Nov. 22, 1966 S. H. KAPLAN 3,287,130

PROCESS OF CATHODE-RAY TUBE SCREENING COMPRISING A BACKWARD EXPOSURE STEP

Filed Aug. 25, 1964

2 Sheets-Sheet 1

FIG. 1

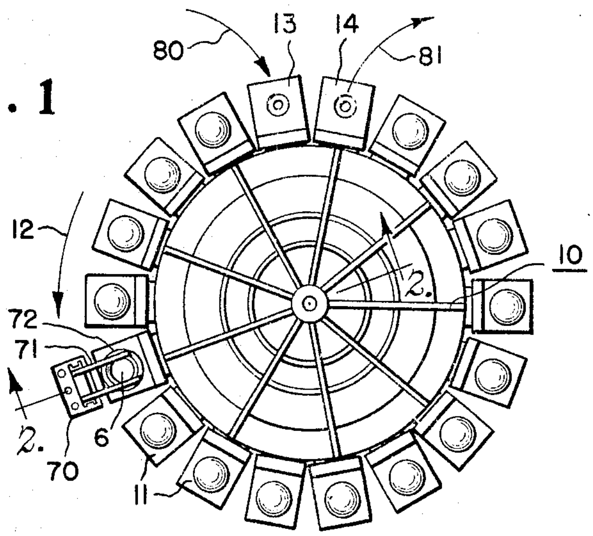

FIG. 3

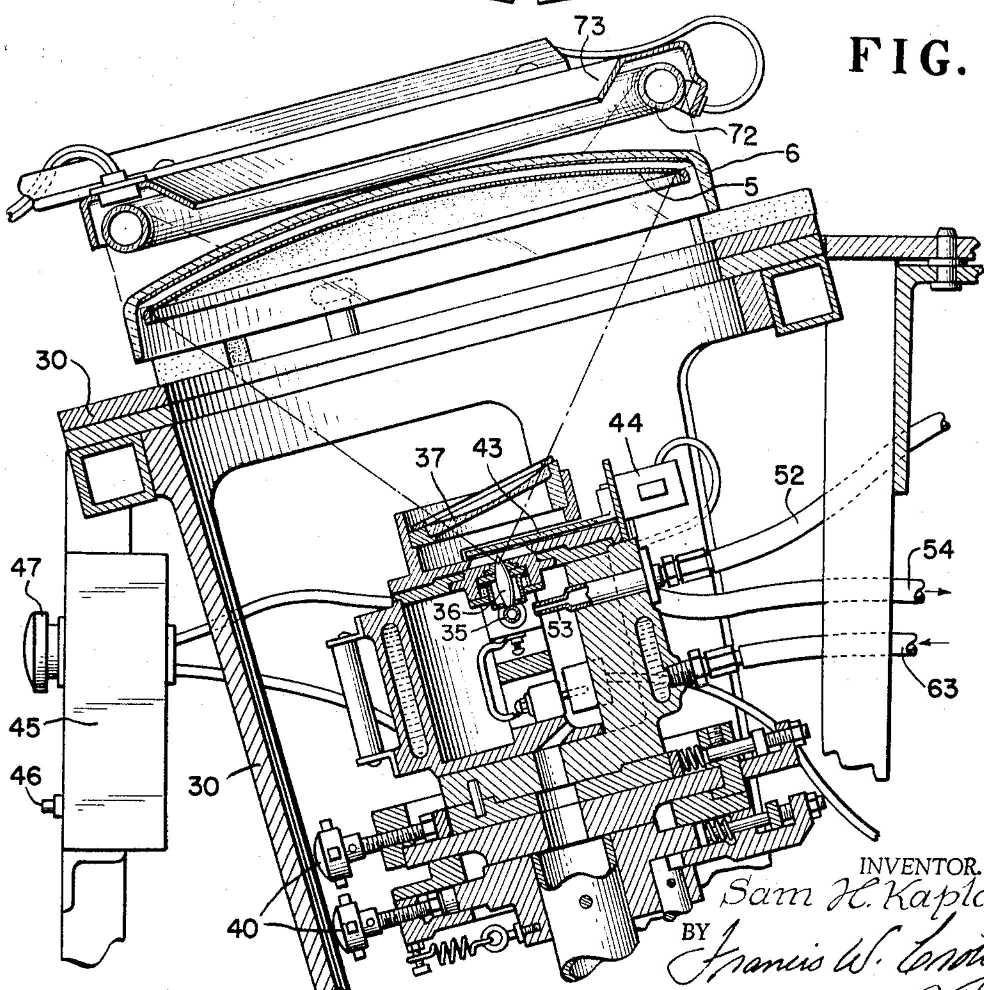

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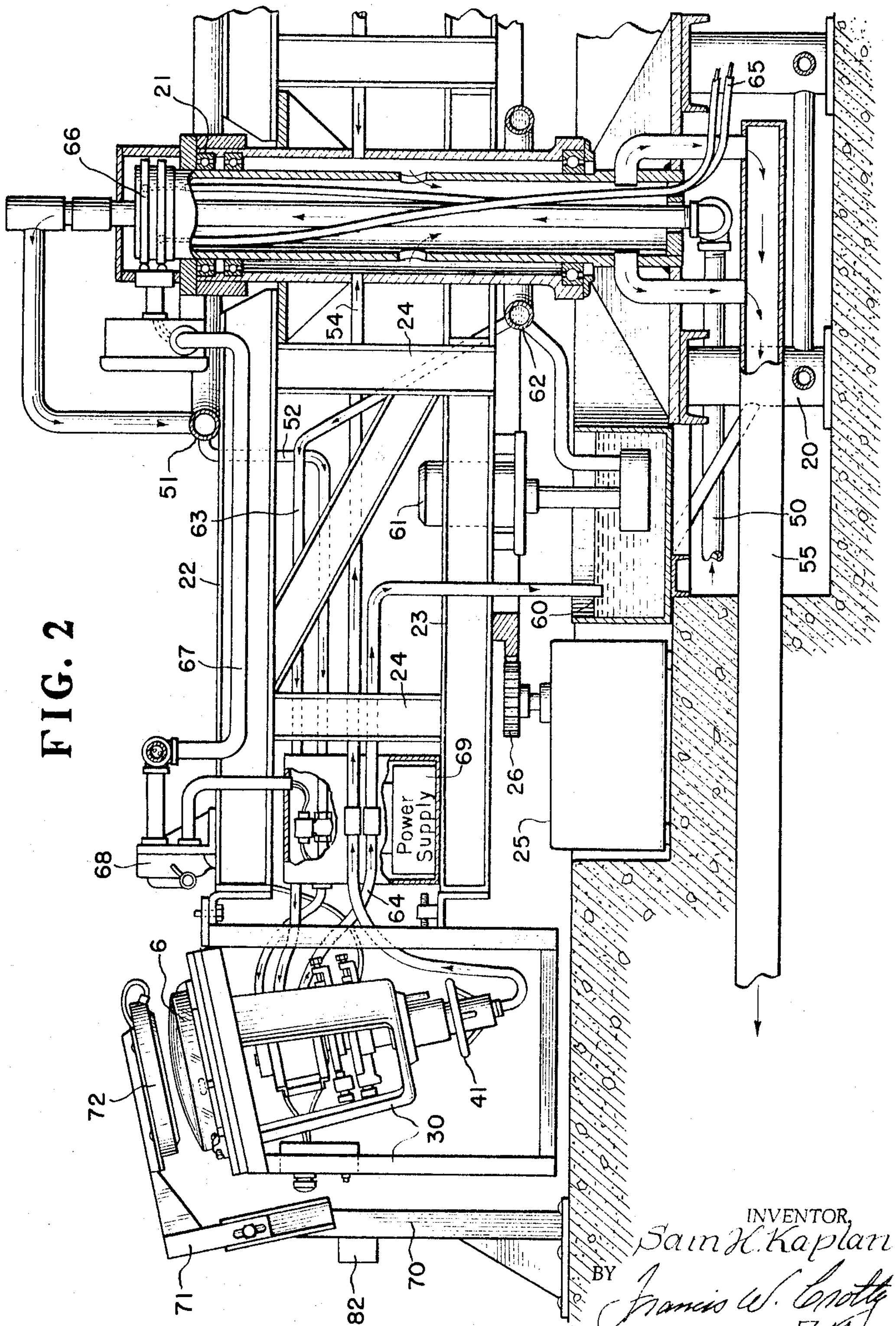
FIG. 2



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PROCESS OF CATHODE-RAY TUBE SCREENING COMPRISING A BACKWARD EXPOSURE STEP

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1 Claim. (Cl. 96—35)

The present invention pertains to the screening of cathode-ray tubes and, while of general application, it is especially suited to the screening of the shadow mask type of color tube and will be described in that environment.

The screen of the present commercial form of shadow mask tube comprises a multiplicity of triads each of which is composed of an island or dot of phosphor which emits light of one of the primary colors in response to an impinging cathode-ray or electron beam. More particularly, each triad has a green phosphor element, a red and a blue element and the tube is provided with three electron guns each of which is to be associated with the phosphor elements of an assigned color. This objective, restricting the influence of each beam of its related family of phosphor dots, is achieved by interposing an apertured shadow mask between the group of guns and the screen of the tube. It is well known that the assembly may be arranged and controlled so that the beam emanating from any gun and traversing the holes of the mask is able to impact only those members of the phosphor group which is associated with that particular gun.

Depositing three interlaced families of phosphor elements on the screen section of such a tube presents difficult problems of fabrication. One useful processing technique contemplates that the entire screen area be covered with the phosphor of one of the primary colors and, in addition, a photo-sensitive resist. After the screen has been coated with such materials, it is placed in a so-called "lighthouse" in which a high intensity lamp exposes the screen through the shadow mask that ultimately is assembled with that screen in the completed tube. By positioning the light source to simulate the action of the electron gun associated with the phosphor being processed, an exposure patetern results which corresponds to the desired location of the elements of the phosphor being processed. If the exposure is adequate in respect of intensity, distribution and time, the portions of the coating representing the desired elements of phosphor are rendered insoluble whereas the unexposed portions of that coating retain their solubility. After exposure, the screen may be washed to remove the unexposed coating and leave as a residue the phosphor elements of one of the primary colors.

Repetition of the same general process permits depositing elements of the other phosphors although it will be understood that the coating in each step of the process includes a phosphor of a given color and its exposure in the lighthouse is with a light source properly positioned to simulate the electron gun assigned to that color.

While this processing has been satisfactorily employed, certian difficulties have been encountered. For example, the usual light source has an energy distribution pattern which is quite the obverse of that ideally required for optimum exposure. Specifically, the ordinary light source exhibits maximum intensity at the center of the screen and the intensity falls off in the direction of the periphery of the screen. If the apertures of the mask are of uniform diameter, the light source ideally should have uniform intensity from the center of the sceen to the periphery in order to achieve uniform exposure. Actually, the apertures near the periphery are smaller than those in the center and this, as well as geometrical considerations, imposes a need for higher intensity of light at the edges to achieve uniform exposure of the screen through the mask.

In an effort to control the exposure, the lens system through which the light is focused on the screen is coated to modify the effective light distribution as required. In theory, this is effective but in practice it introduces troublesome problems. For example, if the coating of the lens has undesirable variations or non uniformities, there may be local areas of the screen that receive insufficient exposure so that the phosphor dots in those areas may not adhere at all, causing the screen to be a reject. As a practical matter, it is found that the dots near the periphery of the screen still may not have adequate exposure and the peripheral portions of the screen may be unacceptable.

It has been proposed that such processing deficiencies be overcome by the practice known as "back exposure." In accordance with this technique, as heretofore carried out, the screen is also uniformly exposed from the side of the faceplate opposite that which bears the phosphor elements. To the extent that this back exposure augments the forward exposure through the mask it may correct such difficulties as the described edge effect but it may also introduce an undesired enlargement of the phosphor dots in the central portion of the screen. It is found that dot size is dependent upon the extent of exposure and the added back exposure may cause an undesired enlargement of certain of the phosphor elements.

Generally, an acceptable exposure of the screen through the mask may be accomplished if the light focused on the screen through the mask is permitted to impinge for a sufficientlly long exposure time. In many screening installations there is no difficulty in meeting this requirement but in others, it introduces further difficulties. For example, in an application of Joseph P. Fiore, Serial No. 391,864, filed concurrently herewith and assigned to the same assignee as the present invention, a screening plant is described which features screening conveyors for coating and other conveyors for exposing the coated screens. The conveyors are of the continuous or endless types and their processing times are interrelated so that work may be fed from one to the next in achieving a highly efficient screening process. This arrangement imposes a distinct limitation on the time allowable for exposure; specifically, the travel time of the conveyor on which the exposure is carried out. Since the exposure time is not necessarily the same for each of the three phosphors, a practical embodiment of the screening plant may find insufficient exposure time for one of the phosphors, especially the red.

Accordingly, it is an object of the invention to provide a process for the screening of cathode-ray tubes which avoids the aforementioned difficulties of the prior art.

It is a specific object of the invention to provide an improved method for screening a color cathode-ray tube.

It is another very particular object of the invention to improve the exposure techniques employed in screening a color cathode-ray tube.

More particularly, the invention has to do with the screening of a cathode-ray tube, having a shadow mask with smaller sized apertures at the periphery than in the center, in accordance with which the screen area of the transparent support is coated with a phosphor material and a photosensitive resist and in which the entirety of the screen area is forwardly exposed, through the shadow mask of the tube, to actinic radiation to which the resist is responsive. In accordance with the invention, there is included in this screening process the step of non-uniformly and backwardly exposing the peripheral portion of the screen area to actinic radiation to which the resist is responsive by projecting actinic radiation through the support upon only the peripheral portion of the screen area.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claim. 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 a plan view of an exposure conveyor for practicing the present invention;

FIGURE 2 is a sectional view taken as indicated by section line **2—2** in FIGURE 1; and

FIGURE 3 is an enlarged detailed view of the principal portions of an individual lighthouse.

Referring now more particularly to FIGURE 1, the arangement there represented is one of the three exposure conveyors which are included in the screening plant described and claimed in the above-identified Fiore application. In that application this apparatus has, for convenience, been called a merry-go-round. It is a circular frame structure **10** which supports on its periphery a plurality of lighthouse carts **11** to drive such carts in the direction of arrow **12** from a loading station identified by the location of cart **13** to an unloading station identified by the location of cart **14**. The travel time of any cart from loading to unloading stations may be devoted to exposing the screen section of a color cathode-ray tube that is being processed.

Structural details of the conveyor, as such, constitute no part of the present invention and are described in the Fiore application. Most of the significant details are shown in the drawings which will be described only briefly.

The frame **20** (FIGURE 2) of the conveyor is supported from the floor and accommodates a vertically extending and centrally located hub **21** from which radiate a number of support arms. Each such arm has an upper structural member **22**, a lower member **23** and interconnecting supports **24**. The lighthouse carts **11** are mechanically connected to the free ends of the frame as indicated in FIGURE 2 so that rotation of the frame transports the carts from the loading to the unloading stations. Movement of the frame and the carts is accomplished by an intermittent or step-by-step drive system **25** of any conventional design coupled through a driving gear system **26** to the rotatable frame.

The details of the exposure carts are also set out in the Fiore application and the significant ones have been illustrated in FIGURE 3 from which it may be seen that each cart has a structural housing **30** with a central aperture over which the screen section **6** of a color cathode ray tube being processed is positioned and supported. Previous to being placed in position on the cart, screen section **6** will have been coated with a composition of phosphor material and a photosensitive resist which may be dichromated polyvinyl alcohol. The resist is normally soluble in water but has the known property that it may be rendered insoluble by being exposed to radiant energy to which it responds, such as ultra-violet light. In order to accomplish selective exposure of the resist, the shadow mask **5** to be assembled with the screen in process is mounted and supported within screen **6** and they collectively are positioned over the aperture of the lighthouse cart. Forward exposure of screen **6** is accomplished by a high intensity arc lamp **35** and a collimator **36** which directs the light of lamp **35** through a lens **37** to the screen-mask subassembly. This is said to be forward exposure in the sense that the impinging light approaches through the shadow mask and in the direction of the free surface of the coating screen **6** bears and distinguishes from so-called back exposure wherein the light reaches the coating by traversing the transparent support surface of screen **6** which bears the phosphor-resist coating. As previously indicated, the desired distribution pattern of the impinging light for forward exposure is achieved by coating lens **37**.

It is essential that the position of light source **35** be selected to simulate the position of the electron gun to be associated with the color phosphor with which screen **6** has been coated and which is subject to exposure in the lighthouse. Adjustment knobs **40** represent the controls by which source **35** may be accurately positioned transversely of the principal axis of the lighthouse cart which extends in a generally vertical direction. It is also desirable to be able to vary the spacing of the light source from the screen-mask subassembly; for that purpose an adjustment **41** has been provided. As described in the Fiore application, rotation of this adjustment causes light source **35** and its whole assembly to move along the principal axis of the lighthouse relative to the stationary frame **30**.

It has been found convenient to have lamp **35** continuously energized and to control the exposure time by means of a movable shutter **43** and a solenoid **44**. The solenoid is actuated through the circuitry of a timer **45** which, when actuated by a starting switch **46**, energizes the solenoid to withdraw the shutter from the optical path between lamp **35** and filter **37**, permitting the light to be focused on the screen-mask subassembly for the interval in which the shutter has exposed the lamp to the optical system. Timer **45** restores the shutter into the light path and terminates exposure after an adjustable period which may be controlled by adjustment **47** of the timer.

There are a variety of necessary services such as power, cooling water and high pressure air supplied to each lighthouse cart through the supporting frame assembly. As shown in FIGURE 2, the central support **21** is hollow and an air line **50** admits air to a manifold **51** through which a line **52** leads to each lighthouse. Through this conduit system high pressure air is directed through a nozzle **53** to light source **35** for cooling purposes and is exhausted through a line **54** which returns to the hollow support **21** and a return high pressure line **55**.

Cooling water is accommodated in an annular trough **60** which is supported from the foundation of the conveyor concentrically with hub **21**. A water pump **61** supported on the rotatable frame has an intake which projects into trough **60**. It delivers cooling water to a manifold **62** feeding a water intake **63** that extends to each lighthouse. The return line **64** discharges into trough **60**.

Power lines **65** also extend upwardly through hub **21** to a commutator **66** from which brushes are able to energize serdvice lines **67** which extend to a service box **68** associated with each lighthouse. The service box is an input to a power supply **69** which develops the necessary D.C. voltage for energizing lamp **35**. As indicated, high pressure air line **52** enters the housing of power supply **69** which, preferably, has a valve arranged to deenergize the power supply circuit unless the high pressure air service is completed and servicing the lighthouse. As thus far described, the individual lighthouse carts and their conveyor are essentially the same as described in the Fiore application although the drive of the exposure conveyor of that application is arranged for continuous rotation of the carts whereas in the instant disclosure the illustrated drive is step-by-step or intermittent although, if desired, it may be continuous.

In practicing the present invention, the cathode-ray tube screen receives not only a forward exposure from light source **35** witihn the lighthouse cart **11** but also a backward exposure from one or more light sources which direct light through the transparent supporting section of screen **6** onto its coating.

As shown, at standard **70** is mounted near the periphery of the conveyor and has a light support **71** which is adjustable through a slot and machine screw coupling to maintain a light source **72** at a desired height with respect to the screen **6** carried by the cart which occupies the processing station under light source **72**. As shown more particularly in FIGURE 3, this light source is arranged to project radiant energy or light in a closed pattern or loop by reason of the fact that light **72** is an ultraviolet fluorescent lamp of circular configuration. A shield **73** of similar configuration encloses the upper portion of light **72** to direct the energy therefrom upon the transperent support of screen section **6**. For the specific arrangement illustrated, light **72** is dimensioned to direct a ring of light on the peripheral portion only of screen section **6** although, depending upon the requirements of the installation, other configurations and locations may be adopted for the light source employed for back exposure. Any conventional energizing circuit (not shown) may be associated with the light which may be energized continuously but rendered effective for short periods by means of a suitable shutter as in the case of a lamp **35** or it may be programmed to come on only for a selected portion of the interval in which a cart is stationed under light source **72** as it is indexed around from loading to unloading stations of the conveyor.

In describing the operation of the illustrated apparatus and also the method of screening contemplated by the invention, it will be assumed that screen section **6** of the cathode-ray tube has received a coating of a phosphor material and a photosensitive resist, this having been accomplished, for example, through the processing steps of the screening conveyor of the Fiore application. The cap section **6** of the tube will have received its mask **5** and will have been delivered as indicated by arrow **80** to loading station **13** of the exposure conveyor **10**. The operator positions the subassembly of mask and screen over the exposure aperture of the lighthouse cart instantaneously at the loading station. Their physical relation is shown in FIGURE 3. When the screen-mask subassembly has been properly positioned and indexed on the lighthouse cart, start button **46** is actuated by the operator which initiates program timer **45** of that particular cart. As a consequence, solenoid **44** is energized and shutter **43** is displaced to permit the entirety of the screen area of cap section **6** to be forwardly exposed with radiant energy from source **35**, this being a radiation to which the resist is responsive in that if the exposure time is adequate the resist becomes insoluble in water.

If the function of light source **72** is neglected momentardily, screen **6** is subject to exposure from light source **35** throughout the major portion of the travel time of cart **30** from its loading to its unloading stations. This travel is of the intermittent or step-by-step variety under the control of driving system **25**. If the intensity of light from source **35** is uniform over the coated screen surface and if the apertures of mask **26** are likewise uniform throughout, there will be a uniform exposure of the coating of cap section **6**. Moreover, if the travel time from unloading to loading stations is sufficient, the desired family of phosphor dots will have been imposed on the screen coating in the form of separated islands of insoluble phosphor-resist material. Subsequent washing of the cap **6** will remove the unexposed portions of the coating and leave these phosphor dots developed as required. This washing may be carried out on the next screening conveyor to which the screen-mask subassembly is delivered as indicated by arrow **81**.

In practice, the apertures of the shadow mask are not of uniform size; they are made of reduced size at the peripheral portions of the mask and this introduces a non-uniform forward exposure pattern. In accordance with the invention, the non-uniformity is fully or partially compensated by the application of back exposure with a non-uniform pattern which substantially complements the non-uniformity of the forward exposure. The back exposure may be accomplished anywhere that is convenient in the processing of the given colored phosphor on screen **6**; it is not critical as to time within the screening process. As illustrated, it takes place during the index time that cart **30** is at the conveyor station which accommodates light source **72**. During this time the screen is subject to non-

uniform backward exposure in that energy from light source **72** is projected upon a selected portion of the cap, a portion which is substantially less than the entirety of the screen area. For the particular non-uniformity under cosideration, it is the peripheral portion of cap **6** that receives back exposure and the exposure time is a minor portion of the time required for the cart to travel from its loading to its unloading stations. The extent of back exposure is controlled so that the total exposure of the peripheral portion, considering the cumulative effect of forward and backward exposures, is sufficient to achieve the same degree of insolubility of all of the phosphor dots or islands required for the screen. Conversely the back exposure of itself should not be of such intensity as to deposit phosphor through insolubilization of the resist in undesirable areas.

In applying this combined forward-backward exposure technique to a screening plant of the type described in the Fiore application where the index interval is of the order 30 seconds, it is usually sufficient to have a back exposure of the order of 5–10 seconds. This is easily attained by equipping light source **72** with its own program timer **82**. Where the index time is of the order of 30 seconds, program unit **82** may operate on the energizing circuit of light **72**; alternatively, this light may be continuously energized and the programmer may operate a shutter to control the duration of back exposure.

Particular consideration has been given to the edge effect in screening but other non-uniformities may also be experienced. As mentioned above, the distribution pattern of light source **35** is controlled by coating lens **37** and if that coating is non-uniform, a non-uniformity of exposure will ensue. By way of illustration, a phenomenon referred to as the "doughnut" effect has ben encountered in which a ring of inadequately exposed dots is found on the tube cap **6**. This effect may be obviated by the use of another light source dimensioned and positioned to introduce back exposure over the area which manifests the undesired doughnut effect. Control of the back exposure time corrects the difficulty and its duration is determined empirically. It is, of course, related to the coating deficiency of lens **37** which gives rise to the doughnut phenomenon.

Other defects in the lens coating may be responsible for the absence of phosphor dots in one or more small areas of tube cap **6**. Any such deficiency may be overcome in accordance with the subject invention through the use of a light source which is positioned and controlled as to pattern to accomplish selective back exposure through the area or areas in question.

Light source **72** has been described as circular in order to correct edge effect in the screen section of a round color tube. This same type of problem may present itself in the fabrication of rectangular color tubes and may be overcome through the same technique of non-uniform back exposure.

Although the description of the back lighting is in terms of producing desired non-uniform exposing patterns, other advantages accrue. Thus lower exposure times becomes possible. Further, it is possible to formulate slurries having more nearly optimum phosphor content since the coating is exposed from both sides and there are no unexposed portions caused by shadowing of phosphor particles. Further, there are fewer rejects for "dot washoff" due to inadequate exposure as this combined exposure eliminates "shadowing."

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 claim is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

In the screening of a cathode-ray tube, having a shadow mask with smaller sized apertures at the periphery than in the center, in which the screen area of a transparent support is coated with a phosphor material and a photosensitive resist and in which the entirety of said screen area is forwardly exposed through said mask to actinic radiation to which said resist is responsive, the step of non-uniformly and backwardly exposing the peripheral portion of said screen area to actinic radiation to which said resist is responsive by projecting said actinic radiation through said support upon only said peripheral portion of said screen area.

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