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Datasheet for the decision of 19 June 2009

Case Number: T 0060/08 - 3.2.04

Application Number: 03760812.2

Publication Number: 1407148

IPC: F04D 19/04

Language of the proceedings: EN

Title of invention:
Apparatus for controlling the pressure in a process chamber and method of operating same

Patentee:
Edwards Limited

Opponent:
Oerlikon Leybold Vacuum GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 52(1), 54, 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Novelty - no (main request, auxiliary requests Ia, I)"
"Inventive step - no (main request, auxiliary requests Ia, II, III)"

Decisions cited:
-

Catchword:
-

Case Number: T 0060/08 - 3.2.04

D E C I S I O N
of the Technical Board of Appeal 3.2.04
of 19 June 2009

Appellant: (Opponent)	Oerlikon Leybold Vacuum GmbH Bonner Strasse 498 D-50968 Köln (DE)
Representative:	von Kirschbaum, Alexander Patentanwälte Deichmannhaus am Dom Bahnhofsplatz 1 D-50667 Köln (DE)
Representative: (Patent Proprietor)	Edwards Limited Manor Royal Crawley, West Sussex RH10 9LW (GB)
Representative:	Clark, Charles Robert Edwards Limited Manor Royal Crawley, West Sussex RH10 2LW (GB)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted 16 November 2007 concerning maintenance of European patent No. 1407148 in amended form.**

Composition of the Board:

Chairman: M. Ceyte
Members: A. de Vries
T. Bokor

Summary of Facts and Submissions

I. The Appellant (Opponent) lodged an appeal, received 8 January 2008, against the interlocutory decision of the Opposition Division posted 16 November 2007 on the amended form in which the European Patent No. 1 407 148 can be maintained, and simultaneously paid the appeal fee. The statement setting out the grounds was received 12 March 2008.

II. Opposition was filed against the patent as a whole and based on Article 100(a) together with Articles 52(1) and 54 EPC 1973 for lack of novelty, and together with Article 52(1) and 56 EPC 1973 for lack of inventive step.

The Opposition Division held that the grounds for opposition mentioned in Article 100 EPC 1973 did not prejudice the maintenance of patent as amended having regard to the following documents in particular:

D1: US-A-5 611 863
D7: Leybold Vacuum : TURBOVAC TW 701 Turbo-Molekularpumpe mit integriertem Frequenzwandler : Gebrauchsanleitung, Marked GA 05. 149/3.01 - 06/2003
D8: EP-B1-0 996 877

III. The Appellant requests that the decision under appeal be set aside and the patent be revoked in its entirety.

The Respondent requests that the appeal be dismissed and the patent be maintained in the version held to be allowable by the opposition division in the decision under appeal, or in the alternative, and in this order, on the basis of the claims according to an auxiliary request Ia filed with letter of 21 April 2009, according to one of auxiliary requests I or II filed with the grounds of appeal, or, finally, according to an auxiliary request III filed at the oral proceedings.

IV. Oral proceedings requested by both parties were held on 19 June 2008.

V. The wording of the independent claims of the requests is as follows :

Main request (as held allowable in the decision under appeal)

Claim 1: "A method of operating an apparatus for controlling the pressure in a process chamber (10), the apparatus comprising a process chamber, a first pump unit (14) having an inlet in fluid connection with an outlet of a process chamber, and a second pump unit (16) having an inlet in fluid connection with an outlet of the first pump unit via a flow control unit (18) comprising a variable flow control device (20; 28) having variable conductance for controlling outlet fluid pressure at the outlet of the first pump unit, the method comprising controlling speed of the first pump unit to increase the range of chamber pressures over which control of the outlet fluid pressure produces changes in said chamber pressure without exceeding the thermal limit and/or motor stall limit of the first pump unit, and controlling the pressure in the processing chamber over said increased range of chamber pressures by varying the conductance of the variable flow control device."

Claim 7 : "Apparatus for controlling the pressure in a process chamber (10), the apparatus comprising a process chamber, a first pump unit (14) having an inlet for fluid connection with an outlet of a process chamber, a second pump unit (16) having an inlet for fluid connection with an outlet of the first pump unit via a flow control unit (18), the flow control unit comprising a variable flow control device (20; 28), the variable flow control device having variable conductance for controlling fluid pressure at the outlet of the first pump unit, and means for controlling speed of the first pump unit to increase the range of chamber pressures over which control of the variable flow control device produces changes in said chamber pressure without exceeding the thermal limit and/or motor stall limit of the first pump unit, and means for controlling the pressure in the processing chamber over said increased range of chamber pressures by varying the conductance of the variable flow control device."

Auxiliary Request Ia

Method claim 1 is unchanged. The independent apparatus claim 7 is as in the main request but for the following amendment: "means for controlling speed ..., and the means for controlling pressure ..." now reads "***a control unit (21)*** for controlling speed ...., and for controlling the pressure ...." (emphasis added by the Board to indicate what has changed). The two means are thus replaced by a single control unit carrying out both functions.

Auxiliary Request I

This request includes only apparatus claims. Claim 1 is identical to the independent apparatus claim of the main request.

Auxiliary Request II

This request includes only method claims. Claim 1 is identical to the independent method claim of the main request.

Auxiliary Request III

This request includes only method claims. Claim 1 is as in the main request but replaces the terms "first pump unit" and "second pump unit" by the terms "turbo molecular pump" and "backing pump" respectively, while also adding at the end of the claim the following wording:
"wherein the speed of the turbo molecular pump is controlled according to

$P_{Inlet} = f(Q,\omega,N)$

$T_{TMP} = f(Q,\omega,P_{Exhaust},P_{Inlet},k)$

$\omega_{Stall} = f(P_{Inlet},N)$

ω is such that

$P_{Inlet} < P_{Required}$

$T_{TMP} < T_{Limit}$

$\omega < \omega_{Stall}$

wherein Q - Mass flow rate of gas

ω - Rotational speed of TMP

N - Molecular mass of the gas

k - Thermal conductivity of the gas

$P_{Exhaust}$ - TMP exhaust pressure

P_{Inlet} - TMP Inlet Pressure

$P_{Required}$ - Required TMP inlet pressure for specific process

ω_{Stall} - Stall speed of the TMP motor

T_{TMP} - TMP thermal level

T_{limit} - TMP thermal limit."

VI. The Appellant argued as follows :

None of the features of the claimed apparatus represent a specific adaptation for carrying out the various steps of the method as claimed. The means for controlling pump speed and the means for controlling chamber pressure by varying conductance are merely suitable for the stated purpose. The backing valve control and alternative speed adjustment suggested in the D1 pump arrangement imply the presence of both control means in the sense of claim 7. Calling the controlling means a "control unit" makes no difference, as it is equally unspecific and does not imply a CPU calculating range changes.

The method itself arises from obvious considerations. The thermal limit in a turbo pump is due also to compression and resulting temperature increases; by reducing compression, i.e. reducing speed, the pump can be moved away from its thermal limit. Whereas at full load, close to the thermal range, the backing valve can be closed only by a small amount from full throttle, further away from the limit the range in which the valve can be operated is much larger. Applying such general knowledge to either D1 or D8, both showing chamber pressure control via the backing valve as well as pump speed control, leads in obvious manner to the claimed method.

Nor do the formulae and conditions of claim 1 of the auxiliary request III add anything inventive. They are entirely unspecific. Insofar they can be fully understood they appear to state the obvious.

VII. The Respondent argued as follows :

The invention's main purpose is to provide a more accurate control of chamber pressure using the backing valve. By selecting an appropriate pump speed the backing valve can control chamber pressure across a wider range without the risk of damaging the pump by driving it beyond the thermal limit. This requires knowledge of the link between speed and increased range. Without this link the blind control of speed and backing valve, each separately, can result in irreparable damage to the pump. The controlling step in the method and the controlling means of the apparatus establishes this link and is pivotal in the invention. This is expressed even clearer in the term "control unit" in the apparatus claim of auxiliary request Ia, which automatically carries out the calculation of range increases on the basis of speed changes.

None of the prior art recognizes this essential link. Though pump speed adjustment and backing valve control may be known individually for controlling chamber pressure, none of the prior art suggests their combination in the way claimed. D1, in any case, does not show backing valve control of chamber pressure, as is clear from the closed state of inlet (throttle) valves 34,35 that any backing valve adjustment will effect only the pressure in the forelines but not the process chamber.

In D8 only speed of the backing roots pump is controlled to reduce the backing pressure of the turbo pump; in this way it acts as a controllable backing valve.

It is in fact counterintuitive to continuously adjust or control speed of a final pump such as a turbo pump. Normally, these pumps, which are inverter driven, allow for speed adjustment to set pump capacity to match process requirements, or to switch to a (lower capacity) saving mode during process down time.

In claim 1 of the auxiliary request III the added formulae and conditions for setting pump speed establish in more detail the relationship linking pump speed and operation range. They highlight the differences with the prior art, where pump setting would normally rely on a single graph of allowable chamber pressure values against backing valve angle. The three functions - empirical multivariable relationships generating a plurality of setting graphs - demonstrate how much more complex the present approach is.

Reasons for the Decision

1. The appeal is admissible. Moreover it is allowable for the reasons indicated below.

2. The Invention and Claim Interpretation

2.1 The invention is concerned with controlling the pressure in a process chamber using a vacuum pumping system with a first (main) pump connected to a process chamber, a second (back-up) pump, and an intermediate controllable valve. This so-called backing valve controls exhaust or outlet pressure of the first, main pump. Chamber pressure is responsive to outlet pressure mainly above a critical backing pressure, see specification paragraph [0018] and figure 4, in a narrow range at nominal pump speed determined at the upper end by the pump's thermal limit, above which the pump will overheat resulting in pump failure.

2.2 The main idea is to change pump speed to increase the above range of chamber pressures by shifting the critical backing pressure and the upper limit further apart, cf. figure 7. As a result chamber pressure can be safely controlled over the wider range by varying the valve conductance, which determines outlet (backing) pressure.

Method and apparatus claims as granted thus include a step, respectively means for so controlling pump speed, as well as step and means, respectively, for controlling chamber pressure over the increased range by varying valve conductance.

2.3 The speed control is described in detail in specification paragraph [0015]: "speed of the TMP may be selected by an operator, using a speed selector, for each process ... and the predetermined speed is maintained ... by a computer or by the operator".

Control of pump speed in the sense of the invention, namely to increase the operation range, thus in fact corresponds to a manual setting by an operator.

Control of chamber pressure by varying valve conductance is described in specification paragraph [0014]: A "control unit 21 ... provides a control signal to the flow control unit [valve] 18 ... The control unit may be operated manually or automatically". Chamber pressure control is thus not uniquely automatic, but may also be effected manually, by an operator directly operating the valve.

2.4 In the light of the above the core idea of the method of the claimed invention can be restated as : selecting or setting pump speed so that the range of chamber pressures possible by controlling of the controllable valve and without exceeding the thermal limit is increased, and then operating the flow control unit to control the chamber pressure over this "safe" increased range.

2.5 The relevant features of the apparatus claim - defined in purely functional terms ("means for controlling ...") and thus to be interpreted as suitable to perform that function or purpose - must be interpreted in the light of the above. The "means for controlling speed of the first pump ..." thus reduces to ***means suitable for selecting or setting speed.*** It should be borne in mind that the effect of increased operation range is inherent in changing pump speed and does not impose any limitation on the means itself.

The "means for controlling the pressure in the processing chamber ..." is likewise read as meaning nothing more than ***means suitable for operating the flow control unit or controllable valve***. That the operation should be commensurate with an increased range of chamber pressures has no clear implications for the means itself, as the embodiment of manual operation mentioned in specification paragraph [0014] demonstrates.

3. Apparatus claims

3.1 From the preceding section it follows that for carrying out the above restated method an apparatus for control of process chamber pressure with a valve between main and backing pump requires only valve control and an adjustable pump speed. Such an apparatus is for example known from D1.

3.2 In more detail, D1, see figure 2, and column 4, lines 29 to 59, discloses an apparatus for controlling the pressure in a process chamber, plasma reaction chamber 26, with a first pump unit, in the form of turbo molecular pumps 36 and 37, connected at their inlets to the outlet or exhaust ports 32,33 of the chamber 26 as is clear from the figure. The inlet of a second pump unit, dry pump 41, is connected to the outlet, exhausts 38,39, of the turbo pumps via a control valve 40 as the flow control unit with variable flow control device of variable conductance of the claim.

3.3 Control valves are specifically designed for controlled closing and opening, cf. column 5, lines 51 to 53, to allow flow to be controlled. The necessary means for controlling valve action are implicit. As flow through the valve determines pressure at the outlet of the turbo-pump, which in turn can be used to regulate pressure in the process chamber, the valve and its control can in principle also be used to control pressure in the process chamber 26 over varying pressure ranges in the manner claimed. This is irrespective of the fact that D1 describes a different use for the valve (namely during cleansing of the surfaces of butterfly valves 34,35 between the turbo pumps and the plasma chamber). The valve and its control are inherently ***suitable for*** the claimed purpose.

Equally immaterial is the alleged (semi) automatic character of the control which would require a complex set of data relating a set speed to a desired range of chamber pressures as described by the Respondent at the oral proceedings before the Board. Such limitations are neither explicit nor implicit in the claim's functional wording. This broad formulation, for example, also embraces manual operation as considered in specification paragraph [0014] ("The control unit may be operated manually ..."). Whether the operator requires the data (as paper graphs or displayed on a personal computer) to perform accurate control is of no import. Firstly, this depends on the skill and knowledge of the operator and also the control specifications. Secondly, the data and its means of generation - which would require the operator as intermediary - can be considered as separate of the control means proper.

At any rate, the means controlling valve action implicit in the control valve 40 of D1 can be seen to correspond with the means for controlling chamber pressure of the independent apparatus claims.

3.4 Whereas D1, column 5, lines 49 to 57, describes increasing pressure in the plasma chamber by controlling valve 40 (in conjunction with gas flow through the closed butterfly valves 34,35 which are of leakage type, see column 6, lines 26 to 31) a further possibility is mentioned in the following lines. Thus, "another means for increasing the [chamber] pressure ... is to decrease the rotational speeds of the turbo molecular pumps...". This passage clearly suggests the presence of means for controlling speed.

The passage could be read as a reference to a modified version of the figure 2 arrangement in which a controlled speed turbo pump ***replaces*** the control valve. However, commercial turbo molecular pumps are invariably inverter driven, as acknowledged by the Respondent, and are thus outfitted with a variable frequency drive, to allow them to operate at different required speeds and capacities. Given this fact, the reader skilled in the field of vacuum pumps reads this passage in D1 as an instruction for an alternative ***use*** of the same figure 2 configuration, which, in addition to a control valve, also includes a turbo molecular pump with speed control.

As noted above, an increase in the range over which chamber pressure responds to valve control is a direct consequence of changing the speed of the pump. Any speed control which allows setting of different speeds in so doing inherently produces this result. Therefore, D1 also discloses a means for controlling speed of the first pump (the turbo molecular pump) in the sense of the apparatus claim.

3.5 The Board concludes that all features of the apparatus defined in the corresponding independent claim of the ***main request*** and the ***auxiliary request I*** are derivable from D1. The subject-matter of this claim lacks novelty, contrary to the requirements of Article 52(1) in combination with Article 54 EPC.

3.6 In claim 7 of the ***auxiliary request Ia*** the means for controlling speed and the means for controlling the chamber pressure are replaced by a single "control unit" carrying out both control functions (which are otherwise unchanged). This conveys no more information than that the functions are directed from a central location in a dedicated part of the apparatus that is identifiable as such. It arguably also implies issuance of electronic control signals and some form of electronic processing circuitry. It does not mean, as argued by the Respondent, that control is fully automatic and that the signals are generated in accordance with a stored relationship between set speed and resultant operation range, see also section 3.1.2 above.

D1 provides no explicit detail of the actual control mechanism or architecture. Nevertheless, the D1 arrangement relates to a semiconductor processing apparatus such as for cyclotron resonance plasma CVD (column 1, first paragraph). Such complex processing of precision components is envisageable only under accurately controlled and monitored conditions. This in turn is possible only if control is electronic and centrally coordinated, i.e. by means of some form of "control unit" managing the various signals and functions. This will be immediately apparent to the skilled reader of D1. For this reason, the feature of the single control unit adds nothing new to the claimed apparatus. The subject-matter of claim 7 of the auxiliary request Ia also lacks novelty.

4. Method claims

4.1 It follows from the above that the apparatus of D1 has all necessary features for carrying out the method as defined in the main request. Nevertheless, D1 does not suggest varying the operative range of chamber pressure by changing pump speed. Nor is this idea in evidence in any of the other citations. The claimed method (main request, auxiliary requests Ia, II and III) is therefore novel. However, in view of further documents D7 and D8 and the skilled person's common general knowledge it is not considered inventive.

4.2 D8 also relates to pressure control in a process chamber, see paragraph [0021]. Figure 5 and paragraph [0045] show an arrangement with a control valve 13 between a main turbo molecular pump 2 and a (roots) pre-vacuum pump 3. Chamber pressure is controlled by regulating the valve in response to sensed pressure and a set-point pressure, i.e. in a similar feedback control loop to that described in specification paragraph [0014] of the patent. The set-point pressure is determined either manually or automatically by a system operator 6, cf. paragraph [0023].

4.3 With regard to D8, the method of claim 1 (main request, auxiliary requests Ia, II) interpreted as above in section 2.4, differs in steps of
- setting the speed of the first (turbo) pump to increase the "safe" chamber pressure operation range
- controlling chamber pressure over this safe range.

Setting speed to increase safe operation range extends control of chamber pressure while avoiding damage to the pump. The problem to be solved by the invention can be formulated accordingly.

4.3.1 D8 does not provide any information as to the range of allowed chamber pressures when regulating the valve. It is however standard practice, as acknowledged by the parties, to operate a pump below its thermal limit to avoid damage, and to set pressure regimes accordingly. In determining the set point pressure in the chamber as in D8 the skilled person will thus follow standard practice and therefore operate the pump over a limited range of chamber pressures and associated valve angles below the pump's thermal limit. This is in fact the starting point of the specification, see column 1, lines 36 to 43, and claims, which refer to ***increasing*** the range. It is also borne out by the Respondent's reference to the prior art use of a graph or similar data setting out chamber pressures against valve angle when operating a turbo pump.

Pumps such as turbo molecular pumps are moreover designed for operation under specified, nominal conditions, one of which is pump speed. Any recommendations or characteristics provided for setting the pump will be understood to be specific to those nominal, design conditions.

4.3.2 It is further known to change the pumping speed of a turbo molecular pump, see for example D7, see page 40, left column ("Saugvermögen über die Drehzahl einstellen"). This passage mentions permanently setting speed at a lower (than nominal) value depending on the particular application. ("Zur Applikationsbedingten Verminderung des Saugvermögens ... dauerhaften, einmaligen Drehzahlreduktion"). This is for example desirable where full pump capacity is not required, as explained by the Respondent.

4.3.3 When permanently lowering speed from its "design" level, it is clear to the skilled person from the physics of the pump and the central role of pump speed therein that the characteristics and response, drawn up for design conditions, may no longer apply. In the case of the complex, precision processes of D8, accurate control is critical, and any changes must be taken into account. Consequently, where a D7 type pump has been fitted (as a matter of obviousness) into an arrangement such as that of figure 5 of D8, and is then set at a lower than design speed, to meet lower capacity requirements, say, the skilled person will as a matter of obviousness check for changes in the pump's response in the arrangement. How the chamber pressure response and range will have changed with regard to thermal limit will be an obvious concern, see above. The skilled person will inevitably establish changes, and adjust control accordingly over a wider range.

This may be clearer in reference to the example of the single graph cited by the Respondent. The graph is normally drawn up for the nominal pump speed. If a lower speed is set as in D7 a new graph will need to be drawn up. That new graph inevitably covers a wider range, as lower speed inherently gives increased control range. Whether or not the skilled person recognizes this link is beside the point. The question to be asked is whether he is motivated to change control in response to changing pump speed. In the Board's view his knowledge of the underlying physics of the pump and the centrality of pump speed therein provides the motivation to do so.

4.3.4 In summary, the skilled person adopts as a matter of obviousness a D7 type turbo molecular pump in a pumping arrangement as in figure 5 of D8, which is obviously operated over a limited range of chamber pressures below the thermal limit. If, as taught by D7, he runs the pump at a lower than design speed, his knowledge of such pumps instructs him to adapt the operation range of chamber pressures to take account of the lower speed. He so arrives at the method of claim 1 of the main request and auxiliary requests Ia and II without the exercise of inventive skill. The subject-matter of claim 1 in each of these requests lacks inventive step.

4.4 Turning to claim 1 of the auxiliary request III, the amendments pertaining to turbo-molecular and backing pumps are immediately apparent from D8 and behove no further comment.

4.4.1 The remaining features elaborate on the particular speed control. As above this is read in the light of the description, specification paragraph [0015], as referring to a particular ***setting*** of the speed to simultaneously meet three different criteria. The first ($P_{Inlet} < P_{Required}$) requires pump inlet pressure (i.e. chamber pressure) not to exceed a required value, the second ($T_{TMP} < T_{Limit}$) sets pump temperature below the thermal limit, while the third ($\omega < \omega_{Stall}$) runs the pump at speeds below stalling speed. Thus formulated these criteria represent common constraints in the operation of a turbo molecular pump. Formulating them in this manner itself does not involve an inventive step.

4.4.2 The relevant parameters (or limits) are expressed in abstract form as multivariable functions including pump speed as variable; the functions otherwise remain undefined in claims and description. What is significant is that this formulation expressly recognizes the dependency on pump speed of the parameters involved, and thus the role of pump speed in the above constraints.

4.4.3 As noted in the previous section, turbo-molecular pumps can be run at lower than design speeds. However, this effects the pump's performance as determined for design conditions, and that performance must, as a matter of obviousness be determined afresh for a chosen non-design speed. The corollary is that the characteristic parameters defining that performance depend on pump speed. The express recognition of this fact in the abstract formulation of common operation constraints also does not involve an inventive step. The method of claim 1 according to the auxiliary request III consequently lacks inventive step.

5. The Board concludes from the above that, taking into account the amendments to the independent claims according to any of the requests, the patent and the invention to which it relates do not meet the requirements of the EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar The Chairman

G. Magouliotis M. Ceyte