

Dec. 25, 1962

J. W. SCHWARTZ
ART OF MANUFACTURING CATHODE-RAY TUBES
OF THE FOCUS-MASK VARIETY
Filed Feb. 27, 1958

3,070,441

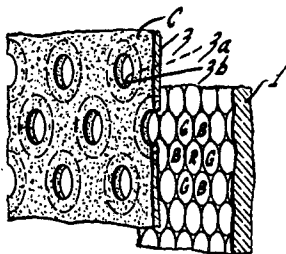


Fig. 3.

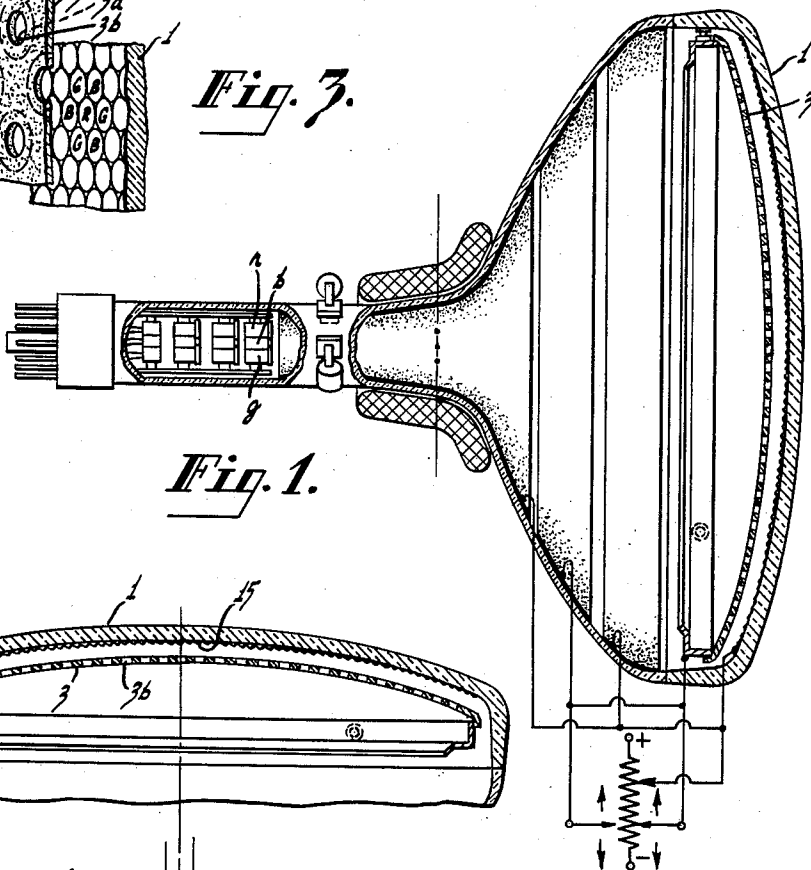


Fig. 1.

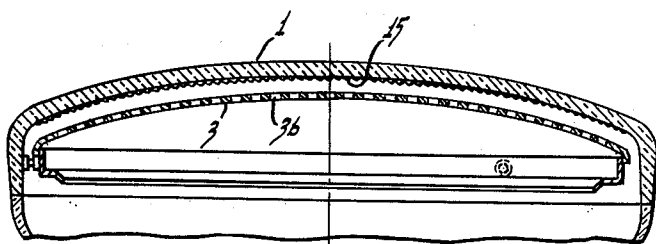


Fig. 4.

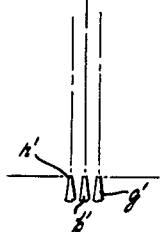
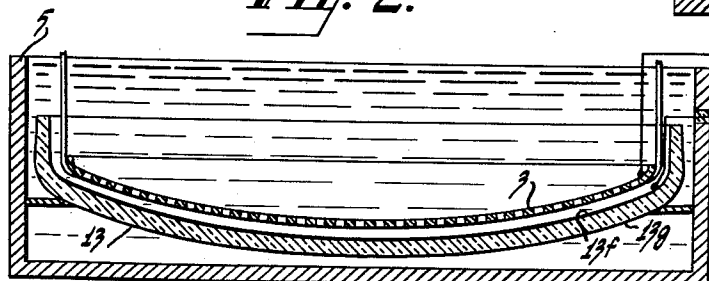
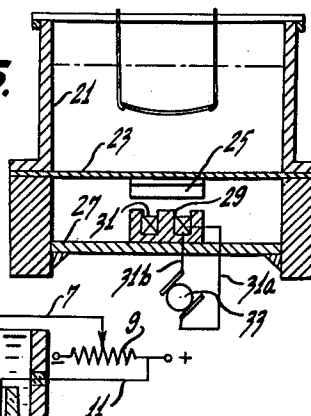


Fig. 2.

Fig. 5.



INVENTOR.
JAMES W. SCHWARTZ

BY *Rodrick Malcolm*
ATTORNEY

1

3,070,441

ART OF MANUFACTURING CATHODE-RAY TUBES OF THE FOCUS-MASK VARIETY

James W. Schwartz, Princeton, N.J., assignor to Radio Corporation of America, a corporation of Delaware
Filed Feb. 27, 1958, Ser. No. 718,044
1 Claim. (Cl. 96—35)

Classified in accordance with their mode of operation there are two kinds of "masked-target" cathode-ray tubes: (1) the "shadow-mask" variety wherein the screen and its mask are maintained at the same potential to provide a field-free space through which the electrons pass along substantially straight paths in approaching the screen and (2) the "focus-mask" variety wherein the mask is operated at a potential considerably lower than the screen potential to provide a beam-focusing electron-optical lens-field in the mask-to-screen space.

Cathode-ray tubes of the focus-mask variety are more efficient than cathode-ray tubes of the shadow-mask variety. The reason for this is that the concentrating effect of the lens-field upon the electron-beams of "jets" in a focus-mask tube permits the use of larger mask-openings than can be used in a shadow-mask tube. Thus, other factors being equal, there are more electrons (and hence more light) available at the screen of a focus-mask tube than in a shadow-mask tube. (As to this see French Patent 866,065 of 1941.) However, up to now there has been no commercially practical way of making a mosaic screen for use in such tubes. Why this is so will be more readily be apparent when it is recalled (a) that the conventional way of making an electron-sensitive mosaic screen involves the use of the tube's mask as a "stencil" in laying-down (or plotting the location of) the elemental phosphor-areas of which the mosaic is comprised and (b) that where, as in the case of a focus-mask tube, the mask-holes are larger than the elemental phosphor-areas of which the mosaic screen is to be formed, any attempt to use the mask as a stencil in the screen-plotting operation would result in oversize (and hence "overlapping") phosphor-areas. This problem has long been recognized and it has previously been proposed, in the case of a "line-screen" tube (see the French Patent, *supra*), to reduce the size of the mask's apertures temporarily, i.e. during the screen-plotting operation, as by coating the parallel wires of which the mask is comprised with glue, and then removing the glue from the wires prior to mounting the mask within the tube. Attempts to apply this method to the manufacture of a screen-unit of the kind wherein the mask comprises a sheet-like metal (or glass) structure containing several hundred thousand holes result in clogged holes or holes of non-uniform diameter.

Accordingly, the principal object of the present invention is to provide a rapid yet accurate and trouble-free method of and means for manufacturing focus-mask tubes of the kind wherein the mask comprises a multiplicity of dot-like apertures and the screen comprises a multiplicity of groups of dot-like elemental areas arranged in a pattern which is systematically related to the pattern of the mask-apertures.

Stated generally, the foregoing and related objects are achieved in accordance with the invention by cathodoretically coating the mask with a suitable (opaque) substance to achieve the desired reduction in the size of the mask-holes, then utilizing the cathodoretically coated mask as a stencil in the optical system used in laying down the electron-sensitive screen-pattern, and finally removing the tightly adherent cathodoretic coating from the mask by subjecting it, as in a fluid medium, to sustained compressional waves of a sonic or ultrasonic frequency, prior to mounting the mask in its ultimate position within the envelope.

2

The invention is described in greater detail in connection with the accompanying single sheet of drawings, wherein:

FIG. 1 is a longitudinal view, partly in section, of a 3-gun, tri-color, dot-screen kinescope of the focus-mask variety, to which the invention is applicable;

FIG. 2 is a sectional view of a "plating tank," showing the mask being subjected to the cathodoretic deposition of an opaque substance, for the purpose of temporarily reducing the effective size of the mask-apertures;

FIG. 3 is a view in perspective, on an enlarged scale of a part of the screen-unit of the kinescope during an intermediate stage in its manufacture;

FIG. 4 is an elevational view, partly in section, of a photographic "lighthouse" with the screen-plate and cathodoretically-coated mask of FIG. 3, set up thereon in a position to record, upon the screen-plate, the pattern of light rays passing through the coated apertures in the mask;

FIG. 5 is a partly diagrammatic sectional elevation of a washing machine for removing the cathodoretic coating from the mask by the use of sustained compressional wave motion in the cleansing fluid in which the coated mask is immersed.

In the 3-gun, tri-color, focus-mask kinescope shown in FIG. 1, the screen-plate is designated 1, the focus-mask 3 and the "red," "blue" and "green" electron-guns are designated *r*, *b* and *g*, respectively. As shown more clearly in FIG. 3, the inner or target surface of the screen-plate 1 comprises a multiplicity of groups of red (R) blue (B) and green (G) phosphor-dots arranged in a hexagonal mosaic pattern. As shown in FIG. 1, the mosaic is covered with an electron-transparent electrically conductive film 1f constituted, for example of evaporated aluminum. The mask 3 for the dot-like mosaic screen contains a multiplicity of circular apertures 3a arranged in the same systematic (hexagonal) pattern as the pattern of phosphor dots on the mosaic screen, there being one mask-aperture for each group of three phosphor dots (RBG). Here, as in other types of masked-target color-tubes, the particular color or colors illuminated at any given instant is a function of the angle at which the beam or beams approach the screen-unit. When, as in the instant case, the mask 3 is operated at a potential several thousand volts negative with respect to the screen, the electrical field (not shown) about each mask aperture, in the space between the mask and screen, comprises a spherical lens which operates to concentrate and to focus the jets of electrons, which pass therethrough, upon the particular color-phosphor dots which lie in their path.

It will be observed upon close inspection of FIG. 1 that in this focus-mask screen unit 1-3 the mask holes 3a are larger than the individual phosphor-dots (RBG). There are several factors to be considered in selecting the optimum relative size of the mask-holes and the phosphor-dots in a focus-mask tube. One factor is the screen-to-mask potential ratio to be employed. The ratio may be as high as 9 to 1 or as low as about 2 to 1. The theoretical maximum potential ratio (i.e. 9 to 1), if used, may give rise to voltage-supply and insulation problems. Accordingly, a lower ("partial focus") ratio is ordinarily preferred. In one such focus-mask tube, to which the present invention has been applied, the phosphor dots were 0.016" in diameter and the mask apertures were 0.018". In this case the mask was about 0.5" from the screen and the recommended screen-to-mask potential ratio was about 4 to 1; the "ultor" or screen potential being of the order of 18 to 20 kilovolts. Here, obviously, the mask as it is illustrated in FIG. 1 condition could not be used as a stencil for the phosphor-spray or the light-rays used in laying-down or plotting the location of the phosphor dots R, B, G on the screen-plate 1. As previously

3

indicated (and as later described in connection with FIGS. 2-6) in order to render the mask suitable for use as a stencil during the screen plotting operation, the present invention dictates the use of a cataphoretic (or electro-phoretic) coating method for temporarily "stepping down" the diameter of the mask-holes. The cataphoretic deposition of the coating material may be carried out in a suitable tank such, for example, as the one shown in FIG. 2. Here the mask 3 is shown supported at three or more places about its rim in a horizontal position within the tank 5. The mask 3 is connected as through an external lead 7 to one terminal of a source of direct current, exemplified by the battery 9. The other terminal of the direct-current source 9 is connected through a suitable lead 11 to an electrode 13 of a configuration generally similar to that of the mask. In the illustrated embodiment of the invention this spherically curved electrode 13 comprises a glass foundation plate 13g somewhat larger than the mask 1 and having an electrically conductive coating 13f on its concave surface. Copper-plated glass is preferred to a solid metal electrode because glass of the correct size and shape is readily available (the "face-plate" of a cathode-ray tube envelope of the proper size may be used) and also because the copper-plating resists polarization and, consequently, is less likely to discolor or otherwise contaminate the bath.

The coating material must be one that is opaque to the rays used in the screen-plotting operation. It should also be one which adheres very tightly to the mask, i.e. it should be free from flaking, chipping etc. when mounting it within (and removing it from) the "lighthouse" (FIG. 2) during the screen-plotting operations. Among the cataphoretic coating suspensions which meet the requirements of the invention are:

Aluminum oxide (Al ₂ O ₃)	-----grams----	100
Acetone	-----cc----	200
Ethylene glycol	-----cc----	13
Nitrocellulose binder	-----cc----	200

In the above formula, magnesium oxide, graphite or carborundum may be used instead of aluminum oxide. The binder stock may comprise 60 g. nitrocellulose, 850 cc. diethyl oxalate and 1950 cc. diethyl carbonate.

The time required to "step-down" the mask-apertures to the desired size, in the cataphoretic coating apparatus of FIG. 2, ordinarily need not exceed a minute or two when the current employed is of the order of 20 milliamperes per square inch of mask area at say 10 volts.

When the mask has been dried it is ready for use in the screen-plotting apparatus, such as the "lighthouse" shown in FIG. 4. At this stage in the manufacture of the finished tube the apertures in the mask 3 have been reduced from their original size (indicated at 3a FIG. 3) to the size (indicated at 3b FIG. 3) required to provide the screen-plate with phosphor-dots (R, B and G) of the proper size when the separately applied red, blue, green phosphor-containing emulsions 15 (FIG. 4) on the screen-plate 1 are exposed, through the mask-apertures 3b, to the appropriate source of light r' , b' , g' . After the three photographic exposures have been made the cataphoretic coating C (FIG. 3) must be removed from the mask-holes prior to mounting the mask for use within the tube.

The cataphoretic coating C could be removed from the mask 3 by scrubbing it with a wire brush (not shown). This, however, could scratch or distort the mask-material and, in any event, is a tedious operation. It has been discovered that the tightly adherent cataphoretic coating C can be removed from the surfaces of the mask, and from the mask apertures, very quickly by immersing the coated mask in water or other cleansing fluid and imparting a sustained compressional wave motion to the fluid. This may be done in a washing machine like the one shown in FIG. 5, for example. In FIG. 5, 21 designates, generally, a cylindrical tub for the cleansing fluid in which the coat-

4

ed mask 3C is immersed, as by suspending it from the rim of the tub. A part of the tub, in this case its bottom, comprises a flexible (brass) disk or diaphragm 23 which is provided on its underside with a driven element or armature comprising a laminated magnetic structure 25. Alternatively, the driven element 25 may comprise a coil (not shown) similar to the voice coil of a "dynamic" loud-speaker. In any event, the driven element 25, and hence the diaphragm 23 to which it is affixed, may be vibrated or driven by a transducer mounted in register with the driven element as on a rigid bracket or cross-arm 27. This transducer or driving element may comprise a magnetic yoke 29 and a coil 31 which is adapted to be connected, as through leads 31a, 31b to a source 33 of low frequency (e.g. 60 cycles), low voltage (e.g. 120 volt) current. When sonic waves of large amplitude are impressed upon the water, or other cleansing liquid, in which the mask is immersed, the water is forced through the mask holes, as well as over the surface of the mask. This movement of the water removes the coating material very quickly, especially so when the amplitude of the impressed waves is great enough to produce cavitation. This phenomenon (cavitation) will be present when the frequency of the actuating force corresponds to the natural resonant frequency of the diaphragm and its load. By way of example, when 60 cycle current is supplied to the coil of non-polarized magnetic transducer, the actuating force has a frequency of 120 cycles per second, hence if the natural resonant frequency of the diaphragm and its load is adjusted (e.g. simply by altering the water level) to that frequency (i.e. 120 cycles) the movement of the diaphragm will be large enough to produce cavitation.

What is claimed is:

In that method of making a screen-unit for use in a cathode-ray tube of the focus-mask variety which comprises the steps of (i) forming in the mask material apertures of the ultimate size and pattern of distribution dictated by the normal operating parameters of said screen-unit, (ii) depositing a light-opaque coating upon the surfaces of said apertured mask material to reduce the size of the apertures therein approximately to the size of the elemental areas of the mosaic pattern to be applied to the screen-plate of said unit, (iii) photosensitizing the target surface of said screen-plate, (iv) exposing said photosensitized target surface to light rays through the pattern of apertures in said coated mask material whereby photographically to record said pattern upon said target surface, and then (v) removing said light-opaque coating from said mask material to restore said mask-apertures to their original dimensions; the improvement characterized, in step (ii), by the deposition of said light-opaque coating by cataphoresis and, in step (v), by the use, in removing said light-opaque coating, of compressional waves applied to said coated surfaces through a liquid medium.

References Cited in the file of this patent

UNITED STATES PATENTS

2,376,047	George et al.	May 15, 1945
2,539,442	Larson	Jan. 30, 1951
2,755,402	Morrell	July 17, 1956
2,767,457	Epstein	Oct. 23, 1956
2,851,408	Cerulli	Sept. 9, 1958
2,910,617	Smith	Oct. 27, 1959

FOREIGN PATENTS

866,065	France	June 16, 1941
634,217	Great Britain	Sept. 27, 1955

OTHER REFERENCES

"Improvement in Color Kinescopes Through Optical Analogy" (Epstein, Kaus, and Van Ormer), RCA Review (vol. 16, page 495 relied upon), December 1955.