June 14, 1966 W. S. MILLER 3,256,388

HIGH SPECIFIC INTENSITY LIGHT SOURCE

Filed July 6, 1962 2 Sheets-Sheet 1

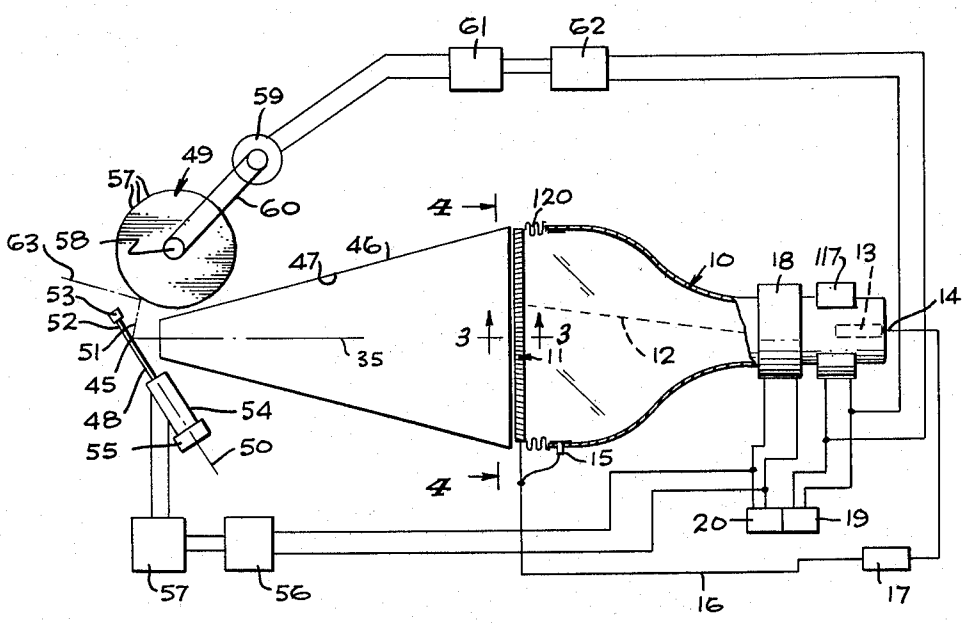



Fig. 1

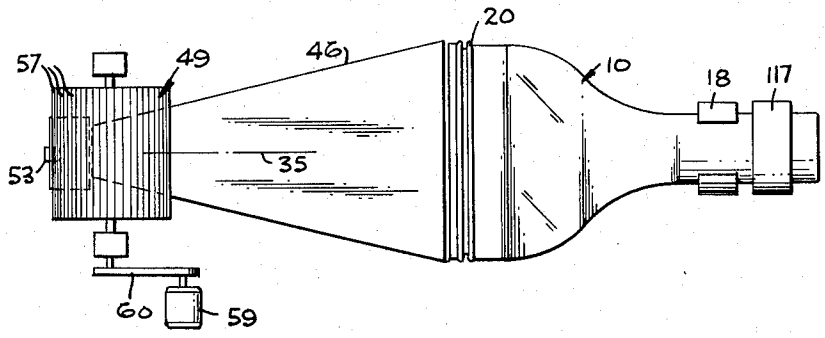



Fig. 2

WENDELL S. MILLER
INVENTOR.

BY William T. Green
ATTORNEY

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Filed July 6, 1962 2 Sheets-Sheet 2

Fig. 3

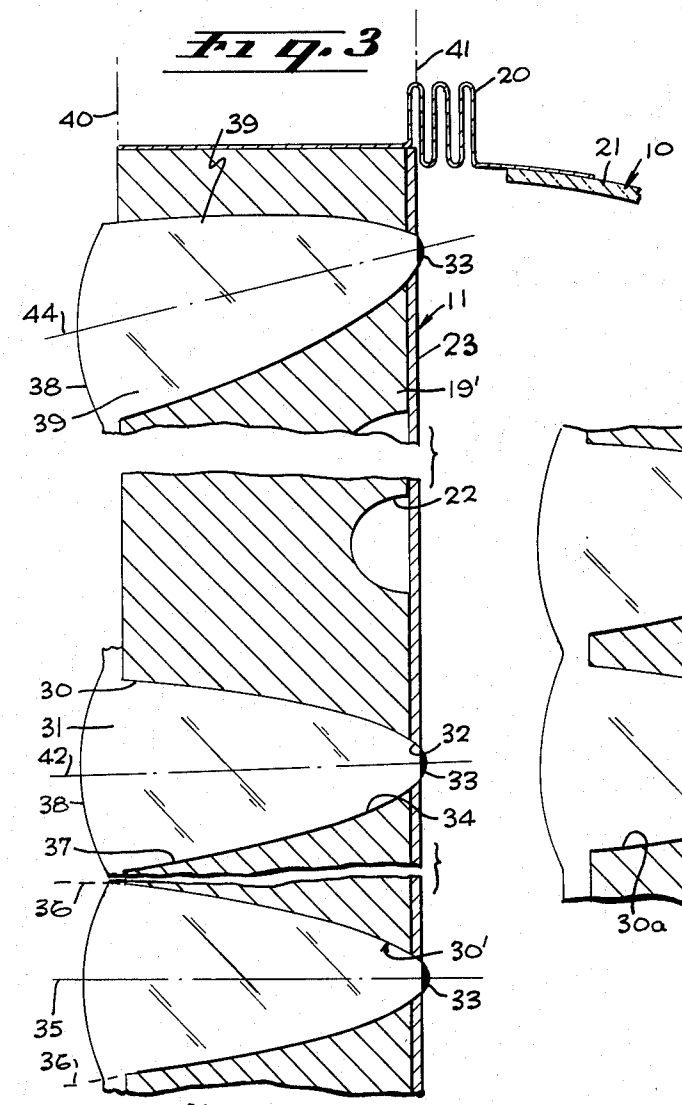
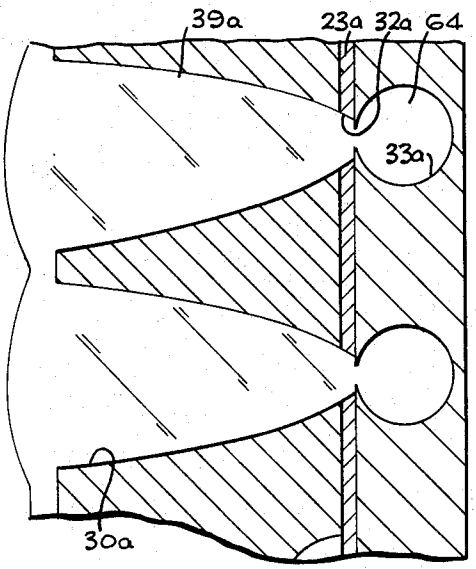



Fig. 5



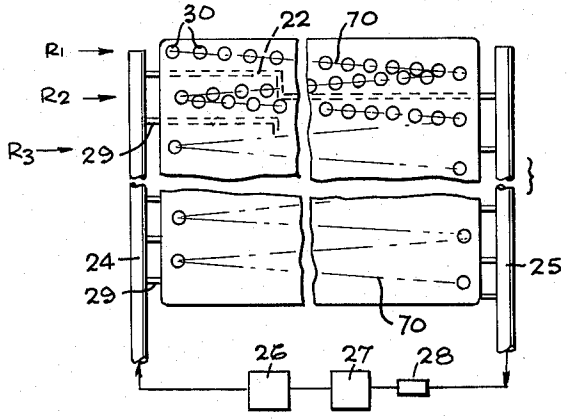




Fig. 4

WENDELL S. MILLER
INVENTOR.

BY William P. Green
ATTORNEY

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3,256,388

# HIGH SPECIFIC INTENSITY LIGHT SOURCE

Wendell S. Miller, 1341 Comstock Ave., Los Angeles, Calif.

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9 Claims. (Cl. 178—7.88)

This invention relates to an improved type of light source, and particularly to a source capable of producing light at a very high intensity. The light may be used for any of numerous different purposes for which a bright light may be desired, one typical use being that of exposing slow photographic papers or film.

It is possible to produce an extremely bright spot of light on the face of a cathode ray tube, by directing an electron beam in the tube against a localized portion of the fluorescent or phosphorescent material in the tube. However, this very bright light can be produced for only a very short period of time, preferably constituting a small fraction of a second, since extended bombarding of the fluorescent material with an electron beam will invariably burn out the fluorescent material. A major object of the present invention is to provide a bright light source which will overcome this disadvantage of cathode ray tubes as a source of intense illumination, and will enable a tube to produce a very bright light continuously without damage to the phosphors.

To attain this result, I cause the electron beam to sequentially impinge against and illuminate a series of different portions of the fluorescent material, and the light output from these various areas is then brought together in a manner such that the different light sources supplement one another and produce an overall beam which may be substantially continuous in operation. While one of the phosphors is illuminated, the others are resting and cooling, so that no single phosphor ever reaches a burn out temperature.

Preferably, the light outputs from the various fluorescent areas are formed into individual beams, which beams may be so directed as to converge toward one another, and desirably toward a single point spaced from the face of the cathode ray tube. The different beams may be formed by individual light directing units, which may consist of reflectors acting to form the light from each of the fluorescent areas into a pencil or bundle of generally parallel rays. Also, the light directing units may include lenses acting to further control the formation and directing of the light beams.

The light directing apparatus preferably includes means acting to direct the different beams from the various fluorescent areas toward positions of closer alignment with one another. In the optimum arrangement, all of the various individual beams are substantially exactly aligned with one another, and are spacially co-extensive in every respect, that is their chief rays coincide and their cross-sectional areas and light distribution patterns are the same, so that there is substantially no variation in the intensity of the light beam in shifting from one phosphor area to another.

To bring the light beams into alignment or coincidence with one another, I may utilize scanning means acting to compensate for the spacing between different ones of the fluorescent areas on the cathode ray tube. These scanning means may include a mirror moving in correspondence with the scanning motion of the electron beam in the cathode ray tube, to eliminate the effect of that electron beam movement. For best results, two such mirrors are employed; one compensating for the vertical scan of the electron beam, and the other compensating for its horizontal scan. One of the two mirrors may oscillate rotatably in opposite directions, while the other mirror may be a multiple face rotating mirror structure.



While the invention is discussed primarily herein as applied to cathode ray tubes, it is contemplated broadly that some of the advantages of the invention may be attained in arrangements in which other types of self luminous screens, such as electroluminescent screens, are employed.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

FIG. 1 is a vertical section through a light source arrangement constructed in accordance with the invention;

FIG. 2 is a plan view of the FIG. 1 apparatus;

FIG. 3 is a greatly enlarged fragmentary generally vertical section through a portion of the face of the cathode ray tube of FIG. 1 taken essentially on line 3—3 of FIG. 1;

FIG. 4 is an enlarged partially diagrammatic section taken on line 4—4 of FIG. 1; and

FIG. 5 is a view similar to FIG. 3, but showing a variational type of light producing face on the cathode ray tube.

Referring first to FIG. 1, I have shown at **10** a cathode ray tube having a transverse end face **11** which is adapted to be illuminated by impingement on that face of an electron beam **12** from an electron gun **13**. The electron beam is produced by the maintenance of a very high difference in electrical potential between the cathode **14** and an anode at the illuminated end of the tube. It is contemplated that this anode may be a conventional anode as represented at **15**, or the face **11** may itself serve as the anode, or both of the elements **11** and **15** may serve together as the anode of the tube, and be connected to the positive side **16** of high voltage power source **17**.

Beam **12** is caused to scan face **11** both horizontally and vertically by the application of appropriate scanning signals to vertical deflection coils **117** and horizontal deflection coils **18**, these signals being supplied by vertical and horizontal signal generators **19** and **20**. The current flowing through coils **117** and **18** from generators **19** and **20** may be such as to cause the electron beam to scan across the rear side of face **11** in a predetermined number of horizontal lines, and to then return to the top of face **11** to repeat the process after the bottom line has been completed. The signal from horizontal deflection signal generator **20** may if desired be a rapid return fly-back type of signal, as in conventional television sets, or, as assumed in the present drawing, may be a sine wave signal, causing the electron beam to scan the tube in both directions horizontally along the zig-zag path represented at **70** in FIG. 4.

The structure of the screen or face **11** will be best understood by reference to FIGS. 1, 3 and 4. Screen **11** includes a main body or plate **19'** which may be formed of metal and which may have the generally rectangular cross-section illustrated in FIG. 4, to extend across the entire front end of tube **10**. At its periphery, plate **19'** may be connected to a bellows **120**, which is in turn cemented or otherwise tightly secured to the front edge portion of the glass wall **21** of tube **10**, in a relation forming an air-tight seal acting to maintain the desired vacuum condition within tube **10**. Bellows **120** is of course sufficiently strong to withstand the pressure differential resulting from this vacuum condition, and for this purpose may be formed of a rather strong metal.

When the screen **11** itself is to serve as the anode, or a portion of the anode, the plate **19'** is rendered electrically conductive, as by forming it of copper or the like, and is connected electrically to anode lead **16**. Also, plate **19'** may be of a highly heat conductive material, so that it may assist in carrying off excess heat developed in the illumination process. Copper of course is also

very desirable for this heat conductive purpose. To carry the heat away from plate **19'**, there may be formed in this plate a series of passages **22**, closed at their rear sides by a cover or rear plate **23**, for conducting a cooling fluid through screen **11**. Cover **23** may also be formed of copper or other suitable highly seat conductive and electrically conductive material, and may be welded, cemented, or otherwise securely bonded to plate **19'**, to maintain the integrity of passages **22**. The passages **22** may extend generally horizontally from one side of screen **11** to the other, and be connected at a first side of the screen to a cooling fluid inlet header **24** (FIG. 4), and be connected at the opposite side to a cooling fluid outlet header **25**. The fluid is forced through the system by a pump **26**, taking suction from a reservoir **27**, to which the fluid returns from header **25** after passing through a cooler **28**. Headers **24** and **25** may be connected to the various fluid passages **22** in the screen by means of small connector tubes **29**.

The plates **19'** and **23** contain several near horizontal rows R–**1**, R–**2**, R–**3** etc. (FIG. 4) of apertures **30** which are shaped to serve as small reflectors acting to direct individual light beams to the left as viewed in FIGS. 1 and 2. Each of these apertures **30** has a relatively large diameter essentially circular light discharge end **31**, and a much smaller generally circular light inlet end **32**. A small spot of phosphorescent material **33** is disposed across the small end **32** of each reflector passage **30**, and acts when bombarded by electron beam **12** to produce light in the associated reflector. The reflectors are desirably of parabolic axial section (see FIG. 3), and have a highly reflective substance coating their inner parabolic surfaces **34** to specularly reflect light emitted from phosphor **33**, and thereby produce individual bundles or pencils of light rays from the different reflectors **30** respectively. For example, the particular reflector designated **30'** in FIG. 3 acts to produce a bundle of approximately parallel light rays centered about an axis or chief ray **35**, and falling within the circular cross-section defined by the lines **36** in FIG. 3. The reflective material coating surfaces **34** may be aluminum, silver, or the like, and is represented at **37** in FIG. 3.

The formation of the light rays from the different reflectors **30** into individual light beams or bundles of rays may be assisted by positioning lenses **38** in front of the discharge ends of the various reflectors. For simplicity of manufacture, these lenses **38** may be all formed of a single piece of molded glass, having the illustrated convex forward lens surfaces acting to assist in preventing divergence of the light rays from the reflectors. The glass plate forming lenses **38** may have integral lugs or projections **39** at its rear side, projecting into and fitting closely within the various reflectors, and carrying the phosphorescent material **33** at the extremities of the lugs. The glass forming plate **38–39** is preferably completely transparent and clear, and may be bonded to the walls **34** of the reflectors by a clear cement capable of forming an effective fluid-tight joint between the glass and the copper of plates **19** and **23** without interfering with the internal reflection within the reflector units. The lens **38** associated with each of the parabolic reflectors **30** is of course centered about the axis of that reflector.

It may be assumed that the reflector designated **30'** in FIG. 3 is the center reflector of the entire screen or face plate **11**. The axis **35** along which the chief ray of the beam produced by reflector **30'** advances may therefore be directly perpendicular to the planes **40** and **41** of the front and rear surfaces of plates **19** and **23**. The reflector just above reflector **30'** is directed slightly downwardly, so that the beam produced by this reflector follows a downwardly inclined axis **42**. The next higher reflector directs its beam downwardly at an even greater angle, and similarly the still higher reflectors direct their beams at progressively increasing angles so that the uppermost reflector has an axis **44** of rather great inclination. In the same way, the reflectors beneath central reflector **30'**, or to the left or right of that reflector are all disposed at angles which progressively increase as the distance from axis **35** increases. The angularity of all the different reflectors **30** is such as to cause all of the beams to focus on a particular predetermined spot **45** spaced from screen **11**. A conical reflector **46**, having an internally aluminized or reflectorized surface **47**, may be disposed about the path of the converging light beams from the different reflectors, to prevent the loss of any stray light from the individual light sources, and assure the ultimate arrival of substantially all of the light energy at the discharge end of cone **46**.

The scanning pattern of electron beam **12** is controlled to cause the beam to first scan horizontally along and illuminate the upper row of phosphors **33**, then scan in the opposite horizontal direction across and sequentially illuminate the second row of phosphors, following which the third row of phosphors are scanned in the first direction, etc.

The converging light beams from the various reflectors **30** are directed by the reflector structure along converging paths and toward a common point **45**, but of course are not aligned axially with one another when they reach that point. In order to bring the beams into such alignment or spacial coincidence, I provide a scanning system acting to compensate for or counteract the scanning motion of the electron beam **12**. This counteracting scanning system may include two mirrors **48** and **49**, acting to compensate for the horizontal and vertical scanning motion respectively of the electron beam. Mirror **48** is a planar specularly reflective element, mounted to rotatably oscillate about an inclined axis **50**, and functioning to direct the light beams from screen **11** upwardly as indicated by the line **51** in FIG. 1. At its upper side, mirror **48** may carry a shaft **52**, which is journaled within a bearing **53** for rotary oscillating movement about axis **50**. The lower side of mirror **48** may be connected to one end of a piezo electric crystal **54**, which is rigidly connected at its opposite end to a stationary frame member **55**, and which is constructed and mounted to operate in a torsion mode, to turn mirror **48** about axis **50** in accordance with the application of electrical energy to crystal **54**. The crystal is energized by a sine wave input signal in timed relation to the energization of horizontal deflection coils **18** of the cathode ray tube, as by providing a timer **56** receiving and responding to a signal from the leads leading to coils **18**, with the timer then controlling the power source **57** which supplies actuating energy to piezo electric crystal **54**. As will be apparent, mirror **48** is turned just sufficiently to always compensate for the extent to which a particular illuminated phosphor is offset laterally from the vertical central plane in which main axis **35** of the apparatus lies, so that the light rays reflected upwardly at **51** by mirror **48** always lie in a common vertical plane, regardless of which reflector **30** may have been the source of the particular beam being reflected at a certain instant. However, mirror **48** does not compensate for the vertical displacement of any particular reflector **30** from axis **35**. To compensate for this vertical scanning of the electron beam, the mirror assembly **49** is shaped to have a number of preferably identical and preferably evenly circularly spaced radially outwardly facing specularly reflective mirror faces **57**, each of which may be planar. As an example, the mirror assembly **49** may present thirty-two such mirror faces. This assembly turns about an axis **58** which may extend generally parallel to the horizontal lines which are scanned by electron beam **12**. The mirror assembly **49** is driven about this axis by a motor **59**, through a timing chain or other drive mechanism typically represented at **60**. The rotation of mirror **49** and its motor **59** are timed to the vertical scanning movement of electron beam **12**, and for this purpose the power source **61** which drives motor **59** may be controlled by a timer **62** which is in turn controlled by the pulses fed to vertical deflec-

tion coils **117** by the vertical signal generator **19**. Preferably, the motor **59** is a synchronous motor to assure accurate timing of the rotation of mirror **49**. The rate of rotation of mirror **49** is such as to exactly compensate for the vertical movement of electron beam **12**, and thereby cause all of the various individual light beams from the different reflectors **30** to be exactly aligned with one another and centered about a common axis **63** as they emit from mirror **49**. Also, the positioning and rate of rotation of mirror **49** are such that, during each complete scan of the entire face of screen **11**, all of the individual light beams produced by that scan will be reflected by a single predetermined one of the mirror faces **57** of assembly **49**. At the completion of that full scan, after the bottom row has been completed by electron beam **12**, the beam returns upwardly to a top row, and at the same time the mirror faces **57** reach a point such that the light beams produced by the next scan will be reflected by the next successive mirror face **57**.

It will be apparent from the above discussion that, when the apparatus of FIGS. 1 through 4 is in operation, the electron beam acts to first sequentially energize and illuminate the various reflectors **30** of top row $R_1$, then scan the second row, etc. At any particular instant, only one of the phosphors is energized by the electron beam, and therefore only one reflector **30** produces a light beam directed toward **45**. At that particular instant, the positioning of mirror **48** compensates for the extent to which the particular phosphor in question is offset laterally from the vertical plane of main axis **35**, and similarly the positioning of mirror **49** compensates for the vertical offset of the phosphor and its reflector from axis **35**, so that the overall result is to cause the particular light beam produced to emit from the apparatus in exact alignment with axis **63**. By the time that the next succesisve phosphor is energized, the mirrors have moved to a position to compensate for the vertical and horizontal offset of that particular phosphor from axis **35**, so that the light beam produced by that phosphor also is aligned with axis **63**. This continues throughout the entire scanning operation, and as a result the light beams all coincide with one another and with axis **63**, to produce a continuous high intensity beam along that axis. In order to assure optimum alignment, it is preferred that the phosphors may be of very low persistence, so that no two phosphors will be illuminated, at least to their maximum intensity, at the same time.

FIG. 5 is a view similar to FIG. 3, but showing a slightly variational form of the invention. In this FIG. 5 arrangement, the glass lugs **39***a* have beads or projections **64** projecting through and beyond apertures **32***a* in rear plate **23***a*, with a continuous layer **33***a* of phosphorescent material being painted on the back side of plate **23***a*, in place of the small spots **33** of such material in FIG. 3. The electron beam then scans across the rear side of phosphorescent material **33***a*, along the different rows of reflectors **30***a*, with the result that when the electron beam is directly behind one of the glass beads **64**, the phosphorescent material surrounding that bead is illuminated, to correspondingly illuminate the bead. More particularly, the space defined by each of the beads **64** functions as a radiation cavity, acting to cause the emission through aperture **32***a* of a maximum intensity of radiation at the frequency at which phosphorescent material **33***a* fluoresces. Thus, the arrangement of FIG. 5 acts under certain circumstances to increase the brightness of the light produced by the assembly.

If a conventional fly-back type of horizontal scanning signal is supplied by generator **20**, instead of the above discussed sine wave signal, the horizontal scanning rows $R_1$, $R_2$, $R_3$ etc. of FIG. 4 then become parallel to one another, and it is desirable in such a case to substitute for oscillating mirror **48** a rotating mirror type of scanning mechanism corresponding to that shown at **49**.

I claim:

**1.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for directing an electron beam against said areas sequentially to excite them to lighted condition, means forming the light from said different areas of said electron excited luminous material into a plurality of different light beams respectively extending in different directions, and means for then directing said different beams toward paths of closer alignment with one another.

**2.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for directing an electron beam against said areas sequentially to excite them to lighted condition, means forming the light from said different areas of said electron excited luminous material into a plurality of different light beams respectively which converge toward one another, and means for then directing said different beams toward paths of closer alignment with one another.

**3.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for directing an electron beam against said areas sequentially to excite them to lighted condition, individual light directing units for said different areas including individual reflectors forming the light from said different areas of said electron excited luminous material into a plurality of individual beams respectively each consisting of a bundle of generally parallel light rays, and a structure of heat conductive material having portions disposed about and between said reflectors.

**4.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for directing an electron beam against said areas sequentially to excite them to lighted condition, individual light directing units for said different areas including individual reflectors forming the light from said different areas of said electron excited luminous material into a plurality of individual beams respectively each consisting of a bundle of generally parallel light rays, and a structure of electrically conductive material having portions disposed about and between said reflectors.

**5.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for directing an electron beam against said areas sequentially to excite them to lighted condition, individual light directing units for said different areas including individual reflectors forming the light from said different areas of said electron excited luminous material into a plurality of individual beams respectively each consisting of a bundle of generally parallel light rays, said reflectors having reduced dimension light inlet ends and larger light discharge ends, and means forming radiation cavities in said luminous material at said inlet ends of the reflectors.

**6.** The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for producing an electron beam and for moving said beam to impinge against said different areas in a predetermined sequence to illuminate them sequentially, and scanning means operable to receive light

extending in different directions from said different areas of said electron excited material and to direct it in generally a predetermined direction and including light directing means and means for shifting said light directing means essentially in timed relation to the movement of said electron beam and in a relation at least partially compensating for the differences in the positions of said luminous areas to direct the light from said different areas in generally said predetermined direction.

7. The combination comprising a cathode ray tube having a face carrying a plurality of different areas of luminous material excitable to an illuminated condition by impingement of an electron beam on said material, said tube including means for producing an electron beam and for moving said beam to impinge against said areas sequentially to illuminate them, means forming the light from said different areas of said electron excited material into a plurality of individual beams respectively which converge toward one another, and scanning means in the path of said converging beams and operable to direct said beams toward alignment with one another and including two power actuated mirrors shifting in essentially timed relation to the operation of said electron beam and in essentially two mutually perpendicular directions respectively to compensate for the differences in the directions in which said converging light beams extend and bring them more into alignment.

8. The combination comprising a luminous screen carrying a plurality of different areas of luminous material excitable to lighted condition, means for sequentially exciting said areas to said lighted condition, means forming the light from said different areas into a plurality of different light beams respectively which converge toward one another, and means for then directing said different beams toward paths of closer alignment with one another.



9. The combination comprising a luminous screen carrying a plurality of different areas of luminous material excitable to lighted condition, means for sequentially exciting said areas to said lighted condition, light directing means for forming light from said areas into different light beams converging toward one another, said light directing means including individual reflectors for said different areas, and lenses coacting with said reflectors to assist in forming said beams.

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DAVID G. REDINBAUGH, *Primary Examiner.*

J. A. O'BRIEN, *Assistant Examiner.*