

The present invention relates to a shadow mask or colour selection electrode for colour television picture tubes. It also relates to the supporting frame allowing the said mask to be stiffened.

A cathode-ray tube intended to reproduce colour television pictures generally comprises a glass envelope composed of a front panel (or front slab) of rectangular shape extended by a side wall in the form of a skirt, sealed to a so-called conical part which narrows down and which terminates in a tubular or cylindrical neck which at the end houses an assembly of three electron guns and externally carries the horizontal and vertical electromagnetic deflectors which enable the scanning of the luminescent screen to be performed.

This screen, composed of phosphors of the three primary colours red, blue and green, is deposited on the internal surface of the front slab. In one kind of colour picture tube in which the electron guns emit three parallel electron beams situated in the same horizontal plane, this screen is formed by a repeated succession of three continuous strips of vertical phosphors of different colours, R,G,B.

A colour selection electrode formed by a metal surface of spherical (or cylindrical) form 10 (figure 1), pierced by a large number of oblong (or elongated rectangular) openings 11, referred to as a shadow mask 12, is positioned in the trajectory of the three electron beams close to and substantially parallel to the screen which has a form analogous to that of the surface 10. The shadow mask 12 has the action of only allowing to pass for each electron beam the part which is directed at a single one of the strips of phosphors R,G,B, so that a first beam is intended for green strips G, a second beam for blue strips B and the third beam for red strips R, by reason of their different angles of incident at the location of

the slots 11. It should be observed that a single beam may comprise a section covering several slots 11 at the same time as well as a circular zone on the metal surface 10 surrounding them. The result is that the greater part, approximately 80%, of the electrons of each beam is received by the metal surface 10 which is also referred to as a masking sheet, which blocks their passage and absorbs their high kinetic energy. This causes rapid heating of the part of the surface 10 scanned by the beams, which has a low thermal inertia.

Since the shadow mask 12 has to be removed and placed in position again several times during the production of the tube and must furthermore be able to withstand predetermined mechanical shocks and vibrations without incurring any permanent deformation or displacement, it is commonly supported by means of a rigid metal frame 16 (figures 1 and 2) which is preferably produced as a profile having an L-shaped cross-section and a thickness which is substantially greater than that of the mask 12 (from 10 to 15 times, for example). In embodiments of slots of the art tube described for example in the publications FR-A-1,470,260 and 1,486,675, the thickness of the metal foil forming the metal surface 10 of the mask 12 is generally between 100 and 200 micrometres, and that of the frame 16 is then generally between 2 and 3 millimetres depending on the dimensions of the screen.

In view of this the thermal inertia of the frame 16 is much higher and it is only heated much more slowly.

The result is that the shadow mask 12 which is bombarded continuously by the electron beams and which is much thinner and lighter than the frame, is heated much more quickly than the latter, which is thick and heavy, as soon as the tube is in operation. The frame itself is

bombarded by electrons only towards the beginning and end of each scanning line and frame and only reaches its equilibrium temperature much later (when the heat input becomes equal to the heat output). As a result, the mask 12 undergoes an expansion in its plane (in the radial direction) well before the frame 16 begins to heat up and expand. What is then observed is a distention or bulging of the mask 12 of which the centre which is at the same time the apex, moves closer to the screen and of which the edges welded to the frame 16 are held in position by the latter which is secured to the skirt of the front panel by means of a conventional mounting comprising blade springs.

This distending of the perforated mask 12 causes corresponding displacements of the slots 11 of the mask 10, which are purely axial at the centre and have decreasing axial components from the centre towards the periphery (at which they are initially null) and radial components which increase from the centre (at which they are null) as far as approximately half-way between the centre and the edge (where they reach their maximum values) and beyond that point they decrease as far as the edge (at which they are initially null). This is illustrated diagrammatically in cross-section in figure 1, in which the dashed trace A shows the outline of a mask 12 and of a frame 16 when cold, and the dash-dotted trace B shows the outline of a hot mask 12 with a cold frame 16 causing the said distention which is indicated by a reduction of the radius of curvature of the mask 12. The aforesaid displacements of the slots 11 have the result of shifting the axes of the beam portions, referred as chromogenic streaks, which traverse them with respect to the vertical axis of the strips of phosphors R,G and B associated in juxtaposed triplets, in such a manner as to cause losses of register or alignment defects which are highest in an annular area situated approximately half-way between the centre and the edge of the mask 12.

This may lead to a relative reduction of the light intensity proportional to the phosphor surface bombarded (if the strips are separated by areas denuded of phosphors) of colour purity defects, since a beam intended for a single phosphor is partially incident on an adjacent strip of a different colour.

After a particular operating period of the tube, the frame 16 is equally heated in a progressive manner by conduction, by radiation and by electronic bombardment, such that it also undergoes a thermal expansion. The frame 16 and the mask 12 being generally produced from an identical material (rolled steel), they have the same coefficient of thermal expansion. The expansion of the frame 16, following on that of the mask 12, has the effect, on the one hand, of reducing its previously observed distention (flattening it as compared to trace B of figure 3), and on the other hand of increasing the gap between its slots 11, that is to say of displacing them radially. This has been shown diagrammatically and in cross-section in figure 2, which shows on the dashed trace A (analogous to that of figure 1), the outline of a mask 12 - frame 16 assembly in the cold state, and the solid trace C shows a mask 12 - frame 16 assembly in the hot state, that is to say having reached the same equilibrium temperature. It is observed therein that the area of the mask 12 has increased, as has the distance between its pairs of parallel branches and that the radius of curvature of the mask 12, following a brief reduction caused by the initial distention, becomes a little greater than that which it had in the cold state.

If the frame 16 is suspended only by means of blade springs of which the longitudinal axes are situated in the same (transverse) radial plane and which are directed substantially tangentially with respect to the circumference, the frame 16 may expand in its plane without incurring

any axial displacement. This has the action of stretching the spherical metal surface 10 in such manner that it spreads whilst flattening slightly. The mask 12 consequently undergoes an axial displacement which is low at the centre and increases with the radial distance, and a spreading in the radial direction which has the result of causing an increase of the pitch and to a lesser degree, of the width of the slots 11. This leads to losses of register caused by spreading of the slots 11 in the plane of the expanded surface 10, which increase with their radial distance from the axis of the tube (that is to say with respect to the centre of the mask 12). It has been discovered that a supplemental displacement of the hot mask 12 - frame 16 assembly (outline C) in the direction of the screen along the axis of the tube, makes it possible to compensate these register losses, since it enables the centre of curvature of the surface of the mask 12 to be kept substantially at the intersection of the axis of the tube with the deflection plane normal to this axis. Such an axial displacement towards the front, illustrated by outline D (without frame) in figure 2, has been obtained either by means of blade springs oriented normal to the maximum deflection beams, which the expansion of the frame causes to pivot around two transverse folds, in such manner that the frame 16 moves closer to the screen (for example see FR-A-1,540,869) or by means of intermediate balancing members inserted between one extremity of the blade spring and the frame 16, made in the form of bimetal blades consisting each of two blades of metals having different coefficients of thermal expansion, which are superposed and intimately joined together. These two solutions appear in the aforesaid publication FR-A-1,486,675. These bimetallic compensating members which may be interposed between the spring and the frame (furthermore see the publication FR-A-2,035,074 of 2,107,515) or formed by bimetallic springs themselves (see FR-A-1,597,297 and

2,011,387), allow the alignment defect of the slots 11 with respect to the R,G,B triplets of the screen to be compensated as a function of the temperature of the frame 16 to which they are joined by welding. Nevertheless, they do not play a part during the initial distending of the mask 12, because of the substantial difference between the respective thermal inertias (and weights) of said mask and frame 16.

This distenting has been able to be appreciably reduced as well as other torsional effects exercised on the edges of the mask 12, by limiting the number of welding spots joining the skirt of the mask 12 to the belt of the frame 16 which are parallel, or by providing the skirt of the mask or the belt of the frame with an alternation of radial projections and hollows which limit the contact surfaces between the frame and the skirt in areas surrounding the spot welds. A supplemental reduction of this distention has been obtained by reducing the radius of curvature of the metal surface compared to that of the conventional mask of which the distance in the cold state with respect to the screen is substantially constant throughout its area. This measure moreover implies a variation of the spacing of the axes of the adjacent slots (11) as a function of the radial distance separating them from the centre of the mask (12) which increases the tolerances. It should be observed at this point that the tubes comprising parallel "in line" guns, lined screens and slotted masks, are hardly liable to incur register losses in the vertical direction, but are highly susceptible to do so in the horizontal direction.

Apart from the overall distention of the perforated mask due to the slower heating of the frame, there is also established a localised distention action which depends on the contents of the image televised. For

example, if the image comprises two highly contrasted areas of which one is bright (light) and the other dark, the number of electrons intercepted by the mask area facing the first will be considerably greater than that received by the mask area facing the second. It is obvious that the area undergoing heavier bombardment will rapidly reach a much higher temperature than that which receives few electrons and, because of the small thickness and low thermal conductivity of the mask, the individual temperatures of its two areas will remain different during a particular period of time, if the contrasted image persists.

The colour picture tubes usable in particular for display in the case of data processing (videography for example) or of high-definition television, will have to comprise screens having finer phosphor strips and masks having closer-set slots (pitch reduced from 0.8 to 0.5 mm, for example) than the tubes available at present, with the consequence that the tolerances are much smaller regarding the axial displacements of the slots, that is to say the register defects caused by distension. From this results that a sizable reduction (15 to 25 μ m) of the transient distention upon starting is essential.

It should equally be observed that a flatter screen (meaning an increase of its radius of curvature) has the effect of increasing the register loss caused by distention. If the flat screen is combined with an improved resolution, the need to reduce the distention increases even more.

It has been discovered by the applicant that it is possible to reduce the amplitude and duration of the transient distention of the mask by utilising a frame of reduced thickness, which has been reinforced by means of at least one rib or fold, to present a mechanical strength comparable to that of a conventional thick frame having an "L"-shaped cross-section.

The invention has as its object to improve the thermal stability of the mask - frame assembly and to reduce, on the one hand the duration and, on the other hand, the amplitude of the distention compared to the prior art solutions, whilst assuring an assembly of adequate rigidity.

According to the invention, this result is obtained by a combination of a short mask skirt of a lightened frame, provided with a rib at its extremity facing away from the mask.

The invention thus has as its object a shadow mask for colour picture tubes, comprising a three-colour lined screen made up by a repeated succession of three strips of different phosphors bombarded respectively by three electron beams through a perforated surface of this shadow mask, provided with slots which constitute a colour selection electrode, the said mask comprising a supporting frame profile having a substantially "L"-shaped cross-section, comprising a side wall or belt bearing against a skirt which integrally surrounds the edges of the mask, and a radial wall or base fixed with said belt and extending towards the axis of the tube. The extremity of this radial wall of the frame comprises a folded lip which, on the one hand, forms a stiffening rib and, on the other hand a window aperture enabling the edges of the mask to be bombarded up to the junction of its sheet with the skirt. A mask of this kind is described, for example, in the Japanese patent application 57105945.

According to the invention, the mask - frame assembly is particularly notable by a combined arrangement of the following features:

- a) The skirt of the mask has a height amounting at most between a third and a quarter of the height of the belt which surrounds it or which it surrounds, and
- b) the thickness of the frame is smaller than ten times the thickness of the sheet of the mask.

The invention will be better understood and others of its objects, features and advantages will appear from the following description and accompanying drawings relating thereto, in which:

Figures 1 and 2, which have already been described, are diagrammatic cross-sections of the mask - frame assembly, Figure 3 shows graphs of the evolution of the respective temperatures of a mask, of a light (thin) frame and of a heavy (thick frame),

Figure 4 is a partial diagrammatic cross-section of a mask having a short skirt with a light frame at the outside,

Figure 5 is a partial diagrammatic cross-section of a mask having a short skirt with a light frame within it,

Figure 6 shows graphs of the variation in alignment defect of a mask with a heavy frame, as a function of the time of operation of the tube, and

Figure 7 shows a similar graph for a mask having a short skirt with a light frame.

Figure 3 illustrates graphs of temperature variations with the period of operation respectively as applicable as perforated mask E, a light frame F and a conventional heavy frame G. The period of operation of the tube (with a cathode of the rapid-heated type) has been plotted as abscissae and the temperature of each element has been plotted as ordinates.

It is apparent from the solid line curve E that the perforated mask, which is of low weight, heats up rapidly and that it reaches its equilibrium temperature (55°C) after 5 minutes of electronic bombardment. A frame of small thickness (approximately 1.2 mm) has a dashed line temperature rise curve F denoting a slower heating action, such that it only reaches its equilibrium temperature at the end of approximately 9 minutes. A heavy frame (of a thickness of 2.8 mms) has an even slower dash-dotted temperature rise curve G. It only reaches its equilibrium

temperature after some 12 to 15 minutes. By comparing the graphs E, F and G, it is easily established that the difference in maximum temperature between the mask and the light frame is reached in approximately 3 minutes, whereas that between the mask and the heavy frame occurs after 5 to 6 minutes of operation, for example. Furthermore, it is possible to establish that the quantity of this maximum difference is greater in the second case, which already demonstrates the advantage of frames of small thickness. The values are only given by way of example and depend in particular on the format (screen size) of the tube.

The utilisation of a thinner and consequently lighter frame, but which is arranged in a manner to retain sufficient mechanical stiffness against shocks and vibrations, appears to be advantageous, on the one hand to reduce the amplitude and period of the distending phenomenon by a rapid expansion of the frame (less thermal inertia) and on the other hand, to shorten the time needed to start compensation of the overall expansion by means of the double blades interposed between the frame and slab, which are heated rapidly in this case.

Two embodiments of an assembly comprising a mask with a short skirt and a light (thin) frame have been illustrated partially and diagrammatically in cross-section in figures 4 and 5. Figure 4 illustrates the embodiment with the mask within the frame and figure 5 illustrates the embodiment with the mask outside the frame.

In Figures 4 and 5, the domed mask 12 provided with slots 11 is laterally bordered by an angled skirt 24, of which the generatrix is parallel to the axis of the tube. The height of this skirt 24 may be selected as a function of the dimensions of the mask 12 in particular of its axial dimension (distance between its apex and its base) and of the height of the side wall 180 of the frame 160 having an "L"-shaped profile. In an advantageous embodiment, the height of the skirt 24 amounts to at most between a _____

quarter and a third of the height of the belt 180 (for example, in the case of a frame 160 having a belt 180 height of approximately 22mm, the height of the skirt 24 may be approximately 7mm). The thickness "E" of the frame 160 is chosen, for example, so that it is smaller than or approximately equal to ten times the thickness "e" of the mask 12 ($E/e \leq 10$). In an embodiment in which the thickness of the sheet 10 of the mask 12 and of the skirt 24 is 0.15 mm, the thickness of the frame 160 is approximately 1.2 mm, the two elements being made of a rolled steel (sheet).

The unperforated edge of the sheet 10 of the mask 12 may be provided with a rib 23. The radial part or base 190 of the frame 160 comprises at its inward extremity a fold towards the base, or a lip 191 which starts at a bend 192, selected in such a manner that the most highly deflected beam F_{Dmax} may strike the edge of the mask 12 up to the skirt 24, in order to reduce the temperature variation of the mask between its centre and its edge.

The angles of inclination I between the lips 191 and the horizontal and vertical median planes of the tube are preferably selected to be at most equal to the maximum deflection angle of the beam in these, so that any electron reflected by the lip 191 will not be directed towards the perforated area of the mask. In other words, to obtain a temperature distribution which is as uniform as possible throughout the area of the sheet 10 of the mask 12, the window aperture 25 formed in the base 190-191 of the frame 160 should be of sufficient size to allow the passage of the beams deflected at the extreme in the horizontal and vertical directions as far as the edges of the sheet 10. It will be noted in this case that the bend 192 equally acts to reinforce and stiffen the structure of the light frame 160.

In both embodiments of the mask - light frame assembly, the skirt 24 may be joined to the upper part of the belt 180 of the frame 160 by means of spaced apart spot welds 26, for example in the manner described in the publication FR-A-1,470,260.

The installation of the frame 160 in the front slab of the tube is commonly performed in a conventional manner, by means of blade springs provided, respectively, with bimetal compensating elements.

It should be observed at this point that the embodiment of figure 4, in which the belt 180 of the frame 160 encircles the skirt 24 of the mask 12, assures a better thermal contact between these latter, but the embodiment of figure 5 in which the unwelded parts of the skirt 24 may move away temporarily from the external surface of the belt 180, may cause a relative slowing-down of the temperature rise of the frame 160. However, the temporary initial distention may be a little greater in the first case than in the second.

Figure 6 shows the variations of the alignment defect or register defect M_R as a function of the period of operation of the tube comprising a mask with a long skirt mounted on a conventional thick frame, for example of the kind with a frame surrounding the skirt throughout its height.

The period of operation t starting from the instant $t=0$ of energisation has been plotted as abscissae, and as ordinate the alignment defect M_R measured by the separation of the axis of a thin beam of one colour with respect to the median vertical axis of the phosphor strip of a given colour, at one or two points situated on the median horizontal axis of the screen, at three-quarters of the distance (or half-way) between the centre and the edge of the three-colour lined screen. A radial deflection towards the centre has been allotted a positive sign and that towards the edges a negative sign.

On the curve H drawn as a solid line in figure 6 which illustrates the change of the alignment defect in the course of time without temperature compensation by means of the bimetallic blades, a positive maximum is observed of 45 micrometres after 6 minutes of operation, a passage through zero at 17 minutes and then an asymptotic approach to a stable negative deviation of -25 micrometres. The dashed line curve J shows this same course with application of bimetallic compensating blades, with a positive maximum of $55\mu\text{m}$ at 6.5 to 7 minutes, followed by a slow approach to a small positive (or negative) value which becomes asymptotic at around 25 minutes of operation. Such alignment defect values are not acceptable for tubes of high or medium resolution (0.5 mm spacing between the axes of the slots 11).

Figure 7 shows similar diagrams to those of figure 6, for a tube having a mask with a short skirt and a thin frame as in figures 4 and 5. The solid-line curve K shows the evolution with time of the alignment defect M_R without compensation by means of compensating blade elements, and the dashed line curve L shows the same with this compensation. It may be observed that for a light mask, the maximum positive of the curve K is 25 micrometres, consequently approximately 40% lower than that of the curve H of figure 6, and it appears after 2.5 minutes of operation, that is to say in half the time of that of a conventional mask. In its further course, it comprises a passage through zero at ten minutes, followed by an asymptotic approach to a negative value of -45 micrometres. The curve L has a positive maximum of approximately $30\mu\text{m}$ attributable to the distention, followed by an asymptotic decrease towards a low positive or negative value.

It will be noted at this point that figures 6 and 7 confirm the deductions drawn from graphs E, F and G of figure 3.



CLAIMS

1. A shadow mask for a colour picture tube, comprising a perforated surface (10) surrounded by a skirt (24) and by a profiled support frame (16,160) of substantially L-shaped cross-section and constituted by a side wall or belt (180) secured to the skirt (24), and by a radial wall or belt (190) secured to the belt (180) and extending towards the tube axis, the free end of this radial wall (190) of the frame (160) comprising a folded lip (191) which constitutes on the one hand a stiffening rib and on the other hand a window opening which allows the edges of the mask (12) to be bombarded up to the vicinity of the junction between its sheet (10) and the skirt (24), characterised in that:

- a) the skirt (24) of the mask (12) has a height between at most a third and a quarter of the height of the belt (180) which it surrounds or by which it is surrounded; and
- b) the thickness (E) of the frame (160) is smaller than ten times the thickness (e) of the sheet (10) of the mask (12).

2. A colour picture tube comprising a three colour lined screen comprising a repeated succession of three strips of different phosphors (R, V, B) which are bombarded respectively by three electron beams through a shadow mask (12) having slots (11) and constituting a colour selection electrode, said mask (12) being supported by a profiled frame (16-60) of substantially L-shaped cross-section which is constituted by a side wall (180) or belt secured to a skirt (24) forming an edge of the mask (12) and by a radial wall or base (190) secured to the belt (180) and extending towards the tube axis, the free end



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of this radial wall (190) of the frame (160) comprising a folded lip (191) which constitutes on the one hand a stiffening rib and on the other hand a window opening which allows the edges of the mask (12) to be bombarded up to the vicinity of the junction between its sheet (10) and the skirt (24),

characterised in that:

- a) the skirt (24) of the mask (12) has a height of between at most a third and a quarter of the height of the belt (180) which it surrounds or by which it is surrounded; and
- b) the thickness (E) of the frame (160) is smaller than ten times the thickness (e) of the sheet (10) of the mask (12).