

Internal distribution code:

- (A) [] Publication in OJ
(B) [] To Chairmen and Members
(C) [] To Chairmen
(D) [X] No distribution

D E C I S I O N
of 27 June 2002

Case Number: T 0372/00 - 3.5.2

Application Number: 89116697.7

Publication Number: 0359153

IPC: H01J 37/32

Language of the proceedings: EN

Title of invention:

Split-phase driver for plasma etch system

Patentee:

LAM RESEARCH CORPORATION

Opponent:

Institute of Technological Information Inc.

Headword:

-

Relevant legal provisions:

EPC Art. 56, 84, 123(2)

Keyword:

"Procedure - late filed request (no) - foreseeable response to an objection"

"Amendments - feature derived from a figure"

"Inventive step - combination of documents not leading to the invention"

Decisions cited:

-

Catchword:

-



Case Number: T 0372/00 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 27 June 2002

Appellant: Institute of Technological Information Inc.
(Opponent) 5-3, Kitahara 2-Chome
Asaka-shi, Saitama-ken
351-0036 Kiyoshi Suzuki (JP)

Representative: Ritter und Edler von Fischern, Bernhard
Dipl.-Ing.
Hoffmann Eitle
Patent- und Rechtsanwälte
Arabellastrasse 4
D-81925 München (DE)

Respondent: LAM Research Corporation
(Proprietor of the patent) 4650 Cushing Parkway
Fremont, CA 94538-6401 (US)

Representative: Browne, Robin Forsythe, Dr.
Urquhart-Dykes & Lord
Tower House
Merrion Way
Leeds LS2 8PA (GB)

Decision under appeal: Interlocutory decision of the Opposition Division
of the European Patent Office posted 28 January
2000 concerning maintenance of European patent
No. 0 359 153 in amended form.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: M. Ruggiu
J. H. P. Willems

Summary of Facts and Submissions

I. The opponent appealed the interlocutory decision of the opposition division concerning maintenance of European patent 0 359 153 in amended form.

II. The following documents were considered during the appeal:

D1: US-A-4 724 296;

D2: JP-A-61 272 928;

D3: US-A-4 626 312;

D4: Elektrotechnik-Elektronik Formeln und Gesetze, Buch- und Zeit-Verlagesgesellschaft mbH, Köln (DE), pages 147, 152, 153;

D5: US-A-4 621 242;

D6: JP-A-63 42 707;

D7: Larousse Dictionary of Science and Technology, ISBN 0-7523-0011-3, 1995, Larousse plc, Edinburgh (GB), page 76, definition of "autotransformer" and related figure;

D8: Grundlagen der Elektrotechnik und Kerntechnik, 1960, Deutsche Verlags-Anstalt GmbH, Stuttgart (DE), pages 480, 481;

D9: Larousse Dictionary of Science and Technology, page 88, definition of "BALUN"; and

D10: hardcopy of the definition of "balun" obtained on 24 may 2002 from the internet site www.dictionnary.com.

III. In reply to a communication from the board annexed to summons to oral proceedings, the respondent proprietor faxed on 27 May 2002 a main request and seven auxiliary requests. Claim 1 of the 5th auxiliary request was as follows:

"A plasma etching system comprising:

a plasma reactor (14) including an electrically isolated upper electrode (19) and an electrically isolated lower electrode (21) in a grounded chamber;

a grounded generator (12) producing a radio frequency input voltage;

means (22, 24, 26, 28) for dividing the input voltage into a first output voltage and a second output voltage, said first and second output voltages having substantially equal magnitudes relative to ground but being 180° out of phase; and

means (30, 32) coupling the first output voltage to the upper electrode and the second output voltage to the lower electrode, characterised in that

the means for dividing the input voltage is a transformer (22, 24, 26) having a variable primary winding (22) directly connected to a center tapped secondary winding (24), wherein the variable primary winding (22) is coupled to the radio frequency generator (12), respective end terminals of the

secondary winding are coupled to the upper and lower electrodes, with the center tap connected to ground (28), a middle winding of the variable primary winding is directly connected to a top one of the end terminals of the secondary winding, and the impedance of the plasma reactor is matched to the radio frequency generator by means of the variable primary winding."

IV. At the oral proceedings before the board held on 27 June 2002, the respondent (patentee) withdrew all its previous requests and filed a new set of four claims as part of a new main request.

The appellant (opponent) requested that the decision under appeal be set aside and that the European patent be revoked, that the new main request be refused as late filed and, in case of admission of this main request, that the proceedings be continued in writing.

The respondent (patentee) requested that the appeal be dismissed and that the patent be maintained in amended form on the basis of the main request as filed in the oral proceedings, namely

- claims 1 to 4 filed in the oral proceedings,
- description columns 1 to 5 as approved by the opposition division with acknowledgement of prior art, filed with letter faxed 27 May 2002, to be inserted in column 2 between lines 28 and 29,
- drawings: Figures 1 and 2 of the patent specification.

V. Claim 1 of the new main request of the respondent reads as follows:

"A plasma etching system comprising:

a plasma reactor (14) including an electrically isolated upper electrode (19) and an electrically isolated lower electrode (21) in a grounded chamber;

a grounded generator (12) producing a radio frequency input voltage;

means (22, 24, 26, 28) for dividing the input voltage into a first output voltage and a second output voltage, said first and second output voltages having substantially equal magnitudes relative to ground but being 180° out of phase; and

means (30, 32) coupling the first output voltage to the upper electrode and the second output voltage to the lower electrode, characterised in that

the means for dividing the input voltage is a transformer (22, 24, 26) having a variable primary winding (22) directly connected to a center tapped secondary winding (24), wherein the variable primary winding (22) is coupled to the radio frequency generator (12), respective end terminals of the secondary winding are coupled to the upper and lower electrodes, with the center tap (28) connected to ground, a middle tap of the variable primary winding (22) is directly connected to a top one of the end terminals of the secondary winding (24), and the impedance of the plasma reactor is matched to the radio frequency generator by means of the variable primary

winding."

Claims 2 to 4 are dependent upon claim 1.

VI. The appellant essentially argued as follows:

The new main request of the patentee filed at the oral proceedings should not be admitted into the proceedings as it was filed late. The new main request differed from the previous requests submitted by the patentee in particular in that the expression "middle winding of the variable primary winding", that was present in claim 1 of the 5th auxiliary request faxed on 27 May 2002, had been replaced by the expression "middle tap of the variable primary winding". The expression used in claim 1 of the former 5th auxiliary request lacked clarity as to which part of the transformer was formed by the "middle winding". The expression used in claim 1 of the new main request had not been considered previously and therefore the appellant needed time to study the new main request and perform a search. Thus, the proceedings should be continued in writing if the new main request of the patentee was admitted into the proceedings.

No basis for a transformer having a direct connection between the primary and secondary windings, ie an autotransformer, might be derived from the application as originally filed, so that the amendments contravened Article 123(2) EPC. In particular, the description did not mention a particular type of transformer. The patent in suit disclosed at column 4, lines 12 to 14 only electromagnetic coupling between the primary and secondary windings, not a direct electrical connection

between these windings. Furthermore, the representation of the transformer in Figure 1, with a winding 22 drawn separately from the core of the transformer, was so unusual that it might not serve as a basis for amendments. The pre-grant prosecution showed indeed that no clear picture of the disclosure provided by the application as filed was present at that time. The principle of legal certainty for third parties did not allow a claim to be based on an unclear, ambiguous disclosure.

Furthermore, Figure 1 of the application as filed showed that the radio frequency generator 12 was connected between a tap of winding 22 and the grounded center tap 28 of winding 24. Thus the primary winding of the transformer included in every case a part of winding 24. Therefore, there was no basis in the application as filed for a transformer having a primary winding formed by winding 22 as specified in claim 1 and the middle tap of winding 22 was not the middle of the primary of the transformer. Thus, the wording of claim 1 was confusing, unclear as to which elements constituted the primary of the transformer and not supported by the original disclosure.

Document D1 disclosed the closest prior art, in particular a system with the features of the preamble of present claim 1, comprising a transformer with a primary winding coupled to a radio frequency generator and a center tapped secondary winding having end terminals respectively coupled to electrically isolated electrodes in a grounded chamber of a plasma reactor. The respective voltages at the electrodes had equal magnitudes but were 180° out of phase. The primary and secondary windings of the transformer shown in Figure 1

of D1 were not electrically connected to each other, but it was known from document D5 to provide voltage to the electrodes in a chamber of a plasma reactor by means of an autotransformer, ie a transformer having a direct electrical connection between the primary and secondary windings. In D5, efficiency of the power transmission between a radio frequency generator and the electrodes of the plasma reactor was improved by matching the impedance of the generator to that of the plasma reactor by means of a variable primary of the autotransformer. Since power efficiency was also a concern in document D1, it was obvious to replace the transformer of D1 by an autotransformer with a variable primary as disclosed in D5. Adapting the autotransformer disclosed in document D5 to the system according to document D1 did not constitute a major hurdle for a person skilled in the art. Furthermore, it was standard knowledge that maximum variability would be ensured by connecting the middle of the variable primary winding to the secondary winding.

Any transformer disposed between the radio frequency generator and the electrodes of the plasma reactor produced an impedance transformation and thus resulted in the effect indicated in claim 1 that the impedance of the plasma reactor was matched to the radio frequency generator by means of the primary winding of the transformer.

It was also obvious, in view of D1, to provide a grounded center tap at the secondary of the autotransformer disclosed in D5, so as to obtain anti-phase voltages at the electrodes in the grounded chamber of the plasma reactor.

VII. The arguments of the respondent can be summarised as follows:

Claim 1 of the new main request had effectively the same scope as claim 1 of the previous 5th auxiliary request and differed therefrom only by a few editorial amendments. Thus, the appellant had not been ambushed by the filing of the new main request and it was not appropriate to give him the possibility to perform a further search.

The feature of claim 1 of the new main request that a middle tap of the variable primary winding (22) was directly connected to a top one of the end terminals of the secondary winding (24) was clearly shown in Figure 1 of the application as filed. Furthermore claim 4 as originally filed supported the feature that the impedance of the plasma reactor was matched to the radio frequency generator by means of the variable primary winding.

Document D1 could be taken as disclosing the closest prior art. D1 mentioned a grounded generator, but not in connection with the system shown in Figure 1 of D1. The transformer of D1 acted as an isolator, so that D1 could not suggest an autotransformer. With respect to the prior art disclosed in D1, the problem solved by the present invention was to provide a single device transmitting power from the generator to the electrodes and which at the same time reduced spurious discharges, matched the impedances and did not introduce large losses. Thus, the problem was essentially to make the anti-phase transformer of D1 more efficient. There was no suggestion in the prior art that an autotransformer would solve this problem. Document D5 disclosed an

autotransformer arranged to transmit power from the generator to the electrodes and match the impedances of the generator and plasma reactor. However, the secondary winding of the transformer of D5 had one of its ends grounded, which was in conflict with D1. To obtain impedance matching and eliminate spurious discharges at the same time, the skilled person would thus add an autotransformer as disclosed in D5 to the anti-phase transformer of D1. Such a combination of two transformers would result in large losses.

Significant modifications to the autotransformer of D5 would be required to arrive at the invention and these modifications could only be the result of hindsight. In particular providing the secondary of the autotransformer of D5 with a grounded center tap would not be obvious and would not provide anti-phase voltages at the electrodes because the reactance 9 of D5, which was connected to the secondary of the autotransformer, would shift the relative phases of the voltages at the electrodes.

Reasons for the Decision

1. The appeal is admissible.
2. *Procedural matters*
 - 2.1 The new main request of the respondent has been filed in response to objections regarding the expression "a middle winding of the variable primary winding" raised by the appellant during the oral proceedings. Claim 1 of new main request differs from claim 1 of the former 5th auxiliary request, which had been communicated to

the appellant, essentially in that the criticised expression has been replaced by the words "a middle tap of the variable primary winding (22)".

- 2.2 The communication of the board accompanying the summons to attend oral proceedings already pointed out (see point 1.1, first sentence of the last paragraph) that Figure 1 of the patent discloses "a direct connection between the middle of the primary winding and the end of the secondary winding which is coupled to the upper electrode". Furthermore the decision under appeal (see page 5, third sentence of the third paragraph) indicated that "the connection disclosed in figure 1 is made to a center tap of the primary coil".

Therefore, it could be foreseen that the respondent might clarify claim 1 by specifying therein that a middle tap of the variable primary winding (22) is directly connected to a top one of the end terminals of the secondary winding (24).

- 2.3 In view of these circumstances, the board considers that the new main request of the respondent should be admitted into the proceedings. Furthermore, the board considers that the new main request was not surprising and that, therefore, it is not appropriate to continue the proceedings in writing.

3. *Amendments*

- 3.1 The application as filed indicates, at page 6, lines 23 to 28 and in claim 6, that the primary winding 22 of the transformer is variable and the impedance of the plasma reactor is matched to the radio frequency generator by means of the variable primary winding 22.

- 3.2 Furthermore Figure 1 of the application as filed unquestionably shows a direct connection between the middle tap of winding 22 and the top one of the end terminals of winding 24. Although this feature is not discussed in the description of the application as filed, it is unambiguously shown in Figure 1 and thus can be directly derived from this figure by the skilled person. Therefore, the board takes the view that this feature is part of the original disclosure.
- 3.3 The features discussed under 2.1 and 2.2 above, which are the only features of present claim 1 that have been added with respect to claim 1 as granted, are thus contained in the application as filed. Furthermore the introduction of these features into claim 1 limits the extent of the protection conferred.
- 3.4 The feature of present claim 2 is unambiguously shown on Figure 1 of the application as filed.
- 3.5 The feature of present claim 3 derives from the passage at page 6, lines 14 to 17 of the application as filed.
- 3.6 Present claim 4 corresponds to claim 2 as filed.
- 3.7 The description has been amended to make it consistent with the wording of claim 1 and acknowledge the prior art disclosed in document D1.
- 3.8 Thus, the amendments contained in the new main request are in conformity with Articles 123(2) and 123(3) EPC.

4. *Clarity*

The skilled person considering Figure 1 of the patent

in suit would realise that current from the grounded generator 12 flows through a part of winding 22 (the actual part depending on which tap of winding 22 is selected), the connection between the middle tap of winding 22 and the top one of the end terminals of winding 24 and the upper half of winding 24 before returning to the grounded generator 12 through the grounded center tap 28 of the winding 24. Thus, from Figure 1 of the patent in suit, the skilled person would realise that the part of the transformer in which primary current flows actually comprises part of the so-called variable primary winding (22) and the upper half of the so-called secondary winding (24). The skilled person would also realise from Figure 1 of the patent in suit that the part of the transformer in which secondary current flows is formed by the so-called secondary winding (24).

It is therefore apparent to the skilled person that the term "variable primary winding" is used in present claim 1 to distinguish this "variable primary winding" from the "secondary winding" and not to identify the part of the transformer in which primary current flows.

Therefore, the board considers that the wording of claim 1 is clear as required by Article 84 EPC.

5. *Novelty*

Document D1 discloses a system in which a transformer transforms the radio frequency input voltage from a generator into anti-phase output voltages that are applied to respective electrodes in a chamber of a plasma reactor. D1 does not show or mention any direct connection between windings of the transformer.

Document D3 relates to a plasma etching system comprising a matching transformer. No direct connection between windings of the transformer is shown or mentioned in D3.

Document D5 relates to a plasma etching system comprising an autotransformer with a variable primary for matching the impedances of a plasma reactor and a radio frequency generator. The secondary of the autotransformer of D5 does not have a center tap connected to ground.

Documents D2 and D6 concern plasma etching systems, but do not disclose any transformer.

Documents D4, D7, D8, D9 and D10 relate to transformers, but do not show or mention plasma etching systems.

Thus, none of the available documents discloses the combination of features defined in present claim 1. The subject-matter of claim 1 is therefore considered to be new in the sense of Article 54(1) EPC.

6. *Inventive step*

6.1 Figure 1 of prior art document D1 shows a system comprising a plasma reactor including an electrically isolated upper electrode and an electrically isolated lower electrode in a grounded chamber, a generator producing a radio frequency input voltage and a transformer having a primary winding coupled to the radio frequency generator and a center-tapped secondary winding. The end terminals of the secondary winding are coupled to the upper and lower electrodes respectively

and the center tap of the secondary winding is connected to ground. Thereby, the transformer divides the input voltage from the generator into first and second output voltages which are coupled to the upper and lower electrodes respectively and have substantially equal magnitudes relative to ground but are 180° out of phase.

According to D1, the transformer may convert the input voltage from the generator to a convenient value or may simply act as an isolator. Furthermore no direct connection between the primary and secondary windings of the transformer is shown or mentioned in D1.

6.2 Thus, taking into account the meaning of the term "variable primary winding" in present claim 1, the subject-matter of this claim differs from the state of the art shown in Figure 1 of D1, taken as closest prior art, in that:

- (a) the generator is grounded;
- (b) a transformer winding, that is coupled to the radio frequency generator, is variable and the impedance of the plasma reactor is matched to the radio frequency generator by means of this variable winding of the transformer; and
- (c) said variable winding of the transformer has a middle tap directly connected to a top one of the end terminals of the secondary winding.

These features relate to the problem of matching the impedances of the plasma reactor and the radio frequency generator in an adjustable manner.

This problem is obvious to the skilled person in view of document D5.

6.3 As regards feature (a) above, it is observed that, although this is not shown in Figure 1, D1 indicates that one side of the generator is generally connected to ground potential while the other side is at preset voltage with respect to ground. Furthermore, in the system according to prior art document D5, current appears to return through the ground to the radio frequency generator.

6.4 Concerning features (b) and (c), it is observed that document D5 discloses a plasma etching system in which the impedance of the plasma reactor is matched to the radio frequency generator by means of the variable primary of an autotransformer comprising a winding having its ends respectively connected to the electrodes in the plasma chamber, so that the whole winding constitutes the secondary of the autotransformer. The primary of the autotransformer is formed by a part of the winding carrying taps, each of which can be coupled to the generator of the radio frequency input voltage. Thus, in the system of D5, the primary and the secondary of the transformer are both formed by parts of the same winding and there is no suggestion in D5, or in any other cited document, to directly connect a middle tap of a variable primary winding to a secondary winding of a transformer.

Thus, even if it would be obvious to the skilled person, in order to solve the problem underlying the invention, to ground the radio generator of the system illustrated in Figure 1 of D1 and, in view of D5, replace the transformer shown in that figure of D1 by

an autotransformer having a variable primary and a center tapped secondary, these modifications would not lead to a system having feature (c) identified above. This feature (c) appears to result in a transformer having a particular structure, comprising a center tapped secondary and a variable primary having parts in common, which is adapted to solve the problem underlying the invention.

6.5 Starting from the prior art plasma etching system disclosed in document D5 and modifying it on the basis of the teaching provided by prior art document D1 would also not lead the skilled person to feature (c) above, because this feature is not disclosed in D5 or D1, or in any other of the cited documents.

6.6 The board comes therefore to the conclusion that, having regard to what is disclosed in the cited documents, the subject-matter of present claim 1, which includes feature (c), is not obvious to a person skilled in the art.

Thus the subject-matter of present claim 1 is to be considered as involving an inventive step in the sense of Article 56 EPC.

Claims 2 to 4 are dependent upon claim so that the subject-matter of these claims is also considered as involving an inventive step.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to maintain the patent in the following version:
 - claims 1 to 4 filed in the oral proceedings,
 - description columns 1 to 5 as approved by the opposition division with acknowledgement of prior art, filed with letter faxed 27 May 2002, to be inserted in column 2 between lines 28 and 29,
 - drawings: Figures 1 and 2 of the patent specification.

The Registrar:

The Chairman:

D. Sauter

W. J. L. Wheeler