparison between a current reference and said output current (iAC);
control means for reversing a direction of said output current of said inverter based on a frequency reference;
comparison means (324) for alternately comparing a change rate of said output current during a cycle of said final PWM signal of ON state in a positive cycle of said output current with a change rate of said output current during a cycle of said final PWM signal of ON state in a negative cycle of said output current; and
adjustment means (325, 339) for adjusting at least one of amplitudes and times of said positive and negative cycles of said output current based on a comparison result of said comparison means.

Claim 19:

"A resistance welding machine for welding a material by the Joule's heat generated by applying electric power to said material, comprising:
an inverter (304) for converting a DC voltage to an AC voltage by pulse width modulation control;

a transformer (305) having a primary winding to which said AC voltage is applied and having a secondary winding which supplies an AC current to said material;
detection means (351) for detecting the polarity and the conduction time at the last half-cycle before the end of the conduction phase;
control means (352, 353) for detecting whether said conduction time is greater or less than a set time value, and starting conduction with the same polarity at the next conduction phase, when said conduction time is less, or starting conduction with the opposite polarity at the next conduction phase when said conduction time is greater."

Claim 21:
"A resistance welding machine for welding a material by the Joule's heat generated by applying electric power to said material, comprising:
an inverter for converting a DC voltage to an AC voltage by pulse width modulation control;
a transformer having a primary winding to which said AC voltage is applied and having a secondary winding which supplies an AC current to said material;
detection means for detecting an output current of said inverter and a modulation factor of said pulse width modulation control;
control means for comparing a difference between a value of said output current and said modulation factor at the time of final pulse width modulation control in a positive half-cycle and a difference between a value of said output current and said modulation factor at the time of final pulse width modulation control in a negative half-cycle, and controlling at least one of amplitudes of said output current in said positive and

negative cycles and conduction time widths of said positive and negative cycles of said output current based on a comparison result in a direction that said differences balance."

III. The Opposition Division concluded that the invention of claim 1 was limited to a DC current applied at the electrodes, this decision being based in part on the number of pulses in each direction and the frequency involved. Reference was made to paragraph 0045 of the patent specification in this respect.

In regard to inventive step of the subject matter of claims 1 and 19, the Opposition Division rejected the opponent's argument that a document dealing with arc welding (D4 - see below) could be considered as the closest prior art and considered document D5 (see below) dealing with resistance welding to be the closest prior art. Since a solution to the problem of avoiding wear of electrodes due to a unidirectional current underlying the invention defined in claims 1 and 19 was not disclosed in the prior art, inventive step was present.

In terms of claims 4, 13, 16 and 21, the Opposition Division also started from D5 when considering inventive step. The features of these claims which were absent from D5 solved the problem of better controlling the weld current and, as these particular features were not known from any other cited prior art, the subject matter of these claims also involved an inventive step.

IV. The appellant (opponent) appealed against the decision of the Opposition Division and requested revocation of the patent. In its statement setting out the grounds of appeal, the appellant submitted that inventive step of all claims was lacking.

In its submissions regarding lack of inventive step of the independent claims, the appellant relied upon the following documents:

D4: DE-C1-38 03 447

D5: DE-C1-41 13 117

Annex 1: "Kursbeschreibung - Maschinenbau", Fachhochschule Deggendorf, Internet printout dated 29.04.2004.

Annex 2: "Inhalte der Lehrveranstaltungen", Fachhochschule Mannheim, Fächerinhalte Maschinenbau/Fertigungstechnik Diplom, Internet printout dated 29.04.2004, pages 1/12 to 12/12.

Annex 3: Copy of Fig. 2 of document D4, marked up with a diagram 1.

Annex 4: Copy of Fig. 2 of document D4 marked-up with diagrams 2 and 3.

The appellant also filed Annexes 5 and 6 in regard to the subject matter of dependent claims.

V. No submission from the proprietor was received in response to the appeal.

VI. Oral proceedings were not requested by the appellant in the appeal procedure.

VII. The arguments submitted by the appellant in support of its request are summarized as follows:

While D4 related to an arc welding apparatus, a person skilled in the art of welding was knowledgeable in both arc welding and resistance welding of conductive materials, allowing the skilled person to draw upon knowledge in both types of welding when considering inventive step, especially as these two particular welding techniques were very closely related. In particular the two techniques were regarded as very close to one another due, for example, to the similarities in the equipment with which each welding technique was carried out, such as *inter alia* the use of DC or AC according to the specific workpiece application to be welded and the use of transformer setups with switching circuits both using frequencies significantly higher than normal mains electrical supply. As a matter of fact, manufacturers of welding equipment normally offered both types of welding machine, and such manufacturers were thus well aware of the technical features of each type.

Annex 1 and Annex 2 were filed as evidence to demonstrate the technical knowledge of the two welding techniques in question as would be possessed by a person skilled in the art of welding.

Contrary to the opinion of the Opposition Division, D4 could indeed be used as the closest prior art and,

interpreted with the aid of Annexes 3 and 4, disclosed a welding machine having all the features of claim 1 with the exception only of the feature that the welding machine was a resistance welding machine for welding by Joule's heat.

Additionally D4 had as its own prior art starting point the document US 4,564,742, which disclosed that current flow in one direction at the welding electrodes formed an oxide layer that needed to be broken up by switching the polarity of the electrodes. Furthermore it was a known fact (e.g. from column 4, lines 52 to 58 of the contested patent) that resistance welding caused wear of the welding electrodes due to the polarisation effect.

In view of this known problem in resistance welding and the problem used as a background starting point in D4, the skilled person would find in D4 an incentive to solve the known problem, since D4 gave the skilled person the information that one-sided effects (e.g. forming an oxide layer or wear of a welding electrode) could be avoided by using the circuitry in D4 to produce a welding current having a waveform which consisted of sequential series of positive-going and negative-going pulses. In this way the skilled person would arrive at the subject matter of claim 1 without an inventive step.

Also when starting from D5 which disclosed the features of the preamble of claim 1, the remaining features disclosed in D4 would be incorporated by a skilled person into D5 since D4 dealt with a solution to the problem of polarised electrode wear.

As regard claim 4, the features which differentiated claim 4 over D5 were features of conventional pulse width modulation control and thus no inventive step was recognisable in their use.

As regard claims 13 and 21, the respective features not disclosed in D5 were features of a pulse width modulation arrangement which were typical when producing a reference current. These features had no functional relationship with the object underlying the patent, nor was any unexpected or advantageous effect recognisable. For these reasons also the subject matter of claims 13 and 21 was without inventive significance.

As regard claim 19, the differences over D5 concerning a detection means for the polarity and conduction time for controlling the polarity in the next conduction phase dependent on the conduction time, were self-evident since polarised wear of the welding electrodes was avoided when the polarity was changed after a predetermined conduction time and as such these features were therefore obvious measures which did not involve an inventive step when considering the problem to be solved.

Reasons for the Decision

1. The appeal is admissible.

2. *Claim 1 (amended) underlying the decision under appeal:*

2.1 Concerning the control means defined in the characterizing part of this claim, the Board agrees with the appellant that D4 discloses a control means which converts the second AC voltage (i.e. the voltage coming from the secondary winding of the transformer 18) to a waveform which alternates between a first DC current composed of a series of positive-going pulses and a second DC current composed of a series of negative-going pulses for applying said waveform to the welding electrodes in an arc welding apparatus.

2.2 The method of operation of the D4 Figure 2 circuitry, albeit referred to as being an "AC" mode (see e.g. column 3, lines 33 to 47), produces a waveform which comprises a series of positive-going pulses followed by a series of negative-going pulses, due to the switching frequency of the control device 13 with respect to the switching frequency of the control device 8 (see e.g. column 2, lines 19 to 26). While the overall effect of such sequences in D4 is the production of pulsed alternating welding current, the terminology in claim 1 does not however allow a technical difference to be attributed thereto when compared with the waveform arising in D4. The definition of e.g. "a first DC current composed of a series of positive-going pulses" indeed qualifies what is to be understood by "DC current" but only to the extent that the individual current pulses have a single direction. Thus the Board judges that the sequential series of pulses which are in D4, at each separate phase in the AC mode, do correspond to the definition used in the characterizing part of claim 1. It may be added in this regard that

claim 1 of the contested patent also does not put any lower limit on the number of consecutive pulses in any one direction (i.e. the time during which the pulses need to be a series of positive-going or a series of negative-going pulses). Thus, the claim scope is not limited to the length of time of the pulse sequences as appearing for example in paragraph 0045 of the patent, upon which the Opposition Division relied.

2.3 Regarding the features in the preamble of claim 1 concerning an inverter for converting a first DC supply voltage to a first AC voltage and a transformer for transforming the first AC voltage at a primary winding to a second AC voltage at a secondary winding, the Board judges that these features are also disclosed in D4, in agreement with the decision under appeal and the appellant's submission in this respect.

2.4 Consequently the subject matter of claim 1 differs from the disclosure in D4 by the feature that the welding machine is a resistance welding machine for welding a material by the Joule's heat generated by applying an electric power to said material via welding electrodes.

2.5 In agreement with the decision under appeal, the Board also concludes that D5 provides the closest prior art starting point for consideration of inventive step. D5 relates to resistance welding machines in which the problem underlying the invention indeed occurs (see e.g. column 2, lines 54 to 56 and column 5, lines 9 to 12 of the contested patent), in particular the problem of polarised wear of electrodes. Contrary to the appellant's argument that D4 aims at overcoming one-sided electrode effects by the welding current control

system disclosed therein, the problem underlying D4 is not disclosed or recognisable as being a general problem of avoiding one-sided effects in the technical area of welding devices but is instead specifically related to problems occurring with arc welding. One example of such an arc welding problem is stated as being the build-up of an oxide layer when arc welding aluminium (see D4, column 1, lines 19 to 25). Thus D4 is concerned with specific problems and solutions relating to arc welding which are distinct from those occurring in resistance welding. The other portions of the description in D4 cited by the appellant, namely column 1, lines 43 to 46 and column 3, lines 49 to 59, do not bring the skilled person closer to such a teaching of general applicability covering resistance welding machines, as these portions are specific to arc welding devices.

2.6 Although resistance welding and arc welding machines are very closely related (as also submitted by the appellant with reference to Annexes 1 and 2), this does not alter the aforegoing conclusion, since a problem which is specific to resistance welding would not cause a skilled person to objectively select the closest prior art to be an arc welding machine.

2.7 Thus, with D5 as a starting point, and looking for a teaching of a solution to the technical problem of avoiding electrode wear due to polarisation effects, such a teaching cannot be found in D4 even though the features *per se* of claim 1, which are missing from D5, are present in D4. Since the problem being solved in D4 is however specifically related to arc welding devices, a skilled person searching for the solution to the

problem in a resistance welding device of e.g. D5, would not be taught by the disclosure of D4 that a solution to this problem exists by using the control circuitry of D4. Such could only occur as a result of an *ex post facto* analysis. The problem of avoiding electrode wear is namely not disclosed in D4, nor is there a disclosure of a general problem of one-sided effects. Furthermore, although it can be accepted that the skilled person is knowledgeable in both arc and resistance welding techniques, as too are manufacturers of both types of equipment, the skilled person is equally aware that there are many differences between these techniques and many aspects of arc welding are not suitable for use in resistance welding and *vice versa*. Thus, intimate knowledge of both welding techniques and the close relation of one technique to the other does not allow the skilled person to obtain a teaching from D4 to solve the specific problem arising out of a resistance welding machine of D5, unless inventive skill is used.

2.8 Likewise, even if D4 *arguendo* were to be used as a prior art starting point from which to consider inventive step, the known existence of polarised wear in resistance welding electrodes generally (or e.g. in the machine of D5) does not by itself bring the skilled person closer to the invention as defined in claim 1, since nothing in D4 indicates that the problem of electrode wear due to polarisation is something to be overcome by the disclosure of D4.

2.9 The subject matter of claim 1 thus involves an inventive step over the prior art cited by the appellant.

3. As regard claim 4, the decision under appeal states that D5 is considered as being the closest prior art. This has not been contested. Said decision further states that the feature "pulse width modulating means for generating said ON PWM signal at a constant modulation cycle and for generating said OFF PWM signal based on a result of comparing said reference control signal (i) and said output current of said inverter" is not known from D5, nor from any other cited document, and serves to solve the general problem of better controlling the weld current. No evidence has been supplied in the appeal proceedings which might show that the decision under appeal is incorrect in this regard. Although the appellant has stated that these features missing from D5 are features comprised in conventional pulse width modulation control, this allegation lacks any support by means of evidence and, therefore, does not constitute a reason to overturn the decision in this regard. Hence the Board concludes that the decision under appeal correctly held that the subject matter of claim 4 involves an inventive step.

4. As regard claim 13, the decision under appeal refers to D5 as being the closest prior art, which is not contested by the appellant. Said decision further states that the features "pulse width modulating means for generating said ON PWM signal at a constant modulation cycle and generating said OFF PWM signal based on a result of comparing said reference control signal and said load current; means for generating, synchronised with said modulation cycle, a dither signal which gradually increases or decreases and for adding said dither signal to one of said current

reference and said load current" are not known from D5, nor from any other cited document, and serve to solve the general problem of better controlling the weld current. The appellant has stated that these features missing from D5 are features of a pulse width modulation arrangement which are typical when producing a reference current and have no functional relationship with the object underlying the patent, nor was any unexpected or advantageous effect recognisable in such features. Again, the lack of documentary evidence to support the appellant's allegations regarding features of a typical pulse width modulation arrangement leads to the conclusion that these statements are mere allegations which as such are not a sufficient reason to overturn the decision in this regard. The appellant gave no explanation for his further contention that there is no functional relationship with the object underlying the patent. The decision under appeal found that these features have the function of improving the characteristics of welding current and the Board concurs. Finally, the existence of an unexpected effect or advantageous effect is not as such required to provide an inventive step, although it is noted that the patent anyway states that the use of a dither signal (as defined in claim 13) has the advantageous effect of reducing noise effects in the output PWM signal (see e.g. contested patent paragraph 0095).

Hence the Board concludes that the decision under appeal correctly held that the subject matter of claim 13 involves an inventive step.

5. As regard claim 19, the decision under appeal refers to D5 as being the most relevant state of the art, which has not been contested by the appellant. Said decision further states that the features "detection means for detecting the polarity and conduction time at the last half-cycle before the end of the conduction phase and control means for detecting whether said conduction time is greater or less than a set time value, and starting conduction with the same polarity at the next conduction phase, when said conduction time is less, or starting conduction with the opposite polarity at the next conduction phase when said conduction time is greater" are not known from D5, nor from any other cited document, and serve to solve the problem of avoiding wear of the electrodes due to a unidirectional current, which problem is not addressed in the available prior art. The appellant has contended that such features are self-evident since polarised wear of the welding electrodes is avoided when the polarity is changed after a predetermined conduction time and as such these features should be considered obvious measures. However, the appellant has not indicated any evidence supporting this contention and there is nothing in the prior art cited which would support that contention. Thus also in relation to the subject matter of claim 19, the Board concludes that the decision under appeal correctly found that it involves an inventive step.

6. As regard claim 21, the decision under appeal refers to D5 as being the closest prior art, which is also not contested by the appellant. Said decision further states that the features "control means for comparing a difference between a value of said output current and

said modulation factor at the time of final pulse width modulation control in a positive half-cycle and a difference between a value of said output current and said modulation factor at the time of final pulse width modulation control in a negative half-cycle, and controlling at least one of amplitudes of said output current in said positive and negative cycles and conduction time widths of said positive and negative cycles of said output current based on a comparison result in a direction that said differences balance" are features which are not known from D5, nor from any other cited document, and serve to solve the general problem of better controlling the weld current.
Although the appellant has alleged that the features of claim 21 which are not known from D5 are a typical application of a pulse width modulation device using a reference current, no evidence has been provided by the appellant to support such an allegation. The same is true for the appellant's further allegation that such features have no special functional relationship considering the object underlying the patent, notably without any special advantageous or unexpected effect in the context of the patent. As pure allegations, these submissions are not sufficient to overcome the reasons for the decision under appeal which state that these features solve the general problem of better controlling the weld current, which is borne out, for example, by column 27, line 41 to column 28, line 14 and Figures 30 to 32 of the contested patent with regard to the effect of reduced saturation influence.
Thus, the Board concludes that the decision under appeal was also correct in its finding that the subject matter of claim 21 involves an inventive step.

7. As the subject matter of each independent claim involves an inventive step, the claims dependent thereon also involve an inventive step *ipso facto.*

8. Since there was no request for oral proceedings (Article 116 EPC) made during the appeal procedure and since the decision on the appeal could be taken on the basis of grounds and evidence on which the parties have presented (or had the opportunity to present) their comments (Article 113(2) EPC), the Board was able to decide the case without further communication to the parties (see also Article 10a(3) of the Rules of Procedure of the Boards of Appeal).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Patin P. Alting van Geusau