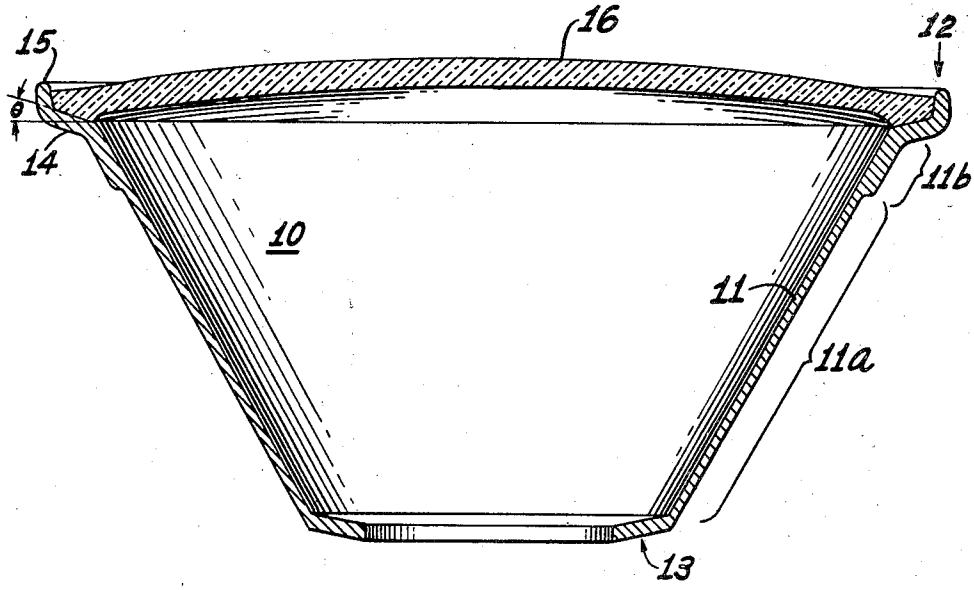
Oct. 23, 1956 R. D. FAULKNER 2,767,466

METHOD OF MAKING METAL CONES FOR CATHODE RAY TUBES

Original Filed Oct. 8, 1945 2 Sheets-Sheet 1

Fig. 1



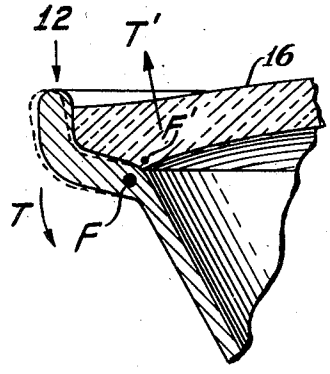


Fig. 2

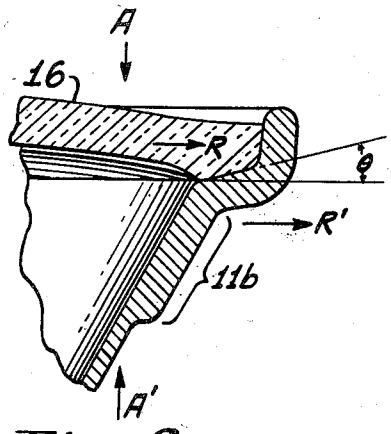


Fig. 3

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METHOD OF MAKING METAL CONES FOR CATHODE RAY TUBES

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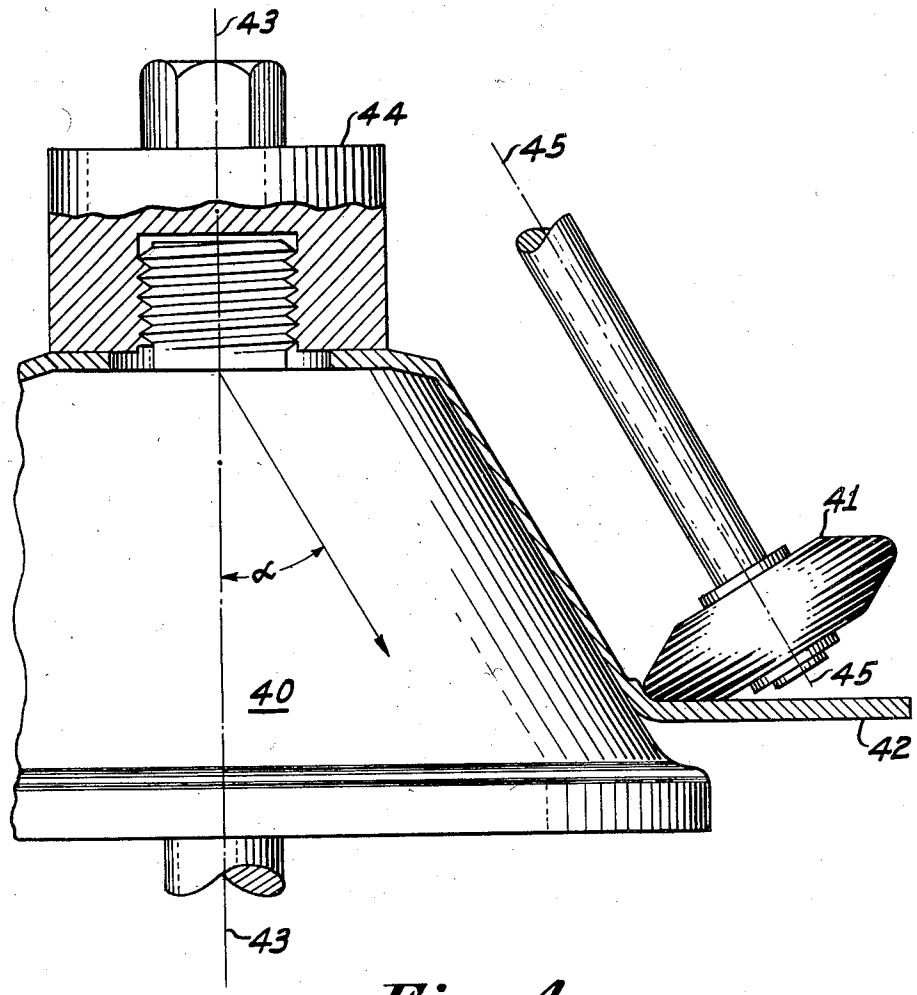


Fig. 4

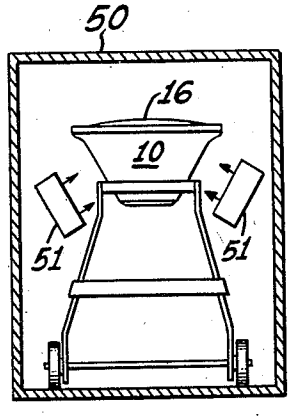


Fig. 5

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United States Patent Office 2,767,466 Patented Oct. 23, 1956

2,767,466

METHOD OF MAKING METAL CONES FOR CATHODE RAY TUBES

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Original application October 8, 1945, Serial No. 120,400, now Patent No. 2,682,983, dated July 6, 1954. Divided and this application April 28, 1953, Serial No. 351,576

4 Claims. (Cl. 29—472.9)

This application is a division of the co-pending application Serial Number 120,400, filed October 8, 1949, now Patent No. 2,682,983.

This invention relates to improvements in a method of making electron discharge devices having composite glass and metal envelopes. More particularly, it relates to improvements in metal shells for the bulb portions of cathode ray tubes.

As is known, there are a number of advantages to be gained by forming the envelopes of cathode ray tubes as composite metal and glass structures. One advantage is that such envelopes usually are very much lighter than all-glass envelopes of equal strength and size. Another is that since they are made of stock materials such as sheet metal and plate glass, they are much easier to fabricate, particularly in large sizes, than to cast all-glass envelopes. There is a further advantage which results from the fact that metal has much higher tensile strength than glass. It is that the envelope may be formed with a more nearly flat glass screen since the rim at the large end of the metal shell will be able to withstand the considerable tension to which it will be subjected when the envelope is placed under vacuum. This, of course, contrasts with the known fact that all-glass bulbs should be made as nearly spherical as possible so that in the main the glass will be subjected almost exclusively to compressive forces or, if they are not so made, then very heavy sections of glass must be used around the periphery of any flattened portion, such as a portion supporting a fluorescent screen, so that the walls supporting it can withstand the tension.

However, the manufacture of composite envelopes presents a number of its own problems and disadvantages. A first problem relates to the costliness of the metals which must be used. In composite envelopes it is usually necessary to employ special alloys for the metal portions in order to obtain satisfactory glass-to-metal seals. For example, one special alloy known as "Kovar" is frequently used for certain types of composite envelopes in which it is desirable that the coefficient of expansion of the metal portions be very nearly equal to that of glass portions. Similarly, other special alloys are used for other types of envelopes, they also being selected usually for their particular coefficients of expansion. In general most of these special alloys are usually quite expensive as they include high percentages of costly metals such as chromium or nickel. While this factor may not present too serious a problem in a great variety of small receiving tubes and the like in which the amount of metal required is very small, it does in the case of large screen cathode ray tubes in which the weight of the metal shell frequently is as much as 12 or 15 pounds.

Accordingly, it has been desirable to construct the metal shell for a large screen cathode ray tube with different wall thicknesses in its different portions so as not to waste material where great strength is not needed, i. e., to use different thicknesses of material according to the forces acting on its different portions. For example, it is desirable to use thin material for the mantle of the cone

(i. e., its sloping-wall portion) where relatively small and fairly uniform forces of atmospheric pressure are exerted and to use thicker material for its two end portions which are respectively, a large-diameter flange, in which the arch of "screen disc" is supported when the envelope is subjected to atmospheric pressure, and a small-diameter flange to which the neck is fastened. Moreover, in so forming the metal cone, it is necessary to avoid manufacturing processes which are as costly as the metal which is saved. For example, it is impractical to use a process including the steps of separately forming the mantle (or sloping-wall portion) of thin material and the flanges of suitably heavier material and of then welding them together since the required welds are too costly. Besides, this process entails the possibility of porosity or air holes and, for a good quality product, it requires finish-grinding.

Accordingly, it is commonly the practice to utilize a rather inexpensive spinning process by which it has been possible to attain ratios of about 2.5 or 3 to 1 between the thicknesses of flange material, i. e., that of the stock material, and that of all the mantle portion. In this process the cone is spun from a circular blank of sheet metal stock of uniform thickness in such a manner that the stock becomes reduced in thickness in its portions from which the mantle is formed.

Nevertheless cone manufacture according to the prior art has not proven to be entirely satisfactory. For one thing, wastage of material in the mantle was not entirely eliminated. The reasons for continued wastage have been that on the one hand these small thinning ratios do not result in an adequately thin mantle when one starts with a heavy blank, and that on the other hand a heavy blank was used for the purpose of obtaining a rim strong enough to support the screen disc when the envelope is evacuated. The amount of reduction in thickness which can be produced by spinning is not unlimited but depends on the steepness of the cone, i. e., it becomes greater only as the top angle of the cone becomes smaller. For the wide angle cones which are most suitable for large screen kinescopes this reduction is no greater than by a factor of the order of 2 or less while if one assumes the use of cones having top angles as small as 30° for other types of cathode ray tubes, then it can be as great as by a factor of 4. For another thing, this practice has entailed considerable increase in manufacturing costs due to the occurrence of numerous "pop-outs" prior to evacuation. As indicated above, in composite large screen kinescopes the screen disc can be made quite thin. Because of this the disc is subject to noticeable inward bending under atmospheric pressure when the envelope is evacuated. This can be objectionable, even if there is no danger of implosion, as it will introduce tensions in the glass of the finished tube and in addition will entail distortion of the glass disc which may have harmful optical effects. It has been the practice to solve this problem by using an alloy and a glass which have appropriately unequal coefficients of expansion so that differential shrinking after the disc has been sealed to the cone will cause the flange to place the disc under compression and thereby bend it outward, i. e., in the direction to shorten both its chord and its radius of curvature, to the end that the subsequent flattening of the disc, which will occur upon evacuation, will restore it to its original shape. It is after the disc is placed under peripheral compression by the flange and before the envelope is evacuated that the greatest number of "pop-outs" occurs.

Accordingly, it is an object of this invention to devise an improved shell for a cathode ray tube the large end of which includes a flange for carrying a convex glass screen disc and is strong enough adequately to support the perimeter thereof to prevent it from imploding when

the envelope is evacuated even though the thickness of the material in the flange is no more than between 2 to 3 times that of the cone mantle while the material of the flange is thin enough not to include any substantial excess.

It is a further object of this invention to devise an improved sub-assembly for a cathode ray tube, which sub-assembly comprises a cone as set forth above and a glass screen disc sealed to the large end thereof in which the cone is so formed that there will be a reduced probability of a pop-out of the screen disc prior to evacuation.

It is a further object of this invention to devise an improved spinning process for forming a metal cone as set forth above.

It is still another object of this invention to devise an improved process for producing an improved sub-assembly as set forth above.

It is a further object to device an improved metal shell to be comprised in the bulb portion of a cathode ray tube and to carry a screen disc thereof in which the metal of the cone has a greater coefficient of expansion than the glass of the disc and in which the end of the cone which carries the disc is so formed that it has adequate structural strength to prevent the disc from imploding, when the envelope is evacuated, by supporting the perimeter thereof under compression, even though said end of the cone is composed of material which is no more than between 2 to 3 times as thick as the material composing the mantle thereof while the mantle is thin enough to not include any substantial excess of material.

It is a further object to devise an improved metal cone to be comprised in the bulb portion of a cathode ray tube and to carry a screen disc thereof in which the metal of the cone has a greater coefficient of expansion than the glass of the disc and in which the end of the cone which carries the disc is so formed that it has adequate structural strength to prevent the disc from imploding, when the envelope is evacuated, by supporting the perimeter thereof under compression, even though said end of the cone is composed of material which is no more than between 2 to 3 times as thick as the material composing the mantle thereof while the mantle is thin enough to not include any substantial excess of material, and in which, moreover, said end of the cone is so formed that there will be a reduced probability of a pop-out of the screen disc during the interval which occurs after the disc is sealed to the cone and prior to evacuation of the envelope.

Other objects, features and advantages of this invention will be apparent to those skilled in the art from the following detailed description of the invention and from the drawing in which:

Figure 1 is a cross-sectional representation of an embodiment of the invention;

Figure 2 represents a detail section of one form of the prior art and assists in disclosing principles underlying the present invention;

Figure 3 shows an enlarged sectional portion of Figure 1 to permit comparison with the showing of Figure 2 in considering the principles underlying the present invention; and

Figures 4 and 5 represent equipment used in making the embodiment shown in Figure 1.

Figure 1 shows an improved metal shell, such as a cone **10** according to the present invention. It comprises a mantle portion **11** and large and small diameter flanges **12** and **13**. The large diameter flange **12** includes a tapered seat **14** and a lip **15**. In the assembly of a composite envelope, a screen disc **16** is joined to the large end of the cone **10** by being placed upon tapered seat **14**, in which position it is surrounded by the lip **15**, and by having its edges sealed to the flange **12** by appropriate application of heat to the periphery of the disc and the flange. The details of how this is done are no part

of the present invention, this being also true of such details as the angle of taper θ of the tapered seat **14**. That this is a critical angle is well known. This and ways of assembling the screen disc to the metal cone are described in detail in U. S. Patents 2,254,090 and 2,296,307 and elsewhere in the literature.

In a completed kinescope, the lower portion **11***a* of the mantle **11** will be subjected primarily only to the moderate and fairly uniform compressive forces which are exerted upon it by the atmosphere. For this reason, this portion of the mantle may be made of very thin material and still have adequate structural strength. I have constructed composite envelopes, in which the mantle thickness is of the order of .04", which, when placed in a compression chamber, have withstood as much as 60 to 75 lbs. per square inch of external air pressure with the inside of the envelope under hard vacuum. However, the flanges **12** and **13** and the portions of the mantle which are adjacent thereto are subjected to much less uniform and, in some cases, much greater forces. For example, the large diameter flange is subjected to tension when the atmosphere presses in on the screen disc **16** and tends to flatten it out, and the small flange is subjected to very complex strains and stresses whenever a kinescope tube is lifted by its neck. For these reasons it has been apparent for some time, as was indicated above, that the cone should be formed employing rather heavy sections of material for the flanges.

In order economically to form the cone **10** to have heavier material in the flanges **12** and **13** than in the mantle **11**, one may employ the spinning process mentioned above. According to recent manufacturing practices in which it has been used, a flat disc blank of uniform thickness, which will be the thickness of the flanges in the finished cone, is first clamped to the small end of a frusto-conical die, like the die **40** of Figure 4 herein, the center of the large end of which is mounted on a shaft, such as the shaft of a heavy duty lathe. Then both the die and the blank are rotated while a heavy roller, like the roller **41** of Figure 4 herein, is brought to bear on the blank to spin it into the shape of the die by moving along its own axis of rotation, i. e. in a direction parallel to the sloping surface of the die, while at the same time being strongly urged toward that surface in a direction normal thereto. If the pressure with which the roller bears on the blank in said direction is great enough, the mantle portion will be produced with a wall thickness equal to the thickness of the blank multiplied by the sine of the one-half top-angle (a of Fig. 4) of the conical portion to be formed. The maximum thinning of the stock material which usually has been obtained, since, as was indicated above, the need has been for wide angle cones, was by a factor of 2.

Some attempts have been made to obtain mantle walls thin enough to not include any excess metal by using blanks of quite thin stock to begin with. While, as was expected, little difficulty was experienced with implosions of the mantle walls (even under test at four atmospheres), considerable difficulty was experienced with implosions of screen discs. Apparently when the large-diameter flange was made of such thin stock it was not strong enough to support the periphery of the glass disc under compression. Therefore it became customary to use heavier stock.

This choice was based on more than mere cost considerations. Any substantial susceptibility to implosion represents a highly dangerous condition which, moreover, due to age fatigue of the glass, increases as the tube becomes older. However, in the matter of cost the use of the heavier stock has left much to be desired both because of the wastage of material in the mantle and because of the costliness of the numerous pop-outs. The pop-outs were accepted as not involving any danger for the eventual consumer since they almost entirely cease to occur after evacuation. In the matter of cost the only

alternatives which have seemed available were to try to see if one could reduce the number of pop-outs by using even heavier stock, and, if this proved successful, to weigh any saving attained thereby against the increased wastage of expensive alloy, or simply to accept the manufacturing shrinkage occasioned by pop-outs as cheaper than the use of more metal. Though there was some evidence of a reduced number of pop-outs with thinner cones, it was not considered possible to use them since this would result in a dangerous finished product.

I have discovered that this was an incorrect conclusion. I made tests to determine if there was any possibility of devising a light cone of such improved structural design as simultaneously to be free of excess material in the mantle; to not incur a substantial number of disc pop-outs prior to evacuation; and to afford a tube not unduly susceptible to implosions, i. e., of such improved structural design that it would no longer be necessary to accept wastage of material and pop-outs as the price for avoiding disc implosions. I found that of several influences which take part in causing implosions there are some which can be eliminated or reduced without necessarily increasing the effective total of those which take part in causing pop-outs, in other words, that the causes for the two difficulties are not as closely related as has been supposed.

Fig. 2 shows a fragmentary view of a cone in which all of the mantle is thin-walled, i. e., in which the mantle is thin all the way up the sloping side of the cone to the inner perimeter of the large-diameter flange **12**. This figure also shows a fragmentary portion of the screen disc **16**.

As pointed out above, in a composite large-screen kinescope it is possible to employ a relatively thin and flat screen disc since the metal flange into which it is sealed can stand considerable tension and therefore can serve as a circular abutment to retain the flat arch of the disc under compression. It is correct to say that in general pop-outs occur if the glass at or near to the glass-to-metal seal is not strong enough to withstand this compression.

It has been supposed that more particularly the reason for the seal breakage was greater stretching of the top portion of the large-diameter flange **12** than of its bottom portion, i. e., of its lip **15** than of its tapered seat **14**, so that the outermost portion of the flange tilts axially backward in the direction T about a center of rotation such as F, pulling the tapered seat **14** away from the seal glass at the periphery of disc **16**. Then, according to this supposition, upon the fracture of the seal, the compressive forces were suddenly released, allowing the flange to tilt axially forward to its original shape at the same time projecting the disc out of the cone. Consistently with this, the reduction in pop-outs, which was occasioned by the use of lighter metal, could be explained as the result of a reduction in the differential stretching of the lip **15** and the tapered seat **14** by an increase in that of the latter and the possibility existed that pop-outs might also be reduced through the use of thicker metal for reducing differential stretching of the lip and the tapered seat by a decrease in the former.

Another supposition has been that seal breakage would probably increase if a quite-thin flange were used since excessive stretching thereof might lead to movement of the seal-glass on the underside of the periphery of the disc with respect to the adjacent top surface of the tapered seat **14**, causing the former to creep on the latter until it sheered away.

I have found instead that the principal reason for pop-outs is to be found in excessive rigidity of the flange, more specifically in its inability to tilt rather than in any tendency for it to do so. When an assembly comprising a cone **10** and a disc **16** is allowed to cool after sealing, the differential shrinking by which the disc is placed under compression reduces both its chord and its radius of

curvature. This causes the periphery of the disc **16** to tilt in the direction T^1 about a fulcrum corresponding to F^1. If the flange **12** is flexible enough to tilt with the periphery of the disc a fracture of the seal is unlikely. However, a heavy flange is not able to do so, and the seal-glass at the periphery of the disc **16** therefore breaks at the fulcrum point.

Although a flange which is thin enough to be flexible will stretch more than a rigid one, it appears that a great deal of stretching can be withstood without fracturing the seal, probably because of the fact that while it is occurring the metal actually is not receding from the glass and therefore the seal is not under tension. However, it should be remembered that there must be a limit to this as excessive stretching is a principal reason for disc implosions.

When the envelope is evacuated the flange **12** is subjected to radial forces in directions corresponding to R of Fig. 3 (due to the flattening of the disc and lengthening of its chord as atmospheric pressure, acting in directions corresponding to A, forces the disc **16** and the cone **10** towards each other). It will be noted that likewise the flange will be subjected to radial forces corresponding to R^1 (due to a slight flattening of the frusto-conical mantle **11**, i. e., due to expansion of the large-diameter end of the mantle **11** when, at the same time, it is subjected to atmospheric pressure). If the end of the mantle is thin-walled it will spread out radially in the directions R^1 and will also exert outward forces on the flange **12**. For this reason it has proven advantageous to thicken the upper portion of the mantle **11** in the manner shown in Figs. 1 and 3.

If a cone of this type is made of light material, the flange will be flexible enough to lessen pop-outs and, since it is freed of the burden of acting as a reinforcement for the large-diameter end of the mantle, the cone will be strong enough to avert disc implosions. In this way, the material may be so light that the cone will not include any excess of material in all of the mantle portion **11***a* even if this portion is not thinned to less than one-half the flange-material thickness by the operation of spinning.

I have tested under external pressures of between 45 and 60 pounds per square inch, i. e., of upwards of three atmospheres, evacuated envelopes whose cones were formed according to the present invention of such thin stock that there was no excess of material in the mantle portion **11***a* when the walls thereof were one-half as thick as the large-diameter flange, and I found them to offer satisfactory resistance to disc implosion.

In practice, this improved design has resulted in saving a considerable amount of costly alloy, e. g., about two pounds of metal for the cone of a 16-inch tube, in addition to a substantial reduction of manufacturing losses due to pop-outs. In addition, it is expected to permit the use of a cheaper alloy which contains less chromium and has a higher coefficient of expansion. The use of this cheaper metal will cause an increase in the differential shrinkage between the large-diameter flange and the screen disc and therefore there will be greater compression and outward bending of the disc. While it is expected that the improved cone shown herein will permit a cone-and-disc assembly to withstand this compression without entailing a pop-out, it is obvious that this would certainly not be true if cones of the prior art type were used.

An improved cone of the kind described herein which will be suitable for use in the envelope of a 16-inch kinescope and has a one-half top-angle α of about 26.5° may be made as follows: the blanks of sheet alloy stock (a suitable alloy is chrome iron having 28% of chrome and 72% of iron), such as the blank represented at **42** in Fig. 4, may be .1 inch in thickness and approximately equal in radius to the radius of the large end of the entire cone **10**, i. e., as measured from the cone axis to the exposed edge of lip **15**, plus the width of the lip **15**. A

blank 42 is clamped to the small end of a frusto-conical die 40 in any appropriate way such as screwing a threaded cap 44 to the end of the die 40. The blank 42 is rotated with the die 40 and spun to form the lower mantle portion 11*a* into the shape of the die by moving a heavy roller 41 along a path parallel to the sloping surface thereof, i. e., along its own axis of rotation, 45, while at the same time urging it toward that surface with sufficient pressure to reduce the material to a thickness about equal to but no smaller than the thickness of the blank (.1 inch) multiplied by the sine of the one-half top-angle (about 26.5°). Since the sine of 26.5° equals .447, this distance will be about .0447 inch for a cone like that selected for the present example. If the pressure of the roller 41 on the stock is so great as to reduce the material to less than .0447 inch, metal will pile up ahead of the roller to create an opposing pressure to slightly push back the roller. For this reason a suitable way of urging the roller toward the die is by hydraulic pressure or a spring, i. e., resiliently. On the other hand, if the pressure is not great enough, the maximum amount of thinning will not be attained and, if it is possible to form the cone at all, a wider blank will be needed to do so. When the roller 41 has been moved along the sloping surface of the die 40 far enough to form the mantle portion 11*a*, the pressure on the roller is reduced so that it is sufficient to force the material against the sloping surface of the die but insufficient to cause thinning and then the roller is further advanced along its axis to form the mantle portion 11*b*. Thereafter, the roller 41 is further advanced along the axis 45, while simultaneously appropriately adjusting the pressure with which it is urged toward the die, so as to form the flange 12 without thinning it. In forming the mantle portion 11*b* and the flange 12 the metal may be considered as being folded or gathered into shape as distinguished from being shaped by the specific metal-thinning type of spinning process described herein. This simple folding or gathering of the metal without thinning it out is particularly feasible in cases, such as the present process, where the metal which is being folded or gathered is near to the edge of the blank.

It is still within the scope of the invention to provide the mantle portion 11*b* with a thickness intermediate the thickness of the mantle portion 11*a* and the rim portion 12.

It is not essential that the mantle portion 11*b* and the large-diameter flange 12 be formed on the spinning lathe by folding or gathering. Instead, if desired, this portion of the cone may be drawn and, if this is done, it is a matter of choice whether the drawing operation precede or follow the spinning operation by which the lower mantle portion 11*a* is formed. Similarly, the small-diameter flange 13 may be formed by any suitable known means other than on the spinning lathe. In other words, wherever the metal is to be formed to a predetermined shape without reducing it in thickness, any suitable process, such as drawing or stamping, may be used, and wherever it is to be both formed and thinned it is essential to employ the above-described spinning process.

The flange 12, by a proper choice of sheet stock, may be flexible enough to obtain an acceptable reduction of pop-outs even if the stock is not the thinnest permissible in so far as the strength of the mantle portion 11*a* is concerned. Because of this it is possible, where an increased safety factor against disc implosion is preferred to maximum economy, to use stock of an intermediate thickness which will afford a sufficiently flexible flange, very strong peripherial support for the disc, and only a slight excess of wall-thickness for the mantle.

The improved cone of the present invention makes possible a simplification in a required operation of annealing the cone-and-disc assembly after the disc has been sealed into the large-diameter flange. According to conventional annealing practices the sub-assembly would be placed in an annealing oven at a temperature high enough to cause the release of strains in the glass without softening it; and thereafter the sub-assembly would be cooled nearly all the way down to room temperature by gradual equilibrium-cooling in which the temperature of the oven is so gradually reduced (or the sub-assembly is so gradually moved along an oven in which a falling temperature gradient exists) that all portions of the sub-assembly would drop in temperature uniformly despite their unequal conductivities, thicknesses, etc. Assuming that the metal has a somewhat greater coefficient of expansion than the glass, the following will take place during equilibrium-cooling: the temperature of the sub-assembly will drop down to the setting-point of the glass without the disc being placed under compression by differential shrinkage since in that temperature range glass will simply be displaced by the contracting flange; as the temperature of the sub-assembly drops below the setting-point differential shrinkage will gradually place the glass disc under increased compression bending it outward and shortening its radius of curvature by reducing its chord.

In the past it has been considered unfeasible to move a structure including glass directly from an annealing oven to surroundings at room temperature as soon as the glass has been cooled to below the setting-point. For example, it has been considered objectionable for sub-assemblies of the kind in question because the metal portions, which are thin and highly conductive, would tend to give up their residual heat very much more rapidly than the glass disc, which is thick and rather non-conductive, so that at least transiently the magnitude of differential shrinking would be very much greater than that intended for the sub-assembly when all of its parts are at the same (room) temperature and that a resulting temporary excess of compression on the disc would very much increase the total number of pop-outs. A more general objection to quick removal from an annealing oven has been that if, upon its removal from the oven for cooling, the structure is placed on a rack or other support, any glass portions which come into contact therewith will cool more rapidly than the other glass portions and thus potentially harmful strains may be set up.

However, by actual test and contrary to expectation, I have found that it is quite feasible to move such a sub-assembly directly from the annealing oven to surroundings at room temperature immediately after it has cooled below the setting-point of the glass. Moreover I have found that this is particularly true if the sub-assembly includes the improved cone of the present invention.

It appears that the reasons for the more general objection do not apply if one uses an external cooling rack in which only the metal cone is in contact with the rack. If this is done there is no difficulty as to strains being set up at the point of support since such strains in the metal cone, as distinguished from similar strains in glass, are of minor importance. When the sub-assembly is so set out to cool the cone affords an ideal form of carrier for the disc since its flange carries the disc symmetrically around its entire perimeter.

The following is a suitable way of using this shortened annealing process for sub-assemblies for 16-inch cathode ray tubes whose metal cones have the particular dimensions set forth above and are made of an alloy including 28% of chrome and 72% of iron and whose glass discs are made of soda lime silica glass (one form of ordinary window glass) which is 3/16 of an inch thick and can be obtained under the trade name "Clearlight" as manufactured by the Fourco Glass Co. immediately after the sub-assembly comes from the sealing fires, i. e., when the glass in the perimeter of the disc is strain-free, place it in an annealing oven which is maintained at a temperature of between 535 and 575 degrees centigrade, preferably near to 550 degrees; keep it there for a least five minutes; and then move it directly to surroundings at room temperature. It is neither necessary to vary the

oven temperature over the five-minute period nor to establish a temperature gradient in the oven along a path of travel for the sub-assemblies. If desired, the sub-assembly may be allowed to remain in the oven for longer than the five minutes and/or a higher initial temperature may be used so long as the take-out temperature is in the region above mentioned. However, if the initial temperature is above that for take-out it is obvious that either the temperature of the oven must vary over time or a temperature gradient must be established within the oven and the sub-assembly moved in accordance with the direction of the gradient.

The amount of differential shrinking between the cone and the disc need not be controlled only as a function of the different co-efficients of expansion of the metal and the glass. In addition, it may be controlled as a function of the manner in which annealing is conducted. For example, Fig. 5 illustrates an arrangement in which it is possible to cause the glass disc to cool down to its setting-point while the metal cone is maintained at a higher temperature. In the annealing oven 50 the cooling of the metal cone 10 is retarded by the fact that it is exposed to infra-red rays from radiant sources 51, whereas the cooling of the disc 16 is retarded only by the temperature of the air within the oven. Therefore, if the sub-assembly is removed from the oven as soon as the temperature of the disc has dropped down to its setting-point the flange will exert an increased amount of compression on the disc as they both cool down to room temperature. Actually, it may be unnecessary to practice this form of annealing inasmuch as it is very satisfactory to obtain differential shrinkage by the appropriate selection of materials, as a matter of fact, since a reduction in the percentage of chromium increases the co-efficient, it is more economical to do so.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated certain specific applications for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or uses indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. A process for forming the metal cone of a cathode ray tube from stock material of uniform thickness comprising the steps of: clamping a disc of the stock material on a die having the same external shape as the intended inside shape for the cone; forming the principal portion of a frusto-conical mantle for the cone at the smaller end thereof to have thinner walls than the rest of the cone by rotating the die and the stock while forcing the stock against a frusto-conical surface of the die with a roller which is supported on an axis of rotation parallel to said surface and which is urged against the stock with sufficient pressure to reduce it to a thickness nearly equal to but no smaller than the original thickness of the stock multiplied by a factor approximately equal to the sine of the one-half top-angle intended for the finished cone, and moving the roller along said axis and said surface; forming another portion of the mantle of the cone to comprise the larger end thereof from material near the periphery of said circular blank by folding or gathering said material against said surface of the die with said roller after reducing the pressure with which it is urged against the stock so that it does not substantially thin the stock during said folding or gathering; and folding or gathering the periphery of the disk to form a large-diameter flange carried on the large end of the mantle by said last-mentioned portion thereof.

2. A process for forming a metal shell for a cathode ray tube envelope from disc-like sheet metal stock comprising clamping the disc against a die form having the same external shape as the intended inside shape for the finished shell, spinning the disc against the surface of said die to form a cone for a major portion thereof on the smaller-diameter end thereof by the use of a roller pressing against said stock with sufficient force to reduce it during the spinning to a thickness less than the original thickness of said disc, reducing the pressure of said roller against the stock and gathering the remainder of said disc against said die to continue forming said disc into a cone without substantially thinning it and folding or gathering the periphery of the disk to form at the large-end thereof a flange whereby the larger portion of the cone and flange have substantially the same thickness equal to the original thickness of said disc.

3. A process for forming the envelope of a cathode ray tube comprising the steps of: forming a metal cone for said envelope from disc-like sheet metal stock having a predetermined coefficient of expansion by clamping the disc against a die having the same external shape as the intended inside shape for a mantle-portion at the small-diameter end of a frusto-conical mantle for the finished cone and spinning the disc against the surface of said die to form said mantle-portion by the use of a roller pressing against said stock with sufficient force to reduce it during the spinning to a thickness less than the original thickness of the disc, forming another mantle-portion at the large-diameter end of the frusto-conical mantle and a large-diameter flange adjacent thereto with wall thicknesses substantially equal to the original thickness of the stock; sealing into said flange a screen disc composed of glass having a smaller coefficient of expansion than that of said metal stock, said screen disc being so formed that each surface thereof has an approximately spherical curvature and being sealed into the metal cone to be convex in the direction outward therefrom; placing the cone-and-disc assembly in an annealing oven at an appropriate temperature to relieve strains in the glass disc without softening it, placing it therein directly after the screen disc has been sealed to the cone and while it still retains substantially all of the heat used in forming the seal; and moving the assembly from the annealing oven directly into an atmosphere at room temperature after the temperature of the screen disc has dropped to a value at or below its setting-point.

4. A process for forming the envelope of a cathode ray tube as set forth in claim 3 in which said metal stock is an alloy including 28% of chrome and 72% of iron, said screen disc is made of soda lime silica glass $\frac{3}{16}$ of an inch thick, the diameter of said flange is approximately 16 inches, the thickness of said first-mentioned mantle-portion is about .04 inch, both said second-mentioned mantle-portion and said flange are about .1 inch thick, and the temperature of the annealing oven at the time when a cone-and-screen-disc assembly is removed therefrom is between 535 and 575 degrees centigrade.

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