tion as compared to what can be obtained in a 4-megacycle bandwidth and one of the lines of development now being pursued by RCA is the construction of a tube with a larger number of picture elements.

SUMMARY

The attempt here has been to distinguish between the three systems on the basis of the color switching rate rather than on the terminal equipment which may have been employed by the three proponents in their demonstrations. This has been done because it is a problem of choosing from among the three color switching rates that is before the Federal Communications Commission in setting engineering standards, rather than the problem of determining which company has developed the best apparatus. Once this decision is made by the FCC, it can be expected that the entire industry will turn to the problem of developing and improving transmitting and receiving equipment for the particular system which has been chosen. Tremendous developments have occurred within the last nine months in the field of color television, and if these continue at their present rate, it can confidently be expected that it will be a commercial reality within a very few years.

ADDENDUM, October 7, 1950

Recent Developments in Color Television

Since the record of the color television proceedings was closed by the FCC, two very interesting alternative systems have been publicly described. These are the frequency interlace system developed by the General Electric Co. and the "Uniplex" system developed by CTI. Neither of these has been tested to date to the extent of constructing complete transmitting and receiving apparatus. However, considerable study has been made of the theoretical aspects of each, and certain critical points have been tested under simulated conditions.

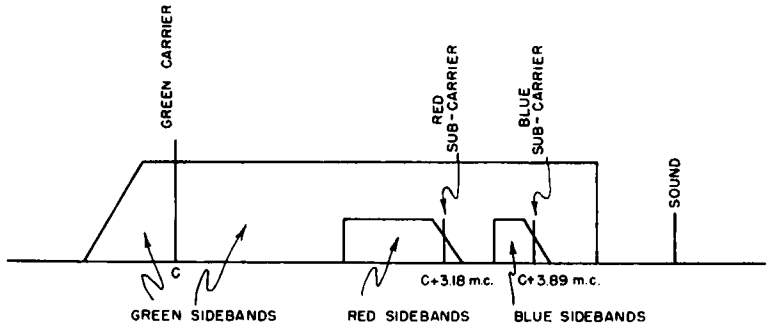
The GE frequency interlace system makes use of the fact that most of the energy in the video waveform is presumed to occur at harmonics of the line frequency of 15,750 cycles/sec. If each line were identical, the energy would be concentrated at these discreet frequencies. Due to the fact that the waveform changes from line to line, the frequency spectrum is spread out somewhat, and as a consequence it is believed by GE that picture information is concentrated in regions of the spectrum lying near the harmonics of the line scanning frequency and occupying about 54% of the total spectrum. Since the other 46% of the spectrum space is not occupied, it is theoretically available for transmission of additional information.

While research has not yet been carried to the extent of determining the best way in which to utilize this unused spectrum space for transmission of

color information, GE has suggested that it might be accomplished in the manner described below.

At the camera the three color signals are produced simultaneously. This could be accomplished, for example, with the RCA color camera. Each signal may contain frequencies extending to 4 megacycles. However, since the higher frequency components in the red and blue signals do not seem to be necessary for the transmission of detail, these signals would be filtered and thereby limit the red bandwidth to 1 megacycle and the blue bandwidth to 0.2 megacycles.

The green bandwidth, being retained to the full 4 megacycles, is considered to be the dominant signal, and it is used to modulate the transmitted carrier using the ordinary vestigial sideband type of transmission. A red subcarrier is then chosen having a frequency such that it will fall midway between two of the sidebands, produced by the green signal. This is accomplished by separating this subcarrier from the green carrier by an odd multiple of one-half the line frequency. One frequency suggested by GE is 3,189,375 cycles/sec which is the 405th multiple of 7,875 cycles/sec. This subcarrier is modulated with video signals from the red channel using a vestigial sideband type of modulation. The red sidebands would then theoretically be interleaved between the green sidebands with very little cross talk between them. A similar method would be used to multiplex the blue subcarrier on the green signal and the blue sidebands would be interleaved between the green in the same manner.



The optimum position of the blue carrier has not been determined. However, one possible arrangement is shown in Fig. 8 which shows the position of the green carrier, the red and blue subcarriers, and the spectral region occupied by the sidebands of each color.

In the color receiver the signal is passed through suitable filters which remove the portions of the spectrum which are not used by the color associated with its particular channel. No attempt is made to remove the interleaved information within this band of frequencies. Mathematical analysis shows that the cross talk which is present due to the presence of these undesired sidebands is 180° out of phase on successive frames so that the net signal over two frames is zero. To the extent to which the persistence of the phosphors and of the eye combines the images of two successive frames, this flicker will not be noticed. The signals accompanying each carrier would be demodulated and would be used to actuate a direct view color tube.

This system is compatible in that the same line field and interlace standards are used as for standard monochrome television. On a black-and-white receiver the green signal would be reproduced. According to GE "Cross talk [from the red and blue sidebands] would cause no trouble because it is geometrically in the same position on the screen as the green signal itself." The red and blue subcarriers would produce a dot pattern which according to GE has been tested and found to be unobjectionable.

The principal advantages claimed for the GE system are compatibility, absence of twinkle, crawl or flicker, and the absence of any precision timing equipment in the receiver. The most serious objection which has been made to the system is the degradation of the picture due to differences in propagation at the three carrier frequencies. The seriousness of this problem can be determined only by field testing.

The Uniplex system described by CTI employs a color switching rate between the dot sequential system of RCA and the line sequential previously advocated by this company. The color repetition rate is 1.008 megacycles which is the 64th harmonic of the line repetition frequency. This is slightly more than one-quarter of the rate at which the colors are switched in the RCA system. Thus the color segments on each line are about four times as long as with the RCA system and it could perhaps be described as a "dash sequential" system. In the transmitted waveform, red, green and blue signals are sent in sequence, the color cycle being completed in approximately 1 μ sec. Mathematical analysis shows that such a waveform will contain very little energy at the third harmonic of 1.008 megacycles but the second and fourth harmonics will be transmitted and will enable reasonably rapid transition from one signal level to another as would be required by varying amounts of primary color in the portion of the picture being transmitted.

An ingenious color camera has been invented by CTI for use in connection with this system. This camera provides the video signal with one image orthicon using a filter printed on 35-mm motion picture film which passes in front of the lens and provides the suitable color separation. The system, however, is not limited to the use of this camera, and the RCA three-tube camera could be adapted to it with ease.

At the receiver the color switching is accomplished by a suitable gating circuit which is synchronized with the color switching at the transmitter by means of low-amplitude 3.024-megacycle signal which is transmitted continually. This signal is 180° out of phase on successive frames and to an extent is canceled out by the persistence of the phosphor and the eye. Color phasing is accomplished by transmitting a burst of energy at 1.008 megacycles during a portion of the vertical blanking period. The demodulated signal is gated in synchronism with the transmitter for separation of the three colors and the three signals are then applied to the picture reproducing device whatever it may be. It is felt that in all probability this will be a direct-view color tube.

The principal advantages claimed for this system are compatibility, a minimum amount of color contamination due to color cross talk, and considerably simplified apparatus. Simulated tests are said to have shown that small area flicker with this system would be no more serious than the RCA system even though the dots are somewhat longer.