FLAT TV TUBE

New design offers greater simplification for color; greater compactness for black-and-white

By ERIC LESLIE

THE picture-on-the-wall TV tube, predicted by several authorities in the field, has at last reached the advanced laboratory stage. Developed in England, it has been produced only in continuously pumped tubes up to the present time though work to produce sealed-off models is now in progress. The new tube is expected to have several advantages other than compactness, especially as a color tube.

Invented by Dr. D. Gabor of London, American patent applications were made as early as 1952 though Dr. Gabor described his invention for the first time only in October, 1956. Work on the project has been carried on at the Imperial College of Science and Technology (London) for the last three years, and patent rights in the tube have been assigned to the National Research Development Corp. For this reason it is often referred to as the NRDC tube.

(Another flat cathode-ray tube, invented by W. Ross Aiken of the Kaiser Aircraft & Electronics Corp., Oakland, Calif., differs somewhat in details but is so similar to the Gabor tube in fundamentals that Kaiser and NRDC have pooled their flat-tube patents in a world-wide agreement.)

In this discussion terms like front, back, top and bottom refer strictly to the picture-on-the-wall. It is necessary to keep this in mind since the tube is bound to be compared subconsciously with more conventional types, and confusion can result because some things in this model are not where they might be expected to be. For example, the phosphor screen is on the front or face, but the electron gun assembly projects its beams downward near the back, parallel to the face instead of toward it as in conventional tubes. See Fig. 1.

The flat tube, which may be only 4.5 inches deep (front-to-back) for a 21-inch screen, is divided internally into two still flatter portions by a magnetic screen or shield (Figs. 1, 2). Behind this screen is the electron gun(s) and some of the deflecting equipment; ahead of it the phosphor screen, the shadow mask (in color tubes) and the *vertical scanning array*, a most important feature.

The electron-gun assembly is mounted at the top rear center and sends the beam directly downward through acceleration and focusing elements (Figs. 1, 2). It passes through the x-axis or horizontal (line) deflection plates (deflection is electrostatic in this tube) and then through two sets of trimmer plates, which compensate for any misalignment.

Next the beam comes to one of the two most important and interesting features of the new tube, the *reversing lens*. Shown probably most clearly in Fig. 1, it is a combination of electrodes that turns the beam around at the bottom of the tube and starts it upward again at the front, between the vertical scanning array and the phosphor screen. The reversing lens is made up of a *repeller*, which actually turns the beam, at cathode potential, and *side* and *central electrodes*, at ultor potential. The lens not only reverses the beam but increases the horizontal deflection angle as much as four times. Thus flat TV tubes may be made with a deflection angle between 110° and 120°, a figure previously unheard-of in electrostatic-deflection tubes and only now being approached by magnetic types. The lens also compensates for the over-focusing inherent in electrostatic-deflection tubes so that the beam remains in perfect focus throughout the length of the horizontal line scan. The beam is further trimmed and straightened to the vertical by an electromagnetic lens or *magnetic collimator*.

The vertical scanning array

Now we have a beam scanning horizontally the full width of the tube, but with no control of vertical deflection.

Left to itself, it would simply trace a line along the inside top of the tube. What is needed is some influence to stop it at a given height and bend it forward to strike the face. The same influence should draw the spot from top to bottom during each field, then permit it to snap back to the top of the frame at each vertical retrace period.

The element that does this is like nothing else that has ever been put into a picture tube. It consists of a sheet of insulating material on which horizontal conducting lines are printed. These lines are connected electrically to absolutely nothing in the tube. This sheet is mounted ahead of the magnetic screen, about ⅛ inch away from it, and its ends are folded around into a pair of loops (Fig. 3) so that the spot can be made to strike the conducting lines at the end of each scan. The lines are tipped upward at the ends—as shown in the figure—as they reach the end folds. In the Gabor tube the conducting lines are rather numerous (about 120) but the number is not critical nor is it related in any way to the number of horizontal scanning lines.

(The Kaiser tube is said to have a scanning array of only seven conductors, energized externally by seven special tubes.)

The phosphor screen on the faceplate of the tube is maintained at or near the ultor voltage. If all the conducting lines of the scanning array were equally positive, the scanning beam would rise without any deflecting effect—it would be traveling in an equipotential field. If, however, the first few top conducting lines of the array were made negative, the beam would find a negative field above and behind it and a highly positive one (the phosphor screen) ahead of it. The beam would be bent sharply forward. This is what actually happens and lower lines are made negative progressively—as we shall see in the next paragraph—so that a negative wave sweeps down the array, with only a few conducting lines forming a boundary region (called the *transition area*) between positive and negative portions of the array. At the end of each field it is necessary to charge all the conducting lines to a high potential again, so the beam is able to reach the top of the tube to start scanning the next field. Strange as it may seem, the opposite functions of charging and discharging the electrically isolated scanning array are both performed by the scanning beam.

How it's done

It will be convenient to start at the beginning of a field, when the whole scanning array is positive, without troubling ourselves at the moment to ask how it got that way. The beam rises to the top of the tube and is deflected forward by a conducting strip at the top of the deflecting array, maintained at cathode potential (Fig. 3). It is also focused by the focusing action of the strong electrostatic deflection. Just after each line flyback, at the beginning of the scan, the spot is held momentarily inside the left fold of the scanning array. The beam strikes the upward-slanted top lines and supplies electrons to them. This makes the top few lines of the array more negative and tends to push the beam down. The staggered-upward design in the end loops causes each successive scan to make the upper lines more negative and to contact lower lines as the beam is forced further down. Thus the whole array becomes progressively negative. By adjusting the beam strength, the time required to make the scan travel from top to bottom of the tube can be made that of a field (1/60 second in the American system of television).

At the end of each field the beam is held in the fold at the *right* end of the array during the period of vertical

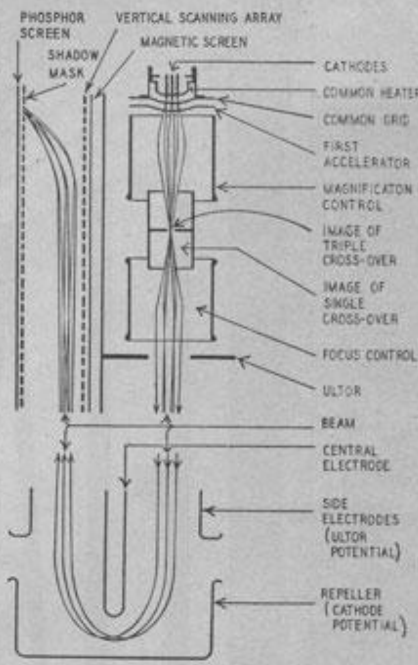

Fig. 1—The reversing lens shows up clearly in this cross-section view.

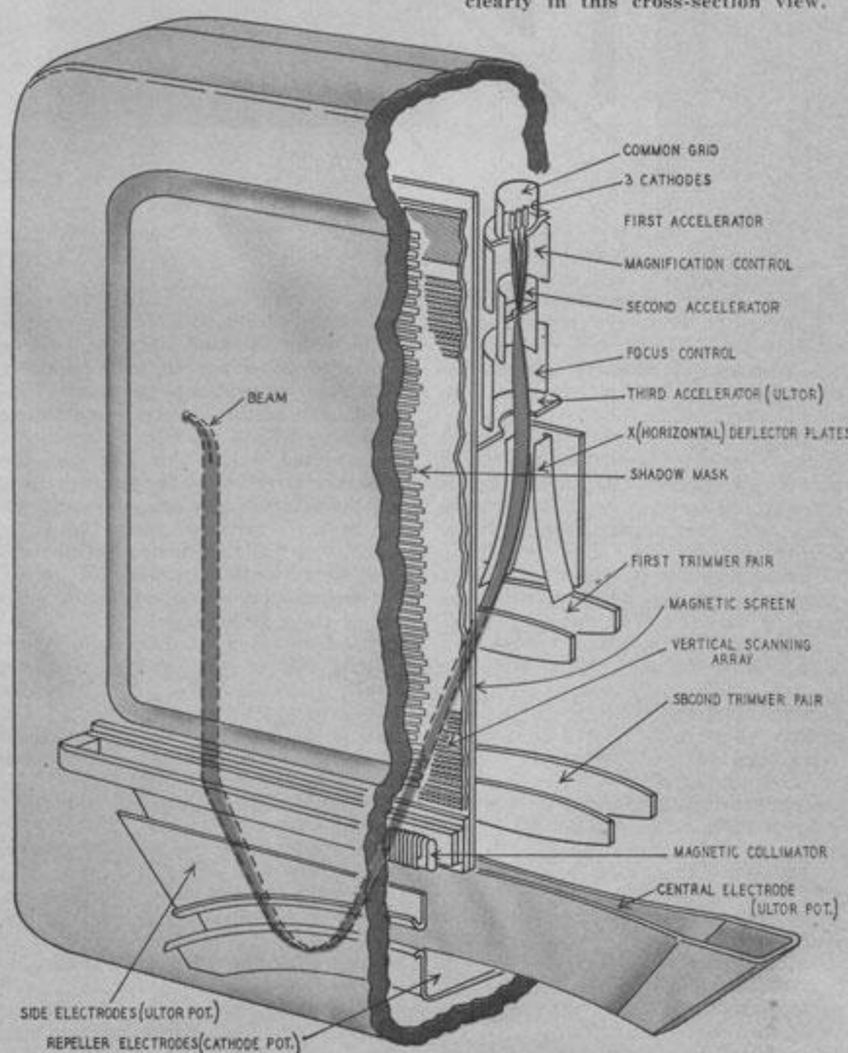

Fig. 2—Cutaway view, with beam deflected toward the left. ➡

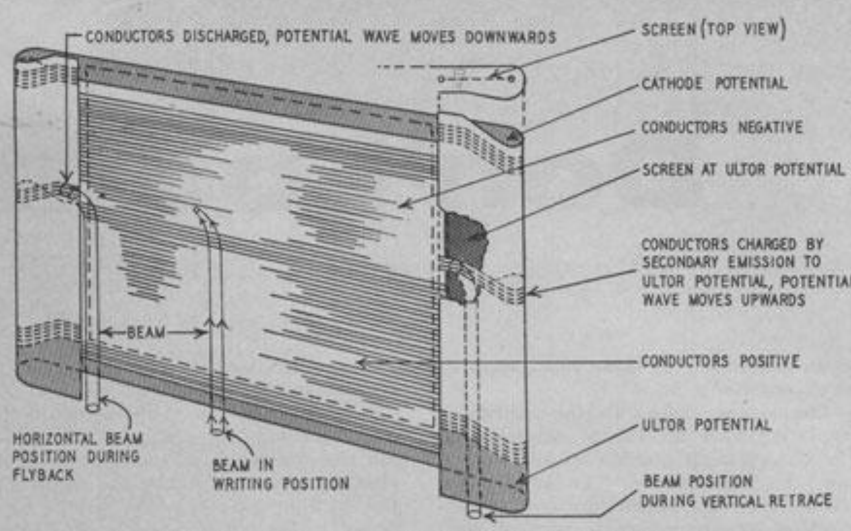

Fig. 3—The vertical scanning array, most striking feature of the tube.

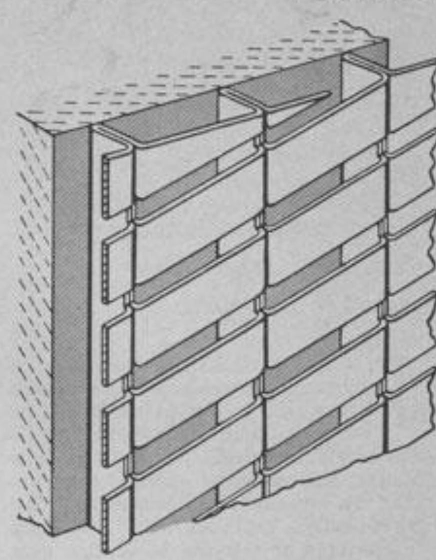

Fig. 5—Section of shadow mask.

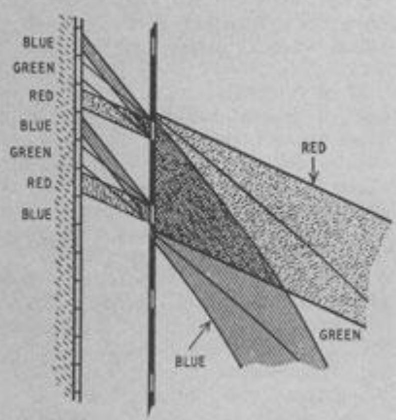

Fig. 4—Path taken by color beams through the shadow mask.

retrace. At this end the beam reaches the conducting lines only after passing through a mesh screen held at a high positive potential (the ultor voltage). The beam knocks electrons loose from the surfaces of the conducting lines, and the highly positive screen attracts most of these electrons to it. Due to this *secondary emission* the conducting lines rise in voltage very rapidly as they lose electrons to the screen.

As each line in turn becomes more positive the beam drifts upward, remaining in the transition area (between positive and negative field) till it reaches the top of the screen and is ready to snap over to the left and start scanning the next field. Design of the stagger angle of the lines, the screen and its spacing from the array, and adjustment of the voltage applied to it, make the time the beam takes to reach the top of the tube exactly that of vertical retrace required by the system of transmission. Thus this electrically isolated element replaces vertical deflection oscillators, amplifiers and coils in the receiver.

Some advantages

The tube is more complicated in design than a conventional black-and-white type but more simple than the three-gun shadow-mask color tube. It also offers some advantages in receiver circuitry, both in color and in black-and-white. The set requires no vertical deflection circuits and, because of the low power required for horizontal deflection, the line (horizontal) scanning circuitry is simpler than in conventional receivers. The synchronizing circuits necessary to keep the horizontal and vertical scan in step with the transmitted signals need be no more complex than in present-day TV circuitry.

The most important advantage is that the three color guns are placed so close together that the three beams are handled as a single beam by the accelerating, focusing and deflecting electrodes. (This eliminates a number of corrections and controls needed on the ordinary color tube, in which the guns are mounted some distance apart and all aimed at the same spot on the phosphor screen.) The three color beams separate just before the final bend and are brought together (Fig. 4), but at different angles, just at the shadow mask.

Due partly to the large convergence angle, the mask can be placed within .025 inch of the screen. Therefore it can be affixed directly to the inside of the tube face, eliminating alignment difficulties which help make the manufacture of color-mask tubes expensive. The mask, incidentally, is slotted (Fig. 5) in present experimental models instead of punched with round holes. The screen is laid simply by dropping the three color phosphors directly onto the tube face through the slots in the mask, with the tube held at a different angle for each color. This is made possible by the close spacing of mask and faceplate and is another factor which would reduce the cost of production.

But manufacture—in quantity at any rate—is not in view in the immediate future. The most important hurdle between the present stage of development and that of a home picture tube is the problem of making a sealed-off tube. There are minor problems, most of them practically solved. From the present information, it is impossible to forecast when we may expect to have flat picture tubes for home TV receivers. END

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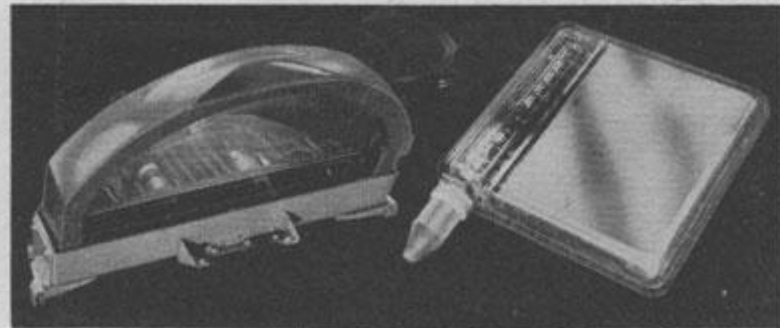

FLAT TV TUBES are foreshadowed by these transparent-screen types already in pilot production for experimental military use. Invented by William Ross Aiken, these follow the same fundamental principles as the flat tube described in this magazine, March, 1957. The electron beam, instead of starting at the back and curving up again behind the face, is injected at the bottom edge. It travels along the bottom, which is coated with a row of deflection plates. By controlling the voltage on these plates, it can be deflected up at any point. Another (transparent) set of plates on the back wall turn the rising beam ahead against the screen at the desired point. These two sets of plates sweep the beam as did the deflection plates in early TV receivers, or the coils in modern ones.

According to officials of the Kaiser Aircraft and Electronics Corp., which developed the tube, refinements in the glass envelope may be all that is needed to make picture-on-the-wall TV a reality, though they feel it is still "a long way from commercial application." One of the photos shows a standard rectangular tube and a transparent-phosphor model which fits into an airplane's windshield. The other is a pictorial prediction of the two-sided TV set of the future.

Radio-Electronics, March 1957

Courtesy of Tom Carlisle