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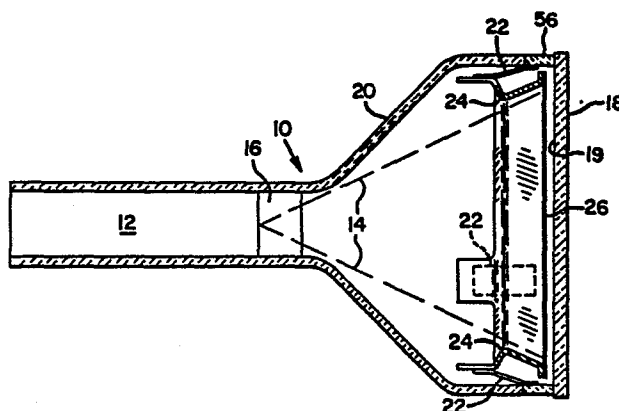
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⑤④ Cathode-ray tube having taut shadow mask.

⑤⑦ A shadow mask assembly for a cathode-ray tube wherein the perforated shadow mask membrane is stretched and in the stretched condition is affixed to a rigid frame. The frame securely holds the membrane in the tensioned condition and as the mask is heated during the operation of the tube, the expansion of the membrane merely relaxes the tension without distortion to the membrane.



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CATHODE-RAY TUBE HAVING TAUT SHADOW MASK

Field of the Invention

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This invention relates to shadow-mask type cathode-ray tubes (CRTs), and more particularly to an improved cathode-ray tube shadow mask assembly that minimizes misregistration produced by electron beam heating of the mask, and that facilitates construction of a flat face cathode-ray tube.

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Description of the Prior Art

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Cathode-ray tubes of the type used in most color television and similar color image display systems normally have three electron guns -- one for each of three primary colors (red, green and blue). The guns are arranged symmetrically with respect to the central axis of the tube, and generate individual electron beams that pass through small holes or slits in a shadow mask (or aperture grill) positioned between the guns and a cathodoluminescent display screen. The display screen is formed of three color phosphors deposited in a regular pattern of dots or stripes on the inner face of the cathode-ray tube. The arrangement of the phosphor deposits and shadow mask apertures is such that, ideally, each electron beam strikes only the deposits of its respective color. A common electromagnetic yoke positioned between the electron guns and the screen deflects the three beams over the screen surface to form visible color images.

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Very nearly all commercial color picture tubes have curved viewing panels, or faceplates. The shadow mask for

such a tube is also curved to follow, at least approximately, the faceplate contour, which may be cylindrical or spherical. It is desirable in certain applications, such as in high resolution avionics displays, to provide a color cathode-ray tube having a substantially flat faceplate. In keeping with the concepts used to design curved faceplate cathode-ray tubes, the shadow mask for a flat face tube also should be flat, or very nearly so. However, unlike conventional curved masks, a flat shadow mask lacks sufficient strength and rigidity to be self-supporting. One way to provide added rigidity is to use a corrugated mask of the type described in U.S. Patent Nos. 4,122,368 (Masterton) and 4,146,816 (Morrell), or to use a spherically-shaped mask, as taught by U.S. Patent No. 4,136,300 (Morrell). However, corrugated or spherically curved masks are difficult to manufacture using thin sheet materials, as required for high resolution masks, and are also susceptible to "doming", a localized bulging of certain portions of the mask toward the screen. Doming is caused by nonuniform heating of the mask by the electron beams, and results in misregistration of the beams and consequent loss of color purity. The effect is most severe in off-axis regions of the display screen.

Another, conceptually superior way to provide a rigid flat mask for a flat face cathode-ray tube would be to put the mask under tension as is done in some commercially available tubes having cylindrical faceplates. Undesirably heavy and expensive frame structures are used to support the tensioned masks in such tubes, however, making them unsuitable for use in cathode-ray tubes that must withstand high levels of shock and vibration. The doming problem mentioned above also may be present in such prior cathode-ray tubes, particularly when used in applications (such as avionics or computer terminal displays) where information frequently is highly localized and the electron beams address particular regions of the shadow mask for extended periods of time. In a high or very high resolution shadow-mask type cathode-ray tube,

the phosphor deposits and shadow mask apertures are very small and closely spaced. Even a small amount of mask movement relative to the screen will produce misregistration and localized loss of color purity.

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Summary of the Invention

According to a preferred embodiment of the invention, which will be described in greater detail below, a flat
10 face cathode-ray tube is provided with a taut shadow mask structure comprising a thin membrane of material having a low coefficient of thermal expansion. The mask membrane is tensioned substantially uniformly to a predetermined fraction, suitably about one-half to three-quarters, of
15 its tensile stress limit, and is secured to a frame member that is sufficiently rigid to maintain the membrane in its tensioned state. In operation of the tube, localized heating of the shadow mask by the electron beams results only in a relaxation of the tension of the membrane, and
20 the mask-to-faceplate spacing remains unaffected. The taut mask permits the use of higher beam current, which increases display brightness, without loss of color purity. In addition, the tension of the membrane can be adjusted, if desired, to provide a resonant vibration frequency far
25 removed from the frequency range of vibrations to which the cathode-ray tube will be exposed.

Brief Description of the Drawing

30 A more complete understanding of the invention will be derived by referring to the following detailed description and the accompanying drawing, wherein:

Fig. 1 shows a cathode-ray tube incorporating the improved taut shadow mask of the present invention;

35 Fig. 2 is an isometric view of the shadow mask and frame assembly utilized in the Fig. 1 CRT;

Fig. 3 is a greatly enlarged section of the Fig. 2 shadow mask membrane;

Fig. 4 illustrates apparatus that facilitates mounting of the shadow mask membrane in its supporting frame; and

Fig. 5 is a sectional view taken along line 5-5 of Fig. 4.

Detailed Description

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Referring first to Fig. 1 of the drawing, a cathode-ray tube 10 includes an electron gun cluster (not shown) normally containing three electron guns in a side-by-side or delta arrangement. The guns are mounted in a known manner within the neck area 12 of the tube, and when energized emit individual electron beams 14 toward a display screen 16 on the inner surface of the CRT's faceplate, which forms part of a vacuum-tight housing, or envelope, 18 for the tube. The electron beams are directed onto selected regions of screen 16 by a common deflection system. Such a system normally will include an external magnetic deflection yoke (not shown) mounted on the neck of the CRT overlying interior region 20 of the tube. In addition to the common magnetic deflection yoke, the deflection system includes means to converge the three beams at the same point on the screen, and to maintain the beams in convergence at all points on the screen's surface. A suitable control system controls the activation of the electron guns in synchronization with the deflection system to direct the beams onto any desired region of the display screen.

Display screen 16 comprises three interlaced arrays of different color-emitting phosphor deposits, preferably separated by a light-absorbing matrix. In the case of a high resolution display, the phosphor deposits usually are arranged in a hexagonal array of circular dots grouped in triads, with each triad containing a dot

of each different color, i.e., red, green and blue. A shadow mask assembly including an apertured metal membrane 22 is positioned in envelope 18 adjacent display screen 16. Electrons from the three guns in the neck of the tube project through the apertured membrane to strike the phosphor deposits forming the display screen, the membrane serving as a color selection device within the tube. As will be understood, shadow mask membrane 22 includes one aperture or hole for each phosphor dot triad, with the arrangement of the dots, holes and electron guns being such that (ideally) each electron beam only strikes dots of its assigned color at all deflection angles.

Referring together to Figs. 1 and 2, shadow mask membrane 22 is mounted, suitably by welding, to a substantially rigid mounting frame 24. The frame is removably secured within the forward end of envelope 18 by four flat spring clips 26 welded to mask frame 24. Each of the spring clips has a hole adjacent its free end that engages one of a corresponding number of tapered metal studs secured to the interior sidewalls of the envelope. As will be understood, the studs are located accurately in the envelope in relation to screen 16, so that the shadow mask membrane is supported in precisely-spaced, parallel relation to the screen.

Referring now to Fig. 3, an enlargement of a small region 28 of Fig. 2, the tiny circular openings, or holes, 30 in mask membrane 22 are provided in a repetitive pattern, with the holes in adjacent rows being offset to allow minimum spacing between the holes. In a high resolution display CRT of the type contemplated for the present invention, display screen 16 suitably is about 15 cm. square and the size of the perforated portion of membrane 22 is about 13 cm. square. The openings in the shadow mask membrane have a diameter (d) of about 0.1 mm. and a pitch or center-to-center spacing

(1) of about 0.2 mm. The holes constitute about 20% of the mask's surface area.

5 As briefly described above, membrane 22 is pulled
taut and secured under substantially uniform tension to
frame 24. This is suitably achieved through the use of
a tension-mounting apparatus 32, which is illustrated in
Figs. 4 and 5. Color CRT shadow masks typically are
10 formed from low carbon steel approximately 0.15 mm.
thick. While such material is suitable for use in form-
ing a taut membrane 22, the preferred material is a low
expansion nickel-iron alloy containing approximately 36%
nickel. Such a material, which has a coefficient of
thermal expansion of about 1.6×10^{-6} per degree
15 Celsius, can be purchased under the trademark Invar from
Wilbur V. Driver Company. Membrane sheet material
having a thickness of about 0.10 to 0.15 mm. may be used
in an entertainment quality tube, but for a high
resolution CRT of the type contemplated herein, the
20 preferred material thickness is about 0.025 to about
0.038 mm.

The desired pattern of holes 30 is chemically
etched into membrane 22 by a conventional photolithogra-
25 phic process prior to mounting the membrane under ten-
sion on frame 24. Thus, for example, a 30 cm. square
sheet of Invar material is etched to provide a 13 cm.
square perforated region 36 containing holes 30. Region
36 is indicated by dashed lines in Figs. 2 and 4. The
30 perforated region of the metal alloy sheet is centered
on a base ring 34 forming part of mounting apparatus 32.
A clamping ring 38 is then placed on top of the membrane
overlying ring 34 and fastened to the base ring using a
plurality of bolts 40 to clamp membrane 22 securely
35 between the two rings. Next, an L-shaped tensioning
ring 42 is placed on top of clamping ring 38 with one
leg 42a overlying the upper surface of ring 38 and the
other leg 42b extending within the clamping ring to
engage membrane 22. The position of the tensioning ring

just prior to stretching of the membrane is shown in phantom outline in Fig. 5. The metal membrane is placed under substantially uniform tension by progressively tightening a plurality of bolts 44 into ring 38 to bring
5 leg 42a of the tensioning ring into contact with the upper surface of ring 38 as shown in solid outline in Fig. 5. As will be understood, the amount of membrane tension produced in this manner is a function of the length of leg 42b (for a given clamping ring thickness).
10 Calculation of the correct length needed to produce a desired tension is within the ability of an ordinarily skilled technician. Alternatively, the length of leg 42b can be determined empirically by routine experimentation.

15 Shadow mask mounting frame 24 of the exemplified embodiment is a substantially square structure formed by channel-shaped side rails approximately 14 cm. in length. The side rails, which include an outer lip surface 46 to which membrane 22 is attached, are configured to provide a strong but light-weight, deflection-resistant support for the mask membrane. Fig. 5 illustrates the attachment of membrane 22 to frame surface 46
20 by spot welding at numerous points around the periphery of perforated region 36 using a welding electrode 48. The resulting pattern of weld spots 50 is shown in Fig. 2. To avoid distorting the membrane by overheating it during the welding process (as by making successive welds in the same area of the mask), membrane 22 preferably is attached by skip-welding around the periphery of
25 the frame -- i.e., by welding one spot on each of the four sides of the frame before returning to weld a second spot on each side, etc., until all of the welds have been made.
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35 After the membrane has been welded to the frame, the resulting assembly is removed from the mounting apparatus and the excess membrane material is trimmed

away. It will be understood that even the slightest buckling of the frame after it is removed from apparatus 32 will result in relaxation of the membrane tension. One way to avoid this problem would be to use a massive frame that would resist the compressive force imparted by the taut metal membrane. However, in many applications the CRT envelope cannot accomodate a massive frame, either because shock and vibration test levels are too high to allow the use of such a frame, or because it would take up too much room inside the envelope and reduce the usable display area of the CRT. A preferred way to prevent buckling of the frame is to apply a compressive force to the siderails before the membrane is attached. Later, when the frame and membrane assembly is removed from the mounting apparatus after the spot welding process has been completed, the outwardly-directed restoring force produced by the previously-compressed side rails counteracts the inwardly-directed force produced by the stretched membrane.

Thus, again referring to Figs. 4 and 5, a compression mechanism represented in the drawing by compression arms 52 is provided to compress the sides of frame 24 in the directions indicated by arrows 54. The amount of compensating force required can be calculated readily, or determined by routine experimentation. The compression arms are shaped to engage the outer sides of the side rails, as shown in Fig. 5, and force them inward toward the enter of the frame, care being taken that the arms do not project above frame 24 and damage membrane 22.

According to the invention, the degree of tension developed in the mounted membrane is such as will equal or exceed the projected release of tension produced by thermal expansion of the shadow mask during operation of cathode-ray tube 10 at its maximum beam power level. It has been found that an Invar metal membrane tensioned to

about one-half to three-quarters of its tensile strength limit will adequately counteract heat expansion in the material when the mask is subjected to a temperature rise of up to 100 degrees C. This is well within the temperature variation expected during operation of the CRT for the applications contemplated. In a conventional domed shadow-mask type CRT, a temperature variation of 30 degrees C will produce an intolerable amount of beam misregistration and loss of color purity in such applications. The loss of color purity caused by distortion of the shadow mask at high beam currents places a relatively low limit on the light output of a domed shadow mask tube. The attainable luminance level typically is only marginal for certain aircraft display applications. However, cathode-ray tubes provided in accordance with the present invention are able to withstand substantially higher beam power input levels because the taut mask counteracts localized heating by relaxing against the tension fixed in the mask when the membrane is welded to the frame. Color cathode-ray tubes manufactured as described herein have been able to withstand power input levels as high as 1.8 W/sq. in. without experiencing a significant loss of color purity due to shadow mask distortion. This is approximately an order of magnitude higher than domed shadow mask tubes of similar size. As a result, the taut shadow mask tubes of the present invention have the capability of providing significantly brighter displays than currently-available domed mask CRTs.

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It will be understood that various modifications and changes can be made in the details of construction, manufacture and use of the improved shadow-mask type CRT without departing from the scope of the invention as defined by the following claims. For example, taut shadow masks of the type described may be used in tubes where the mask and screen are held at different poten-

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tials (focus mask tubes) as well as those in which the mask and screen are at the same potential.

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CLAIMS

1. A cathode-ray tube comprising; an electron beam source and transmitting means for transmitting electron beams from the source onto selected areas of a display screen to produce images thereon, and a shadow mask assembly positioned between the source and the screen to restrict impingement of the beam to the designated areas of the screen, said shadow mask assembly being characterized by, a frame and a perforated thin membrane of material mounted in the frame, said membrane being fastened to the frame in a tensioned condition whereby heating of the membrane relaxes the tension without producing physical change in the size or location of the perforations.

2. A cathode-ray tube as defined in Claim 1 wherein the tensioned membrane is a metallic electron beam absorbing material having a pre-determined coefficient of thermal expansion.

3. A cathode-ray tube as defined in Claim 2 wherein the tensioned membrane is a nickel-iron alloy and is uniformly tensioned to within half to three-quarters of its stress limitation.

4. A cathode-ray tube as defined in Claim 3 wherein the tensioned membrane material has 36% nickel and a coefficient of thermal expansion in the order of 1.6×10^{-6} per degree centigrade.

5. A cathode-ray tube as defined in Claim 4 wherein the tensioned membrane material has a thickness in the range of .0025 centimeters to .0038 centimeters.

6. A cathode-ray tube as defined in Claim 1 wherein the display screen has a flat surface on which the electron beam impinges, and the tensioned membrane is correspondingly flat in position parallel to the screen.

7. A cathode-ray tube as defined in Claim 2 wherein the heat rise within the tensioned membrane during operation of the cathode-ray tube is predetermined and the physical stretching of the tensioned membrane in a non-operational mode exceeds the expansion of the membrane within said heat rise.

8. A cathode-ray tube as defined in Claim 1 wherein the frame is precompressed so as to exert an outwardly directed force to counterbalance the inwardly directed force generated by the tensioned membrane.

9. A process for producing a shadow mask assembly for a cathode-ray tube comprised of; stretching a sheet of membrane material to a predetermined tension, holding the membrane in the tensioned condition, and securing the membrane to a frame and thereby maintaining the membrane in its tensioned condition.

10. A process for producing a shadow mask assembly for a cathode-ray tube as defined in Claim 9 which includes etching a pattern of perforations into the sheet prior to stretching.

11. A process for producing a shadow mask assembly for a cathode-ray tube as defined in Claim 9 wherein the membrane material is a metallic membrane having a predetermined stress limit and which includes stretching the membrane to within the range of half to three-quarters of its stress limit.

12. A process for producing a shadow mask assembly comprised of selecting a shadow mask membrane material, determining a temperature range within which membrane distortion is to be avoided, stretching the membrane at the low end of the temperature range to the extent that would be produced by heat expansion of the material at the top of the temperature range, and securing the stretched

membrane to a frame.

13. A process for producing a shadow mask assembly
as defined in Claim 12 including spring loading the frame
5 during securing of the membrane to generate an outwardly
directed force to counterbalance the inwardly directed
force of the tensioned membrane.

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FIG. 1

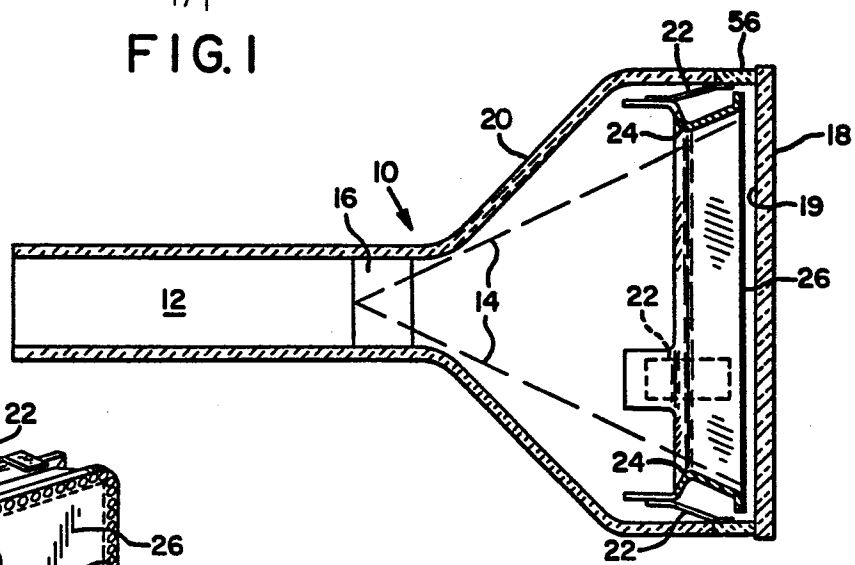


FIG. 2

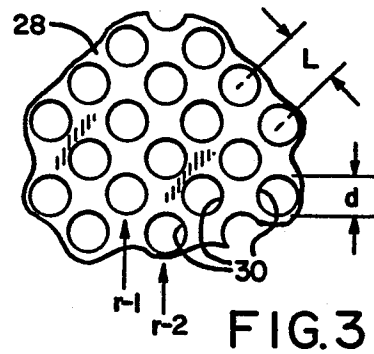
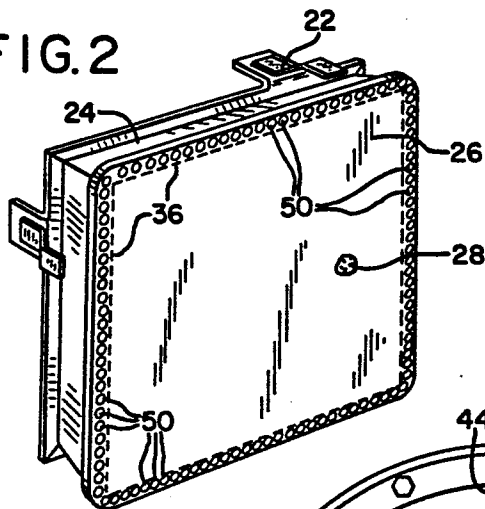


FIG. 3

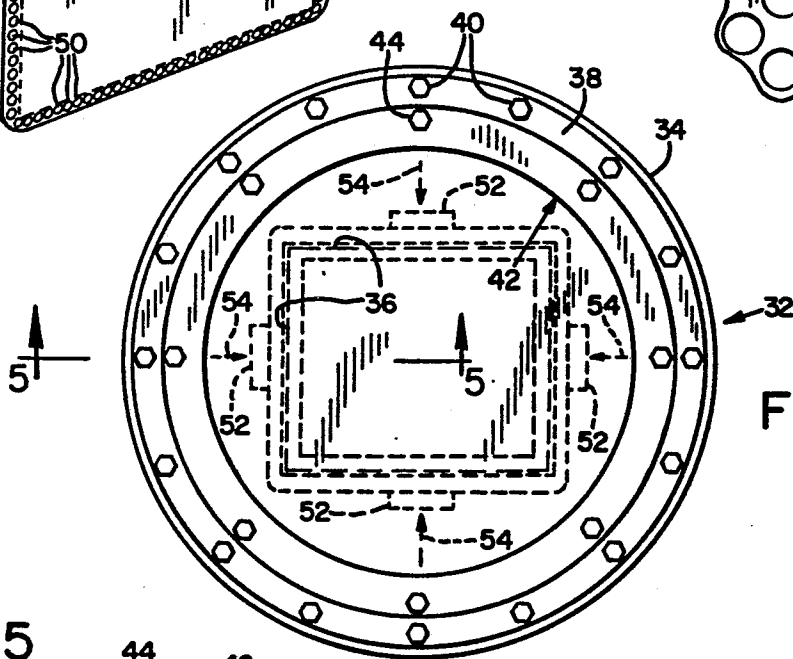
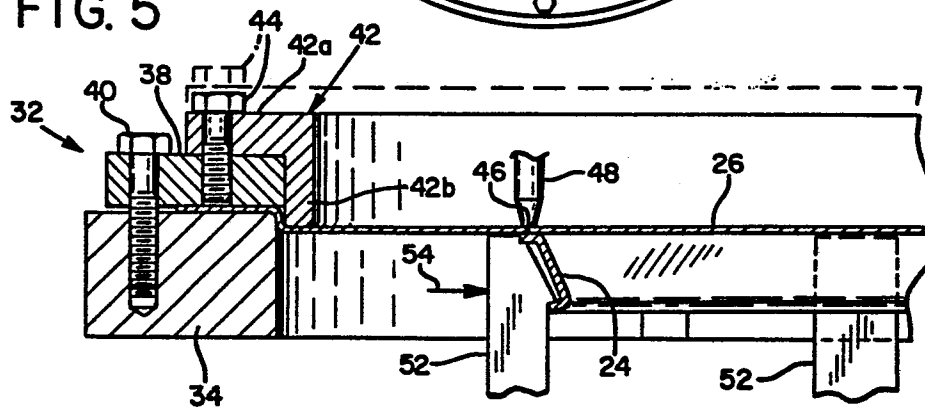


FIG. 4

FIG. 5





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	US-A-2 611 100 (R.D. FAULKNER et al.) * Column 1, lines 1-44; column 3, lines 16-49; figure 2 *	1,6	H 01 J 29/07
Y	--- US-A-3 894 321 (J.H. MOORE) * Column 4, line 3 - column 6, line 3; figure 8 *	1,2,5,6,9	
A	--- US-A-4 069 567 (J.W. SCHWARTZ) * Column 4, line 26 - column 5, line 24; figure 1 *	1,2,4,6,9	
A	--- US-A-4 333 034 (A. OHGOSHI et al.) * Column 5, lines 10-36; figure 5 *	1,8,13	
A	--- BE-A- 666 836 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) * Page 2, lines 10-29 *	2-4	TECHNICAL FIELDS SEARCHED (Int. Cl. 3) H 01 J 29/00 H 01 J 9/00 H 01 J 31/00
A	--- US-A-2 750 524 (F.G. BRAHAM) * Column 1, lines 15-51; figure 3 *	10	

The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 07-06-1984	Examiner DAGLISH B.D.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	