Jan. 10, 1967 J. P. FIORE 3,296,850

MASK FORMING

Filed Aug. 25, 1964 3 Sheets-Sheet 1

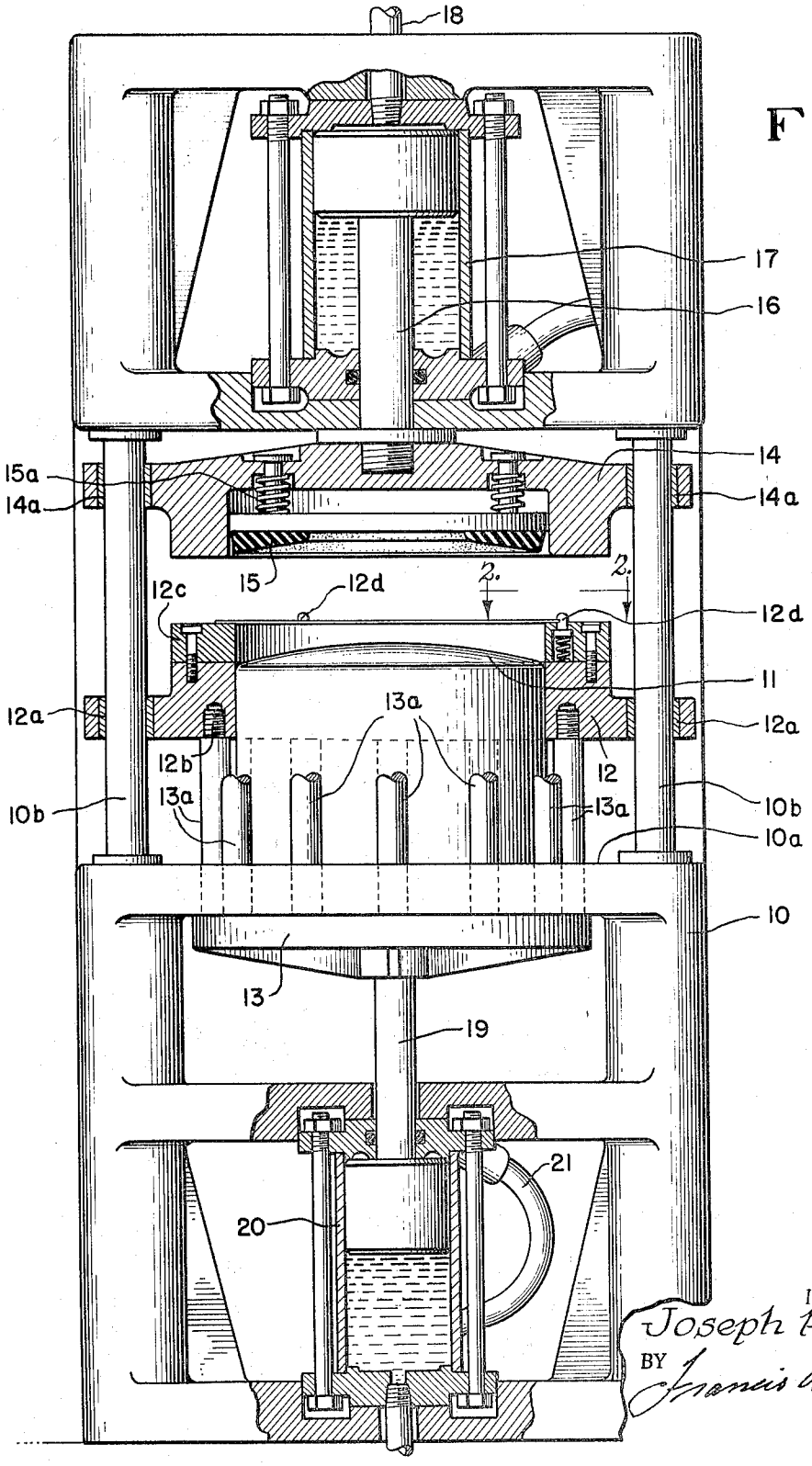


FIG. 1

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FIG. 2

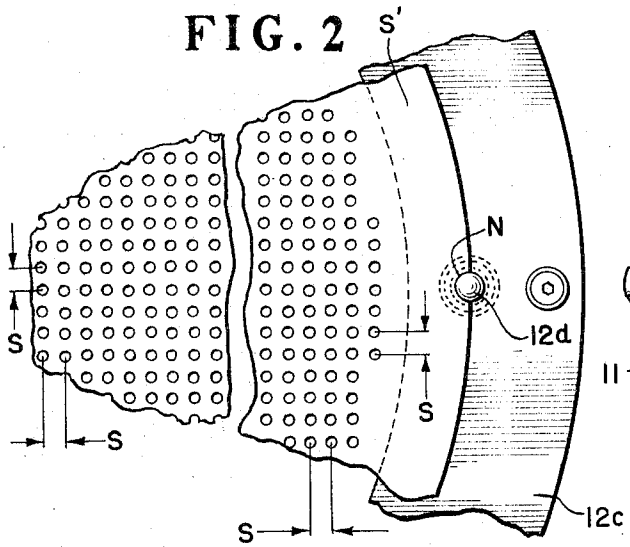


FIG. 3

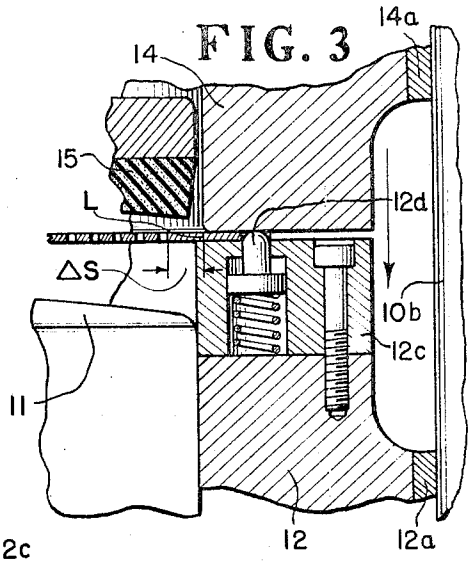


FIG. 4

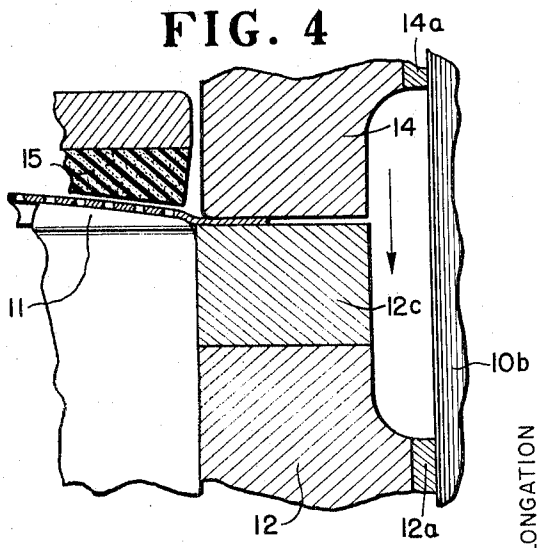


FIG. 5

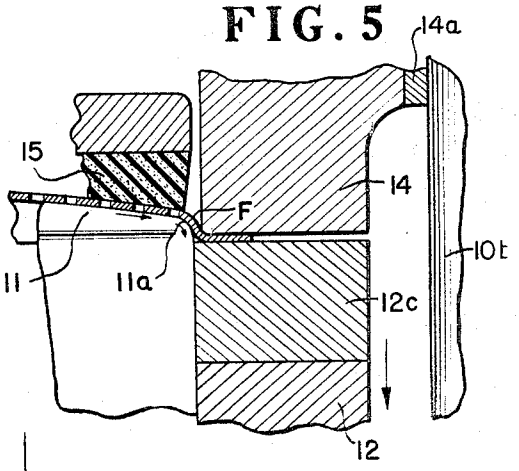


FIG. 6

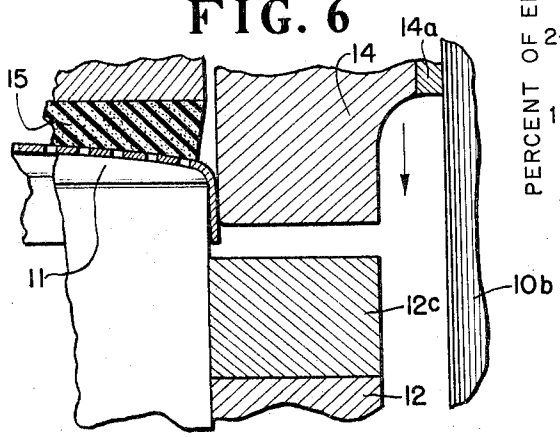


FIG. 7

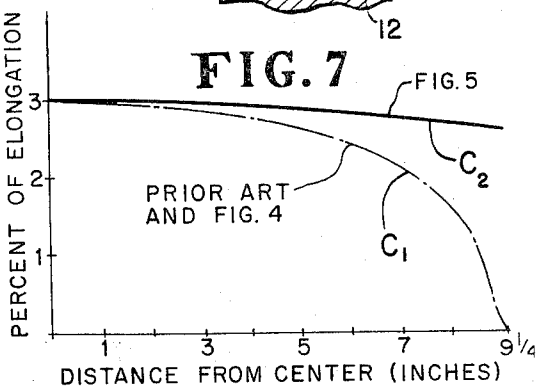


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FIG. 8

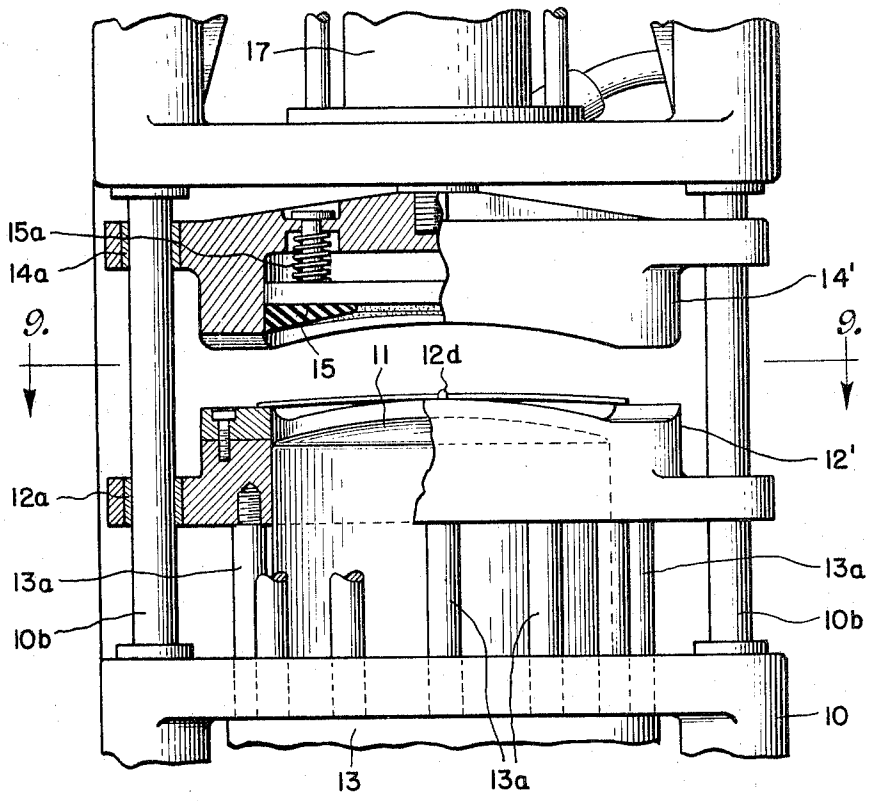
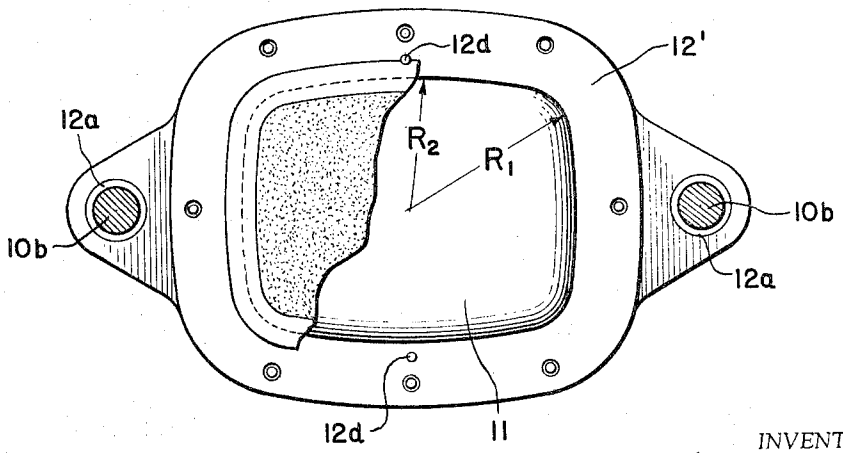



FIG. 9

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3,296,850

# MASK FORMING

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Filed Aug. 25, 1964, Ser. No. 391,986
6 Claims. (Cl. 72—351)

This invention is directed to the manufacture of a shadow-mask type of color television tube and is especially concerned with the formation of the shadow-mask or color selection barrier of such a tube.

In one commercial form of the shadow-mask color tube, the screen is formed directly on the faceplate and comprises a multiplicity of triads or three-element phosphor clusters disposed over the entire screen area. The three phosphor elements of any such triad respond when scanned by a beam of electrons and emit light of the three primary colors, red, green and blue. Usually, the tube has three electron guns each of which directs a beam of electrons toward the screen and these beams are controlled by a common deflection field to scan the screen simultaneously. The various color fields of an image result from imposing on the beam of each gun chroma information pertaining to the color field assigned to that gun and by confining the beam issuing from any such gun to the phosphor dots that emit light of that particular color.

The restriction of each gun to its assigned phosphor dots, or what is sometimes referred to as color selection, is accomplished by a parallax barrier in the form of an apertured mask interposed between the family of guns and the screen. The mask has a multiplicity of apertures and the physical structure is arranged to the end that any gun sees only its assigned phosphor elements through the mask apertures. It is preferred that the apertures of the mask to be arranged in a field which has the same configuration as the screen of the tube, that is to say, the apertures are arranged in a circular field or array for a round tube and are arranged in a rectangular field for a rectangular tube.

It is also important for optimum operation to control the spacing of the mask from the screen. From the standpoint of the parallax principles considered alone, and this, of course, is the basis of attaining effective color selection, there is a uniform spacing of mask to screen across the scan raster. If the screen is on the faceplate, which usually is a sector of a sphere, then it is appropriate that the shadow-mask likewise be a spherical section. This is the structure currently in use although it is also known that the screen and parallax barriers may be planar or they may be cylindrical in configuration.

It will be appreciated that the formation of an aperture pattern in the mask is a difficult problem, bearing in mind the need for controlling the size and disposition of the apertures throughout the mask area. Techniques have been developed by which the mask is formed through etching of the mask material which is usually steel. After the apertures have been formed in the mask and the blank has been suitably annealed, it is formed to the desired configuration. It has been the practice to mount the mask blank in a press in which cooperating die elements clamp the blank at the edge of the aperture field and, while it is thus clamped, shaping is accomplished by drape drawing over a suitably formed punch.

Although this permits shaping the mask to the desired configuration, it suffers from the disadvantage of introducing a non uniform elongation to the apertures in the mask, especially those at the edge of the field. This results from the fact that the mask is clamped and held fixed at the periphery of the aperture field and since the peripheral apertures are held against movement, they



suffer less elongation in the drawing process. As a consequence, the center to center spacing of the apertures is not uniform throughout the field.

Accordingly, it is an object of the invention to provide an improved method for forming the shadow-mask of a shadow-mask type of color television tube.

It is another object of the invention to provide a method for forming the shadow-mask of such a tube in which uniform center-to-center spacing of the mask apertures is maintained.

It is a specific object of the invention to provide an improved method for forming the shadow mask for such a tube characterized by the fact that the center to center spacing of the apertures is controllable.

Another particular object of the invention is to provide an improved method for forming a shadow mask without introducing non-uniformities into the aperture field of the mask.

In accordance with the method of the invention the mask of a shadow-mask type of color cathode ray tube is formed from a sheet of metal having a multiplicity of apertures within a field of predetermined configuration bounded by a strip of the metal. The method of the invention accomplishes forming of the mask without introducing non-uniformities, especially variations in the center to center spacing of the mask apertures throughout the aperture field. The method comprises clamping the sheet along a clamping line within the boundary strip of the sheet but spaced a predetermined minimal distance from the aperture field. The clamped sheet is then drawn over a punch to drape draw the sheet to the contour of the punch and to draw a fillet in the sheet. The punch has the same peripheral configuration as the aperture field and an area larger than that of the field but smaller than that enclosed by the clamping line to locate the fillet in the portion of the strip between the field and the clamping line. Thereafter, the sheet is unclamped and the remaining portion of the boundary strip beyond the clamping line is formed into a skirt extension of the fillet.

This method may be employed in forming the shadow-mask for round or rectangular tubes or tubes of any other acceptable configuration. Moreover, it is useful in the manufacture of tube structures in which the mask to screen spacing is uniform or non-uniform since this is controllable through the contour of the draw die or punch.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is an elevational view, partly in section, of a press for practicing the method of the invention;

FIGURE 2 is an enlarged view taken along line 2—2 of FIGURE 1;

FIGURES 3–6, inclusive, are views representing various positions of the apparatus of FIGURE 1 in the mask forming process;

FIGURE 7 comprises curves used in explaining the method of the invention;

FIGURES 8 and 9 are used to explain the application of the inventive method in forming a rectangular mask.

Referring now more particularly to FIGURE 1, the apparatus there represented is a die press for carrying out the method of the invention in forming the mask of a circular shadow-mask type of color television tube. The press, as a structure, is conventional, having a vertical framework 10 which supports the punch and die

components as well as an hydraulic system for exerting the necessary drawing forces or pressures. The punch over which a mask blank is to be drape drawn is designated **11**. It is mechanically supported from, and centrally located of, a fixed bed **10***a* of the press frame structure. If it be assumed that the mask is to have the shape of a spherical section, punch **11** will have the same shape and will have a radius corresponding to that to which the mask blank is to be drawn.

There is a pressure ring assembly concentrically positioned with respect to punch **11**. This assembly includes a base member **12** having a number of bushings **12***a* which receive vertically extending guide posts **10***b* of the frame structure of the press; it is convenient to have four such bushing-guide arrangements located at the corners of the pressure ring assembly which has a generally rectangular overall configuration. The base **12** has another series of apertures **12***b* arranged on a circle between the inner periphery of the base and its bushing provisions **12***a*. This series of apertures **12***b* threadably receives coupling members **13***a* which extend vertically of a platen **13** and mechanically couples the pressure ring assembly to this platen in order that they may move unitarily, being guided by posts **10***b*. There is an upper or die portion **12***c* of the pressure ring removably secured to base **12**. The inner diameter of the punch ring is only slightly larger than the external diameter of punch **11**. There are a number of locating pins **12***d* accommodated by apertures in die ring **12***c*. Generally, there are three such locating elements spaced from one another on die **12***c* and spring pressed normally to project above the upper surface of the die but arranged to recede into die recesses which accommodate the bias springs of the locating pins.

Disposed above pressure ring **12** is a draw ring **14** which, likewise, has bushings **14***a* through which guide posts **10***b* extend. The draw ring has similar dimensions to the die portion **12***c* of the pressure ring and their facing surfaces are lapped to represent mating die areas. The internal diameter of draw ring **14** is slightly greater than the internal diameter of pressure ring **12**. It is dimensioned to have an internal diameter exceeding the external diameter of the piston or cylindrical portion of punch **11** by approximately twice the thickness of the mask blank. Disposed within draw ring **14** is a resilient pressure pad **15** supported from the draw ring by means of pins **15***a* surrounded by springs which tend to extend the pad in the direction of pressure ring **12**. The entire assembly of draw ring and pad is mechanically secured to the piston **16** of an hydraulic motor **17** constructed in the upper portion of the frame **10** of the press. The hydraulic system is designated schematically at **18**. It is of conventional construction and is employed to advance the piston **16** downwardly on a pressure stroke during the drawing operation and to retract it after that operation has been completed.

Similarly, there is an hydraulic system comprising a piston **19** and motor **20** formed in the bed of the press and having a similar hydraulic system **21** through which piston **19** may be moved to vary the position of platen **13** and pressure pad **12** to accomplish mask forming. The vertical displacement of pistons **16** and **19** is, of course, controlled by the hydraulic systems. No claim of invention is predicated on this portion of the die press which may be of well-known design, programmed through microswitches or the like to achieve precisely controlled displacement of the die parts in the drawing operation.

The mask blank to be formed for a circular tube has a multiplicity of apertures within a field of predetermined configuration, specifically, within a circular field. This field is bounded by a strip of the blank metal. A segment of such a shadow-mask blank is shown in FIGURE 2 where the center to center spacing of the apertures is designated by the dimension line S and the boundary strip of metal S′ is the material of the blank extending from the periphery of the circular field of apertures to the outer periphery of the mask. Usually, the mask blank is annealed steel. As indicated in FIGURE 2, there is a notch N formed at the outer edge of boundary strip S′ to accept a locating pin **12***d*. As there are three such pins, there are a similar series of three notches. The pin and notch locations may be arranged to the end that the blank will fit pressure ring **12***c* in only a single position which facilitates designating a top or bottom portion for the mask. In practicing the invention, the circular mask blank is first positioned on draw ring **12***c* by means of the locating pins **12***d* and the notches N. The draw ring is then in the position illustrated in FIGURE 1. The initial or starting position is one in which platen **13** has been advanced to its uppermost position by piston **19**.

After the blank has been positioned, hydraulic fluid is admitted to cylinder **17** and draw ring **14** closes down upon pressure ring **12**. The positions that the die sections assume is that of FIGURE 3 from which it is seen that locating pins **12***d* recede into the apertures provided in pressure ring **12***c*. At this step, the mask blank is clamped along a clamping line L located within strip S′ of the blank and spaced a predetermined minimal distance $\Delta S$ from the periphery of the aperture field. The distance $\Delta S$ is large compared to the diameter of the mask apertures and preferably is at least equal to several times the diameter of the mask apertures.

While pressure exerted concurrently on the draw and pressure rings provides the necessary clamping force for the blank, the pressure exerted on the draw ring is the greater and the differential pressure causes the closed die assembly to descend, drawing the mask blank over punch **11** to drape draw the sheet to the contour of the punch. The relative positions of the dies and the punch is that of FIGURE 4.

The descending stroke of the punch assembly is continued beyond that of FIGURE 4 to achieve the position illustrated in FIGURE 5 in order to draw a fillet F in the mask sheet or blank. While the peripheral configuration of punch **11** is the same as that of the field of apertures, both being circular for the case under consideration, the area of the punch is larger than that of the aperture field but smaller than the area enclosed by clamping line L. As a consequence, the fillet F is located in the portion of strip S′ between the aperture field and clamping line L.

The final position of the cooperating dies in relation to punch **11** has an important bearing on the characteristics of the formed mask. This is best illustrated by the curves of FIGURE 7 in which the broken-line curve $C_1$ depicts the variation of the dimension S, the center to center spacing of the apertures, in terms of distance from the center of the mask blank if the draw and pressure rings stop in the position of FIGURE 4 without having first pulled the radius or drawn the fillet F in the sheet. The curve indicates a non-uniform center to center spacing which is undesirable. By continuing the draw to attain the position of FIGURE 5, the center to center separation of the mask apertures may be made substantially uniform as represented by full line curve $C_2$. Intermediate final positions in the drawing operation permit controlling the aperture spacing but it is generally preferred that the spacing be uniform over the aperture field of the mask. This is attained by drawing the fillet to the point which is essentially tangent to the radius **11***a* of the punch.

After the fillet has been drawn to the appropriate depth, the programming of the die press retracts piston **19** to lower platen **13** and pressure ring **12** as indicated in FIGURE 6. This unclamps the sheet by separating the draw and pressure rings. The descent of draw ring **14** is now continued to form the portion of strip S′ which extends from clamping line L radially outwardly into a skirt extension of fillet F which completes the mask formation.

In the final descent of draw ring **14**, pressure pad **15** is brought to bear against the aperture field of the formed mask blank as indicated in FIGURE 5. As the draw ring is returned to the starting position of FIGURE 1,

pressure pad **15** retains the formed blank on punch **11** and releases its pressure thereon after draw ring **14** has cleared away from the blank. Finally, however, the pressure pad **15** rises with draw ring **14** and releases the blank. In the last step of the process pressure ring **12** is elevated to its starting position of FIGURE 1 which strips the formed blank free of punch **11** so that the operator may remove it from the press.

In forming the mask blank for a 21 inch circular tube, the hole diameter is appropriately 10 to 12 mils and the separation of clamping line L from the edge of the aperture field is approximately 1/16 of an inch. It is found that by drawing the blank over the punch, forming the fillet F, the desired uniform elongation of apertures particularly at the marginal portions of the field is attained and a substantially uniform center to center spacing of apertures is retained over the field.

Essentially, the same method is employed in forming the mask for a rectangular tube. In this case, the plan view of the punch and pressure ring is that of FIGURE 9. If it again be assumed that the mask is to have the configuration of a spherical section, the dimension of the punch from the center to various points on its periphery is non-uniform. For example, the radius $R_1$ to the corner is a maximum dimension whereas the radius $R_2$ to the middle of the long dimension of the rectangle is the shortest. Therefore, the specific shape of the draw ring **14'** of FIGURE 8 and its pressure ring **12**, employed for forming the rectangular mask, is specifically different from the corresponding die sections of the arrangement of FIGURE 1. In FIGURE 1, the mating die surfaces are simple planar surfaces whereas the view of FIGURE 8 shows that for the rectangular mask, the die elements have a spherical contour. This, of course, results from the fact that the punch in the latter case has a peripheral configuration of a rectangle whereas in the former case it had the symmetrical configuration of a circle. Preferably, for forming rectangular masks the spheroidal surfaces of the mating dies have the same radius of curvature as the contiguous periphery of punch **11**.

The apparatus of FIGURES 8 and 9 carries out essentially the same process as described in the discussion of FIGURES 3 to 7 but in this case bringing the draw ring **14'** against pressure ring **12'** results in preforming. The sheet or mask blank is a flat planar sheet at the outset and clamping it between dies **12'** and **14'** which have a spherical contour causes the sheet to have a similar contour. This is referred to as preforming. A color tube including a rectangular mask which may be formed through the described apparatus is described and claimed in Patent 2,897,392, issued July 28, 1959, in the name of Joseph P. Fiore and assigned to the assignee of the present invention.

The description has proceded on the assumption that punch **11** is a section of a sphere as would be used in drawing a mask blank that is to be spherical in configuration. Obviously, the invention is not confined to the use of perfect spherical sections; the punch may have specifically different contours to which the mask blank may be formed by drape drawing. For example, it is sometimes advantageous to have a smaller mask to screen spacing at the edges than at the center of the mask. To achieve this result punch **11** has a larger radius at its periphery than at the center and dimensional change is smooth and continuous rather than sharp and discontinuous.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

**1.** In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a field of predetermined configuration bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

clamping said sheet along a clamping line within said strip and spaced a predetermined minimal distance from said field;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet, said punch having the same peripheral configuration as said field and an area larger than said field but smaller than that enclosed by said clamping line to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

**2.** In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a field of predetermined configuration bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

clamping said sheet along a clamping line located within said strip and spaced from said field by an amount that is large compared to the diameter of said apertures;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet, said punch having the same peripheral configuration as, but a larger area than, said field to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

**3.** In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a field of predetermined configuration bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

clamping said sheet along a clamping line located within said strip and spaced from said field by an amount that is large compared to the diameter of said apertures;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet of such depth that the center-to-center spacing of the apertures is substantially uniform within said field, said punch having the same peripheral configuration as, but a larger area than, said field to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

**4.** In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a circular field bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

clamping said sheet along a circular clamping line located within said strip and spaced from said field by an amount that is large compared to the diameter of said apertures;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet, said punch being a substantially spheroidal section having a chord dimension larger than the diameter of said field to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

5. In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a rectangular field bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

clamping said sheet along a rectangular clamping line located within said strip and spaced from said field by an amount that is large compared to the diameter of said apertures;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet, said punch being a substantially spheroidal section, having a projected area of rectangular configuration and having principal dimensions larger than the corresponding dimensions of said field to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

6. In the manufacture of a shadow-mask type of color cathode-ray tube, the method of forming a shadow-mask from a sheet of metal having a multiplicity of apertures within a rectangular field bounded by a strip of said metal and without introducing non-uniformities into said field, which method comprises:

preforming by clamping said sheet between a pair of mating dies having spherically shaped die surfaces



dimensioned to engage said sheet along a rectangular clamping line located within said strip and spaced from said field by an amount that is large compared to the diameter of said apertures;

drawing said sheet over a punch to drape draw said sheet to the contour of said punch and to draw a fillet in said sheet, said punch being a substantially spheroidal section having a radius at the periphery approximately equal to radius of said die surfaces, having a projected area of rectangular configuration and having principal dimensions larger than the corresponding dimensions of said field to locate said fillet in the portion of said strip between said field and said clamping line;

unclamping said sheet;

and forming the remaining portion of said strip beyond said clamping line into a skirt extension of said fillet.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 689,330 | 3/1901 | Thurber | 72—350 |
| 1,513,644 | 10/1924 | Sindelar | 72—328 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 637,759 | 5/1950 | Great Britain. |

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