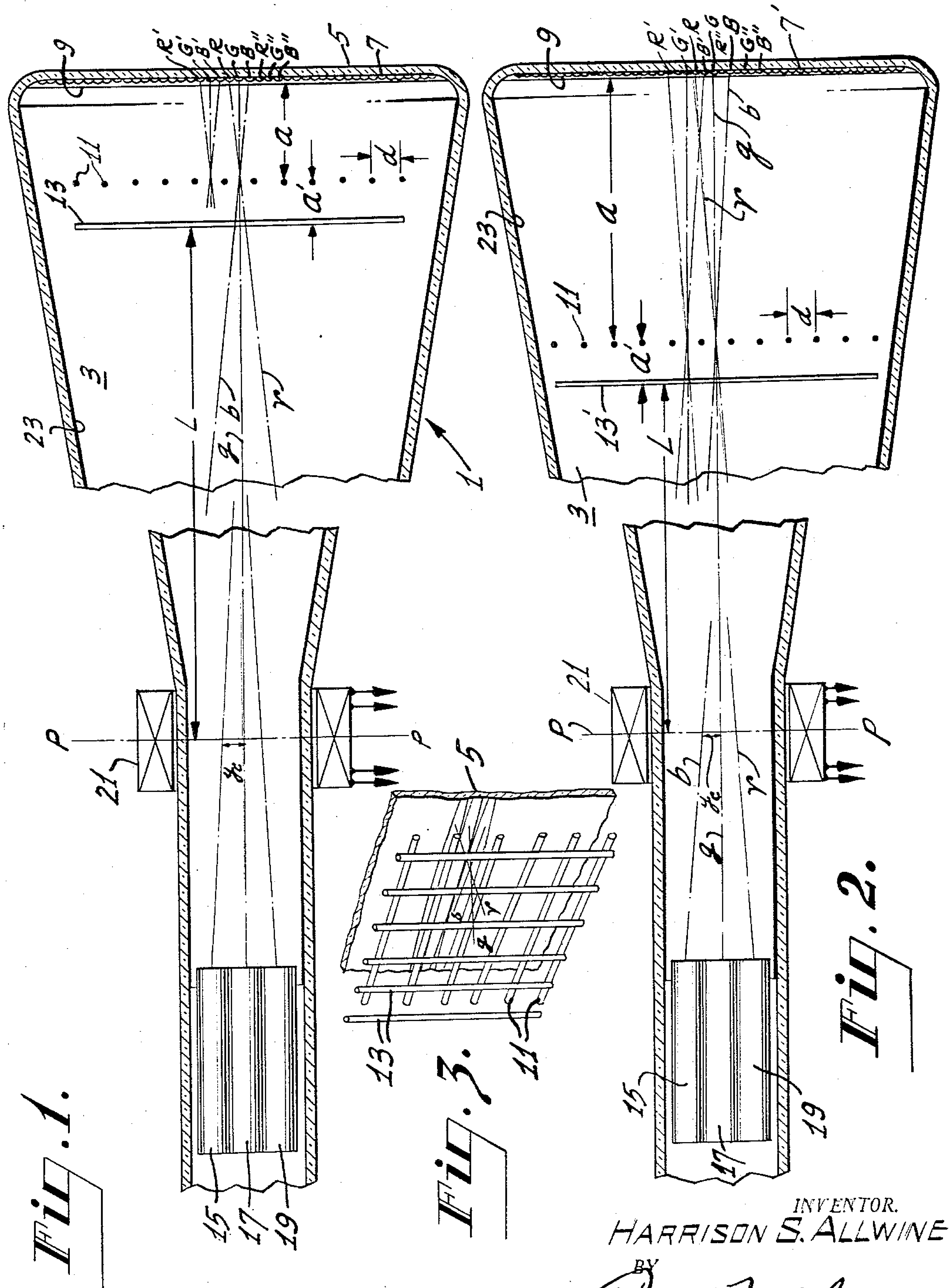
COLOR-KINESCOPES, ETC

Filed Feb. 23, 1956 2 Sheets-Sheet 1



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Sept. 2, 1958 H. S. ALLWINE 2,850,659

COLOR-KINESCOPES, ETC

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Fig. 4.

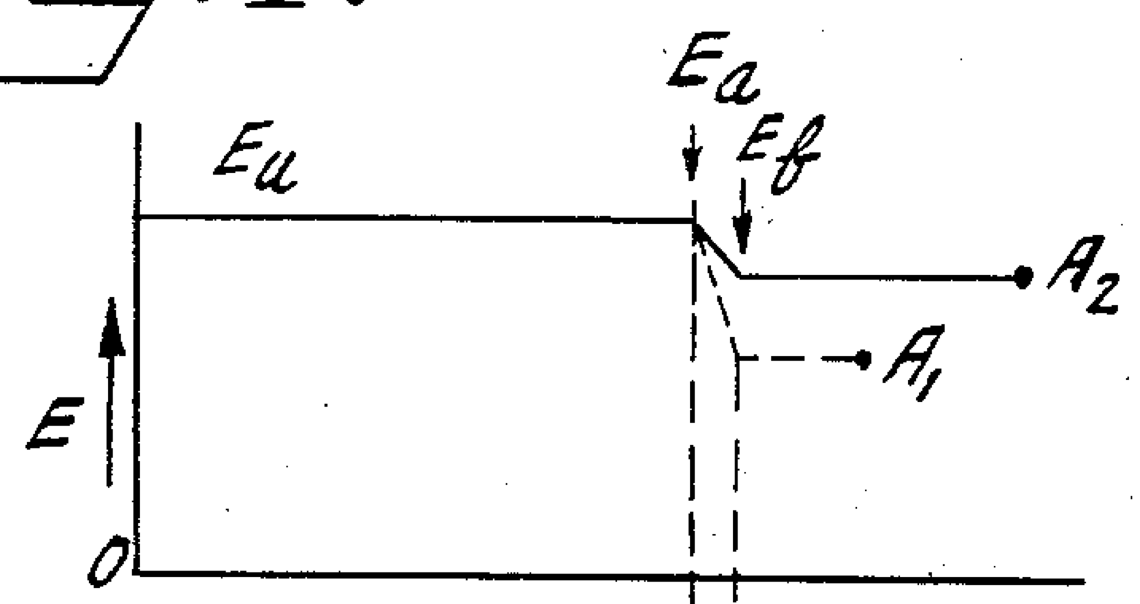


Fig. 5.

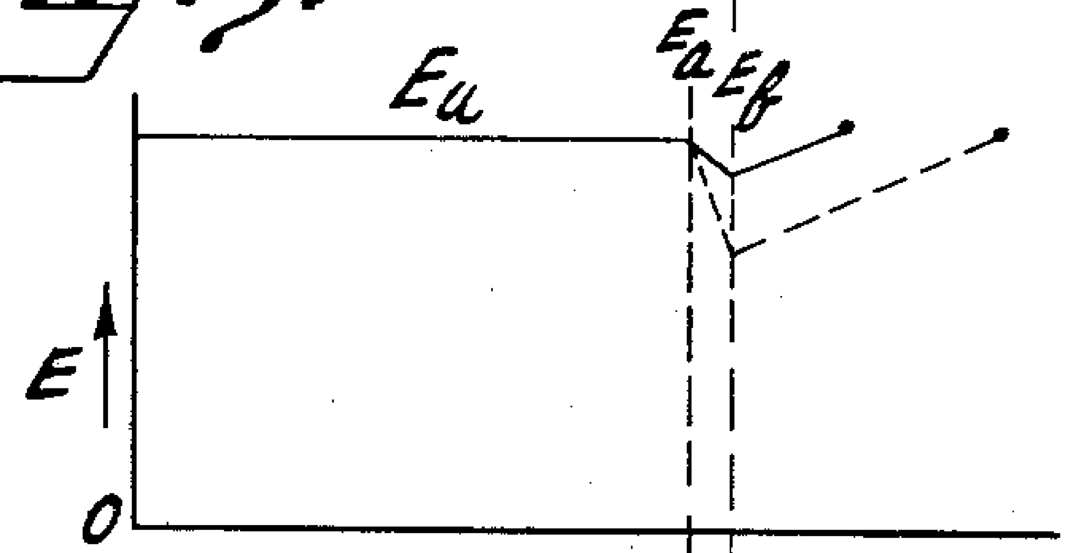


Fig. 6.

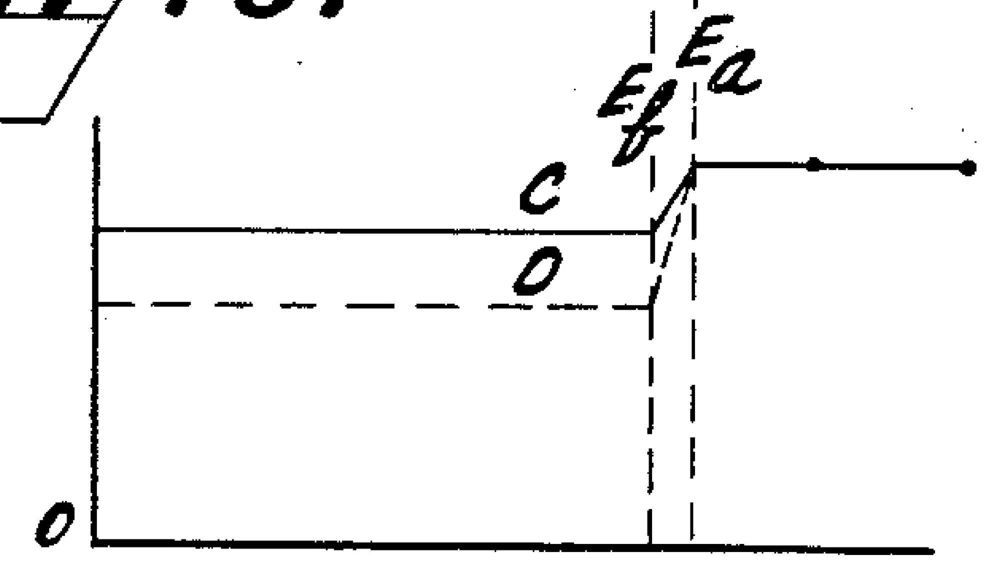
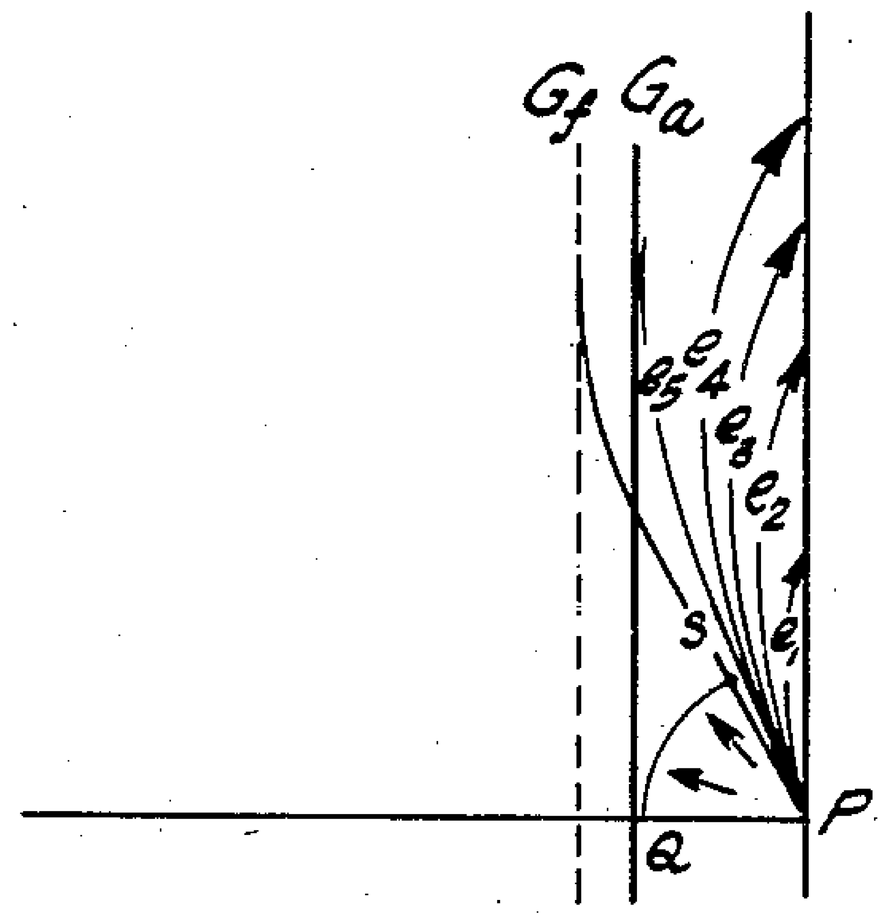


Fig. 7.



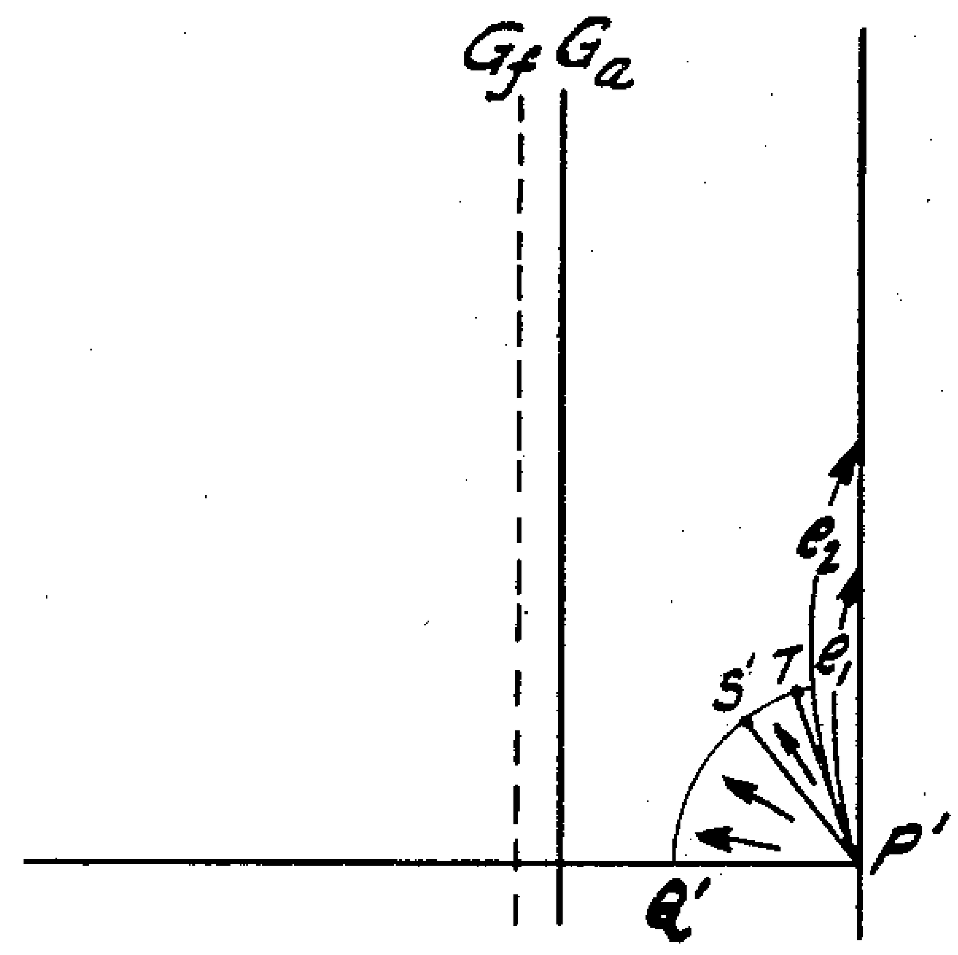
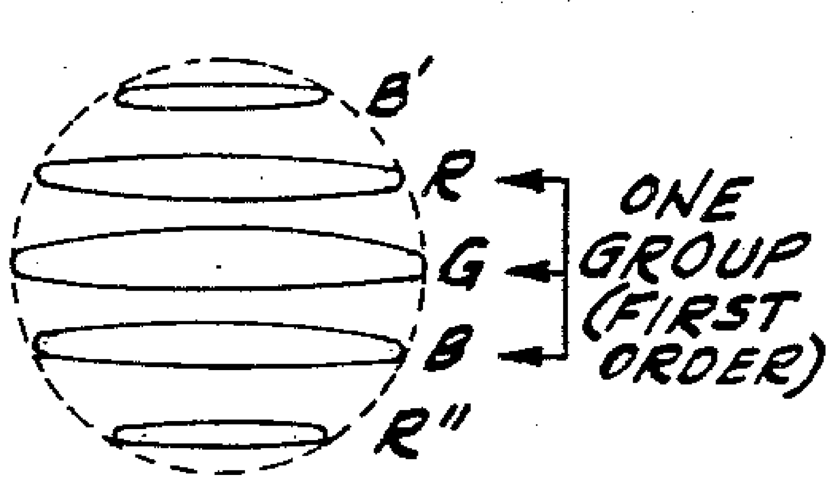


Fig. 8.



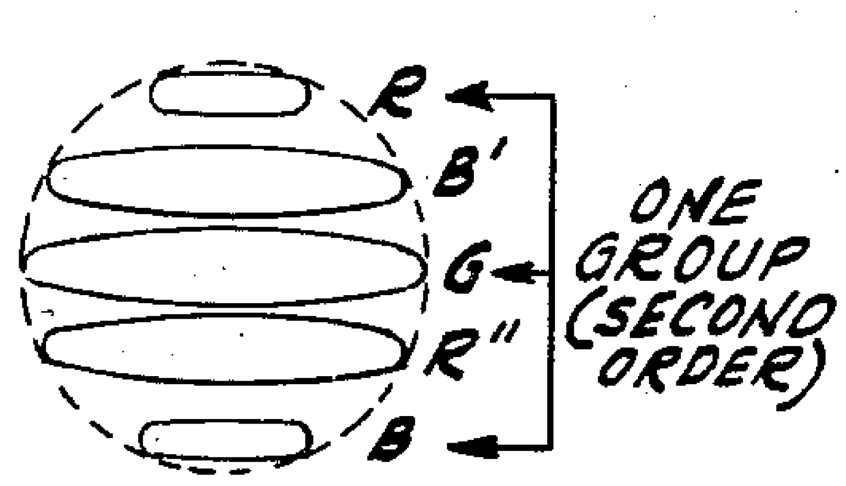


Fig. 9. Fig. 10.

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COLOR-KINESCOPES, ETC.

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Application February 23, 1956, Serial No. 567,177

2 Claims. (Cl. 313—70)

This invention relates to improvements in color-kinescopes and other cathode-ray tubes (e. g. stereoscopic and camera tubes) of the "multi-gun, plural grill, line-screen" variety disclosed by Edward G. Ramberg in U. S. Patent 2,728,024.

The principal object of the invention is to provide an improved picture tube of the general character described, and one characterized by its enhanced brightness and freedom from picture defects. Other objects of the invention are to effect (I) a more efficient utilization of voltages; (II) a more complete dissipation of disturbing "back-scattered" electrons and (III) to minimize grill-wire vibration and thus to permit the use of grill wires of finer gauge and lower tension and, consequently, a reduction in the weight of the frames upon which said wires are strung.

Stated generally, the foregoing and related objects are achieved in accordance with the invention by the provision of a target assembly wherein by reason of a unique ("second order") spacing of the screen-electrode with respect to the separate focusing grills, those parts of the several electron beams which have passed, along converging paths, through a single space in the focus grill now pass along substantially straight diverging paths to non-adjacent color-phosphor lines and are "interlaced" with electrons which have passed through adjacent apertures, and are focused upon non-adjacent screen lines, instead of upon adjacent ones of said lines. The larger grill-to-screen spacing permits the use of a higher potential on the screen, or on the gun, or on both (and hence greater picture brightness) and a smaller difference in potential between the two grills. The reduction in the relative potential of the two grills reduces the intensity of the electric-field therebetween and consequently reduces the tendency of the grill-wires to vibrate. Furthermore, in another embodiment, more fully described in connection with Figs. 7 and 8, the reduction in the relative potential of the two grills results in a reduction in the quantity of back-scattered electrons that are returned to the screen, and in a consequent improvement in contrast.

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

Fig. 1 is a partly diagrammatic longitudinal sectional view of a 3-gun, plural grill, line screen color-kinescope similar to the one shown in perspective in Fig. 1 of Ramberg 2,728,024; this drawing being here included for purposes of comparison in describing the improved tube of the present invention;

Fig. 2 is a similar view of the Ramberg tube, modified in accordance with the present invention;

Fig. 3 is a fragmentary view in perspective of a screen-unit of plural-grill line-screen of the type used in the tube of Fig. 1 and showing the relative arrangement of the wires of the two grills with respect to the color-phosphor lines which comprise the mosaic target surface of the screen of said unit;

Fig. 4 is a diagram showing the voltage distribution

that exists along the axis of the cone portion of the color kinescopes of Figs. 1 and 2;

Fig. 5 is a similar diagram showing the voltage distribution that exists along the axis of another type of plural focusing grill tube, similar in appearance to that in Figs. 1 and 2, but designed to be operated with the phosphor screen at the potential of the auxiliary grill instead of at the potential of the focusing grill.

Fig. 6 is a diagram showing the voltage distribution that exists along the axis of another type of plural focusing grill tube, similar in most respects to the type shown in Figs. 1 and 2, but differing primarily in that the phosphor lines on the screen are parallel with the wires in the grill nearer the gun instead of parallel with those in the grill nearer the screen.

Fig. 7 is a diagram showing the trajectories of some of the back-scattered electrons in the screen unit of a tube having the voltage distribution shown by the broken line in Fig. 5.

Fig. 8 is a diagram similarly showing trajectories of some of the back-scattered electrons in the screen unit of an improved tube having a voltage distribution such as that shown by the solid line in Fig. 5.

Fig. 9 is a diagram illustrating how a small white picture element is synthesized in the prior-art tube of Fig. 1 and

Fig. 10 is a similar view of the synthesization of a white picture element in the tube of the present invention.

The color-kinescope diagrammatically illustrated in Fig. 1 is of the "3-gun, plural focusing-grill line-screen" variety disclosed in the above-mentioned Ramberg patent, and comprises an evacuated envelope **1** having a main chamber **3** in the form of a frustum which terminates at its large end in a window **5** constituting the transparent foundation plate of the target or screen **7** of the kinescope.

The inner surface **7** of the window **5** is provided with a multiplicity of parallelly disposed phosphor lines R (red), G (green) and B (blue) of different color-emissive characteristics, arranged in a repetitive pattern in groups of three. An electron-transparent light-reflecting film **9** constituted, for example, of evaporated aluminum, coats said phosphor lines and renders the entire target surface of the screen conductive.

The other elements of the screen or target assembly comprise two wire grills **11** and **13** mounted in spaced apart parallel relationship in front of the conductive target surface **9** of the screen **7**. The wires of the focusing grill **11** extend substantially parallel to the elemental line-like areas R, G, B on the screen of which line-like areas there are three, one of each color, for each space between adjacent wires in said focusing grill. The wires of the auxiliary grill **13**, on the other hand, extend substantially at right angles with respect to the screen-lines R, G and B.

The beam source of electrons, and the beam-focusing and deflecting means employed for scanning the target assembly **7**, **9**, **11**, **13** include three electron guns **15**, **17**, and **19** which are individual to the three screen colors. The three broken lines, *r*, *g*, *b*, indicate respectively the three individual electron beams. Although the beams are actually separate bundles of electrons, each beam is represented, in the interests of simplicity, merely as a line.

As indicated in Fig. 1, the beams *r*, *g* and *b* approach the target assembly along converging paths and eventually impinge upon separate ones of the color phosphor lines R, G and B, respectively. In operating the tube, as is well understood in the art, the three beams are simultaneously scanned over the target assembly by scanning fields produced by two pairs of deflecting coils contained in a yoke structure **21** on the neck of the tube. Each scanned beam is directed to elemental screen areas of the color to which that beam is allotted by the action of already described focusing grill.

It will be observed that in the color-kinescope shown in Fig. 1, the three phosphor lines R, G and B with a single space between consecutive wires of the focusing grill **11** are disposed adjacent to each other exclusively of any line associated with a different space between wires in the focusing grill. Any three phosphor lines thus associated with a single space in the focusing grill **11** will hereinafter be referred to as a "group." In Fig. 1, therefore, lines R, G, B constitute one group, while above them, lines R′, G′, B′, constitute another group and below them lines R″, G″, B″, constitute still another group. Attention is called to the fact that in this known type of plural focusing-grill tube the electron-guns **15**, **17** and **19** are arranged in inverse order of the color phosphor lines in each group. Thus, where the color-phosphor lines of each group are arranged (reading top to bottom in the view shown) in the sequence R (red), G (green), B (blue) the guns are necessarily arranged in the reverse sequence, namely, B (gun **15**) G (gun **17**) R (gun **19**). This arrangement or "nesting" of the phosphor-lines with respect to each space between the focusing-grill wires and with respect to the order of the (red, blue and green) electron guns will hereinafter occasionally be referred to as "first-order nesting."

Referring now to Fig. 2, there is shown a tube which embodies "second-order nesting" in accordance with the present invention. The tube of Fig. 2 is provided with a tri-color "line" screen here designated **7′**, a focusing grill **11′**, and an auxiliary grill **13′**, and sources for three converging electron beams, *r*, *g*, and *b*. The tube is the same as the tube illustrated in Fig. 1 (except as otherwise specified below), and corresponding parts are identified by the same reference numerals. Referring to the screen **7′** consecutive phosphor strips (e. g., B′, G, R″) are seen now to be arranged in reverse color sequence to Fig. 1 (although the guns are in the same sequence in both Figures 1 and 2). However, these three consecutive strips do not constitute a "group."

The three lines, R, G, B, which do belong to a single group are not in this case arranged consecutively. Instead, they are spread apart farther than in Fig. 1, and in the spaces between them there are now located line B′, belonging to the group above, and line R″, belonging to the group below.

Thus, in this "second-order nesting" each group can be considered as interlaced partly with the group above it and partly with the group below it.

In using the second-order nesting color display arrangement of Fig. 2, the spacing between the focusing grill **11′** and screen **7′** is preferably increased by a factor of approximately 2 (more precisely, 2.3, in this particular "post-decelerated" tube) as compared with the first-order nesting arrangement of Fig. 1. Typical dimensions and voltage ratios are given below for purposes of comparison of the tubes of Figs. 1 and 2. The symbols employed in the drawings and in the following comparative tables, are:

L=distance from the plane-of-deflection (P—P) to the grill nearer the gun end,

a=distance from the phosphor screen to the grill nearer said screen,

a'=distance between grills

d=distance between adjacent wires in the focusing grill

y_c=the off-axis distance of the upper or lower beam axis, measured in the plane-of-deflection.

$\overline{V'}$=higher of the two voltages applied to the two grills.

V=lower of the two voltages applied to the two grills.

(The above notations are the ones used by Ramberg in USP 2,728,024).

One typical set of values for a "post decelerated" tube of this construction using second-order nesting is given below, along with the corresponding values for the conventional tube using first-order nesting, for comparison.

	Second-order	First-order
L, inches	13	13
a', inches	.125	.125
a, inches	1.3	.56
y_c, inches	.18	.18
d, inches	.035	.035
$V/\overline{V'}$, inches	.84	.695

In this case, by using second-order nesting, the voltage efficiency is raised to 84 percent, whereas for first-order nesting it is less than 70 percent—and this gain is achieved with no change in the gun convergence angle, spacing between grills, or fineness (pitch) of the focusing-grill. A typical set of values for a "post-accelerated" tube of this construction (the voltage distribution of which is illustrated in Fig. 6) is as follows:

$$L=13'',\ y_c=.024'',\ d=.035'';\ a'=.125'';\ V/\overline{V'}=.81$$
(second-order); $V/\overline{V'}=.695$ (first-order)

With the above values the optimum spacing, in inches, between focusing grill and phosphor screen for second-order nesting is shown below as a function of the radial distance from the center of the target assembly; for comparison the corresponding values for first-order nesting are shown also:

Inches from center	Second-order	First-order
0	1.30	0.68
2	1.27	.66
4	1.22	.62
6	1.14	.57
8	1.04	.51
10	.94	.45

(Although the phosphor screen is shown as flat in the drawings, the optimum shape is curved, as recognized by Ramberg.)

The correct line pattern image can be obtained using an electron-exposure technique similar to that described by H. B. Law in U. S. Patent 2,727,828.

As a result of the approximately doubled value of "a" the focal length of the cylindrical lenses formed by adjacent wires of the grill **11′** is required to be approximately doubled, and since this means that lenses only half as strong are needed, the voltage difference required for focusing is reduced by about 50 percent, thus reducing by this amount the required voltage between the auxiliary or "collector" grill **13′** and the focusing grill **11′**.

Although there are benefits resulting from the use of the aforementioned second-order nesting in the other varieties of plural focusing grill tube also, the results of its use in the particular tube type shown in Fig. 2 will be described in detail first.

Assuming the top (or "ultor") voltage remains fixed at some value determined by the economics of receiver circuit design, then reducing the voltage difference between grills allows operating focusing grill at a higher voltage (e. g. at 17.5 kv. instead of at 15 kv. Since the phosphor screen is at the same potential as the focusing grill in the type of tube here shown, this results in higher phosphor screen voltage, and therefore higher picture brightness when the tube is constructed so as to use second-order nesting. This is indicated in Fig. 4, where the voltage distribution along the axis of the tube is represented by a solid line for second-order nesting, and, for comparison, by a broken line for a conventional first-order tube.

In this Figure 4, E_u indicates the highest or "ultor" voltage in the tube; E_a indicates the auxiliary grill voltage; E_f the focusing grill voltage. The value A_2 indicates the phosphor screen voltage for a tube using second-order nesting, while the value A_1 is the corresponding voltage for a conventional tube employing first-order nesting.

Reducing the voltage difference between grills results in a reduction in the forces which under some conditions tend to cause grill wires to vibrate and incorrect colors to appear in parts of the screen. This will be understood from the following:

In all economically practical television receivers there is some internal impedance (particularly to low frequencies) in the high voltage supplies. The supply impedance in series with each of the two high voltage leads connected to this tube is a source of some undesired variations in the values of the voltages applied to the tube, because part of the beam current flows through each of the two leads, and the beam current normally is modulated in such a manner that besides having a D. C. (direct current) component it also has an A. C. (alternating current) component, the latter usually including frequencies between 30 cycles and 4 megacycles per second. Shunt capacitance effectively by-passes the high frequencies in this range but it is not uncommon for voltage variations in the range below 1000 cycles per second to appear on these leads as a result of the above; and these voltage variations may easily have an amplitude of 50 or 100 volts or more.

If an appreciable fraction of these voltage variations appears as a component of the difference voltage between the two grills, mechanical vibration of the grill wires can be produced, in a manner analogous to the operation of an electrostatic loudspeaker; and if this occurs, the colors appearing in some parts of the picture are incorrect. If the intended operating conditions for grill-type tubes are such that the electrostatic forces tending to cause vibrations happen to be large, it has been the practice in the past to adopt some severe measures in the design of the tube to minimize such vibrations. These measures may include one or more of the following: use of thicker wire than otherwise desired (resulting in lowered grill transmission and therefore reduced beam efficiency); use of greater wire tension than otherwise desired (necessitating stronger and therefore heavier frames); use of cross-ties, connecting each wire to those adjacent to it (adding to the cost of grill fabrication and sometimes causing shadows of the cross-ties which detract from picture quality). However, when second-order nesting in accordance with this invention is used, such severe measures are not required because, as shown below, the use of second-order nesting results in a large reduction in the forces tending to cause vibration.

It can be shown that the exciting force is proportional to the product of the A. C. and D. C. components of the difference between the two grill voltages, i. e., of the grill difference voltage, indicating that a reduction in either component can effect a similar reduction in the exciting force tending to cause wire vibration.

Since the use of second-order nesting reduces the D. C. component of the grill difference voltage by about 50 percent, it similarly reduces the vibration tendency.

In addition to the benefit gained directly in the manner just described, there is another indirect benefit which can be obtained. By capacitively coupling one grill to the other (as described in co-pending application Serial No. 367,270, filed July 10, 1953) the A. C. component of the grill difference voltage can be reduced, also. If the grills in a conventional tube using first-order nesting are thus coupled, the capacitor must have a rating of 5 kilovolts or more, while if the tube is constructed so it employs second-order nesting in accordance with this invention, the required voltage rating for the capacitor is reduced by 50 percent. If the capacitor is .06 mfd. for instance, this can represent a cost reduction of several dollars, and might make such capacitive coupling (and consequent reduction of A. C. component in grill difference voltage) a practical thing to do, whereas, with the conventional tube using first-order nesting, the capacitor may be considered prohibitively expensive.

By these means, then, both the D. C. and A. C. components of the grill difference voltage can be reduced easily through the use of second- instead of first-order nesting. In this manner a very considerable reduction in vibration tendency is achieved.

This reduced vibration tendency then makes measures referred to earlier unnecessary; that is, with second-order nesting, it is possible to use smaller diameter wires and lighter frames, and eliminate cross-ties, thus permitting a lighter kinescope, and a picture that is brighter and free from cross-tie shadows, and at the same time free from any wire vibration that can cause incorrect colors to appear.

A further indirect benefit from reduced grill difference voltage is reduced leakage current across insulators, and reduced tendency toward field emission of electrons from grill wires, both of which alleviate the voltage regulation problems in the receiver.

Thus far in the description of the advantages of second-order nesting position only the kinescope variety having an axial voltage distribution as shown in Fig. 4 has been considered.

It should be mentioned that all the indirect advantages (e. g. less vibration tendency, thinner wires, lighter frames) of reducing the grill difference voltage are obtained in any one of the varieties of multi-gun plural field-electrode, or "Ramberg kinescopes." The axial voltage distribution for another one of these types is given in Fig. 5, where the various values are labeled in the same manner as in Fig. 4.

If the tube under consideration is the post acceleration variety (to which Fig. 6 refers), then the benefits of designing the tube to employ second-order nesting are somewhat different from those already described in detail for the post deceleration variety. Also, the factor of increase in spacing between focusing grill and phosphor screen is different, being about 1.9 instead of 2.3. If, as before, it is assumed the top or ultor voltage remains fixed by receiver design considerations, then in the post acceleration kinescope the use of second- instead of first-order nesting allows the cone 23 of the tube to be operated a higher voltage. This permits the electron guns to operate more efficiently—either to give higher beam current, or to give the same amount in a narrower beam. If the former is chosen, brighter pictures result; if the latter, the result can be either higher resolution in the picture, or greater color purity tolerance, or both. In actual practice the benefit obtained is usually distributed among all three of these items, so a small improvement is obtained in each.

In this post acceleration variety of double grill color kinescope the contrast is already considerably better than in a simple post acceleration tube of the Flechsig type, because the larger fraction of back-scattered electrons pass through the grills and do not return to the phosphor screen, and because the low velocity secondary electrons released from the focusing grill are accelerated to a velocity so small (e. g. 5 kv.), they dissipate most of their energy in the aluminum film covering the phosphor.

However, when second- instead of first-order nesting is employed in this tube, the contrast is improved still more.

This is because the number of back-scattered electrons returning to the phosphor screen is reduced still more, and their average velocity component perpendicular to the screen is also reduced; also because the low velocity secondaries released from the focusing grill are in this case accelerated by (for example) only 2.5 kv. instead of 5 kv.

This is made more clear by reference to Figs. 7 and 8.

In Fig. 7 the primary beam in a double grill type kinescope strikes the phosphor screen at point P, emitting high velocity secondary electrons (or reflected primary electrons) in all directions. For simplification only those back-scattered electrons traveling in a vertical plane which passes through the tube axis are considered; and for further simplification only the half of these which have an upward velocity component are represented in the diagram.

It can be seen that the paths of many of these lie within the sector PQS and have a horizontal velocity component great enough that the 5 kv. field between the grills is insufficient to make them reverse direction. Most of them therefore pass through the auxiliary grill, G_a, and are collected by the focusing grill G_f, or by the cone (not shown). Paths of some other back-scattered electrons, having horizontal velocity components corresponding to 4, 3, 2 and 1 kilovolt are represented, respectively, by the lines e_4, e_3, e_2, and e_1. These are turned back by the field between the grills and strike the phosphor screen, reducing the contrast somewhat (though not nearly so much as it is reduced in a simple post acceleration tube such as shown in Flechsig's French Patent 866,065, in which nearly all the back-scattered electrons are returned to the screen).

By reference to Fig. 8 the improvement possible through use of second-order nesting can be shown. In this case, the field between the grills is only half as great as for the case represented in Fig. 7, and therefore the only back-scattered electrons which can be returned to the phosphor screen are those having horizontal velocity components of under 2.5 kilovolts, for example (such as those having paths indicated by lines e_2 and e_1). The electrons having paths which would have corresponded to lines e_3 and e_4 in Fig. 7 are, in the case represented by Fig. 8, included in the large sector P'Q'T', the extension from S' to T' representing the improvement gained by the use of second-order nesting.

The convergence angles and beam paths, as shown in Figs. 1 and 2, are represented in agreement with common practice; that is, in general, when descriptions are given of multi-color tubes having directional screens, the diagrams show the beams as if converged in the plane of the focusing grill (or shadow mask, in the case of the tube using that kind of structure).

In actual operation, however, the convergence is adjusted while the operator watches the image on the screen. The bundle of electrons from each gun, even after passing through the focusing grill (or shadow mask) is so shaped that a cylindrical sheath can be visualized as circumscribing all parts of the bundle. That cylindrical sheath intersects the phosphor screen in a circle, and when proper convergence adjustments have been made, the circles enclosing the three bundles (at the screen) are superimposed.

This is indicated in Fig. 9, in which is shown the appearance (under magnification) of a "white" picture dot on the screen of a conventional double grill tube. The lines B', R, G, B, R'' correspond respectively to the similar lines B', R, G, B, R'' in Fig. 1. The circles circumscribing the three bundles coincide, and so appear as one circle, shown as a broken line.

In Fig. 10 is shown a similar "white" picture dot as it appears on the screen of a tube using second-order nesting. The lines R, B', G, R'', B correspond respectively to the similar lines R, B', G, R'', B in Fig. 2. Again the three circles representing the envelopes of the three bundles of electrons (one from each gun) coincide, and so appear as one circle. This is because the operator adjusting convergence has a control which allows him to achieve this condition, and achieving it is simply the routine method of adjusting the receiver. It is not obvious at first that this is the way these tubes operate. However, it is an important point, because it explains why interlacing the "groups" of lines as described earlier in connection with Fig. 2, introduces no greater resolution limitations than are present when conventional first-order (or non-interlaced group arrangement) is used. It is because in either case the actual convergence takes place in the plane of the phosphor screen (not in the plane of the focusing grill as usually represented for convenience); that is, the axes of the three bundles, one from each gun, intersect in the plane of the phosphor screen.

What is claimed is:

1. In a 3-gun tri-color kinescope of the plural grill line-screen variety wherein the color-phosphor lines are disposed on the screen in a repetitive pattern and each gun is individual to a particular color, the improvement which comprises: (I) the arrangement of said guns in the same order as the color-phosphor lines of which said repetitive screen-pattern is comprised and (II) a gun-to-grill and grill-to-screen spacing such that the electrons passing along converging paths from said guns to a common aperture in one of said grills pass in substantially straight diverging paths to non-adjacent ones of the color-phosphor lines on said screen.

2. A color-kinescope comprising a screen-electrode having a multiplicity of groups of color-phosphor lines of different color-response characteristics arranged in a repetitive pattern on the target surface thereof, a plurality of electron-guns mounted in a position to scan said target surface, the electron-beam from each of said guns being individual to a particular color and said guns being arranged in the same order as the color-lines of which said groups are comprised, a plurality of parallel-wire grills mounted in spaced relationship in the path of beam-electrons from said guns with the wires of one of said grills extending substantially at right angles to said color-phosphor lines and the wires of another of said grills arranged substantially parallel to said lines and defining the boundaries of as many apertures as there are groups of lines, the spacing of said guns with respect to said grills and the spacing of said screen with respect to said another of said grills being such that said electron-beams in passing along converging paths from said guns to a common aperture in said last mentioned grill pass in substantially straight diverging paths to non-adjacent color-phosphor lines in adjacent ones of said groups.

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