Natlock units and error signals. Subcarrier is also distributed throughout the building.

Having found the necessity for Natlock color-phase comparators on all mixer inputs and Natlock timing comparators on the mixer inputs used for remote sources, it is a small step to consider the implications of giving every source, internal and remote, a timing waveform generator controlled by Natlock error signals. For this use the Natlock system already developed for remote working could be modified to improve the lockup time of the system and to take advantage of a distributed frequency reference to simplify the equipment.

PAL Color Natlock for Interstudio Application

A proposed system is shown in a simplified form in Fig. 3. All points in the program chain requiring synchronizing pulses would be supplied with a locking frequency of 567/2 × the line scanning frequency and a 12½-Hz square wave from central equipment. In addition, color subcarrier frequency, derived from and related to the locking frequency, would be distributed. Although each point could itself generate subcarrier frequency, the synthesizer required is an expensive unit and provision of the number required would probably cost more than the value of the distribution equipment saved. The 567/2 × line-scanning frequency is applied to drive units to produce twice line-scanning frequency for feeding to synchronizing-pulse generators. The variable divider ratio of the drive unit and the setting of the digital phase shifter are determined by the information contained in the control signal generated by the comparator at the mixing point. The error signal would take the form of modulated audio-frequency tones exactly as described previously.

Before the picture source is routed to the mixing point and receives an error signal, coarse timing would be accomplished by the use of the 12½-Hz signal. This signal, of square waveform, contains transitions indicating the time of start of the PAL four-field sequence. All points in this system would use this reference signal to field-phase their synchronizing pulse generators. The object of this is to shorten the lockup time of a source after it is routed to its destination.

Time to Establish Synchronism

The theoretical lockup time of this arrangement can be calculated. If it is assumed that the accuracy of comparison of the field-phase system and the path-length of the signals give a timing error of about 200 μs, the first part of the Natlock correction, which uses a twice line frequency change of one part in 5,600, will reduce the error to 12 μs in about 1 s. The slow rate of correction would then take over and reduce the 12 μs error to one of insignificant magnitude in about 27 s. The color-phase shifter may then have to correct a 180° error and this will take a further 5 s. The maximum time of 33 s will, of course, only be obtained between sources and destinations inside the distributed signal system. The equipment described would be capable of working with that described earlier for remote use, although the field phasing facility would then not be available to shorten the lockup time. It will be noted that three feeds of distributed waveforms are required in this synchronizing system but these do not need to be accurately timed between the central apparatus and the studio equipment. In addition, the higher frequency signals are sinewaves and do not require complex equalization.

Conclusion

The Natlock system, originally developed for use with monochrome remote sources, has been successfully extended for use with PAL color signals. In addition, it may supplant the long established system of timing by pulse distribution within buildings. On a national scale the aim of Natlock is to provide synchronization as a matter of course whenever a source, remote or local, is routed to a mixer.

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ADDENDUM

Edit. Note: After summarizing the paper presented on November 14, 1968, and published here, Mr. Gregory provided the following to bring the subject up to date before the Panel Discussion.

When the BBC was planning its color service a source synchronization system was needed to replace the monochrome genlock units then in use. This was required for synchronizing remote sources and also for color phasing within studio centers.

A system was designed, aiming to be automatic both during initial lockup and in steady state and allowing any number of sources to be synchronized at one point. The use of expensive equipment, such as atomic frequency sources, was avoided, so that every source and mixing point could be equipped in due course with the synchronizing units. The design did not require the equipment to be able to synchronize one remote source at two places simultaneously.

The BBC considers that the synchronization of international sources which are so distant, or of "pool" origin, that a feedback lock is impossible, is best accomplished by a standards conversion technique. The BBC has built an advanced converter able to derive from a 525/60 NTSC signal a 625/50 PAL picture with its waveform locked to local pulses. The BBC's 625/50 PAL to 525/60 NTSC equipment has also been completed and was used to convert live pictures of the Investiture of HRH Prince Charles as Prince of Wales to the U.S. standards for transmission throughout the world.

This unit is to be modified during 1969 to perform a 625/50 to 625/50 translation for synchronizing purposes, in addition to its conversion ability. It is particularly for such use that the very small distortions produced by the solid-state field store converter makes it much more attractive than optical conversion units. The performance of the unit when used in this mode is even better than when it is used for standards conversion, as no interpolation process is required.