The Skiatron or Dark Trace Tube

and its Applications

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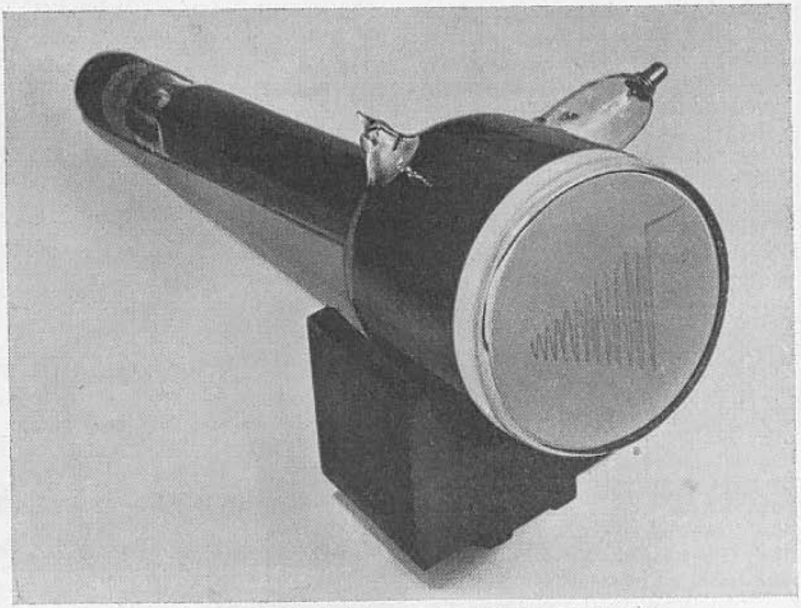

Fig. 6. British dark trace tube with trace on screen

DR. A. H. ROSENTHAL, of the Scophony Laboratories, suggested in 1938,[1] the use of a new kind of cathode-ray tube for television reception, or in general for short duration recording of electrical signals. In this tube the ordinary fluorescent screen is replaced by a screen consisting of alkali-halide crystals, which become darkened under electron bombardment.[2]

The effect of this tube is based on electron opacity and it was discovered in the early days of cathode-ray research, *i.e.*, in 1894 by E. Goldstein,[3] that various alkali-halide crystals, if subjected to cathode rays, become intensely coloured.

R. W. Pohl[4] investigated the effect further and recently Mott and Gurney[5] also made a detailed study of the behaviour of alkali-halides under electron bombardment.

The reader is referred to these references for detailed information on this effect; here the author is only attempting to convey a simple picture of what might be taking place.

If a thin layer of alkali-halide crystals is bombarded with electrons, some electrons are displaced from the halides and secondaries are produced. These free electrons take up position in the faults of the crystal lattice and they vibrate at frequencies corresponding to certain wavelengths of the visible light spectrum. This vibration, of course, causes absorption of this wavelength, the result of which is a dark trace on the originally semi-transparent crystal layer. The colour of this is the complementary colour of the absorption.

The wavelength of absorption depends on the material used, the most common being potassium chloride. The absorption of this is in the green region of the visible spectrum, therefore the dark trace appears as a magenta colour; in other materials such as potassium bromide the absorption occurs more in the bluish range of the spectrum, and the trace is brownish. In sodium chloride the trace is of a more orange colour.

If the screen on which this trace is formed is irradiated intensely with light or heat rays or both, due to the absorption of further energy by the electrons, they leave the "holes" and tend to revert to their original position, forming again the alkali-halide with the full number of electrons, therefore the dark trace disappears.

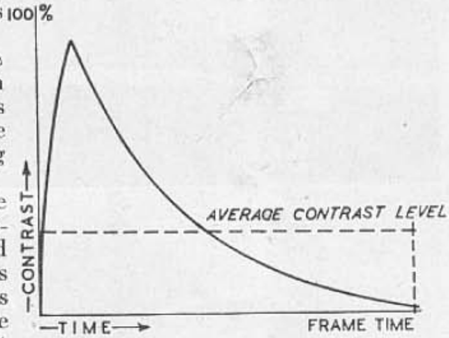

Fig. 1. Fading characteristics of trace during television frame time

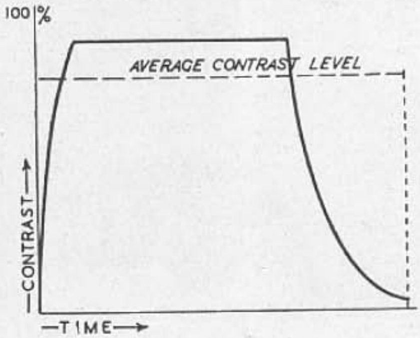

Fig. 2. Ideal fading characteristics

Before the War, Dr. Rosenthal succeeded in showing a television image received on a "Skiatron" tube, of the standard 405-line interlaced television transmission of the B.B.C., although the picture was not quite satisfactory. It was recognised at that time that much work would be required to achieve the necessary perfection. Unfortunately work on this application had to be interrupted due to the War intervening, since at the commencement of hostilities television transmissions in England ceased. The images received were not satisfactory mainly because of insufficient contrast. This was due to the fact that the trace remained on the screen too long, and disappeared only gradually. The time of disappearance of the trace is a function of the amount of the original discolouration, darker traces requiring a longer time, and to prevent blurring of successive pictures (which were transmitted at the rate of 25 pictures per second) it was necessary to limit the darkening to very faint traces.

Further, the contrast is weak in the picture because the dark discolouration dies away according to

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approximately an exponential function and, of course, the human eye during one picture frame sees the integrated effect over the frame scanning time. Due to the fact that a dark trace is produced which fades away gradually, the contrast in the received picture is very low (*see* Fig. 1).

However, this initial experiment proved that tubes of this description using extraneous illumination should be capable of providing sufficient screen illumination even for large projection.

The question then remained to find ways and means of producing the required contrast for television work. At the same time it was also recognised that the method showed great promise for applications where it would not be necessary for the trace to disappear at a quick rate as in television, say in 1/25 or 1/50 second. Indeed, it was often a great advantage for the trace to remain on the screen for a considerable time in applications where single indications were required.

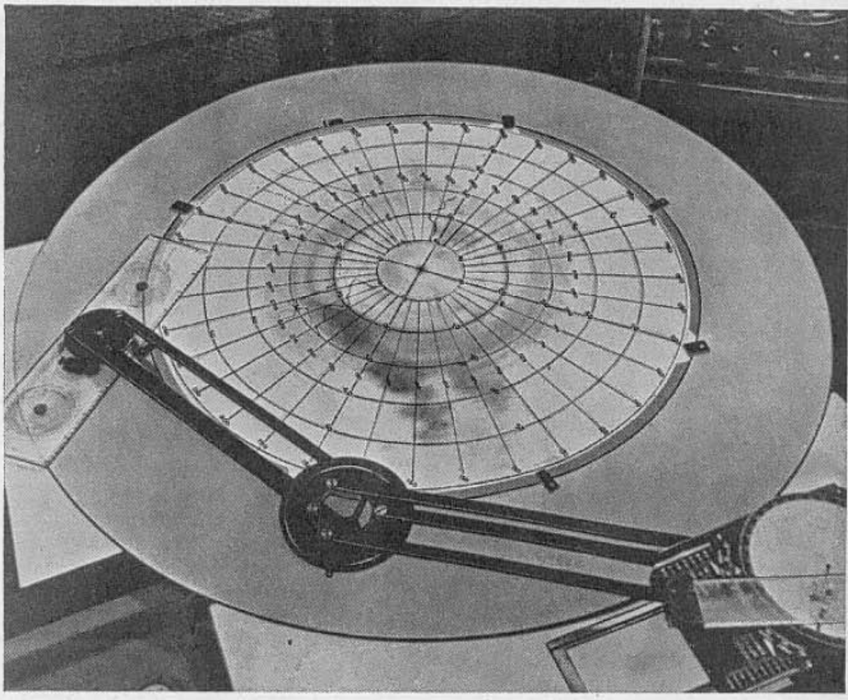

Fig. 4. Screen of the plan position indicator with dark trace tube

The ideal shape of the time curve of the discolouration would be a square shape curve as illustrated in Fig. 2, in which case the trace could remain on the screen with full contrast for the desired length of time, and then it would be erased quickly after the required time. Due to the fact that, as mentioned above, heat and light are essential for the erasure, a certain amount of time must elapse to bring it about. In some cases it is necessary for the screen to reach a temperature, say, of a few hundred degrees centigrade.

During the War in England, and in other countries as well, this tube was used exclusively for P.P.I. work and small and large screen direct view and projected type P.P.I. instruments have been designed and constructed for indicating reflected radar signals from ships, aircraft or any objects reflecting the radar impulses.

It was found that for this purpose it was a great advantage that the signals remained on the screen for a considerable length of time. The obvious advantages of the tube in this application are, of course, that the display can be seen on the tube directly in bright ambient illumination. Further, it was possible to produce large screen projected

Fig. 3. Large screen plan position indicator with "Skiatron" tube, as used by the Admiralty

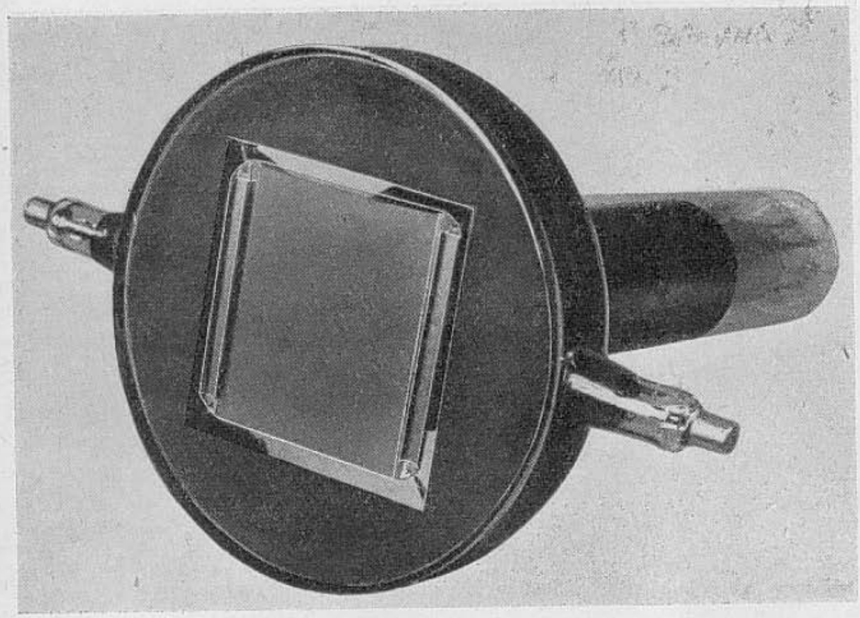

Fig. 5. Dark trace tube developed in Germany

images of the P.P.I. display where many observers were able to watch the display simultaneously. These advantages, apart from the fact that the trace remains for a considerable time on the screen, are of great importance.

Figs. 3 and 4 show the equipment developed and used by the Admiralty for this purpose, these tubes being irradiated with heat and light for cancellation of the trace.[5] Parallel developments have taken place on the same idea in Germany where tubes of similar description were used in various radar equipments

The tubes developed and made in Germany approached to a greater degree, the ideal shape of the time curve of the discoloration because heat was directly applied to the halide screen to cancel the trace. The method was as follows: On a thin sheet of mica a thin layer of tungsten film was deposited, thin enough to be transparent to visible light, but at the same time electrically conductive. The tube was not heated normally during the recording, but only when it was desired to cancel the trace was a current passed through the tungsten film which heated up quickly, thereby producing a temperature rise in the alkali halide. According to the German specification it was possible to achieve erasure, even of a very dark trace, between 5 and 10 seconds.

Fig. 5 shows a tube of this nature made in Germany by Telefunken. The metal caps on the sides of the tube provide connexion to the tungsten film.

Possible Applications for "Skiatron"

Most of the possible applications of the dark trace tube are self-evident, but generally they fall into two categories. For research and engineering applications the tube can be used as an oscilloscope to provide short time recording of transient non-recurring electrical phenomena. This is shown in Fig. 6 which illustrates the British tube made during the War for radar applications with a trace of a damped 25-cycle wave.

The tube provides immediately a visible record which can be kept on the screen until erased and examined in detail at leisure. This record can, of course, be traced on paper or photographed with a simple camera. In transient recording equipment with fluorescent screen great care has to be taken to synchronise the camera shutter to the electrical phenomena. High speed lenses and films are required, therefore the advantages of the use of the "Skiatron" electron-opacity tube for transient recording are obvious. For most of the applications it was found that direct observations were sufficient.

The "Skiatron" large screen P.P.I. used during the War for aircraft tracking purposes, appears to have found its way into post-war civil aviation and according to the All-Weather Flying Centre[6] at Wilmington, Ohio, a large screen "Skiatron" will be an essential part of the equipment of an aerodrome control installation. The track of every aircraft within a radius of 50 miles round the aerodrome will be recorded by a search "Skiatron" projector indicating the track of the aircraft to the controllers.

There are other applications which are, of course, essentially the same as those for transient recording, which come into the field of facsimile transmission and reception, or instantaneous recording of a single frame television image.

The speed of operation not being limited in any way by the inertia of the facsimile scanning mechanism, provided a sufficient bandwidth is available for the transmission, high definition images can be transmitted and received considerably quicker than with the present-day methods.

For television applications, although the electron opacity is very attractive, insofar that practically unlimited screen illumination can be achieved, the length of time required to erase the picture and the lack of contrast due to the exponential decay of the dark trace, excludes the use of this method at present. Further research is necessary to ascertain whether a method of erasure quick enough for television is possible, or alternatively if the contrast can be increased by other methods. Work is going on in both directions.

The author would like to express his thanks to the Admiralty for the photographs showing the large screen P.P.I. as used during the War.

References

1 British Patents Nos. 513,776; 514,155; 514,776.

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5 "Electronic Process in Ionic Crystals."

6 Hotz., R. B.: "Radar Traffic Control System developed at All-weather Center," *Aviation News*, Feb. 3, 1947 (Transport Section).