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D E C I S I O N
of 8 August 2001

Case Number:	T 0405/97 - 3.4.1
Application Number:	90914602.9
Publication Number:	0490997
IPC:	G01T 1/24

Language of the proceedings: EN

Title of invention:
Multi-Element-Amorphous-Silicon-Detector-Array for real-time
imaging and dosimetry of megavoltage photons and diagnostic
x-rays

Applicant:
THE UNIVERSITY OF MICHIGAN, et al

Opponent:
-

Headword:
Real-time imaging away/THE UNIVERSITY OF MICHIGAN et. al.

Relevant legal provisions:
EPC Art. 56, 123(2)

Keyword:
"Inventive step (no - main request)"
"Subject-matter extending beyond the content of the application
as filed (yes - all auxiliary requests)"

Decisions cited:
T 0795/93

Catchword:
-

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Case Number: T 0405/97 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 8 August 2001

Appellant: THE UNIVERSITY OF MICHIGAN
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Decision under appeal: Decision of the Examining Division of the
                              European Patent Office posted 7 November 1996
                              refusing European patent application
                              No. 90 914 602.9 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: G. Davies
Members: H. K. Wolfrum
             M. G. L. Rognoni

Summary of Facts and Submissions

I.   European patent application 90 914 602.9 (publication
     No. 0 490 997) was refused by a decision of the
     examining division posted 7 November 1996, on the
     ground that the independent claims of the requests then
     on file infringed the provisions of Article 123(2) EPC.

     The examining division considered specific values for
     the time constant RC included in said claims to have no
     basis of disclosure. As an *obiter dictum*, the examining
     division raised objections under Articles 52(1) and 56
     EPC, making reference to documents:

     D1:   DE-A-38 29 912,

     D2:   EP-A-0 316 222, and

     D3:   EP-A-0 239 808.

II. The appellants lodged an appeal against the decision on
     2 December 1996, paying the prescribed fee the same
     day. A statement of grounds of appeal was filed on
     17 March 1997.

III. Oral proceedings were held on 8 August 2001 at the
     request of the appellant.

IV. The appellant requested that the decision under appeal
     be set aside and that a patent be granted on the basis
     of:

     claim 1 filed in the oral proceedings; claims 2 to 5
     filed on 2 March 1996 and claims 6 to 16 filed on
     28 February 1994 (main request);

claim 1 filed on 2 March 1996, as amended by letter
filed on 17 March 1997; claims 2 to 16 as for the main
request (first auxiliary request);

claim 1 filed on 23 October 1996 (second auxiliary
request);

claim 1 filed on 23 October 1996 (third auxiliary
request);

claims 1 of all three auxiliary requests as further
amended by letter filed on 17 March 1997 (fourth to
sixth auxiliary requests, respectively).

V.   Independent claim 1 of the **main request** reads as
       follows:

"1.   *A real-time imaging array for use with an incident
radiation beam (10), comprising :*
          *conversion means (46,44) for converting said
          radiation beam to visible light;*
and
          *a plurality of imaging devices arranged in a two-
          dimensional array, each*
imaging device including :
          *signal detection means including an a-Si:H sensor
          (30) for detecting the visible*
light and for deriving a signal; and
          *switching means including a transistor (52) for
          reading out the signal derived by*
said signal detection means,
          *each sensor (30) having a capacitance C for
          storing the signal corresponding to*
*the detected light, and each transistor (52) having an
on-resistance R, thereby yielding a time constant RC;*

characterised in that the time constant RC is less than or equal to 10 μs, the arrangement being such as to permit real-time imaging of said radiation beam."

Claim 1 of the **first auxiliary request** is directed to an individual real-time imaging device comprising the conversion means, signal detection means and switching means as specified in claim 1 of the main request and requires a time constant RC for the device of less than or equal to 65.2 μs.

Claim 1 of the **second auxiliary request** is directed to a real-time imaging array comprising a plurality of imaging devices as defined in claim 1 of the first auxiliary request and having a two-dimensional array of the a-Si:H sensors disposed upon a substrate.

Claim 1 of the **third auxiliary request** is based on claim 1 of the second auxiliary request, further specifying a scintillation layer included in the conversion means and disposed upon the array of sensors for converting electrons to said visible light.

Claims 1 of the **fourth to sixth auxiliary requests** correspond to those of the first to third auxiliary requests, respectively, with the value "65.2μs" for the time constant RC being replaced by "50μs".

VI.   The appellant's submission in support of its main request may be summarized as follows:

Although documents D1 to D3 all referred to similar radiation detectors based on a-Si sensors, document D3 had to be regarded as the closest prior art because it was the only document on file which was concerned with the problem of real-time imaging. In an individual

sensor of the imaging device according to D3, charges (electrons) were directly generated by absorption of the radiation beam in a metal layer next to the a-Si insulator. Due to the very weak interaction of the radiation beam with a thin metal layer, it was necessary to form a complicated multilayer structure of metal and a-Si, inevitably resulting in a sensor having such a high capacitance that in practice real-time operation was not feasible. The teaching of D3 was thus only a paper proposal as far as real-time imaging was concerned, leaving the skilled person in the dark about the fact that the huge capacitance of the sensor was the problem. Hence, the objective problem to be solved was to design a structure which could be successfully operated in a real-time manner. In this respect, it was the achievement of the inventors to recognize that in the complicated circuitry of a sensor array two specific components, namely the capacitance C of the sensor and the on-resistance R of the switching transistor, had an overriding significance for real-time operation. Supporting evidence for the fact that the inventors' achievement was more than a trivial recognition of the relevance of a time constant in a switching circuit was given by a recent scientific paper of *Karim et. al.* filed with the letter of 6 July 2001. This paper explicitly presented the RC time constant of a pixel and the on-resistance of an associated thin film transistor switch as the decisive parameter for the time required for readout and in this context made reference to a 10-year old paper of the present inventors discussing the present invention.

Document D1 did not address the problem of real-time imaging and, consequently, made no reference to the capacitance of the sensor nor to the on-resistance of

an associated switching transistor. Moreover, it did
not concern a two dimensional array of sensors but
showed a linear arrangement of sensors as was used in
CT-scanners.

Nor did document D2 refer to a real-time operation or
draw the skilled person's attention to the significance
of the time constant RC as specified in the present
invention. Moreover, the sensor structure according to
D2 was more complicated than that of the invention.
Hence D2 taught in fact away from the invention because
it required the provision of an additional capacitance
in order to increase the capacitance of the sensor. A
high capacitance, however, made a real-time operation
impossible.

Thus, on the basis of the cited prior art, a skilled
person could not have arrived at the claimed subject-
matter without the benefit of hindsight.

VII.   As regards the basis of disclosure for the subject-
        matter of the auxiliary requests, the appellants
        considered the claimed value of 65.2 μs to be
        implicitly disclosed by information given on page 13,
        lines 27 to 29, in combination with indications on
        pages 12 and 14 as to the number of columns and an
        indication from page 17, line 25 relating to the time
        interval between radiation bursts. The limit of 50 μs
        was considered to be apparent from information
        disclosed on page 14, lines 7 to 27, of the published
        description.

Reasons for the Decision

1.   The appeal complies with the requirements of
      Articles 106 to 108 and Rule 64 EPC and is, therefore,
      admissible.

2.   *Main request*

2.1   Amendments

      Independent claim 1 is based on original claim 3 in
      combination with information concerning the time
      constant disclosed in original claim 5 and on page 14,
      penultimate paragraph, of the published application.

      The Board is thus satisfied that amended claim 1
      complies with the requirements of Article 123(2) EPC.

2.2   Inventive step (Articles 52(1) and 56 EPC)

2.2.1 Closest prior art

      An imaging array as defined in the preamble of claim 1
      is known from each of documents D1 (cf. claim 2;
      Figures 1, 2, 6 and 7A,B, with the corresponding
      description; and column 9, lines 33 to 39) and D2 (cf.
      Figures 1a,b and 2a,b with the corresponding
      description; and, in particular, column 6, lines 27 to
      32). The known two-dimensional imaging arrays make use
      of conversion means which convert incident radiation,
      such as X-rays, into visible light which, upon
      absorption in the a-Si:H sensor, is transformed into
      electrical charges that are stored in the capacitor
      formed by the sensor.

In the imaging array known from document D3 (cf. in particular Figure 14 with the corresponding description; page 7, lines 25 to 29; and page 23, lines 9 to 21) the conversion means are provided in the form of a stack of metal layers which convert the incident radiation into photoelectrons instead of visible light. The metal layers directly form the electrodes of the a-Si:H sensor capacitor.

It follows that the imaging arrays known from each of D1 and D2, making use of conversion means operating on the same physical principle as in the claimed array and being also provided as an entity separate from the sensors, are in closer functional and structural agreement with the claimed subject-matter than is the array known from D3. In accordance with well-established case law (cf. for instance T 795/93 (point 5.1 of the reasons)) and contrary to the appellants' respective submissions, the Board thus identifies D1 or D2 as equally suitable starting points for evaluating the inventive merits of the invention.

2.2.2   The subject-matter of claim 1 of the main request differs from an array known from D1 or D2 in that the time constant RC resulting from the sensor capacitance C and the on-resistance R of the associated switching transistor should be chosen to be less than or equal to 10 μs.

The technical effect of this measure, which is also indicated in the characterising part of claim 1 under consideration, is the capability of the array for real-time imaging of a radiation beam.

Thus, the objective technical problem is to be seen in the aim to render a prior art imaging array capable of a real-time operation for the reading out of signals stored in the sensors.

2.2.3   The problem as such was known to the skilled person
         from document D3 (cf. page 23, lines 9 to 21) and
         therefore its recognition does not involve any
         inventive activity.

         Contemplating the suitability of the imaging arrays
         known from D1 and D2 for real-time operation, the
         skilled person would have been immediately aware of the
         facts that the sensors constitute capacitances of
         substantial size (since otherwise a sensor could not
         collect significant amounts of electric charges) and
         that the associated thin-film transistor switches
         possess a considerable electrical resistance. Moreover,
         it is to be regarded as basic knowledge of the skilled
         person, having in the technical field at issue the
         qualification of a physicist or electrical engineer,
         that the time required for reading out a signal stored
         in the sensors of an imaging array is determined by the
         operating speed of the electrical circuitry involved,
         and thus mainly by the capacitances and resistances of
         the circuit elements present. Hence, on the basis of
         the available technical information, the skilled person
         would have been neglected of fundamental physical
         principles determining the operation of switched
         circuits if he had failed to take account of the time
         constant RC of each pixel as given by the capacitance
         of the capacitive sensor and the on-resistance of the
         transistor switch.

         As regards the claimed upper limit of 10 μs for the
         time constant RC, the appellants admitted in the oral
         proceedings that no specific technical effect was
         associated with the claimed limit, its significance
         residing mainly in the fact that the value of 10 μs
         happened to be the only value which had been explicitly
         disclosed. As a matter of fact, the upper limit for the
         time constant RC would in practice be determined by the
         circumstances of a specific application, including

inter alia the number of pixels and the type of
radiation. As is evident from the application
specification (cf. in particular page 14, lines 13 to
18), a time constant   less than or equal to 10 μs
would for instance be required for the real-time
imaging of pulsed radiation having a time interval
between radiation bursts set to 2.56 ms if an array of
256 x 256 pixels is used. For a larger array or a
higher frequency of radiation bursts, a time constant
less than or equal to 10 μs would be too long to allow
real-time imaging. Apart from that, it is to be noted
that documents D1 and D2 contemplate the use of the
same type of transistor switches (a-Si thin film
transistors) as the present application and that the
dimensions of the sensors known from D1 and D2, such as
the thickness of the a-Si:H capacitors and their areas,
are at least of the same order of magnitude as those of
the specific examples according to the application
specification. Thus, the skilled person, applying the
teaching of D1 or D2, would have observed time
constants of at least the same order of magnitude as
claimed in present claim 1. For these reasons, the
choice of the specific upper limit for the time
constant RC also would not have required the exercise
of inventive skill.

2.2.4   In consequence, it would have been obvious to the
skilled person to design the RC time constant in an
imaging array known from either D1 or D2 so as to
permit real-time imaging of the radiation beam and thus
to arrive at an imaging array as defined by claim 1
under consideration.

The Board cannot accept the appellants' submission that
the recognition of the time constant RC in particular
of the sensor and switching transistor as having an
overriding significance for real-time operation of an
imaging array was an inventive achievement. As regards

the alleged supporting evidence by the paper of *Karim et. al.*, the Board notes that this paper relates to theoretical considerations concerning the modelling and simulation of the effects of the leakage current behaviour of a-Si:H thin film transistors in a passive pixel sensor and that it is only for the purpose of justifying simplified assumptions for the simulation regarding the read-out of pixels that reference is made to an earlier publication of the present inventors. Moreover, as far as the appellants refer to alleged structural differences between the invention and the imaging arrays known from documents D1 and D2, the Board notes that claim 2 of document D1 explicitly refers to two-dimensional arrays of imaging devices and that the provision of additional capacitances in a sensor as shown by document D2 falls within the scope of claim 1 on file.

2.3   For the foregoing reasons, in the Board's judgment, the subject-matter of claim 1 of the main request does not involve an inventive step within the meaning of Article 56 EPC. Claim 1 is therefore not allowable.

2.4   Dependent claims 2 to 16 are also not allowable because of their dependency on an unallowable claim 1.

3.   *Auxiliary requests*

3.1   Claims 1 of the first to third auxiliary requests require the time constant RC to be less than or equal to 65.2 μs , whereas claims 1 of the fourth to sixth auxiliary requests specify a limit of 50 μs.

The original application documents do not explicitly disclose these specific values.

As regards the alleged indirect disclosure of the value of 65.2 μs, a passage on page 13, lines 24 to 29, of the description refers in the context of imaging pulsed radiation to a constraint demanding the RC time constant to be less than the time interval between radiation pulses divided by the number of columns in the array. On pages 12 and 14 of the description, reference is made to an array of 256 rows and columns, whilst a passage on page 17, lines 15 to 29 of the description as published, discloses a specific range of 2 to 16.7 milliseconds for the time intervals between the radiation pulses from a megavoltage beam machine with a variable pulse repetition rate. Indeed, a value of 65.2 μs would be obtained from a time interval of 16.7 ms when divided by 256.

The value of 50 μs is derived from information disclosed on page 14, lines 7 to 27 of the published description, by choosing the disclosed example of a sensor capacitance C of 50 pF and selecting a transistor resistance of R = 1 MOhm from the disclosed range of 0.1 to 1 MOhm.

3.2   However, in the Board's opinion, a skilled reader of the application as filed would not have made such calculations by selecting and combining particular parameter values in order to determine a universally valid upper limit for the RC time constant because he would have understood that the time constant of the sensor would have to be selected according to the needs and specification of the imaging device and not *vice versa* (cf. page 7, lines 7 to 18; page 13, lines 15 to 29; and page 19, lines 1 to 25, of the description) and recognized that no technical effect would be associated with any such arbitrary limit. Moreover, the

combination of parameters leading to the value of
65.2 μs would be particularly meaningless because it is
based on the least strict constraint; thus, the
resulting device would not allow real-time operation
for time intervals between radiation pulses shorter
than 16.7 ms.

3.3   For these reasons, in the Board's judgement, the
definitions according to the claims 1 of the auxiliary
requests contravene Article 123(2) EPC.

The auxiliary requests are therefore not admissible.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

R. Schumacher   G. Davies