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**Datasheet for the decision
of 18 January 2007**

Case Number: T 0631/04 - 3.2.05

Application Number: 97109536.9

Publication Number: 0836009

IPC: F04D 27/00

Language of the proceedings: EN

Title of invention:

Vacuum pump in combination with an electronic control unit

Patentee:

VARIAN S.p.A.

Opponents:

Pfeiffer Vacuum GmbH
Leybold Vakuum GmbH

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step - (all requests) - no"

Decisions cited:

-

Catchword:

-



Case Number: T 0631/04 - 3.2.05

D E C I S I O N
of the Technical Board of Appeal 3.2.05
of 18 January 2007

Appellant: VARIAN S.p.A.
(Patent proprietor) Via Varian 54
IT-10040 Leini' (Torino) (IT)

Representative: Robba, Pierpaolo
Interpatent
Via Caboto 35
IT-10129 Torino (IT)

Respondent I: Pfeiffer Vacuum GmbH
(Opponent 01) Emmeliusstrasse 33
D-35614 Asslar (DE)

Representative: Knefel, Cordula
Patentanwälte Knefel & Knefel
Postfach 19 24
D-35529 Wetzlar (DE)

Respondent II: Leybold Vakuum GmbH
(Opponent 02) Bonner Strasse 498
D-50968 Köln (DE)

Representative: Selting, Günther
Patentanwälte
von Kreisler, Selting, Werner
Postfach 10 22 41
D-50462 Köln (DE)

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 18 March 2004
revoking European patent No. 0836009 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: W. Zellhuber
Members: H. Schram
P. Schmitz

Summary of Facts and Submissions

I. The appellant (patent proprietor) lodged an appeal against the decision of the Opposition Division posted 18 March 2004 revoking European patent No. 0 836 009.

Oppositions were filed against the patent as a whole and based on Article 100(a) EPC (lack of novelty, Article 54 EPC, and lack of inventive step, Article 56 EPC) and on Article 100(b) EPC (insufficiency of disclosure, Article 83 EPC). In the decision under appeal the Opposition Division held that the subject-matter of claim 1 of the sole request of the appellant was new, but did not involve an inventive step having regard to the cited documents.

II. Oral proceedings were held before the Board of Appeal on 18 January 2007.

III. The appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of claim 1 of the main request or claim 1 of any of the auxiliary requests one to three, all submitted on 12 January 2007.

The respondents I and II (opponents 01 and 02) requested that the appeal be dismissed.

IV. Claim 1 of the main request of the appellant reads as follows:

"1. Combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit (1), said unit (1) comprising:

- a casing (2);
- a first plurality of leads (50) for electrically feeding said control unit;
- a second plurality of leads (60) for electrically feeding said motor of the vacuum pump (100);
- a circuit for generating a voltage system adapted to feed said electric motor of the vacuum pump (100), said circuit providing for a plurality of main pulsating drive signals for controlling the generation of said voltage system, said drive signals including at least one pulsating signal (PWM) the pulse width of which can be modulated, said circuit including a pair of discrete power components for generating each voltage of said voltage system, and means for combining said at least one modulated pulsating signal (PWM) with at least another one (A, D, G) of said main pulsating drive signals in said circuit, the signal originated from said combination being an intermittent signal of spaced bursts or train of pulses,

characterized in that for at least one of said pairs of discrete power components a first one of said components is driven by said intermittent signal originated from the combination of said modulated pulsating signal (PWM) with one of said main pulsating drive signals and the other one of said components is driven by one of said main pulsating drive signals, whereby the rms voltage of at least one voltage of said voltage system is modified proportionally to the width of said modulated pulsating signal (PWM) and the heat dissipation in said pair of discrete power components is kept at a minimum."

Claim 1 of the first auxiliary request differs from claim 1 of the main request in that the expression "Combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit (1)" is replaced by the expression "Combination of a turbomolecular vacuum pump, an electric polyphase asynchronous motor for driving said vacuum pump and an electronic control unit (1) for feeding said electric motor".

Claim 1 of the second auxiliary request differs from claim 1 of the first auxiliary request in that the feature "said voltage system being a square wave polyphase system" is added after the expression "- a circuit for generating a voltage system adapted to feed said electric motor of the vacuum pump (100)".

Claim 1 of the third auxiliary request differs from claim 1 of the second auxiliary request in that the expression "polyphase asynchronous motor" is replaced by the expression "three-phase A.C. asynchronous motor".

V. The following documents were *inter alia* referred to in the appeal proceedings:

E12 *TEMIC Siliconics - AN714 A Compact Controller for Brushless DC Motors*, Wharton McDaniel, 17 March 1994, pages 47 to 54.

E16 *TMP/NT-50 Turbomolecular Pump & Frequency Converter Manual*, Leybold Vacuum Products Inc., Edition D, September 1989, front page, pages 2-15,

4-4, 4-6, 6-5 to 6-26, Figures 7.3 and 7.4, back page.

VI. The appellant argued in writing and at the oral proceedings essentially as follows:

The expression "proportionally to" in claim 1 of all requests did not mean "linearly proportionally to", but rather "depending on". This followed from considering the real waveforms of the voltages in operation (see e.g. Figure 3g, of the patent in suit). Since the motor exerted an inductive load, these waveforms were not ideal square waves. The relationship between the rms voltage and the width of the PWM signal proposed by the respondents was thus not correct. It followed that the invention was disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art, Articles 100(b) and 83 EPC.

The limitations according to the first and second auxiliary requests were subsequent restrictions, which were both disclosed in claim 6 of the application as filed. The further limitation according to the third auxiliary request was disclosed in column 3, lines 31 to 36, of the application as filed (published version). All auxiliary requests thus met the requirements of Article 123(2) EPC.

The object of the present invention was to provide a compact control unit for turbomolecular vacuum pumps, capable of varying the feeding voltage level supplied to the pump motor with low heat dissipation (see paragraphs [0021] and [0013] of the patent in suit). The decision under appeal was flawed, because

document E12 - rather than document E16 - was taken as the closest prior art for assessing inventive step. Document E12 was not a suitable starting point for inventive step, because (i) there was no hint or suggestion, let alone a disclosure, in this document that the controller described therein could be applied to the motor of a vacuum pump, or more specifically, to the motor of a turbomolecular vacuum pump; (ii) whilst this document disclosed a controller for brushless DC motors it did not disclose the motors themselves (or the devices containing them); (iii) the controller known from this document was not suitable for a turbomolecular vacuum pump, since the voltage range of from 20 to 40 V DC was much lower than the usual voltage necessary to attain a rotation of 24,000 to 62,000 rpm (see paragraph [0046] of the patent in suit); (iv) document E12 was silent about the problem of minimizing heat dissipation; (v) chopping off only the bottom MOSFETs by the PWM signal was merely disclosed as a possible mode of operation, it was not disclosed as an actual mode of operation. In this respect it was noted that document E12 was silent about any advantages, with respect to minimizing heat dissipation, of driving only bottom discrete power components by the intermittent signal originated from the combination of the modulated pulsating signal (PWM) with one of the main pulsating drive signals. In the control unit for a turbomolecular vacuum pump disclosed in document E16, both top and bottom discrete power components were driven by said combination signal. The subject-matter of claim 1 of the main request thus involved an inventive step, Articles 100(a) and 56 EPC.

Claim 1 of the first auxiliary request was directed to a combination of a turbomolecular vacuum pump, an electronic control unit and an electric polyphase asynchronous motor. Since document E12 disclosed a controller for brushless DC motors, this was an additional strong obstacle for the person skilled in the art to apply the controller known from document 12 to a turbomolecular vacuum pump with a polyphase asynchronous motor. The subject-matter of claim 1 of the first auxiliary request thus involved an inventive step, Articles 100(a) and 56 EPC. This applied likewise to the subject-matter of claim 1 of the second and third auxiliary requests, which related to special embodiments of an electric polyphase asynchronous motor.

VII. Respondents I and II argued in writing and at the oral proceedings essentially as follows:

The technical term "proportional" in claim 1 of all requests was unambiguous and meant linearly proportional. The rms voltage, however, was not linearly proportional to the width of the square wave PWM signal, as required by claim 1 of all requests of the appellant, but was, as a standard calculation showed, proportional to the square root of the width of the PWM signal. Hence the invention could not be carried out by the person skilled in the art, Articles 100(b) and 83 EPC.

Claim 1 of the first auxiliary request was restricted to the case whereby the electric motor was "an electric polyphase asynchronous motor" (cf. claim 6 of the application as filed) but did not require the

additional feature of claim 6 of the application as filed that "said voltage system adapted to feed the motor of the vacuum pump (100) is a square wave polyphase system". The claim did thus not meet the requirements of Article 123(2) EPC. Moreover, since claim 6 of the application as filed referred back to claim 1 of the application as filed via dependent claims 3 and 2, respectively, all features of claims 2, 3 and 6 of the application as filed should be incorporated in claim 1 of the first auxiliary request in order to meet the requirements of Article 123(2) EPC.

Document E12 was to be considered as the closest prior art, since it had, of all cited documents, the most features with claim 1 of the main request in common. Document E12 disclosed a motor, see the title of the document and the caption of Figure 8. The problem of document E12 was to provide a compact controller (see the title of the document) without the need for having heat sinks (see page 47, left column, lines 7 and 8), which problem was substantially the same problem as the invention sought to solve. The power range mentioned on page 47, right column, lines 6 to 9, of document E12 was no obstacle to apply the controller disclosed in this document to a turbomolecular vacuum pump, since it was known to the person skilled in the art how to adjust the power level. On page 48, right column, lines 11 to 15, the default condition for the control input signal QS was stated to be "only bottom MOSFETs chopped by PWM". For this default condition the heat dissipation was reduced, since the number of switchings of the gates, i.e. the number of opening and closing of the gates, was reduced. It followed that all the

features of claim 1 of the main request pertaining to the electronic control unit were known from document E12. Using the electronic control unit known from this document to control the motor of a turbomolecular vacuum pump was obvious to the person skilled in the art. But also starting out from the combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit known from document E16 the person skilled in the art would realize that chopping off of only the bottom MOSFETs by the PWM signal as taught by document E12 would reduce the heat dissipation and would thus arrive at the invention without exercising inventive skills, Articles 100(a) and 56 EPC.

The above reasoning also applied to the subject-matter of claim 1 of the first to third auxiliary requests, since in the description of the patent in suit itself it was stated that "the above described circuit can be equipped with means that are known to the person skilled in the art for other types of motors that drive vacuum pumps" (see paragraph [0047] of the patent in suit). Moreover, the additional features of said requests relating to the type of motor used were all known from document E16. The subject-matter of claim 1 of the first to third auxiliary requests thus lacked an inventive step as well, Articles 100(a) and 56 EPC.

Reasons for the Decision

1. *Interpretation of claim 1 (all requests)*

The term "proportionally" in the expression "the rms voltage of at least one voltage of said voltage system is modified proportionally to the width of said modulated pulsating signal (PWM)" in claim 1 of all requests of the appellant cannot, in the opinion of the Board, be construed in a mathematical sense to mean that the rms voltage and the width of the PWM signal are related by a constant ratio.

On the one hand, the person skilled in the art would expect that the rms ("root mean square") voltage of a perfect square wave periodic signal with a period P and a width t, viz. having a voltage V for t seconds and a zero voltage for P - t seconds, is proportional to the square root of the width of said square wave signal, or $V_{\text{rms}}/V = \sqrt{(t/P)}$. On the other hand, it is evident that the real waveforms of the voltage on the common junction terminal T shown in Figures 3e to 3g at different rotation speeds (see paragraph [0045] of the patent in suit), which voltage levels are periodically zeroed for an interval depending on the width of the PWM signal, are not perfect square waves. It will be clear, however, to the person skilled in the art, that, *ceteris paribus*, the rms voltage at terminal T can be increased by increasing the width of the PWM signal (see the block diagram of the electronic circuit shown in Figure 1 and the theoretical waveforms in said circuit shown in Figure 2).

In the judgment of the Board, the expression "is modified proportionally to" in claim 1 of all requests of the appellant therefore does not have the meaning "is modified linearly proportionally to" but should be construed in this particular case, in the light of the

disclosure of the patent in suit as a whole, to mean "is modified according to".

2. *Objection of insufficiency of disclosure
(Articles 100(b) and 83 EPC)*

The objection of respondents I and II under Articles 100(b) and 83 EPC is based on the premise that the term "proportionally" in claim 1 of all requests of the appellant necessarily meant "linearly proportionally". Since the Board cannot follow this interpretation (see point 1 above), the objection under Articles 100(b) and 83 EPC is unfounded.

The Board is satisfied that the subject-matter of claim 1 of all requests interpreted as in point 1 above is disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

3. *Objection of inadmissible extension beyond the content of the application as filed (Article 123(2) EPC)*

This objection was raised by respondents I and II only against claim 1 according to the first auxiliary request. In particular, it was argued that by restricting the electric motor in claim 1 of the main request to an electric polyphase asynchronous motor, an intermediate generalization had occurred, since the relevant disclosure of "said electric motor is a polyphase asynchronous motor" was dependent claim 6 as filed, which claim however further stated "and wherein said voltage system adapted to feed the motor of the vacuum pump (100) is a square wave polyphase system"

(henceforth referred to as the "square wave" feature). The "square wave" feature could not be omitted without contravening Article 123(2) EPC.

The Board is of the opinion that the "square wave" feature is presented in claim 6 as filed as an additional feature ("and wherein ...). It may be noted that the "square wave" feature is also present in claims 7 and 8 of the application as filed as an additional feature, which claims relate to a D.C. "brushless" motor and a switched reluctance (S.R.) motor, respectively. The "square wave" feature is thus not inextricably bound up with an asynchronous motor.

The passage in column 3, lines 31 to 36, of the application as filed (published version) reads: *In a preferred embodiment in which the vacuum pump is equipped with a three-phase A.C. asynchronous motor, the three-phase system of square-wave voltages for feeding the motor of the vacuum pump is generated by the circuit disclosed in details hereinbelow with reference to Figures 1, 2 and 3a to 3g.*

In the judgment of the Board, this passage read in combination with claim 6 makes it clear that the use of a polyphase asynchronous motor is a preferred embodiment, that a square-wave voltage system for feeding said motor is a more preferred embodiment and that a three-phase asynchronous motor with a square-wave voltage system for feeding said motor is a most preferred embodiment.

It follows that the restriction to an electric "polyphase asynchronous motor" in claim 1 of the first

auxiliary request does not lead to an extension of the subject-matter beyond the content of the application as filed.

The other amendments to claim 1 of the first auxiliary request are also found to meet the requirements of Article 123(2) EPC. This holds likewise for the amendments to claim 1 of the main request, and of the second and third auxiliary requests. Since this was not disputed by respondents I and II, there is no need for further substantiation of this matter.

MAIN REQUEST AND AUXILIARY REQUESTS 1 TO 3

4. *Objection of lack of inventive step (Articles 100(a) and 56 EPC)*

The Board concurs with the appellant that document E16 can be taken as a starting point for assessing inventive step. This document discloses a combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit, whereby the electric motor is an electric polyphase asynchronous motor, in particular a three-phase AC asynchronous motor having a polyphase system of square-wave voltages for feeding said motor (see Figures 6-3 and 6-4, and page 6-6, fifth paragraph). The turbomolecular vacuum pump known from document E16 is thus equipped with an electric motor as claimed in the main request and in each of the auxiliary requests of the appellant.

The electronic control unit employed in document E16 differs from the electronic control unit claimed in claim 1 of all requests of the appellant in that, in

the controller known from document E16 (see Figures 6-3 and 6-4), both transistors of the pairs of top and bottom transistors Q_1 to Q_6 are driven by a PWM signal, whereas in the controller according to the invention (all requests) only one transistor of the pairs of top and bottom transistors is driven by a PWM signal, leading to a reduction in heat dissipation. The Board further concurs with the appellant that the objective problem to be solved vis-à-vis document E16 is to provide a combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit having a lower heat dissipation than the electronic control unit known from document E16.

The subject-matter of claim 1 of the main request and document E16 both concern a combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit. Accordingly, the person skilled in the art addressing the objective problem indicated above, is, among others, an expert in the field of providing an electronic control unit for feeding an electric motor.

Document E12 concerns an electronic control unit for an electric motor. Moreover, it refers to the problems of compactness and heat dissipation of such electronic control units, cf. the paragraph in the left column of page 47. The content of document E12 and the characteristics and functioning of electronic components used in such control units thus belong to the common technical knowledge of the notional person skilled in the art seeking to solve the problem posed.

In the judgment of the Board, the person skilled in the art would recognize that switching only one of a pair of transistors as suggested in document E12 (see page 48, right column, lines 8 to 10, 13 and 14) gives rise to a reduction of heat dissipation, although this is not explicitly stated in document E12, since it belongs to the basic knowledge of the person skilled in art that switching electronic components, such as transistors, gives rise to dissipation of heat (see also column 5, lines 23 to 25 of the patent in suit).

A person skilled in the art seeking to solve the problem of reducing heat dissipation in an electronic control unit as disclosed in document E16 would thus consider applying the PWM signal to only one transistor of the pairs of transistors shown in Figure 6-3 of document E16.

It may be noted that the implicit teaching of document E12, viz. that switching only one of a pair of transistors gives rise to a reduction of heat dissipation, is not restricted to the voltage range or to the type of motor described in document E12 (the electronic component Si9979 known from document E12 is operated over an input voltage range of 20 to 40 V DC, see page 47, right column, lines 6 to 9). Furthermore, the question to be answered is whether or not a person skilled in the art would apply said teaching of document E12 to the electronic control unit known from document E16, rather than whether or not he or she would use the specific electronic component Si9979 itself described in document E12 in the motor drive known from document E16 (see Figures 6-3 and 6-4).

Thus, in the judgment of the Board, the person skilled in the art, starting from a combination of a turbomolecular vacuum pump, an electric motor and an electronic control unit as known from document E16 and seeking to reduce the heat dissipation of the electronic control unit would have driven only one transistor of the pairs of top and bottom transistors by a PWM signal and thus would have arrived at the invention.

It follows that the subject-matter of claim 1 of the main request is obvious to the person skilled in the art, Articles 100(a) and 56 EPC.

The same applies to the subject-matter of claim 1 of the first, second and third auxiliary requests for the same reasons, since, as already pointed out above, document E16 already specifies the additional features of each of these claims.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

D. Meyfarth

W. Zellhuber