

PATENT SPECIFICATION

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(54) SHADOW MASK FOR USE IN COLOR PICTURE TUBE AND METHOD FOR FABRICATING SAME

(71) We, HITACHI LTD., a Japanese Body Corporate, of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a shadow mask for use in a television picture tube and a method of fabricating the same.

According to the present invention, there is provided a method of fabricating a shadow mask for use in a color picture tube, such method comprising the steps of rolling, photo-etching and mask-shaping, in which said rolling step comprises the steps of a first annealing step in which a shadow mask material is annealed, a rolling step in which the annealed material is rolled to a desired thickness, a second annealing step in which said rolled material is annealed, and a skin-pass step for skin-passing said material after being annealed during said second annealing step.

The present invention will be further described with reference to the accompanying drawings, in which:—

Fig. 1 is a flow diagram showing steps of fabricating the conventional shadow mask;

Fig. 2 is a stress-strain curve for the conventional shadow mask;

Fig. 3 is a flow diagram for explaining an embodiment of the present invention and showing steps involved in fabricating the shadow mask;

Fig. 4 is a diagram showing the relationship between the annealing temperature and crystal grain size;

Fig. 5 is a diagram showing the relationship between crystal grain size and strength; and

Fig. 6 is a diagram showing stress-strain curves before and after a skin pass step.

Generally, the conventional color picture tube of shadow mask type employs, of all the magnetic metals, an iron sheet as a shadow mask material for reasons of workability

and cost, and a shadow mask made from an iron sheet is fabricated according to the steps shown in Figure 1.

First, a shadow mask material in the form of iron sheet belt approximately 700 mm wide and approximately 0.3 mm thick is annealed, rolled to an approximate thickness of 0.18 mm by means of two-high tandem rolling mill, cut to a width of about 550 mm and taken up in a roll. The rolled iron sheet belt is cut into a plurality of iron sheets each weighing about 400 kg and transferred to the photoetching step. In the photoetching step, each iron sheet is coated with a sensitizer on both sides and cut into a plurality of sheets each weighing about 50 kg. Glass reference patterns preformed with predetermined dots or slots are closely attached onto both sides of the iron sheet, the iron sheet is exposed to ultraviolet ray and developed with a hot-water spray. After the predetermined dots and slots have been formed, the sheet is subjected to a burning process at about 320°C for about 5 minutes to heat and harden the remaining photosensitive film. The sheet is etched by spraying thereon a ferric chloride solution thereby to cut apertures of predetermined size. Thus a flat base sheet of the shadow mask is obtained. This base sheet is annealed for 10 minutes at 940°C, smoothed with a roller leveller and passed through a press to form predetermined curvatures and side walls. Finally, the shadow mask surface is blackened to form a layer of triferric tetroxide for the purpose of corrosion resistance.

In the above-described conventional steps of shadow mask fabrication, the process of rolling the iron sheet 0.30 mm thick to a thickness of 0.18 mm after annealing involves a rolling reduction of as large as 40% (the rolling reduction being defined as the ratio of the thickness reduction of a sheet to the original thickness thereof in a rolling process), so that crystal grains of the iron sheet as viewed from a section thereof parallel to the direction of rolling are spindle-shaped, very fine and have an elongation of 1 to 2%.

Since an elongation of at least 3% is required for the step of press-shaping, however, the iron sheet thus rolled into the thickness of 0.18 mm will be broken as shown by curve 1 of Fig. 2, if press-shaped without any preliminary protective measure. As such a protective measure, the step of annealing is added as a step preliminary to the press-shaping. As a result of the annealing, the crystal grain diameter in the iron sheet section, as expressed in ASTM ferrite grain size number, changes to 4 or 5 as compared with 10 or 11 for the original sheet material. This represents an elongation at break of about 30%, which eliminates the risk of the iron sheet being broken during the press-shaping step as will be seen from curve 2 in Fig. 2. Even though the larger the crystal grain diameter, the higher the annealing temperature, an annealing time of more than 10 minutes is not very effective because of the small weight of the shadow mask base sheet. In other words, in the case of crystal grains having an ASTM grain size number lower than 3, for example, an ASTM ferrite-grain size number of 2 or 1, the diameter of the grains is so large that the surface of the shadow mask base sheet is roughened causing deterioration of the quality of the shadow mask. Further, the heat required for prolonged annealing causes excessive consumption of furnace materials, thereby adversely affecting economy of cost. A low annealing temperature, on the other hand, results in less growth of grain diameter in the iron sheet section. Even though it is a known fact that a roller leveller process following an annealing process reduces the yield point extension as shown by curve 3 of Fig. 2, grains having an ASTM grain size number larger than 5 or 6, for example, those of 7 to 8, are not reduced below 2% in yield point extension even if they are applied through a roller leveller repeatedly many times, for example, 50 times. As a result, during the press-shaping process accompanied by a maximum elongation of 3%, what is called the stretcher strain phenomenon presents itself conspicuously in which the elongation is different at different points of the iron sheet, ranging from 1 to 3%, thereby leading to the disadvantages of partial lack of uniformity of both mask aperture pitches and sizes. A shadow mask with such mask apertures also lacks uniformity in transmission of electron beams and the resulting color picture tube is a product having unevenness in white color and brightness and low in commercial value. Specifically, when the mask apertures are arranged at a pitch of 600 μ , a discrepancy as small as 2 μ causes lack of transmission uniformity. In fact, this severe rule also applies to the mask aperture diameter. In the case of mask apertures 200 μ in diameter, for example,

an error of 2 μ will result in lack of transmission uniformity if it occurs with several successive apertures.

In the conventional shadow mask comprising an iron sheet with crystal grains of 4 or 5 ASTM grain size number, the mask apertures are enlarged on the other hand during the well known post-etching step. The post-etching step is often carried out when producing shadow masks for use in the conventional post deflection acceleration color picture tubes of both black matrix type and non-black matrix type. Thus the strength of the shadow mask material is reduced, with the result that when a localized large beam current brightens part of the viewing screen of the color picture tube incorporating such a shadow mask, shadow mask portions about 60 mm inwardly of the periphery thereof, unlike the central and peripheral portions, are often distorted, thereby causing relative displacement of the positions at which the electron beams impinge on the screen and phosphor materials and hence the image thereat shows an entirely different color from the correct one. Specifically, when a beam current of 2 mA flows in an area within 60 mm in diameter at the portions in question, a displacement of about 140 μ occurs in the electron beam impinging on the screen in the case of a 20" black matrix color picture tube of 110° deflection type.

In Fig. 3 which shows a flow diagram for explaining the fabricating steps according to an embodiment of the invention, those sections which are identical to those shown in Fig. 1 have the same functions as those of the corresponding sections in Fig. 1; and it should be noted that the annealing step after etching must not be adopted and the roller leveller step may be eliminated.

In embodying the present invention, as a preparatory step for the conventional press-shaping step, a second annealing step and a skin-pass step is shown by *a* and *b* respectively in Fig. 3 are inserted between the step of rolling the iron sheet to a thickness, of say, 0.18 mm and the step of cutting it to a width, say, of 543 mm. The annealing step *a* is accomplished at a temperature from 550°C to 750°C, preferably from 600°C to 700°C, and more preferably from 660°C to 700°C. The annealing of the iron sheet at these temperatures for about 10 minutes causes the spindle-shaped crystal grains rolled to a thickness of 0.18 mm to be recrystallized and finally stabilize, and as will be seen from Fig. 4 showing results of an experiment conducted on the relationship between annealing temperatures and grain size, they change to an ASTM grain size number of 7 to 8. It will also be seen from Fig. 5 showing the relationship between grain size and strength that crystal grains with an ASTM grain

number of 7 to 8 have a high strength and the surface of the iron sheet is not uneven.

The skin pass step *b*, on the other hand, involves a rolling reduction of 0.5% to 5%, an optimum reduction being 1.5% to 2.0%. The slight rolling effected by the skin-pass process eliminates the yield point extension 4α of the stress-strain curve 4 prior to the skin-pass process as shown in Fig. 6, so that the extension becomes about 45% after the skin-pass process as shown by the stress-strain curve 5, thereby preventing breakage during the press-shaping step. It is important to follow the annealing step *a* and skin-pass step *b* in this order. If the press-shaping step is entered into immediately after the annealing step *a*, for example, the stretcher strain phenomenon is not eliminated; nor is it possible to eliminate it during the roller leveller step. On the other hand, a rolling reduction in the skin-pass of as high as 10% makes the surface of the iron sheet so hard that there is too great an amount of spring-back after the press-shaping step making it impossible to obtain a predetermined curvature. Again, therefore, the optimum rolling reduction in skin-pass is 1.5% to 2.0%.

In addition to the black matrix tube of post-etching type as mentioned above, the present invention is applicable with equal effect to those black matrix tubes in which post-etching is not effected but a light source is appropriately operated to form small diameter graphite holes by the use of a shadow mask with larger diameter apertures as well as to color picture tubes other than black matrix type. That is to say, in these additional fields of applications where the thickness of the shadow mask is not reduced nor aperture diameter enlarged during color picture tube fabrication steps, it is possible to achieve the same high strength of crystal grains thereby making a reduction in quality due to shadow mask distortion a rarity. Furthermore, in spite of the fact that the steps of fabricating color picture tubes with a shaped mask involve three and four applications thereof through a furnace, the size of grains in the shadow mask section remains unchanged.

It will be apparent from the foregoing

description that in the above described embodiment a shadow mask is made from an iron sheet with grains having an ASTM grain size number 7 to 8, in the sections of the sheet which form the shadow mask making possible a high-quality color picture tube with stable characteristics which develops no distortion.

WHAT WE CLAIM IS:—

1. A method of fabricating a shadow mask for use in a color picture tube, such method comprising the steps of rolling, photo-etching and mask-shaping, in which said rolling step comprises the steps of a first annealing step in which a shadow mask material is annealed, a rolling step in which the annealed material is rolled to a desired thickness, a second annealing step in which said rolled material is annealed, and a skin-pass step for skin-passing said material after being annealed during said second annealing step.

2. A method of fabricating a shadow mask according to claim 1, in which said second annealing step is effected at a temperature in the range from 600°C to 700°C whereby the crystal grains of said shadow mask material have an ASTM grain size number of from 7 to 8.

3. A method of fabricating a shadow mask according to claim 1, in which said skin-pass step involves a rolling reduction of 1.5% to 2.0%.

4. A shadow mask for use in a color picture tube, the shadow mask being made by the method of claim 1, in which the shadow mask is made from an iron sheet having an ASTM grain size number of from 7 to 8.

5. A method of fabricating a shadow mask substantially as hereinbefore described with reference to Figures 3 to 6 of the accompanying drawings.

6. A shadow mask fabricated by the method of claim 1, 2, 3 or 5.

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2. A method of fabricating a shadow mask according to claim 1, in which said second annealing step is effected at a temperature in the range from 600°C to 700°C whereby the crystal grains of said shadow mask material have an ASTM grain size number of from 7 to 8.

3. A method of fabricating a shadow mask according to claim 1, in which said skin-pass step involves a rolling reduction of 1.5% to 2.0%.

4. A shadow mask for use in a color picture tube, the shadow mask being made by the method of claim 1, in which the shadow mask is made from an iron sheet having an ASTM grain size number of from 7 to 8.

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