# United States Patent [19]

**Galves et al.**

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[54] **CATHODE RAY TUBE SCREEN HAVING BOTH SHORT AND LONG PERSISTENCE PHOSPHORS**


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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **313/473;** 313/466

[51] **Int. Cl.**[2] ..... **H01J 29/26;** H01J 29/30

[58] **Field of Search** ..... 313/473, 470



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[57] **ABSTRACT**

In cathode-ray tubes utilising screens with a luminescent layer made up of two kinds of phosphors having different spectra, one having virtually no remanence (1), and the other being of remanent kind (2), with switching of the voltage between two values, low and high, the second phosphor only being excited at the high value, due to the presence of a barrier B, in order to prevent the unwanted flash of different colour, produced by the non-remanent phosphor at the instant of appearance of the remanent trace, the invention provides for the addition to the aforementioned two constituents, of a third non-remanent phosphor (3) equipped with a barrier B and having a spectrum such that the superimposition of the flash which it yields at high voltage, and that yielded by the phosphor (1), produces the colour corresponding to the phosphor (2). Application to radars using real and synthetic video signals.


**3 Claims, 4 Drawing Figures**

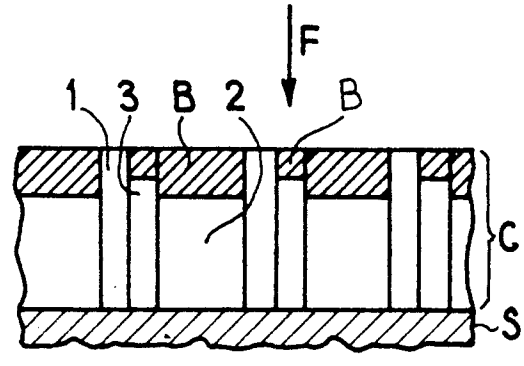


FIG. 1

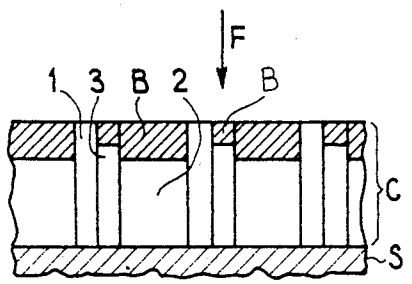



FIG. 3

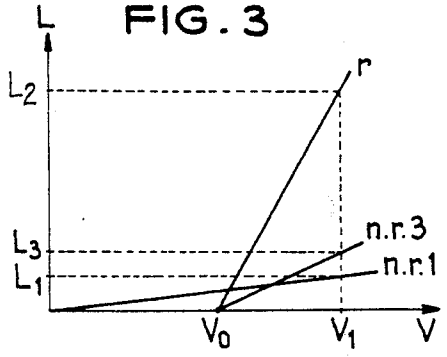



FIG. 4

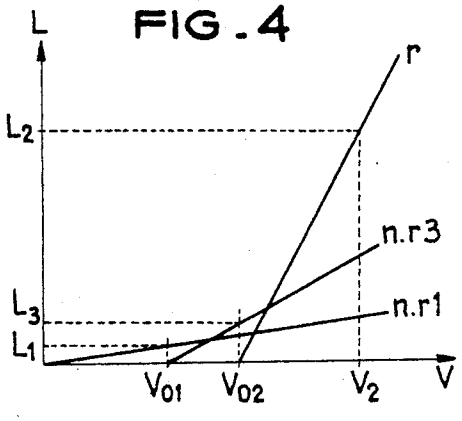
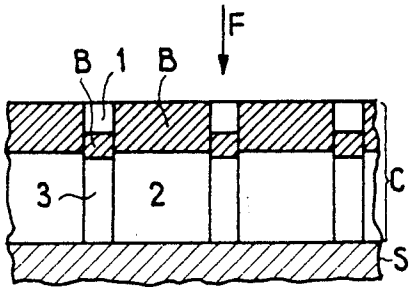



FIG. 2



# CATHODE RAY TUBE SCREEN HAVING BOTH SHORT AND LONG PERSISTENCE PHOSPHORS

The present invention relates to cathode-ray tubes. It relates more particularly to tubes of that kind which are designed for the simultaneous display of two pieces of information in different colours and with different persistences.

Before describing the arrangements proposed in accordance with the invention for the attainment of this end, by way of example reference will be made to one of the applications of tubes of this kind, namely the application to PPI type radars using simultaneous display of a synthetic piece of information originating outside the radar, and the information collected by the radar itself, without any possibility of confusion between one and the other kind of information.

Generally speaking, to this end cathode-ray tubes are employed which comprise a screen the luminescent layer of which is made up of kinds of phosphors having different remanences and different spectra, that is to say kinds of phosphors whose light traces at the location of electron impact have different colours and different decay times, and, among these kinds of phosphors, in particular those whose decay time can be controlled by means of the acceleration voltage applied to the electrons. Screens of this kind are known from the prior art, in particular from the U.K. Patent Specification No. 1,303,749.

As explained in this patent, by making the luminescent layer of the screen of a mixture of two kinds of phosphors, one having virtually no remanence at all and the other having a not insubstantial degree of remanence, several seconds for example, and protected by a barrier layer (that is to say a layer which does not luminesce under the effect of electron bombardment), it is possible, by a mere variation of the accelerating voltage applied to the electrons, to achieve degrees of persistence on the part of the light trace produced on the screen, which are variable from a value of virtually zero. If, moreover, the two kinds of phosphors have different spectra, the colours of the two traces will differ from one another. If the accelerating voltage is low, the trace produced in the colour of the kind of phosphor which has no remanence, will be the only one excited at said voltage; if the voltage is high, the trace will effectively have the colour of the kind of phosphor which possesses the remanence property

Thus, using screens of this kind which are known from the art described in the aforementioned Patent, the problem referred to earlier, namely that of two-colour display, is resolved, while this is the problem which the present invention is supposed to seek to solve.

From the foregoing, it would sem sufficient to vary the voltage applied to the tube in order to obtain the desired two-colour display. By periodically switching the voltage between two values, one low and the other high, one would think that it would be possible to achieve the desired different colours and persistences.

In reality, however, this problem is not properly resolved when certain other particular conditions are imposed, as for instance in the cited example, namely that of a PPI radar screen which utilizes simultaneous display of another piece of information on the same screen.



In order to provide a more concrete idea of what is involved here, we shall discuss the example, the conditions pertaining to which have been specified hereinbefore.

The screen of the cathode-ray tube is supplied with two pieces of information, that coming from the radar, or in other words the real video information, and that coming from an outside source, which we shall refer to as the synthetic video information and which consists for example of various symbols, beacons, vectors, etc. These two kinds of information are recorded on the tube in the form of light traces produced by the impact upon the screen of electrons forming part of the beam issuing from the electron-gun of the cathode-ray tube.

The radar screen, in its turn, operates in the PPI mode for example (plan position indicator mode) with the following characteristics:

one complete revolution in a certain number of seconds, 5 seconds for example, and a scan time on the part of each radius, of 1/**1000** of a second; the radar emits pulses of 1 microsecond duration, every millisecond.

As far as the external information is concerned, this is displayed upon the screen of the tube in accordance with another scanning function, known random scanning, in respect of which it is sufficient to say that it takes place at a frequency of 50 Hz for example, that is to say at a rate of one complete scan of the screen every 20 milliseconds. This frequency is sufficiently high to give the impression of a signal in which there is no flicker.

This being the case, low voltage pulses, at the preceding low voltage of 10 kv, for example, are applied to the beam during a small fraction of the aforesaid time of 20 miliseconds. This voltage is nothing more than the potential on the anode of the tube or the conductive layer of the luminescent screen, the potential of the gun cathode being taken as the reference. During each of these pulses the screen is fully scanned in accordance with the random scanning function, the latter being repeated, as already mentioned, every fiftieth of a second and there being recorded upon the screen, in the form of a light trace, synthetic video information.

In respect of this voltage value the light trace on a screen having two kinds of phosphors, such as the screens of the prior art disclosed in the said Patent, has the colour of the non-remanent kind of phosphor, this being the only one excited at the voltage in question.

The precise duration of these pulses will not be specified since it has no real bearing upon the invention. The pulses, in accordance with what has been stated earlier, are spaced at around 20 millisecond intervals, the duration of each pulse, as already mentioned, being only a small fraction of the 20 millisecond interval. Throughout the whole of the time separating two successive pulses, the aforementioned high voltage, 18 kv for example, is applied to the beam, during said time only the PPI radar scan being operative; it is during this time that there are produced upon the screen real video data from the radar, these persisting upon the screen following electron impact, for several seconds for example, as specified earlier on.

At this voltage, the high voltage, the two kinds of phosphors compounds, the non-remanent one and the remanent one equipped with its barrier, are both excited, each in accordance with the colour of its own

spectrum, green for instance for the non-remanent one and orange, for example, for the remanent one.

Consequently, in the PPI display the observer will successively see two traces, one green and the other orange. Of course, ephemeral might well be imagined that the ephermal nature of the non-remanent kind of phosphorus, whose persistence is virtually zero, would mean that this trace would not in effect be seen by the eye of the observer and that all that would in fact be perceived would be a kind of mean between the colours of the remanent and the non-remanent traces.

The situation is in reality quite different, for a reason associated with the fundamental nature of the phosphors, and this reason is in fact stated hereinafter: when a cathodoluminescent substance such as the kinds of phosphors in question here, that is to say a substance which is capable of emitting visible radiation under the effect of electron bombardment, is subjected to the impact of an electron beam, at the location of said impact it exhibits a light spot whose brilliance increases for a certain time during the impact. This increase is the faster the less the remanence of the substance and is incomparably faster in the case of non-remanent substances than it is in the case of remanent substances. This is why even the non-remanent, ephemeral trace, is perceived by the eye of the observer, the very high brilliance which it reaches extremely quickly during the electron impact time making it preponderant, despite its short persistence, over the remanent trace.

Thus, the true video information (PPI) and the synthetic video information, can be effectively displayed, using a screen with two different kinds of phosphors as described in the prior art referred to hereinbefore, the said kinds of phosphors producing different colours, by a suitable choice of the spectra of the two kinds of phosphors; although the trace corresponding to the true video information will, at the instant of its appearance on the screen and for a short time thereafter, have a colour identical to that of the synthetic video information; thus, each orange trace corresponding to the PPI scan function, will be preceded by a kind of green flash. This is more generally referred to as a "flash" phenomenon. The presence of this kind of flash is extremely undesirable from the observer's point of view not because of the confusion which it might produce between the traces corresponding to the two scanning functions, but because of the rapid alternation between the perceptions of the two different colours with which the observer is confronted.

The object of the invention relates to cathode-ray tubes in which this drawback is avoided.

This result is achieved by the use of a third kind of phosphor in order to form the luminescent layer of the screens of these tubes, as described in detail hereinafter.

In order to achieve this result the invention provides for the luminescent layer of the screens of cathode-ray tubes to consist of three kinds of phosphors having different spectra, two of which possess barriers in the sense intended in accordance with the earlier description, this under the conditions specified hereinafter, with the help of the attached figures in which:

FIGS. **1** and **2** illustrate two variant embodiments of the luminescent layer used in the screens in accordance with the invention.

FIGS. **3** and **4** are diagrams corresponding to two cases of operation of screens in accordance with the invention.

To the two constituents **1** and **2** of the prior art screens described in the aforementioned patent, there is added, in the case of the screens in accordance with the invention the third element shown by **3** in the figures. In these FIGS. **1** and **2** respectively illustrate the kind of phosphor which has virtually no remanence, and the remanent phosphor, whilst B signifies the barrier associated with the remanent phosphor and defined in the aforementioned patent, in respect of which barrier it is known, from said patent, that it plays the essential part in the creation of the variable remanence effect. This part will be recapitulated here:

under the impact of the electrons of the beam, a light trace is produced in the remanent phosphor **2** only if the voltage applied to the electron beam is higher than a given value, $V_o$ in the case of operation in accordance with FIG. **3**, due to the presence of the barrier B (that is the cross-hatched surface) which the electrons can only completely cross before they reach the phosphor **2**, if the voltage applied to them is in excess of said value. If the voltage V rises beyond $V_o$, remanence whose duration varies in accordance with V is obtained by reason of the relative disposition of the straight lines $r$ and $nr_1$ which respectively, as a function of V, represent the luminances L of the beam traces on the remanent phosphor **2** and on the non-remanent phosphor **1**, this disposition being such that the fraction of the overall luminance of the trace appearing on the screen, at the point of impact of the beam, which is due to the remanent phosphor, varies in accordance with said voltage.

In the screens of the tubes in accordance with the present invention, the luminescent layer comprises, as FIGS. **1** and **2** show, a third component **3** consisting of a kind of phosphor which likewise has virtually no remanence, associated with a barrier B as in the case of the phosphor **2** The straight line $nr_3$ represents, in the diagrams of FIGS. **3** and **4**, the luminance of said third phosphor equipped with its barrier.

By way of a schematic illustration, in the figures the three constituents of the luminescent layer C of the screens, the substrate having been marked S, have been shown side by side, with the barrier B superimposed upon the kinds of phosphors with which it is associated, at the side at which the electron beam, illustrated by the arrow F, is incident. This is purely a schematic illustration designed to simplify understanding and covering all the possible arrangments compatible with the technology of these screens, and, in particular, the arrangement in which the phosphors components are mixed with one another, the barrier-equipped kinds of phosphors in this case being completely coated by their barriers. All these arrangements, which are equivalent with one another, are considered as having been illustrated in the schematic arrangements adopted in FIGS. **1** and **2**. This being so, when the low voltage, less than $V_0$ in the case illustrated by the example of FIG. **3**, is applied to the beam, that is to say when the random scanning operation corresponding to the synthetic video information is being carried out, only the non-remanent phosphor **1** produces a light trace, for example green as assumed earlier. When the high voltage, in excess of $V_0$, is applied to the beam during PPI scanning of the real video information ($V_0$, as in the case of

the example of FIGS. 1 and 3, being the voltage which is just sufficient for the electrons to pass through the whole of the barrier B associated with the non-remanent phosphor 3) there then appears upon the screen a trace in the colour which corresponds to the phosphor 3, this being superimposed upon the colour produced by the phosphor 1 which, at this voltage, is also excited, a fortiori. Thus, at this voltage the flash will have a colour which is the resultant of the superimposition of the preceding green and the colour of the non-remanent phosphor 3. The light trace due to the remanent phosphor 2, which also appears in the examples of FIGS. 1 and 3 at the foregoing voltage $V_0$, will have the colour of the remanent phosphor 2, that is to say orange as assumed earlier.

By a suitable choice of the spectrum of the phosphor 3 and the conditions of mixing of the kinds of phosphors 1, 2 and 3, with the cathode-ray tubes of the invention a flash is obtained, the colour of which, due to the superimposition of the spectra of the kinds of phosphors 1 and 3 is substantially the same as that of the remanent trace due to the phosphor 2; taking the colours green and orange referred to earlier, a phosphor 3 will be chosen which produces a red.

Thus, the unwanted flash effect during PPI scanning is suppressed.

It should be borne in mind of course that the choice of the phosphor 3 and of its associated barrier, for given kinds of phosphors 1 and 2 (and the associated barrier), is subject to a number of conditions.

First of all, as already mentioned, the spectrum of the phosphor 3 should be chosen so that superimposition of the spectra of the kinds of phosphors 1 and 3 yields substantially the same colour as that produced in accordance with the spectrum of the phosphor 2.

However, in choosing these spectra, account should also be taken of the "rise" characteristics of each of the kinds of phosphors 1 nd 3, that is to say of the law governing the rise in the luminance of the light trace appearing in respect of each of them at the time of impact of the electrons, commencing from the instant at which said impact takes place.

In the case of the two-remanent kinds of phosphors, as for example those 1 and 3, these rises, which are extremely steep as has been stated earlier, do not necessarily follow the same law; the law depends upon the nature of each of the kinds of phosphors.

Account must be taken, furthermore, of the times during which these luminances are maintained, these times being very short in the case of the non-remanent kinds of phosphors but not being strictly zero and not necessarily being the same for the two kinds of phosphors. These two considerations are determinative as far as the colour of the flash and its intensity are concerned.

For a given low voltage $V_0$, the value of the high operating voltage $V_1$ (FIG. 3) also has an effect, this voltage corresponding with the luminances $L_1$, $L_2$, $L_3$ of the traces produced by the three kinds of phosphors, as indicated in the diagram of FIG. 3.

Similarly, the thicknesses of the barriers associated with each of the kinds of phosphors 2 and 3 have a part to play, these barriers, generally made of the same material, having been uniformly illustrated in the drawings by the letter B and by the cross-hatched areas. A wide variety of these materials are known in the art of luminescent screens.

In the case where the thicknesses of the barriers differ, operation is in accordance with the diagram of FIG. 4.

This diagram is similar to that of FIG. 3. $V_{01}$ and $V_{02}$ are the values of the voltage V beyond which excitation of the phosphor 3 and the phosphor 2, respectively, takes place. In this case, for a voltage V ranging between $V_{01}$ and $V_{02}$, there is obtained, moreover, a non-remanent trace of a colour intermediate between those of the traces of the non-remanent kinds of phosphors 1 and 3, yellow in the case of the colours cited in the preceding example. $V_2$ is the operating high voltage.

Finally, of course, the proportions of each of the kinds of phosphors 1, 2 and 3, in the luminescent layer C, play a part. All these parameters are determinative as far as the final result is concerned.

FIG. 2 pertains to another example of the invention in which the non-remanent phosphor 1 covers the non-remanent phosphor 3 and the barrier B associated with the latter.

In the case of this example, the non-remanent phosphor 1 to some extent plays the part of a barrier vis-a-vis the phosphor.

In one example, a mixture of two non-remanent phosphor powders, red and green, was produced, both carrying the Jedec P.22 references, Jedec being a publication of the "Electron Tube Council", with a third powder of a remanent orange phosphorus, carrying the reference P.26 corresponding to the same document; all these powders had a grain size in the order of 5 to 20 microns. The two non-remanent kinds of phosphors were used in proportions of between 20 and 30% by weight, in the mixture.

The grains of the non-remanent red phosphor 3, as well as those of the remanent phosphor 2, were coated with a barrier layer of non-luminescent material, around 1 micron in thickness. The green phosphor had no such barrier.

The screens were operated at 10 and 18 kilovolts and at beam currents which could be in excess of 500 microamps.

The invention is not limited to the application described hereinbefore, which latter was given purely by way of example.

What is claimed is:

1. A cathode-ray tube with an electron gun; a screen whose luminescent coating comprises two kinds of phosphors; one having no persistence, on which an electron beam, at the location of its impact, produces a light trace of given spectrum which disappears virtually as soon as said impact appears; and the other having a certain persistence, upon which said trace, having a spectrum differing from that of the preceding one, remains visible for a certain time after said impact, and being equipped with an inert barrier producing no light trace under the effect of such an impact; said screen producing a persistent trace if a voltage accelerating the electrons of the beam is higher than the value necessary for said excite to cross said barrier and exicte luminescence in the persistent phosphor, and a non-persistent trace in respect of any voltage lower than said value, characterized in that said coating further comprises a third non-persistent kind of phosphor equipped with a barrier, the latter being such that said third phosphor is also excited when the voltage exceeds said value, its spectrum, superimposed upon that of the other non-persistent phosphor, yielding a colour sub-

stantially the same as that of the persistent phosphors, so that the light trace appearing on the screen at the location of impact of the beam, when the voltage exceeds said value and due to the two non-persistent kinds of phosphors, accordingly presents a colour substantially the same as that due to the persistent phosphor thus avoiding the flash effect, that is to say the appearance of a flash of a different colour preceding the appearance of the persistent trace of the screen.

**2.** A cathode-ray tube as claimed in claim **1,** characterised in that said luminescent coating consists of the three kinds of phosphors, said barriers completely covering each of said kinds of phosphors to which they are applied.

**3.** A cathode-ray tube as claimed in claim **1,** characterised in that said luminescent coating consists of the said three kinds of phosphors, said barriers completely covering each of said kinds of phosphors to which they are applied; and in that the non-persistent phosphor which has no barrier, completely covers the barrier of the other non-persistent phosphor.

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