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Datasheet for the decision of 25 July 2014

Case Number: T 1836/11 - 3.2.04

Application Number: 04732236.7

Publication Number: 1625290

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Language of the proceedings: EN

Title of invention:
TURBOCHARGER SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

Patent Proprietor:
VOLVO LASTVAGNAR AB

Opponents:
ABB Turbo Systems AG
BorgWarner, Inc.

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (no)
Inventive step - combination invention (no)

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Catchword:

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Case Number: T 1836/11 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 25 July 2014

Appellant: (Opponent 1)	ABB Turbo Systems AG Bruggerstrasse 71a, Postfach 5400 Baden (CH)
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Appellant: (Opponent 2)	BorgWarner, Inc. 3850 Hamlin Road Auburn Hills, MI 48326 (US)
Representative:	Peterreins, Frank Fish & Richardson P.C. Highlight Business Towers Mies-van-der-Rohe-Strasse 8 80807 München (DE)
Respondent: (Patent Proprietor)	VOLVO LASTVAGNAR AB 405 08 Göteborg (SE)
Representative:	Fröhling, Werner Otto Volvo Technology Corporation Corporate Patents 06820, M1.7 405 08 Göteborg (SE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 8 August 2011 concerning maintenance of the European Patent No. 1625290 in amended form.**

Composition of the Board:

Chairman	A. de Vries
Members:	J. Wright
	T. Bokor

Summary of Facts and Submissions

I. The appellant-opponent I and appellant-opponent II lodged separate appeals, received on 4 October 2011 and 23 August 2011 respectively, against the interlocutory decision of the opposition division posted 8 August 2011 on the amended form in which the European patent No. EP-B-1625290 can be maintained. Both appellants paid the appeal fees at the same time as filing their notices of appeal. Statements setting out the grounds were received from the appellant-opponent I on 16 December 2011 and from appellant-opponent II on 7 September 2011.

The oppositions were based *inter alia* on Article 100(a) EPC (inventive step). The opposition division held that the patent as amended according to the main request met all the requirements of the EPC, *inter alia* because the subject matter of claim 1 as amended involved an inventive step, having regard to the following documents amongst others:

E3: D. Japikse: "Centrifugal Compressor Design and Performance", Concepts ETI Inc, USA, 1996; pp.1-4, 2-12, 2-23, 6-1 to 6-19

E4: C.Rodgers : "Centrifugal compressor design options for small turbochargers"; IMechE Conference Transactions, 6th International Conference on Turbocharging and Air Management Systems, London, 3-5 November 1998, 23-31

It decided not to admit the following documents amongst others into the proceedings:

E13: DE-C1-42 42 494

E14: N.Watson et al.:"Turbocharging the Internal Combustion Engine", New York, Wiley&Sons, 1982; selected passages;

E17: D.Tennant:"A compact two-stage turbocharger module", IMechE 1990-6, Proceedings of the Institution of Mechanical Engineers, 4th International Conference : Turbocharging and Turbochargers, London 22-24 May 1990;

E18: "Introduction to Turbochargers", Schwitzer, USA, 1984

II. Oral proceedings before the Board were duly held on 25 July 2014.

III. Both appellants request that the decision be set aside and that the patent be revoked in its entirety.

The respondent-proprietor requests that the appeals be dismissed and the patent be maintained in the form held allowable by the opposition division, or in the alternative, that the patent be maintained in amended form according to one auxiliary requests 1 to 7. Of these the first and second auxiliary requests were filed on 19 May 2011 at oral proceedings before the division and the third to seventh auxiliary requests were filed with the respondent's reply to the appeals on 2 May 2012.

All parties requested oral proceedings.

IV. The wording of claim 1 of the various requests is as follows:

Main request (as held allowable by the division) and second auxiliary request:

"A turbocharger system for an internal combustion engine (10) having at least one exhaust line (15, 16) for evacuating exhaust gases from the combustion chamber (11) of the engine and at least one inlet line (12) for supplying air to said combustion chamber, comprising a high-pressure turbine (17) interacting with a high-pressure compressor (19) and a low-pressure turbine (21) interacting with a low-pressure compressor (23), for extracting energy from the exhaust flow of the engine and pressurizing the inlet air of the engine, characterized in that both compressor stages are of the radial type and are provided with compressor wheels having backswept blades (35) in which the blade angle ($ß_{b2}$), between an imaginary extension of the centerline of the blade between root section and tip section in the direction of the outlet tangent and a line (36) connecting the center axis of the compressor wheel to the outer point of the blade, is at least about 40 degrees, in that the high-pressure turbine (17) is of the radial type and is connected to the low-pressure turbine by a short intermediate duct (20), that the low-pressure turbine (21) is provided with inlet guide vanes (34) and in that the high-pressure turbine (17) is provided with a feed worm with double inlet, in which each inlet duct (15, 16) supplies half the turbine with gas flow via inlet guide vanes."

Claim 1 of the first auxiliary request reads as in the main request except that the term "guide vanes" is replaced by "guide rails".

Claim 1 of the third auxiliary request reads as in the main request but (*italics* added by the Board to emphasise added text):

- adds the wording "*high pressure turbo unit (18) comprising* a" before the words "high pressure turbine (17) interacting..."
- adds the wording "*low pressure turbine unit (22) comprising* a" before the words "low-pressure turbine (21) interacting..."
- and adds to the end of the claim the wording "*,and in that the two turbo units (18, 22) are oriented along essentially the same longitudinal axis.*"

Claim 1 of the fourth to seventh auxiliary requests read as in the main request but add the following features to the end of the claim as follows (again *italics* added by the Board emphasise added text):

Fourth auxiliary request: "*, and in that the lower pressure turbine (21) is connected to the low pressure compressor (23) and the high pressure turbine (17) is connected to the high pressure compressor (19) via respective separate shafts (32, 31)*".

Fifth auxiliary request: "*, and in that the low-pressure turbine (21) is of the axial type.*"

Sixth auxiliary request: "*, and in that the intermediate duct (20) is annular, having an inner body (20a) of a cross section which increases in the direction downstream.*"

Seventh auxiliary request: "*, in that the low-pressure turbine (21) is of the axial type, and in that the intermediate duct (20) is annular, having an inner body (20a) of a cross section which increases in the direction downstream.*"

V. The appellants mainly argued as follows:

The division had erred in not admitting documents E9 to E20, while admitting late requests that were contrary to Rule 80 EPC into the proceedings

Starting *inter alia* from E17, claim 1 as upheld and according to all auxiliary requests lacks an inventive step. The subject matter of claim 1 of all requests differs by the features of compressor vanes backswept by 40° and by the high pressure turbine having a double feed worm with separate inlets. The two features provide no synergic effect and so should be treated separately for assessing inventive step. Turbochargers with compressor vanes backswept by 40° are known to increase turbocharger efficiency *inter alia* from documents E3, E4 and E14. Turbine feed worms with double inlets for efficiently using pulsed energy from separate exhaust manifolds belong to the general knowledge of the skilled person. Such arrangements are disclosed *inter alia* in textbooks E14 and E18.

VI. The respondent mainly argued as follows:
The aim of the patent is a more efficient turbocharger that is also compact. E17 is unsuitable as a starting point for assessing inventive step since most of its figures are missing and since it relates *inter alia* to marine engines not truck engines as the patent does. If the skilled person did start from E17, the differing features are compressor vane backsweep of at least 40° and double inlet feedworm. Starting from E17, the skilled person would not consider backsweep angles of 40° since, prior to the patent, this implied increased compressor diameter, thus a less compact turbocharger. By using backsweep the compressor and turbine can rotate at higher speed, thus the turbine can be smaller

and more responsive. A smaller turbine can be more efficiently driven by a double entry feed worm, thus the differing features interact synergically to achieve the aim of an efficient turbocharger. Nothing in the prior art suggests the combination of these features.

Reasons for the Decision

1. The appeals are admissible.

2. Admissibility of certain documents

2.1 The opposition division decided not to admit *inter alia* documents E13, E14, E17, E18 and E20 into the proceedings.

In a communication to the parties dated 28 May 2014, the Board noted that the opposition division ostensibly based the non-admission of E9 to E20 on an assessment of their prima facie relevance. However, from the decision, reasons 2.1, it appeared that the division had not considered the relevance of the content of these documents to the features of the invention claimed, but rather had based their decision on incorrect criteria (obviousness cannot be based on more than two documents; evidence to prove general knowledge mostly patents or papers, where some are indeed textbook documents). The Board concluded that the division appeared to have exercised its discretion in a wrong manner and that the Board would therefore have to reconsider the question of admissibility of these documents.

In the communication the Board also noted that in particular E13, E14, E18 and E20, *prima facie* appear to relate to double inlet feed worms in turbochargers, a

feature challenged by the respondent as not present in prior art admitted by the division, while E17 appeared *prima facie* relevant as a starting document for assessing inventive step of claim 1 of the main request and sixth auxiliary request. The Board informed the parties that as these documents, even if late, were nonetheless filed at a relatively early stage before the first instance and the proprietor had been given sufficient opportunity to respond thereto (and had indeed done so), it was inclined to admit them into the proceedings.

Also considering the absence of any arguments of the parties against the foreseen course of action, the Board exercises the discretion afforded it under Article 114(2) EPC and decides to admit documents E13, E14, E17, E18 and E20 into the proceedings.

2.2 The Board adds that in this case the division's discretionary exercise according to the wrong principles did not in itself violate the appellant-opponent's right to be heard. Nor is such a violation apparent in the division's admission of new requests at the oral proceedings after having considered the arguments for and against admissibility under the *wrong* legal provision (which should have been sufficiency of disclosure rather than clarity). The arguments were considered and thus the right to be heard respected. Such an error in substantive law also does not constitute a procedural violation, much less a substantial one given that the outcome (admission of requests) would have been the same.

3. Background of the invention

The Patent concerns a two stage turbocharger for an internal combustion engine [0001]. The stated object of the invention is to make better use of the energy in the exhaust flow for increased efficiency, without engendering significant spatial requirements, in other words to increase turbocharger efficiency without increasing overall size, see specification paragraph [0005].

4. Main request, inventive step

4.1 In the Board's estimation, E17 is a good starting point for assessing inventive step because it relates to a two stage turbocharger for an internal combustion engine (page 1 synopsis) which like the patent aims to achieve an efficient turbocharger (introduction, second paragraph) and has principal components similarly arranged (cf. E17, figure 1 and patent, figure 2).

4.1.1 The respondent argued at the oral proceedings before the Board that E17 is incomplete and thus an invalid starting point for assessing inventive step. In particular figures said to show the compressor wheel are missing.

4.1.2 The Board is unconvinced by this argument, which was made at such a late stage that the appellants could not reasonably have been expected to address it (unless the proceedings were adjourned to a later date so that they might provide the missing figures). What might or might not have been shown in those figures had they been so provided is pure conjecture. At best it might have shown vanes that were not backswept or backswept at a lower angle, but this would have had little impact on the discussion of inventive step as explained below.

4.1.3 Nor is the Board convinced that E17 is an invalid starting document since it relates to a turbocharger for marine engines (section 1, introduction). The claim does not specify a particular field of application, thus this consideration plays no role in choosing a suitable starting document. Furthermore the specification, paragraph [0025] mentions that the invention is also applicable to marine engines.

4.2 E17's main features can be seen in figure 1, see also introduction, final paragraph. In particular these include "a back to back high pressure and low pressure turbocharger arranged on the same axis", with (from left to right in the figure) a high pressure compressor driven by a high pressure radial type turbine connected via a short interstage duct to an axial flow low pressure turbine driving an associated low pressure compressor. Exhaust gasses are supplied to this turbine through a single inlet feed worm (shown above and below the high pressure turbine). The gasses leave the high pressure turbine via the short intermediate duct (shown in the middle of figure 1) before entering the low pressure turbine driving the low pressure compressor of the radial type, shown at the far right of the figure. Both low and high pressure turbines have inlet guide vanes: see section 3.4 ("vanes"); section 3.2 ("nozzled flow areas") and section 5, 2nd paragraph ("nozzled rings for each turbine"; cf. E18, page 7, figure and text), recognizable in figure 1 as the rectangular elements preceding the turbine blades in either turbine. The presence of these features in E17 is indeed not in dispute.

4.3 Thus E17 discloses all the features of claim 1 except that i) the compressor wheels both have backswept blades in which the blade angle (β_{b2})... is at least

about 40° or more and ii) that the high pressure turbine is provided with a feed worm with double inlet, in which each inlet duct supplies half the turbine with gas flow (via inlet guide vanes). E17 shows only a single inlet feed worm as stated above, while those parts of the document available provide no detail as to the form of the blades of its compressors.

4.4 Turning first to the backsweep angle, the technical effect that can be objectively associated with this feature *per se* is seen to be improved or increased compressor efficiency, cf specification paragraph [0016], lines 26 to 33. As explained there, backsweep angle effects the efficiency of the compressor by changing the velocity differential between flow along the pressure and suction sides of the blades (specification, column 4, lines 26-32). The increase in efficiency is thus an aerodynamic effect due to the particular shape of the compressor blades.

It may be that this increased efficiency results in the compressor wheel and associated turbine rotating at higher speed for a given pressure ratio (and a given turbine) in turn allowing a smaller turbine to be used with a concomitant improvement in transient response for the reasons given in the same paragraph at lines 17 to 26. However, such effects are consequential, i.e. subsidiary, to the increased efficiency due as a primary effect to the improved aerodynamic shape of the backswept compressor blades. In any case the speed of the compressor and turbine or their dimensions are not reflected in the claim.

4.4.1 A double inlet feed worm with each inlet duct supplying half the turbine with gas flow is seen to make optimal use of the energy in the exhaust gasses from the diesel

engine, see patent specification paragraph [0020], also representing an increase in efficiency. This is indeed not disputed.

4.4.2 Both features can be seen to contribute to overall efficiency of the turbocharger, but in different ways. Double inlet feed pertains to the input of the turbocharger and produces an increased *input* efficiency, whereas compressor backsweep angle relates to its output and thus gives an increase in *output* efficiency. The mechanisms by which they do so are also inherently different: conducting different parts of the exhaust to drive different parts of the turbine against changing the aerodynamic shape of compressor blades.

4.4.3 The respondent (proprietor) has argued that the backsweep and dual feed worm features cannot be considered separately since they synergistically contribute to the stated aim of increasing efficiency. In particular, the chosen compressor blade backsweep angle would allow smaller turbines and larger turbine speeds to be used, which in turn requires a more optimal use of the exhaust.

However, there is no suggestion in the patent that the double inlet feed would be associated in any way with the particular choice of turbine, let alone with its size or speed. The skilled person might infer, from the presence of separate manifolds 13,14 and inlets 15,16 (figure 1) associated with two cylinder sets, that the double inlet feed makes handy use of exhaust pulses produced by the two sets, but that this might be desirable or beneficial or particularly suitable for turbines of reduced dimensions rotating at higher speeds will not be apparent to him.

4.4.4 The Board is thus unable to see any synergy between the two features. Rather, each contributes separately and independently of the other to improving the overall efficiency of the turbocharger. That they both serve the same overall purpose does not establish a functional reciprocity between the two, just as it fails to demonstrates a combinative effect beyond the sums of their individual effects, cf. the Case Law of the Boards of Appeal, 7th edition, 2013 (CLBA), I.D.9.2.1, in particular T1054/05. The Board concludes that the two features represent different and separate measures that rely on inherently different effects for improving the efficiency of a turbocharger - the associated objective technical problem underlying either measure - and each can therefore be considered separately when assessing inventive step.

4.5 Both measures are known in the prior art to beneficially effect turbocharging action, i.e. to improve the overall efficiency of a turbocharger.

4.5.1 Textbook E14, for example, deals specifically with turbocharger design, and in section 3 (page 73) considers radial compressors. Its introductory section 3.1 specifically mentions backsweep. Far from being an obscure parameter, it is presented there first and foremost, i.e. an important aspect of compressor design. Page 74, first paragraph states that since the 1970s backsweep angles approaching 20 to 50° are routinely used and have lead to improved stage performance, in other words improved efficiency. Here the Board notes that the backsweep angle β_{2b} is defined on page 89, figure 3.14 with respect to the *tangent* to the impeller wheel, rather the *normal* line as in the patent and its claims, cf. specification figure 3. Thus, using the definition of the angle in claim 1 the

above backsweep angles mentioned in E14 equate to (90-20°) to (90-50°), that is 70° to 40°.

The same teaching is derivable from textbooks E3 and E4. E3 deals with compressor design, *inter alia* of turbochargers (see top of figure 6.6 on page 6-9). It teaches that backsweep blading improves efficiency (see passage bridging pages 6-17 and 6-18 and page 6-19, last paragraph). The latter paragraph in particular suggests *inter alia* the value of 40° backsweep. E4 specifically deals with compressors for turbochargers (title), and on page 27, section 4, maximum stage efficiency is estimated to be achieved with 60° backsweep.

E17, in the form before the Board, gives the skilled person no information as to the design of its compressor wheels (see section 3.1). When tasked with realizing a turbocharger as in E17 with the overall aim of increased efficiency in mind he will obviously look towards relevant prior art offering him more detail of compressor wheel design. As stated any of E14, E3 or E4 offer him such detail. Adopting their teaching he will arrive at the backsweep feature claimed in an obvious manner.

It appears to the Board that the same result would be obtained even if missing figure 5 of E17 had been available. The figure might i) have revealed compressor wheel blades having a backsweep angle falling within the ambit of claim 1, or ii) wheels having a backsweep angle of less than 40°, including no backsweep or iii) have provided no information about backsweep angle. In the first case the missing information would render the backsweep feature even known from E17. In the second and third cases, tasked with improving compressor

efficiency, irrespective of whether or not the skilled person knew the backsweep characteristic of the compressor blades, he would apply the backsweep angle disclosed in E3, E4 or E14 in order to improved efficiency, as explained above. In all cases the skilled person would arrive at a turbocharger having a backsweep angle as claimed at the very least without inventive effort.

4.5.2 As regards double inlet feed worms, E18 (page 4) in particular teaches that, in order to "gain efficiency engine manifolds are split ... dividing flow to the turbine housing". Figure 4b shows one option, the double flow housing, with separate throats and "each passage feed[ing] for only one half of the turbine wheel circumference", i.e. a double inlet feed worm as in the patent. The double flow housing is shown in figure 5 on page 7 (together with nozzle ring vanes).

Textbook E14 mentions volutes or feedworms on page 156, second paragraph, and also suggests the use of double volutes (feedworms) to the same effect, where an engine has separate exhaust manifolds. Thus separate paths isolate pulsed gas flow from each manifold as shown in figure 4.7 together with inlet vanes. There a first path (dashed line) supplies one half of the turbine and a second path (solid line) the other half.

Both E14 and E18 thus emphasise that the choice of feedworm depends on the exhaust arrangement of the motor to which the turbocharger is fitted. In the case of E17 this is not known. Tasked with improving efficiency, when fitting the turbocharger of E17 to a motor for example having two separate exhaust manifolds, on consulting E14 or E18 the skilled person will immediately realise that to use the pulsed output

gasses from each manifold efficiently he should replace the single feedworm with either a twin or double feedworm. As a matter of obviousness he will simply choose one of the two equivalent feedworm options available (twin or double). Thus he will arrive at the double inlet feed worm feature of claim 1 without making an inventive step.

4.6 In summary, for the above reasons, neither of the differing features involves an inventive step. Adopting both of these unrelated, obvious modifications adds nothing over and above their individual effects and is thus a mere juxtaposition of individually obvious measures. The subject matter of claim 1 therefore lacks inventive step, Article 56 EPC.

5. Auxiliary requests

5.1 Auxiliary requests 1 and 2

Claim 1 of auxiliary requests 1 and 2 have the same scope as that of the main request. Auxiliary request 1 merely replaces the word "vane" with its synonym "rail", whilst that of auxiliary request 2 is identical to claim 1 of the main request. Therefore for the same reasons as given for the main request, the subject matter of claim 1 of these requests lacks inventive step.

5.2 Auxiliary requests 3 to 7

Claim 1 of these requests add various features to claim 1 of the main request, all of which are known from E17.

5.2.1 In Auxiliary request 3, the terms "high pressure turbine unit" and "low pressure turbine unit" are

merely labels for the high and low pressure turbine/ compressor pairs already defined in the main request and known from E17. That these units are oriented along essentially the same longitudinal axis is likewise known from E17, see figure 1, where both turbines and both compressors lie on the longitudinal axis indicated by the chain line.

5.2.2 Auxiliary request 4 adds that the high pressure turbine and compressor and low pressure turbine and compressor are respectively connected via separate shafts. E17, figure 1 likewise shows this feature: the two shafts being separated by the short duct, see section 3.5 and figure 1.

5.2.3 Auxiliary request 5 adds that the low pressure turbine is of the axial type. This is clearly also the case in E17, see section 3.3, first paragraph "axial flow turbine" and figure 1, second rotating component from the right.

5.2.4 Auxiliary request 6 adds that the intermediate duct is annular with an inner body of increasing cross section downstream. This is known from E17, see section 3.5, second paragraph "centrebody" for the duct. The inner body is seen in figure 1 as the truncated cone shape in the middle of the short duct.

5.2.5 Auxiliary request 7 adds both features of auxiliary requests 5 and 6. Both these features are known from E17, see above, sections 5.2.3 and 5.2.4.

5.2.6 Since the subject matter of claim 1 of all the auxiliary requests is either the same as the main request or adds features known from E17, it lacks inventive step for the same reasons as apply for the

main request. Therefore the auxiliary requests must fail.

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 A. de Vries

Decision electronically authenticated