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D E C I S I O N
of 11 November 1997

Case Number: T 0230/95 - 3.2.1

Application Number: 88304388.7

Publication Number: 0292213

IPC: B23H 9/10

Language of the proceedings: EN

Title of invention:

Method and apparatus for electrochemically machining bladed disks

Patentee:

GENERAL ELECTRIC COMPANY

Opponents:

Leistritz Aktiengesellschaft
AEG-Elotherm GmbH
MTU Motoren- und Turbinen-Union München GmbH

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



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Boards of Appeal

Chambres de recours

Case Number: T 0230/95 - 3.2.1

D E C I S I O N
of the Technical Board of Appeal 3.2.1
of 11 November 1997

Appellant I:
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Decision under appeal: Interlocutory decision of the Opposition Division of the European Patent Office posted 16 February 1995 concerning maintenance of European patent No. 0 292 213 in amended form.

Composition of the Board:

Chairman: P. Alting van Geusau
Members: S. Crane
J. Saisset

Summary of Facts and Submissions

I. The mention of the grant of European patent No. 0 292 213 in respect of European patent application No. 88 304 388.7, filed on 13 May 1988 and claiming priority from US application 49080 filed on 13 May 1987 in the United States of America, was published on 23 October 1991.

II. Notices of opposition were filed by the appellants I and II (opponents 01 and 03) and other party (opponent 02) on 11 July 1992, 23 July 1992 and 15 July 1992, respectively, on the grounds of Article 100(a) EPC. In respect of an alleged lack of novelty (appellant I) and inventive step (both appellants and other party) the opposition was supported by a number of prior art documents and alleged prior uses. During the opposition proceedings essentially only the prior art disclosed in document

D28: US-A-4 657 649

was relied upon.

III. By a decision which was issued in writing on 16 February 1995 the Opposition Division maintained the patent in amended form.

The independent claims 1 and 7 maintained by the Opposition Division read as follows:

"1. A method of forming a bladed disk (98) from a workpiece (12) having a plurality of circumferentially spaced workpiece blanks (14), each having oppositely facing first and second side faces (120, 122) defined by a radially inner base (13), a radially outer top (128), a first edge (124), and a second edge (126),

said method comprising:

positioning first and second electrodes (18, 20) adjacent to said first and second faces (120, 122), respectively, of a first one of said blanks (14);

supplying a positive voltage to said first blank (14) and a negative voltage to said first and second electrodes (18, 20);

channelling an electrolyte (28) between said first blank (14) and said first and second electrodes (18, 20) for electrochemically machining said first blank (14);

moving said first and second electrodes (18, 20) toward said first and second faces (120, 122) of said first blank (14);

moving said first blank (14) toward said first and second electrodes (18, 20) during electrochemical machining of said first blank;

wherein, in such movement, said first and second electrodes (18, 20) translate toward said first blank (14) and rotate with respect thereto, and said first blank (14) translates toward said first and second electrodes (18, 20); and

indexing said workpiece (12) by rotation for aligning a second blank with said first and second electrodes (18, 20) and sequentially forming a second blade (100) therefrom in a similar manner."

"7. An apparatus for electrochemically forming a bladed disk (98) from a workpiece (12) having a plurality of circumferentially spaced workpiece blanks (14), each having oppositely facing first and second side faces (120, 122) defined by a radially inner base (130), a radially outer top (128), a first edge (124), and a second edge (126), said apparatus comprising:

a housing (16);

a pair of electrodes including a first electrode (18) and a second electrode (20);

means (22) for mounting said electrode pair to

said housing (16);

means (24) for mounting said workpiece (12) to said housing (16);

means (26) for channelling electrolyte (28) to said electrode pair;

means (30) for powering said electrode pair with a negative voltage and said workpiece (12) with a positive voltage;

said electrode pair mounting means (22) comprising:

a first turntable (56) attached to said housing (16) and rotatable about a first axis (58);

a first translation means (60) attached to said first turntable (56) for mounting said first electrode (18);

a second translation means (64) attached to said first turntable (56) for mounting said second electrode (20); and

said electrode mounting means (22) being effective for translating said first and second electrodes (18, 20) toward each other and for rotating both said first and second electrodes (18, 20) about said first axis (58);

said workpiece mounting means (24) comprising:

a third translation means (76) attached to said housing (16);

a second turntable (74) attached to said third translation means (76) and rotatable about a second axis (82); and

said workpiece mounting means (24) being effective for translating said workpiece (12) toward said first and second electrodes (18, 20) and rotating said workpiece (12) about said second axis (82); and

means (50) for controlling movement of said electrode pair mounting means (22) and said workpiece mounting means (24) during electrochemical machining of the blank."

The Opposition Division was of the opinion that, starting from the prior art disclosed in D28, neither this starting point nor the further available prior art disclosed or gave a hint to the subject-matter of the independent claims 1 and 7, in particular to the features in these claims relating to the movement of the blank towards the electrodes and a rotational movement of the electrodes with respect to the blank.

- IV. Notices of appeal were lodged against that decision by appellant I on 9 March 1995 and by appellant II on 12 April 1995 together with payment of the appeal fee on the same respective days.

The statements of grounds of appeal were filed on 12 June 1995 by appellant I and on 9 June 1995 by appellant II.

The appellants requested setting aside of the decision under appeal and revocation of the patent. In addition, appellant I requested that an expertise report be provided dealing with the question whether the possibility of rotation of the table to which the electrodes were mounted indeed resulted in a simpler form of the electrodes, as had been submitted by the respondent.

- V. In a communication issued in preparation for oral proceedings the Board raised the question of interpretation of the feature in the amended claim 1 relating to the blank being moved towards the electrodes during machining, in the context of finish-machining of the blank. Discussions in the oral proceedings should also address the issue as to why the

skilled person would have changed the configuration of the apparatus known from D28 and why he would then have arrived at the finishing method in accordance with claim 1 or apparatus in accordance with claim 7 of the amended patent.

The Board further expressed the provisional opinion that there was no legal basis for allowing the appellant's I request for an expertise report.

- VI. Oral proceedings were held on 11 November 1997 in the presence of the appellants and respondent (proprietor of the patent). The other party had given notice with letter dated 13 March 1997 of its non-appearance at the oral proceedings.

The respondent requested that the appeal be dismissed.

- VII. In support of their requests the appellants essentially relied upon the following submissions:

The most relevant prior art was disclosed in D28 and this known apparatus for electrochemically machining blades already comprised means for adjustment of the blanks to be machined in all the directions defined in the method and apparatus in accordance with the amended patent, at least when considering the relative movement of the blade and electrodes.

In particular, a rotating movement of the blade to be finished with respect to the electrodes by adjustment about a pivot and an approaching movement of the blade and electrodes was disclosed and although the first of such movements was merely an initial set-up adjustment before machining of the blade was started, it was obvious to the skilled person that such correction movement could also be carried out during machining if so required. In fact, the abstract of D28 already

hinted to a more general positioning of the workpiece. . .
Therefore, having regard to the fact that all the
necessary movements for finishing a blade by
electrochemical machining were already known and the
differences between the known method and apparatus for
electrochemical machining of a blade merely concerned
simple mechanical adaptations to obtain the same
relative movements also in case the shape of the blade
was more complex, the skilled person did not have to
exercise any inventive activity for arriving at the
method in accordance with the amended claim 1 or
apparatus in accordance with claim 7.

It could not be maintained either that the electrodes
in accordance with the patent were of simpler form when
compared to the electrodes known from D28. The finished
shape of the blades was essentially a foot-print of the
electrode surface which fact also applied to the
electrodes of the patent in suit. Since no technically
convincing arguments were submitted by the respondent
as to why the claimed movements of the electrodes could
lead to a simpler form of the electrodes this dispute
should be settled by asking an independent expert to
provide an expertise report on this point.

VIII. The respondent disputed the appellants' views and its
arguments may be summarised as follows:

The present invention was distinguished from the method
and apparatus disclosed in D28 at least by the features
relating to a feeding movement of the blank towards
said first and second electrodes and rotation of the
electrodes with respect to the blank during
electrochemical machining.

Since during electrochemical machining of the blank in the apparatus known from D28 the blank was locked in position and the electrodes moved only in a skewed direction toward the blank such new combination of movements during machining was neither disclosed nor hinted at in this prior art.

Relative movements were not the issue at stake because the amended claim 1 clearly specified the combination of movements in which the electrodes rotated and translated toward the blade. The concept of rotation of the electrodes increased the flexibility of machining by providing universal movement where previously there was only the possibility of machining in the plane of the two opposing electrodes.

The rotation of the electrodes simplified the design of the electrodes at least in the sense that it allowed the operator to change the angle of the blade tip with respect to the centerline axis during machining as was disclosed in the patent in column 6, beginning at line 5.

The description and also the abstract of D28 indicated that the electrodes had pockets to receive airfoil blades adjacent the individual blade to be machined and as such opposed any impression that the electrode pair could be rotated in unison. Therefore, since the prior art lacked any hint in the direction of the method or apparatus defined in the present claims 1 and 7, the subject-matter of these claims was based on an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 The present claim 1 is based on the combination of the granted claims 1, 3 and 5 to which subject-matter was added that the movement of the blank toward the electrodes and the rotation of the electrodes was carried out during electrochemical machining. Support of the current claim 1 can be found in the originally filed claims 1, 3 and 5 and the text on page 32, lines 8 to 15 of the originally filed description (see also column 17, lines 18 to 25 of the granted patent).

Movement in the Z direction (movement of the blade in the direction of the electrodes) is in fact also carried out during finishing machining for electrochemically machining in addition to the blades also the platform situated between the roots of adjacent blades. Such machining and consequential movement of the blade and bladed disk in the direction of the electrodes follows from the text in the originally filed description on page 25, line 7 to 32 (see column 13, lines 35 to 56 of the patent description).

Claims 2 to 18 are essentially based on the subject-matter of the originally filed claims 4 and 7 to 22, which themselves correspond to the granted claims 4 and 7 to 22.

In view of these assessments no objections under Article 123(2) EPC or Article 84 in respect of support, arise against the present set of claims.

2.2 The patent description was adapted to take account of the prior art disclosed in D28 and was further brought in line with the subject-matter now claimed. The amended description therefore does also not give rise to objections under the EPC.

3. *Novelty*

Novelty of the subject-matter of the independent claim 1 follows from the fact that none of the available prior art documents discloses a method of electrochemically forming a bladed disk from a workpiece in which during electrochemical machining a blank is moved towards first and second electrodes and in such movement the electrodes translate toward the blank and also rotate with respect thereto.

Novelty of the subject-matter of the independent apparatus claim 7 follows from the apparatus features providing such combined movements of the blank and the electrodes.

Novelty was in fact not in dispute during the appeal proceedings.

4. *Inventive step*

4.1 There is agreement between the parties and the Board that D28 represents the closest prior art document.

This document discloses a method of and an apparatus for forming a bladed disk from a workpiece having a plurality of circumferentially spaced workpiece blanks, each having oppositely facing first and second side faces defined by a radially inner base, a radially outer top, a first edge and a second edge.

The method derivable from the functioning of the apparatus disclosed in D28 comprises

- (a) positioning first and second electrodes adjacent to said first and second faces, respectively, of a first one of said blanks; supplying a positive voltage to said first blank and a negative voltage to said first and second electrodes; channelling an electrolyte between said first blank and said first and second electrodes for electrochemically machining said first blank;
- (b) moving said first and second electrodes toward said first and second faces of said first blank; and
- (c) indexing said workpiece by rotation for aligning a second blank with said first and second electrodes and sequentially forming a second blade therefrom in a similar manner.

4.2 In particular when forming a bladed disk having high camber, high twist and/or high solidity, i.e. relatively closely spaced blades, substantial problems for economically electrochemically machining blades thereon in one operation are encountered in the known method because of the limitations implied by the electrode movements applied in D28 (see page 2, line 33 to 37 of the amended description of the patent in suit).

Accordingly, the object of the present patent is to provide an improved method and apparatus for electrochemically machining a bladed disk in which in a single operation both the leading and trailing edges of a workpiece blank in addition to the surfaces there between and/or a platform between adjacent blades on a bladed disk can be electrochemically machined

simultaneously with the blade thereon and which method and apparatus is suitable for electrochemically machining bladed disks having such high camber, twist and solidity (see page 2, line 33 to page 2A, line 18 of the amended description of the patent).

- 4.2 This problem is solved by the combination of features of the independent method claim 1 and apparatus claim 7 of the amended patent.

By providing in the method known from D28 the additional features that

- (d) said first blank is moved toward said first and second electrodes during electrochemical machining of said first blank;
- (e) wherein, in such movement, said first and second electrodes translate toward said first blank and rotate with respect thereto, and said first blank translates toward said first and second electrodes,

a combination of the translational and rotational movements of the electrodes and the translational movement of the blank to be machined is provided. This combination movement results in a rotational screwing movement of the electrode pair on to the blank and thus a movement of the electrode pair allowing minimal space between electrodes during insertion and machining and, consequently, allowing sufficient clearance with respect to the adjacent blades of the bladed disk even in case of machining bladed disks with high camber, high twist and high solidity.

The apparatus claim 7 includes in addition to the features of the closest prior art in accordance with D28 the constructional features

- (p) the electrode pair mounting means comprising a first turntable attached to the housing and rotatable about a first axis;
- (q) a first translation means attached to said first turntable for mounting said first electrode;
- (r) second translation means attached to said first turntable for mounting said second electrode; and
- (s) said electrode mounting means being effective for translating said first and second electrodes toward each other and for rotating both said first and second electrodes about a first axis;
- (t) said workpiece mounting means comprising:
 - a third translation means attached to said housing;
- (u) a second turntable attached to said third translation means and rotatable about a second axis; and
- (v) said workpiece mounting means being effective for translating said workpiece toward said first and second electrodes along said first axis and
- (w) means for controlling movement of said electrode pair mounting means and said workpiece mounting means during electrochemical machining of the blank

which provide the combination of movements defined by features (d) and (e) of the method of claim 1.

4.3 None of the available documents discloses the claimed complex movement or the specific constructional features to obtain the specific movements of the electrodes and workpiece during machining of the workpiece.

4.4 The appellants I and III argued that all the necessary relative movements were already disclosed in D28 and therefore the skilled person was well aware of the different possibilities of movement of the workpiece with respect to the electrodes.

Moreover, the rotational movement of the workpiece with respect to the electrode pair being addressed in general terms in the abstract of D28, the skilled person was led to apply such movement also during electrochemical machining of the blank if he wanted to. In this respect it was clear for the skilled person that, where a high twisted blade had to be machined, adaptation of the known method and apparatus to include the features (d) and (e) which, in fact, were related to nothing else than simple kinematic reversal of the known movements, became necessary.

Considering this argumentation, the Board draws attention to the fact that the possible movements of the workpiece in the arrangement of D28 are limited to indexing of the individual blanks and rotational adjustment of the blank to a fixed angular position with respect to the electrode surfaces (column 12, lines 18 to 35 of D28) before machining is initiated.

The electrodes can be moved in X- and Y-directions to provide a bi-directional movement with may be a curvilinear path (see column 16, lines 58 to 63 of D28) so that during the approaching movement of the electrodes the available space between the adjacent blanks is optimally used. This bi-directional movement,

the nature of which is apparent from the comparison of the successive electrode (cathode) positions depicted in Figures 44, 45 and 46 of D28, is such that the electrodes can be positioned between the adjacent blanks also in the case of machining of blades with relatively high twist. Because of the fact that the movements of the electrodes in their respective X-directions are movements each under an angle of 30° with respect to the horizontal plane, approaching of the electrodes to each other results in a combined horizontal and vertical movement with respect to the workpiece. Such combined electrode feeding movements does not allow independent finishing machining of the platform between the blades when compared to the blade itself.

- 4.5 In view of these assessments of the disclosure of D28 the Board of is the opinion that the electrode movement in this prior art is based on the principle of a combined movement of the electrodes for approaching the blanks before and during machining and that the workpiece positioning is clearly an adjustment to the machining position before machining takes place.

In contrast thereto the concept of the method and apparatus in accordance with the patent in suit is based on the principle of independent feeding movements of both the workpiece and electrodes to allow independent feeding movements for machining of the blade surfaces and platform. During machining the electrodes may translate and rotate in the horizontal plane and the workpiece can be translated along the vertical axis to approach the electrodes. It will be apparent that such specific attribution of the different degrees of freedom allow insertion of the blank between the electrodes in an almost closed position of the electrodes by merely rotating the electrodes when the blank is inserted into the space

between the electrodes thereby optimally making use of the available space between the blanks in case of machining bladed disks with high twist and high solidity, while the feeding movement in the vertical direction can also be used for finish machining of the platform during the machining of the blade surfaces. Electrode translation movements are thereby independent of the vertical translation movement of the blank.

4.6 Because of the different concept involved in D28, the known electrode and workpiece support and resulting limitation of relative vertical and rotational movement could not give the skilled person any lead towards adapting the known apparatus to totally change the feeding movements during machining. Furthermore, document D28 contains no suggestion that the machining of bladed disks with blades having high camber, high twist and/or high solidity could be improved by a new combination of feeding movements during machining, let alone to the specific selection of translation and rotation of the electrodes combined with a feeding movement of the blank in the direction of the electrodes for finishing machining the platform between adjacent blades.

4.7 The appellants submitted that if high twisted blades had to be machined the skilled person would be immediately aware of the necessity to adapt the known means for initial fixed angular setting-up of the workpiece to become a controlled rotational movement during machining, as was in fact suggested by the text of the abstract of D28. However, even if it were accepted that all the relative movements of the electrodes with respect to the bladed disk (the workpiece) are in principle known from D28 it is the particular selection of the combination of the movements, which results in a different machining method, suitable for the intended use.

4.8 Therefore, in the absence of any suggestion in D28, or the other available prior art not any longer relied upon by the appellants in the appeal proceedings, to the particular combination of movements, or the constructional features for allowing such movements, neither the method in accordance with claim 1 nor the apparatus in accordance with claim 7 is obvious to a person skilled in the art.

5. *The appellant's I request for an expertise report*

5.1 As has already been expressed in the Board's communication for preparation of the oral proceedings, as regards the alleged simplification of the electrodes the principle of unfettered consideration of evidence applies.

It is up to the parties to present the evidence in support of their allegations and the deciding Board then considers whether a particular means of evidence is convincing (see T 482/89, OJ 1992, 646).

In the present case the Board considers that an expert report is not needed.

5.2 The Board in any case accepts the appellants' submission that the electrode surfaces establishes the finished blade outer contours. Nevertheless, the electrode construction of the apparatus in accordance with D28, when considered as a whole, is indeed of more complicated form than that of the patent because, as a result of the skewed translation movement under 30°, cathode pockets are necessary for allowing sufficient clearance with respect to the blanks adjacent to the blank that is machined (see also the Figures 44 to 46 of D28), in particular when the height of the blanks is relatively large.

In view of this the Board is convinced that the use of a turntable indeed results in a simplification of the design of the electrodes, at least with respect to the outer form of the electrodes so as to give the necessary clearance with respect to the adjacent blanks.

Order

For these reasons it is decided that:

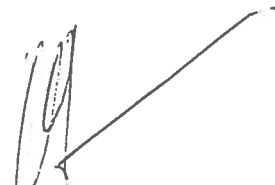
The appeal is dismissed.

The Registrar:



S. Fabiani

The Chairman:



P. Altling van Geusau



