

OBSERVATIONS OF JOHN CHRISTENSEN  
OF THE CTI COLOR TELEVISION DEMONSTRATION

At San Francisco

May 17, 1950

According to my observations, the CTI color television demonstration at the FCC Hearing in San Francisco on May 17, 1950 failed to indicate any significant improvements of the CTI systems then used over the CTI systems used in previous demonstrations. I believe the interlaced shift system, as demonstrated, showed no significant advantages over other CTI systems, and while its use apparently resulted in a slight decrease in line structure under certain conditions, this advantage was offset by its increase of vertical line jitter.

Specifically, I should like to comment briefly on line structure and vertical line jitter, registration, definition and color fidelity as applied to the San Francisco demonstration. The effects I shall describe were clearly observable from the furthestmost viewing position easily accessible to me, which was at a distance equal to that of the third row of seats, and which, estimated on the basis of information furnished by CTI was approximately 12 to 15 times picture height for receivers #1, #2, and #4 and approximately 18 to 24 times picture height for receiver #3 (RCA direct view color receiver).

LINE STRUCTURE AND VERTICAL LINE JITTER. The line structure to which I shall refer is of a much coarser nature than, and should not

be confused with the line structure normally present in a standard monochrome receiver. The vertical line jitter to which I shall refer is an effect in which the lines apparently move up a short distance and then down a short distance at a rapid, but observable, rate. In this sense it is similar to a line crawl in which the direction of crawl is reversed at a rapid rate. It also has a very similar appearance to, and may sometimes be called, a form of interline flicker. A very objectionable amount of coarse line structure and vertical line jitter was visible at all times throughout the CTI demonstration on monochrome receiver #2 and color receivers #1 and #4 whenever color signals, including monoscope signals, were being received. Vertical line jitter was somewhat increased and line structure was somewhat decreased whenever interlaced shift was being used. Both effects were at a maximum, and at such time were visible on receiver #3, when colored material, particularly only one color, was being received, and were at a minimum, though even then objectionable, when only black and white was televised by the CTI color system. Both effects were most noticeable on the standard monochrome receiver (#2), probably due to that receiver's having the greatest highlight brightness.

Problems inherent with CTI systems employing shifts other than the new interlaced shift have been previously discussed in the record. I should like to show why I believe line structure and vertical jitter are fundamental system defects of the present CTI interlaced shift system and as such, whenever using this system, must remain independent of equipment improvements. Their apparent cause can be seen by studying

the scanning sequence of this interlaced shift as indicated in CTI exhibit No. 453: Instead of scanning alternately even and odd lines with successive fields as is the custom in present monochrome standards, and I believe in all color systems considered to date, CTI interlaced shift requires three successive field scans of odd lines only, then three successive field scans of even lines only, then three successive field scans of odd lines only, and so on. Thus, referring again to CTI exhibit No. 453 successive fields III, IV, V and IX, X, XI etc. are scanned in only even lines, while successive fields O, I, II, and VI, VII, VIII and XII, XIII, XIV etc. are scanned in only odd lines.

If white is being televised with interlaced shift and is being received on a monochrome receiver, the observer sees only equally bright odd lines for three successive fields or  $1/20$  sec. and then only equally bright even lines for three successive fields or  $1/20$  sec. From the observer's standpoint this is very nearly equivalent to slowing down a standard monochrome transmission from 60 to 20 fields per second or from 30 to 10 frames per second, and at this slow rate both gross line structure and vertical line jitter at a 10 cycle/second rate are naturally evident.

The same reasoning applies if a color receiver is substituted for the monochrome receiver in the above case. Here the eye integrates for  $1/20$  sec. the three successive odd fields of odd-red, odd-green and odd-blue into odd-white; following which the eye likewise integrates for  $1/20$  sec. the three successive even fields into even-white. The observer then apparently sees as before, white fields of only even lines alternated with white fields of only odd lines at a 10 cycle per second frame rate.

The above two cases correspond to what would be expected and was observed to be the condition of minimum line structure and vertical line jitter for the CTI interlaced shift system.

Let us next consider the case in which a single primary color is being televised using the CTI interlaced shift and is received on a monochrome receiver. Referring again to CTI exhibit No. 453, we see that the eye of the observer will be confronted with a succession of fields, in each of which only  $1/6$  of the line are bright and therefore form an open grid of bright lines, i.e. any two bright lines are separated by five dark lines. During the three successive even-line field scans the entire grid appears to move up four lines in two two-line jumps. During the following three successive odd-line field scans the entire grid appears down four lines in two two-line jumps. Between odd and even or even and odd field scans the grid appears to jump either up or down three lines in one jump. The open grid of bright lines therefore appears to the eye to move up four lines during the first  $1/30$  sec., up or down three lines during the next  $1/60$  sec., down four lines during the next  $1/30$  sec., and so on. It is difficult to say just how much of the above line motion is integrated and smoothed by the eye before reaching the brain, but it is evident from the CTI demonstration that the smoothing action is far from being complete; hence the very objectionable line structure and vertical line jitter accompanying the CTI transmission of a single primary color.

Again, if in the above case a CTI color receiver were substituted for the monochrome receiver, exactly the same reasoning applies since the color receiver would be producing only one primary color, and except for

brightness considerations, would be for the purpose of this analysis identical to a monochrome receiver with a color filter added.

This last described effect was intense enough that the CTI demonstration to be objectionable on the RCA direct view color receiver (#3) at a distance of 18 to 24 times picture height, and it is entirely possible that it was visible to other observers at greater distances.

Moreover, if two instead of one primary colors are transmitted using the CTI interlaced shift, the previous arguments may be essentially used, since in sending two primary colors one primary color is always missing, and the bright grid of the previous argument becomes a dark grid, so that the eye sees, when sending two colors a black shadow grid moving up and down in the same manner as the bright grid does when sending only one color. This latter effect was again very objectionable on all receivers at the CTI demonstration.

I should again like to emphasize my belief that the above observed and described effects of line structure and vertical line jitter are fundamental to the CTI interlaced shift system and as such, when using the latter system, can never be eliminated regardless of improvements in apparatus. I should also like to point out my belief that the presence of line structure and vertical line jitter undoubtedly mask other defects and in so doing likely lead to false interpretations regarding interference ratios etc.

REGISTRATION. Problems of registration in the CTI San Francisco demonstration appeared to remain unchanged as compared with previous demonstrations. Continual adjustment of registration on receivers #1 and #4 was required. RCA receiver #3 appear to have the least problems concerning registration but this receiver unfortunately was inoperative for a considerable portion of the time due to other difficulties. Even with the best adjustment, however, receiver #1 showed noticeable color fringing at the upper right corner and receiver #4 showed color fringing along the upper right corner and also along the left vertical edge of the raster. Before readjustment #4 showed as much as an estimated 1/4 inch of red and blue color fringes on some subject material. Again, as at previous demonstrations, gross misregistration at the camera was indicated at numerous times during the San Francisco demonstration by the two, and sometimes three, separate and displaced images visible on the standard black and white receiver (#2). Misregistration often occurred when changing the camera distance or angle to the object being televised. The worst misregistration noticed occurred during test 1 (live talent) and during paddle tests #5 and #7. In test #7, while the paddle was momentarily still, two of the misregistered images appeared to be displaced horizontally approximately 1/5 of the paddle width.

A considerable and objectionable horizontal jiggle of the upper portion of the raster was observed on receivers #1, #2 and #4 during a large portion of the demonstration. This appeared to be trouble with horizontal synchronization. I question whether this is a fundamental difficulty that may be encountered when standard monochrome receivers are

receiving CTI horizontal shift signals, since in this case the standard receiver, instead of scanning odd and even lines alternately in the normal fashion, is required to scan three sets of odd lines, then three sets of even lines, then three sets of odd lines, and so on.

DEFINITION. No significant improvement in overall CTI system definition was apparent at the May 17 demonstration. As with previous demonstrations, definition, as measured on the receivers while using a test pattern in front of the camera was poor. Average measured values of the four receivers at the CTI San Francisco demonstration showed approximately 170 lines both vertically and horizontally. These measurements, however, were made on a vertically stationary test pattern and then only with difficulty due to the presence of very objectionable and disturbing moiré patterns in the horizontal wedges. My observations would indicate that with normal colored moving subject material, usable CTI system definition, especially vertical definition, was considerably less than the 170 lines indicated. In test #1 closeups of faces failed to ever show any lines separating teeth and all eye structure was often absent. During test #10 most of the medium and small size color print on the commercial products that should easily be read with standard monochrome television was completely unreadable over the CTI system.

COLOR FIDELITY. I believe no improvement in the color fidelity of the CTI system was demonstrated at the San Francisco hearing. From my point of observation least color distortion appeared on RCA receiver #3 whenever that receiver appeared to be operating properly. On all color receivers, however, non-saturated hues and especially colors requiring a delicate blending of two or three unsaturated primaries, such as skin tones, were grossly distorted.