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(54) **Cathode ray tube with a panel portion**

(57) A cathode ray tube (1) comprises an panel portion (2), a funnel portion (3) and a neck portion (4) with an electron gun (5) and a shadow mask. The shadow mask is made of a material with a high thermal expansion coefficient, and the panel portion has an outside radius of curvature (R) larger than 30000 mm. The thicknesses of the panel portion have the following ratios:

$$0.85 \leq T_s/T_d \leq 1$$

$$0.6 \leq T_l/T_d \leq 0.72$$

$$0.67 \leq T_c/T_d \leq 0.34$$

wherein T_c is a glass thickness at the centre of the front portion
T_s is a glass thickness at the end of the short axis, at the end of the effective screen area
T_l is a glass thickness at the end of the long axis, at the end of the effective screen area
T_d is a glass thickness at the end of the diagonal, at the end of the effective screen area.

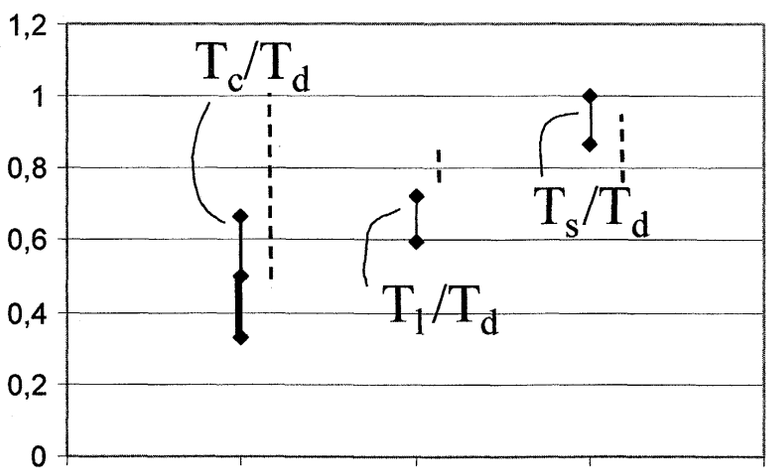

Fig. 4

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a cathode ray tube comprising a panel portion with a long axis, a short axis and a diagonal, and provided with a skirt, a funnel portion and a neck portion comprising an electron gun for generating one or more electron beam(s), and a deflection system mounted on said funnel portion for generating electromagnetic fields for deflecting said electron beam(s) and a colour selection electrode.

[0002] The invention also relates to a panel portion for a cathode ray tube.

[0003] The invention also relates to a display apparatus comprising a CRT.

BACKGROUND OF THE INVENTION

[0004] Cathode ray tubes (CRT's) of the type described in the opening paragraph are known.
An example is given in US 6,274,977.
In such tubes the colour selection electrode is often also called a shadow mask.

[0005] The cathode ray tubes have to meet a number of sometimes conflicting conditions. They have to be strong for safety reasons, provide a good image, i.e. provide an image of high quality, be cheap, and have a nearly flat front. Although every one of these conditions is relatively easily obtainable, it is very difficult to provide for a cathode ray tube which meets all or most such requirements simultaneously, i.e. provide a good balance between costs and quality.

SUMMARY OF THE INVENTION

[0006] It is an object of the invention to provide a cathode ray tube of the type described in the opening paragraph which does provide a good balance between costs and quality.

[0007] To this end the cathode ray tube is characterized in that the color selection electrode is made of a material with a high thermal expansion coefficient and in that the panel portion has the following features:

- an outside radius of curvature of more than 30000 mm
- wherein the following relations hold
- $0.85 \leq T_s/T_d \leq 1$
- $0.6 \leq T_l/T_d \leq 0.72$
- $0.67 \leq T_c/T_d \leq 0.34$
- wherein T_c is a glass thickness at the centre of the front portion
- T_s is a glass thickness at the end of the short axis, at the end of the effective screen area
- T_l is a glass thickness at the end of the long axis, at the end of the effective screen area
- T_d is a glass thickness at the end of the diagonal, at the end of the effective screen area.

As explained above the cathode ray tube has to meet several partially conflicting conditions. The use of a color selection electrode made of a material with a high thermal expansion coefficient is cost effective. The high value for the outside radius of curvature gives a nearly flat appearance to the front of the cathode ray tube. The difference in glass thicknesses T_c, T_s, T_l and T_d allow for a relatively strong front portion. The ratios of the various thicknesses determine the inner radii of curvature of the panel portion. These ratios influence the radii of curvature of the color selection electrode and the intensity variations of the image seen by a viewer. Generally it holds that the greater the curvature of the color selection electrode, the stronger the color selection electrode becomes and the less susceptible it becomes to doming, microphony and drop test. It also holds that the greater the curvature of the color selection electrode, in general the larger the variations in image intensity.

[0008] The inventor has realized that the indicated ranges of ratios of curvature on the inner side of the panel portion allow in particular the doming behavior to be considerably improved in relation to known devices having a color selection electrode with a high thermal expansion coefficient, thus providing an improvement in image quality, while in relation to devices having a color selection electrode made of a material with a small thermal expansion coefficient, considerable cost savings (approximately 10% of total costs of the CRT) are obtained while yet preserving a high standard in image quality. Thus the cathode ray tube of the invention provides, in relation to prior art devices, a better balance between costs and quality. Surprisingly the quite considerably thickness variations of the glass, which prima facie one could imagine to have a "rounding" effect on the image as perceived by the viewer, do not noticeably negatively influence the overall flatness impression of the image, as long as the curvature on the outside of the front portion is small. A material having a large thermal expansion coefficient has a thermal expansion coefficient of larger than $5\ 10^{-6}\ ^{\circ}C^{-1}$. An example of such a material is Akoca steel having athermal expansion coefficient of $11.7\ 10^{-6}\ ^{\circ}C^{-1}$, an example of a material having a low thermal expansion coefficient is Invar with a thermal expansion coefficient of approximately $1.2\ 10^{-6}\ ^{\circ}C^{-1}$.

[0009] In preferred embodiments the following relation holds: $0.5 \leq T_c/T_d \leq 0.34$.
Within this range the best conditions are obtained.

[0010] Preferably the aspect ratio of the cathode ray tube is 3:4

[0011] These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the drawings:

Fig. 1 illustrates a cathode ray tube and a picture display device in accordance with the invention.

Fig. 2 shows a front panel of a cathode ray tube.

Fig. 3 shows a panel portion.

Fig. 4 illustrates in a graphical form the various relationships between thicknesses in accordance with the invention.

[0013] The figures are not drawn to scale. Generally, identical components are denoted by the same reference numerals in the figures.

[0014] A cathode ray tube and a picture display device according to a preferred embodiment of the invention is shown in FIG.1.

[0015] It comprises a cathode ray tube 1, which includes a panel portion, sometimes also called a display window 2, a funnel portion 3, and a neck portion 4 (or neck as it is called hereinbelow). In the neck 4, there is as a means 5 for generating electron beam(s) in this example three in-line electron beams 6, the in-line plane being parallel to the long axis of the display screen, such means are herewithin in short described by the word "electron gun". A means for generating an electron beam is usually an in-line electron gun. Such designs are standard designs. The inner surface of the panel portion 2 comprises a large number of phosphor elements which form a display screen 8. When one or more of the electron beams 6 hit phosphor elements, the latter become phosphorescent, thereby creating a visible spot on the display screen 8. In the undeflected state, the middle one of the electron beams 6 substantially coincides with the tube axis 7. The direction of the tube axis is hereinbelow denoted by the z-direction. The direction along the long axis of the display screen is denoted by the x-direction, the direction along the short axis of the display screen by the y-direction. The line scanning direction (i.e. the direction in which scanning with the highest frequency takes place is usually parallel to the long axis (the x-direction) of the display screen. On its way to the display screen 8, the electron beams 6 are deflected by means of a deflection system 9 covering a part of the funnel portion 3. It is in particular this part 3a of the outer contour that the invention relates to. Said deflection system 9 comprises a line deflection subsystem 12 and a frame deflection subsystem 13, in order to create a two-dimensional picture on the display screen 8. In this exemplary embodiment, the deflection system 9 is made up of sets of coils, one set for the line deflection subsystem 12 and another set for the frame deflection subsystem 13. The figure shows an in-line CRT, having a shadow mask 14. The electron beams pass apertures in the shadow mask 14 before they hit the screen 8. A large percentage of the electrons are absorbed by the shadow mask which consequently is raised in temperature. Differences in intensity of the electron beams lead to local differences in temperature, which lead to local distortions of the shadow mask so-called doming. These doming distortions lead to image flaws.

[0016] The figure also indicates the x-direction, i.e. the direction along the long axis of the display screen and the z-direction. The z-coordinate of the deflection plane is usually (and hereinbelow) taken to be zero, with positive values of z being closer to the display screen.

[0017] As can be seen from FIG. 2, the panel portion (8) has an elongated shape with two perpendicular axes of symmetry : a long axis whose length, measured from screen end to screen end, is L_{scr} and a short axis whose length is S_{scr}. Often the short axis is the vertical axis, the long axis is the horizontal axis. In order to quantify the amount of elongation of the display screen (8), the aspect ratio of the display screen (8) is defined as $A_{scr} = L_{scr}/S_{scr}$. The diagonal, measured from screen comer to an opposite screen comer has a length D wherein approximately $D^2 = L^2_{scr} + S^2_{scr}$. The panel portion comprises an upstanding wall 21 and a front part 22. Figure 2 also shows the maximum deflection angle Θ as being the angle between the tube axis (7) and the deflected electron beam (10) when the electron beam is deflected so as to hit a point on the display screen which is the furthest away from the intersection between the tube axis (7) and the display screen.

[0018] The following relation holds

$$\mathrm{Tan}(\Theta)=A_{scr}$$

[0019] Depending on the design A_{scr} is usually 3/4 or 9/16. In preferred embodiments the aspect ratio is ¾.

The outer side of the panel portion is nearly flat, i.e. it has an outside radius of curvature R of more than 30000 mm (30 m). If there are more than one radii of curvature, for instance vertically and horizontally each of the radii of curvature has a value of more than 30000 mm. Preferably all radii of curvature are larger than 40000 mm. Preferably the outside radius is less than 100000 mm (100 m). For nearly completely flat front surfaces sometimes shows hollow impressions.

The thicknesses of the panel portion, except for the centre glass thickness are taken at the end of the screen

The following thicknesses are of importance:

T_c, the glass thickness at the centre of the front portion,

T_s, the glass thickness at the end of the short axis S_{scr},

T_h is a glass thickness at the end of the long axis L_{scr},

T_d is a glass thickness at the end of the diagonal D.

[0020] The ratios between these thicknesses are, for cathode ray tubes in accordance with the invention set between:

- $0.85 \leq T_s/T_d \leq 1$
- $0.6 \leq T_h/T_d \leq 0.72$
- $0.67 \leq T_c T_d \leq 0.34$

[0021] The invention is based on the following insights:

[0022] The thickness variations of the panel portion are set between the indicated limits. This strengthens the shadow mask and makes it less susceptible for doming. Use is made of a shadow mask of high thermal expansion coefficient. A considerable reduction in prize, compared to devices using a shadow mask with a small thermal expansion coefficient, while yet preserving high image quality is obtained.

Surprisingly the quite considerably thickness variations of the glass, which prima facie one could imagine to have a "rounding" effect on the image as perceived by the viewer, do not noticeably negatively influence the overall flatness impression of the image, as long as the curvature on the outside of the front portion is small, i. e. radius R is large. Even larger inner radii of curvature (i.e. ratios outside the indicated ranges), do, however, lead to a visual effect on the image, reducing the sought-after flat image effect. So the cathode ray tube in accordance with the invention pairs a flat image reproduction, to a cost reduction, while yet preserving image quality, in particular reducing doming errors. Doming constitutes for color selection electrodes made of a material with a high thermal expansion coefficient, and such in contrast to color selection electrodes made of a material with a small thermal expansion (such as Invar), a serious problem with a serious detrimental effect on image quality.

[0023] It is remarked that the curvature of the front part is grossly exaggerated in this figure. Figure 3 illustrates in more detail a panel portion. The thicknesses are taken at the end of the screen area, i.e. where the phosphor layer ends.

[0024] Figure 4 illustrates in a graphical form the ranges for the ratios. Indicated are the ratios in accordance with the invention, as well as for the ratio T_c/T_d for preferred embodiments. Indicated in this figure are also, for easy reference, the ratios mentioned in US 6,274,977, by means of the dotted lines. There are clear differences in the ratios, furthermore, US 6,274,977 does not discuss the material for the shadow mask. Despite the fact the US 6,274,977 mentions that thickness ratios T_l/T_d would lead to a shadow mask of inadequate strength, the inventors have realized that using a shadow mask of a material having a high thermal expansion coefficient, it is possible to maintain adequate structural strength, while yet maintaining good image reproduction, in particular having good doming behavior, and reducing costs in respect of using a shadow mask of a material having a low thermal expansion coefficient. In an example, a 21" CRT with an aspect ratio of 3/4 the value for T_s/T_d was 0.88, the value for T_l/T_d was 0.67 and the value for T_c/T_d was 0.41. For a 25" CRT the values are 0.88, 0.67 and 0.40 respectively.

[0025] The invention is particular useful for CRT's in the range between 20" and 27".

[0026] In short the invention may be described as follows:

A cathode ray tube (1) comprises an panel portion (2), a funnel portion (3) and a neck portion (4) with an electron gun (5) and a shadow mask. The shadow mask is made of a material with a high thermal expansion coefficient, and the panel portion has an outside radius of curvature (R) larger than 30000 mm. The thicknesses of the panel portion have the following ratios:

$$0.85 \leq T_s/T_d \leq 1$$
$$0.6 \leq T_l/T_d \leq 0.72$$
$$0.67 \leq T_c/T_d \leq 0.34$$

wherein T_c is a glass thickness at the centre of the front portion

T_s is a glass thickness at the end of the short axis, at the end of the effective screen area

T_l is a glass thickness at the end of the long axis, at the end of the effective screen area

T_d is a glass thickness at the end of the diagonal, at the end of the effective screen area.

[0027] It will be clear that within the concept of the invention many variations are possible. It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Reference numerals in the claims do not limit their protective scope. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements other than those stated in the claims. Use of the article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

Claims

1. A cathode ray tube (1) comprising a panel portion (2) with a long axis, a short axis and a diagonal, a funnel portion (3) and a neck portion (4) comprising an electron gun (5) for generating one or more electron beam(s) (6), and a deflection system (9) mounted on said funnel portion (3) for generating electromagnetic fields for deflecting said electron beam(s) (6), and a color selection electrode (14) **characterized in that** the color selection electrode (14) is made of a material with a high thermal expansion coefficient and **in that** the panel portion (2) has the following features:

- an outside radius of curvature (R) of more than 30000 mm
- wherein the following relations hold
- $0.85 \leq T_s/T_d \leq 1$
- $0.6 \leq T_l/T_d \leq 0.72$
- $0.67 \leq T_c/T_d \leq 0.34$
- wherein T_c is a glass thickness at the centre of the front portion
- T_s is a glass thickness at the end of the short axis, at the end of the effective screen area
- T_l is a glass thickness at the end of the long axis, at the end of the effective screen area
- T_d is a glass thickness at the end of the diagonal, at the end of the effective screen area.

2. A cathode ray tube as claimed in claim 1, wherein $0.5 \leq T_c/T_d \leq 0.34$.

3. A cathode ray tube as claimed in claim 1 or 2, wherein the outside radius of curvature (R) is less than 100000 mm.

4. A cathode ray tube as claimed in any of the preceding claims wherein the aspect ratio is substantially 3/4.

5. A panel portion (2) for a cathode ray tube with a long axis, a short axis and a diagonal, a funnel portion (3) and a neck portion (4) **characterized in that** the panel portion (2) has the following features:

- an outside radius of curvature (R) of more than 30000 mm
- wherein the following relations hold
- $0.85 \leq T_s/T_d \leq 1$
- $0.6 \leq T_l/T_d \leq 0.72$
- $0.67 \leq T_c/T_d \leq 0.34$
- wherein T_c is a glass thickness at the centre of the front portion
- T_s is a glass thickness at the end of the short axis, at the end of the effective screen area

6. A panel portion as claimed in claim 5, wherein the panel portion has an aspect ratio of 3/4.

7. A panel portion as claimed in claim 5 or 6 wherein the outside radius of curvature is less than 100000 mm.

8. A display apparatus comprising a cathode ray tube as claimed in any of the claims 1 to 4.

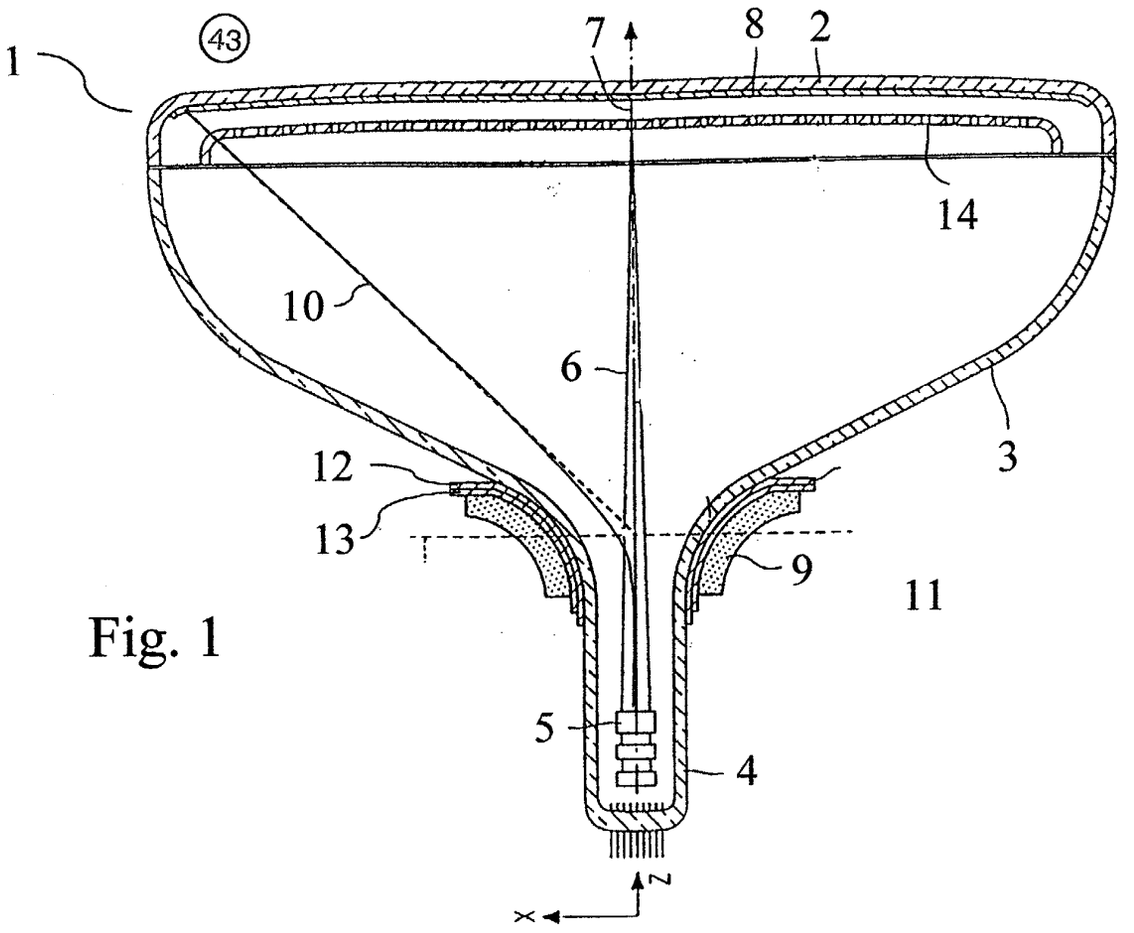
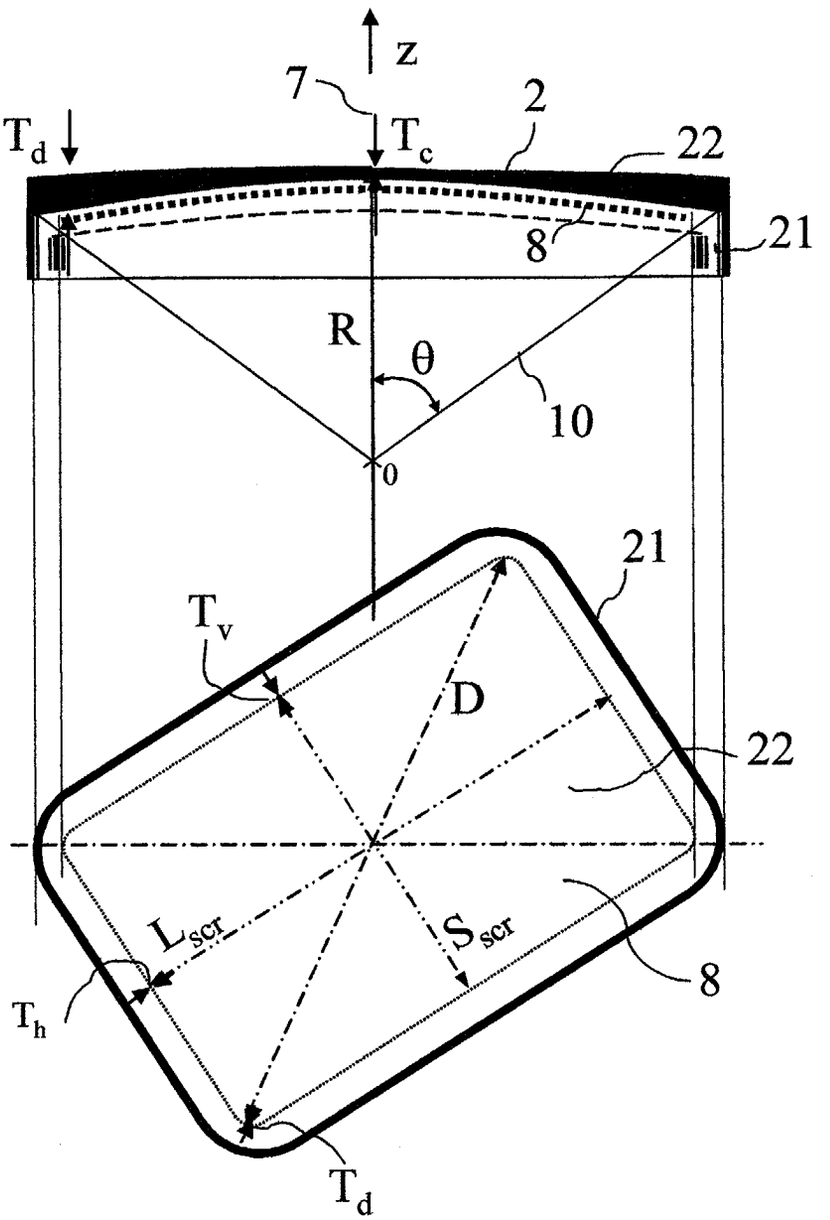


Fig. 1

Fig. 2



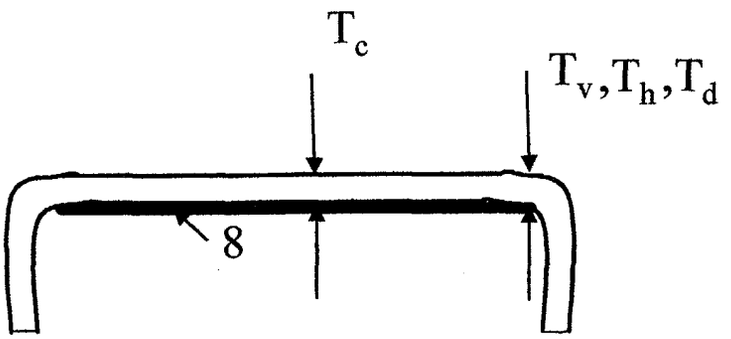


Fig. 3

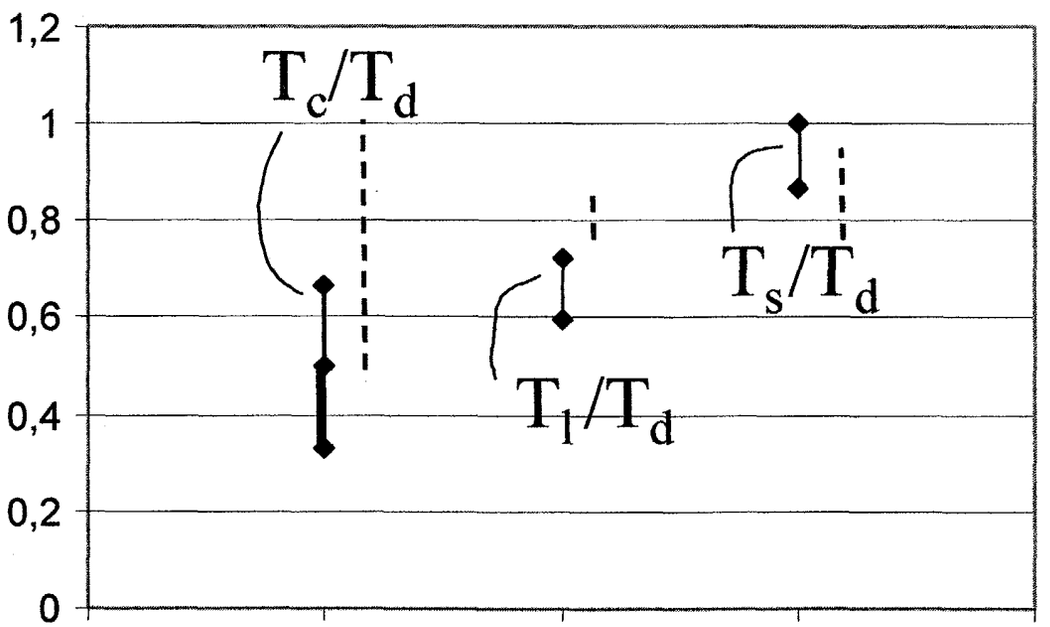


Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 04 07 5133

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 December 2004	Meyer, J

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EUROPEAN SEARCH REPORT

Application Number
EP 04 07 5133

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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 07 5133

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