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H. MIRZWINSKI B.Sc(Eng), C.Eng, M.I.E.E

TIMING COLOUR STUDIO CENTRES

INTRODUCTION

In days gone by some studio centres were not planned, they simply grew by adding facilities which were never originally envisaged and by spreading into any available area, however unsuitable. The problem of timing was rarely mentioned; very often it was simply left to a resourceful installation engineer with a good pair of cutters and a few reels of coaxial cable. But the black-and-white signal was so tolerant that it could suffer the most appalling abuses without any apparent ill effects.

The greater complexity of colour systems does not leave much room for improvisation, however gifted, or for counting on luck which more often than not is on the opposite side. In colour much more careful planning is required. The capital investment and the running costs are higher; therefore all the equipment must be fully utilized and the available technical staff more efficiently employed. The performance specifications, aimed at ensuring that the best quality colour pictures reach viewers' homes, are very demanding, requiring constant compromise between facilities provided and the performance which can be achieved. Colour television centres must be planned as an integral whole taking into account the layout of technical areas, the facilities required, operational techniques, staffing problems and overall performance. The plans should not only cover the present-day requirements but should also be projected well into the future so that the expansion can be carried out easily. This is not a simple task in a constantly changing world but nevertheless a crystal ball must form an essential part of the planning engineer's equipment. Sometimes circumstances do not permit the building or equipping of the complete studio

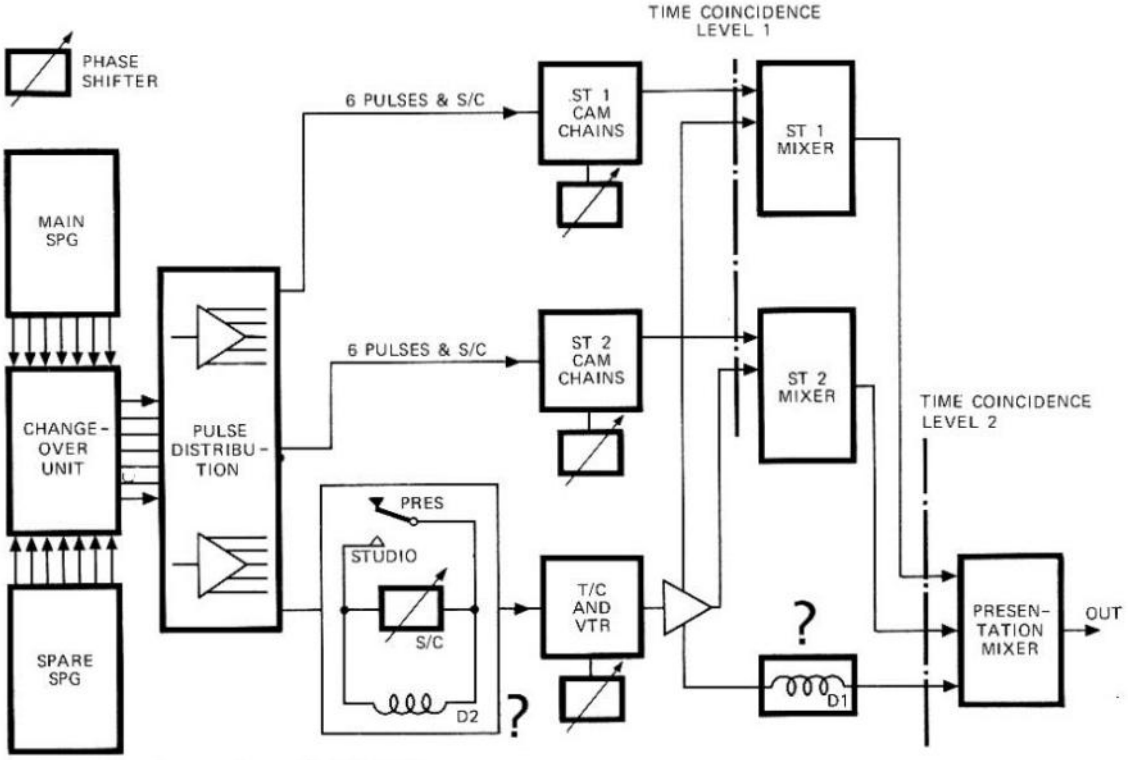

Fig.1 Facilities diagram of a small studio centre.

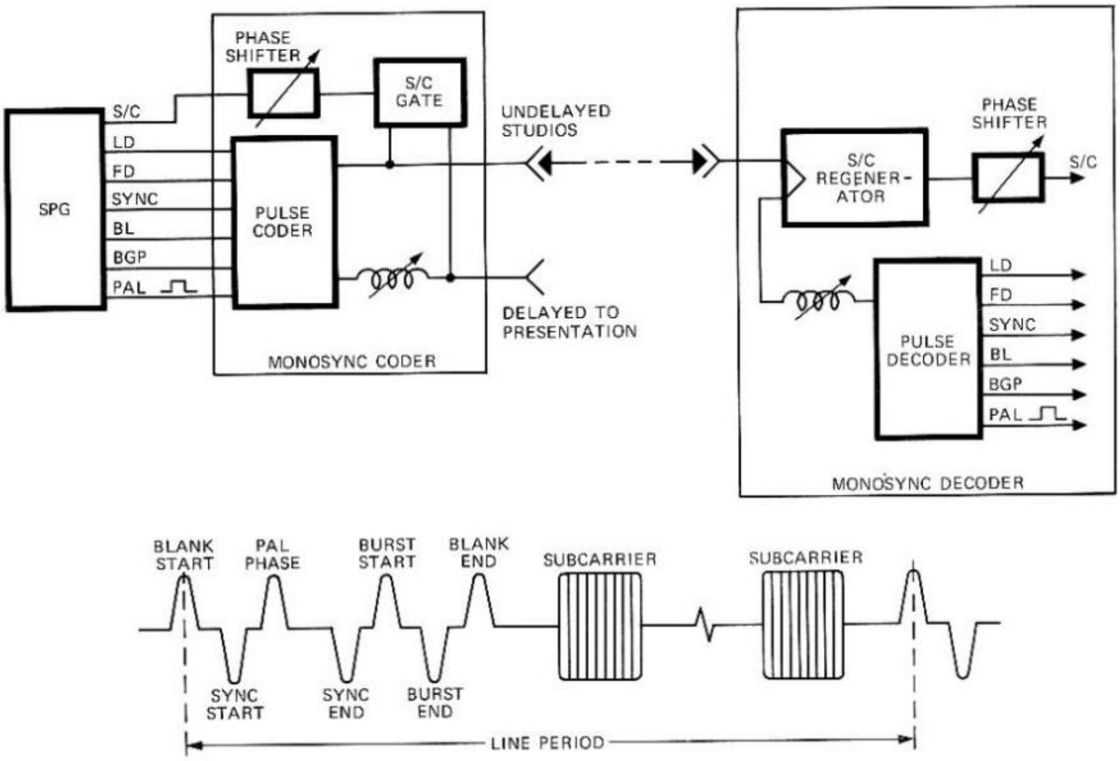

Fig.2 Monosync pulse coding.

centre at one go and work has to proceed in stages. Once the plan for the final size is formulated certain parts of it can be selected as 'phase one' for detailed system planning and implementation. But at all stages of the decision the final requirements should always be considered so that allowances can be made for future expansion and the schemes adopted are as flexible as possible, to leave a margin for inevitable changes.

THE IMPORTANCE OF TIMING

One of the problems which a system engineer has to face in the early stages of planning a studio centre is the timing of all picture sources at the inputs to the different mixing equipments (studio vision mixers presentation or MCR switchers etc). In black-and-white it is sufficient to time the front edges of sync of all the inputs to be within ±50ns of each other, any serious mis-timing manifesting itself as a horizontal shift on picture monitors. With the encoded PAL or NTSC signals, in addition to the same black-and-white requirement of sync timing, it is necessary to ensure that the phase of subcarrier burst on all inputs is within about ±1ns. Any serious difference in phase can result in a change of hue of the picture.

There are two types of distortion which affect the hue of the transmitted colour picture:

(a) differential phase distortion which depends on the magnitude of the luminance signal and is caused by nonlinearity of vision amplifiers.

(b) static phase error, i.e variation of the original phase relationship between the chrominance signal and the colour burst, independent of luminance level.

Static phase errors, or chrominance signal phase errors as they are sometimes called, can originate in mixing equipment during special effects or mixing or in output processing amplifiers when the original colour burst of an encoded signal is replaced with a burst obtained from a different encoded signal or from a local subcarrier. The careful phasing of signals at the inputs to mixing equipment is necessary to keep the static phase errors at an acceptable value.

In a direct cut between any two signals the burst is switched simultaneously with the picture signal and the phase difference can be as high as 15ns. The recovery time of the receiver burst controlled oscillator for sudden changes of 15ns is usually well within the physiological reaction time of the viewer. In the case of additive mixing the resultant burst is the vector sum of the bursts of the two input signals and therefore during crossmixing timing errors of up to 15 or 20ns are acceptable. On the other hand during sustained additive superimpositions, errors of more than 6ns can sometimes be detected.

The most stringent timing requirements are posed by special effects and non-additive mixing when the sync and burst of one input are used during wiping and other effects for both inputs. In this case timing errors should not exceed 2 or 3ns.

Some output processing amplifiers used in conjunction with vision mixers reinsert into all local signals a burst obtained from local subcarrier. This method can produce a static phase error of magnitude equal to the sum of the timing errors of the vision mixer inputs and delay equalization errors between different routes through the vision mixer. For example if the inputs are timed to ±1ns and the delays through different paths are equalized to within ±1·5ns the maximum static phase error will

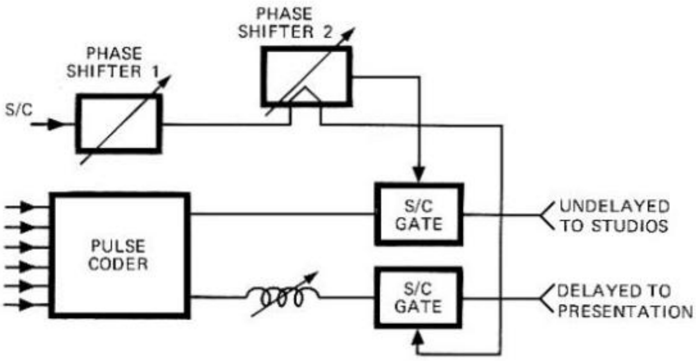

Fig.3 Alternative arrangement of Monosync coder.

be 2·5ns. To avoid any phase errors the processing amplifier should preferably leave the burst either in its original form or regenerate it in a phase-locked oscillator.

In general it is very difficult to give an exact figure for an acceptable tolerance for a single type of distortion occurring in an isolated piece of equipment. In practice it is the cumulative effect of several types of distortion occurring in a long vision chain from the picture source to the transmitter which determines the over all quality of the picture. Television studio centres differ enormously in complexity and it is the number of vision amplifiers, mixers, etc. connected in tandem which determines the tolerances that can be allocated to individual units.

PULSE AND SUBCARRIER DISTRIBUTION

Television studio centres are not all alike, because each of them has to serve different local needs. A small provincial station producing only two or three short local programmes per week and utilizing mainly programmes fed from a national network or from films is designed on different principles from a major station contributing many programmes to network and producing simultaneously a number of video-tape recordings. The difference is not simply a question of size, number of studios, machines etc, but lies in the methods of interconnecting the various facilities into an efficient, purpose-designed centre. But whether a station is large or small the problem of timing is equally important.

The successful timing of a station for colour depends to a large extent on the system of pulse and subcarrier distribution adopted. Such a system should fulfil the following requirements:

(a) an alternative source of pulses should always be available in every production area;
(b) genlocking in one area should not disturb recording in another area;
(c) the system should be as far as possible automatic, e.g the correct studio pulses should be automatically connected to a machine when it is working into a studio vision mixer;
(d) the system should provide an easy adjustment of pulse delays and an independent adjustment of subcarrier phase. In this way the need for large video delays and the trimming of coaxial cables for delay adjustment can be minimized.

THE SMALL STATION

Figure 1 shows a simplified facilities diagram of a small station which has to survive on a very limited budget: two studios, two VTR's, two telecines, one slide scanner, one caption scanner and a presenta-

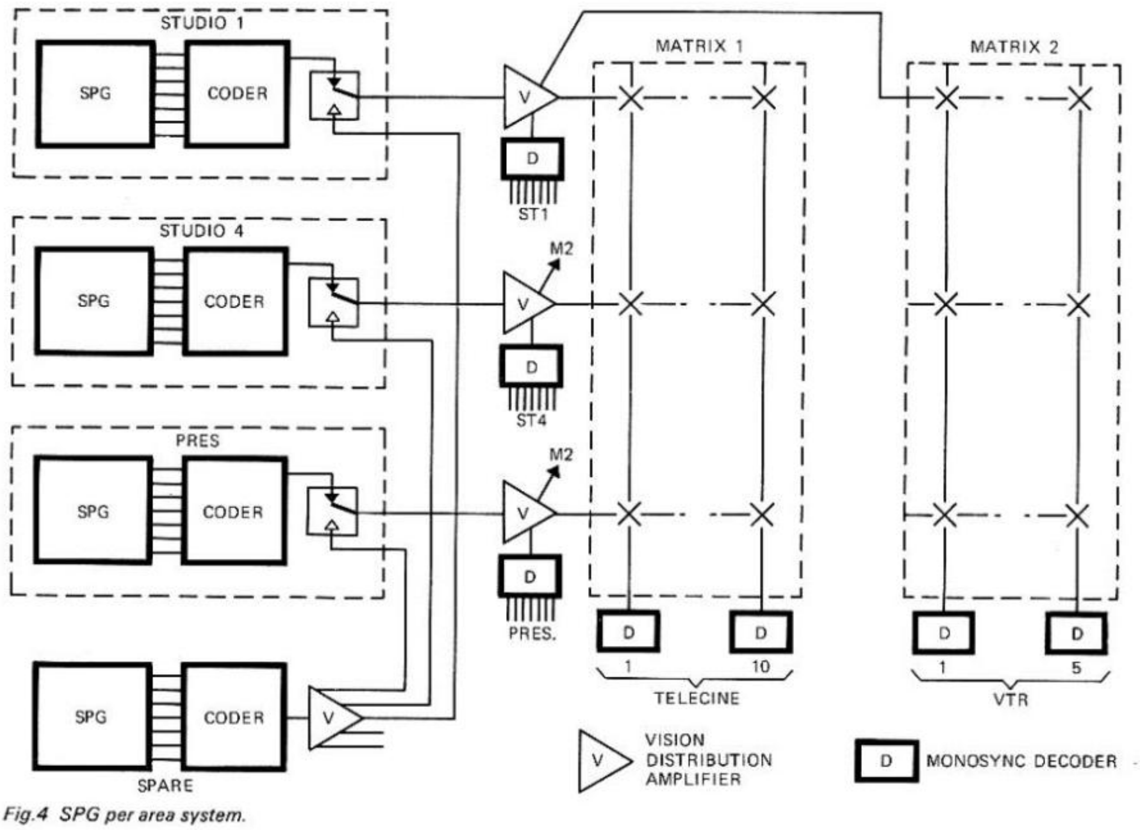

Fig.4 SPG per area system.

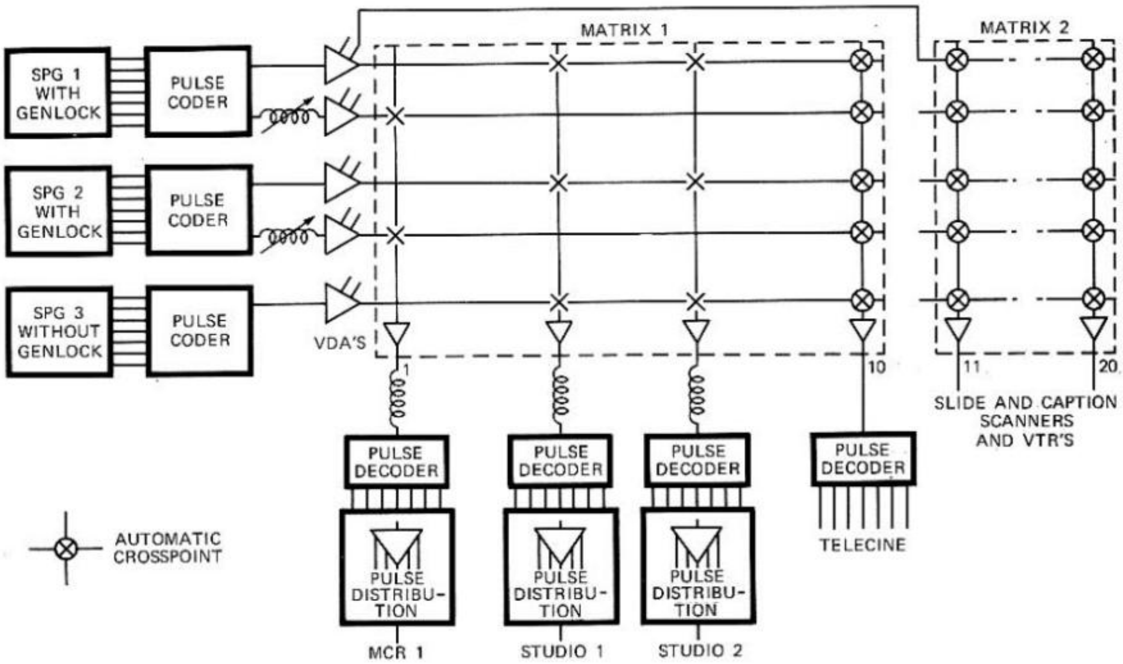

Fig.5 SPG assignment system.

tion mixer. Assuming that the station can manage to make all its recordings during the times when the sync pulse generator (SPG) is not genlocked, it is sufficient to provide a single SPG assembly (main and spare SPG's with a changeover unit). All six pulses (PAL) or five pulses (NTSC) and the subcarrier are distributed to studio cameras and to all the machines. Because of the limited number of sources, vision mixers can easily accommodate all inputs and there is no need for machine assignment; outputs of all machines are distributed to all mixers.

Assuming that all the paths through the mixers are delay equalized it is sufficient to establish time coincidence levels at the inputs to the mixers. Timing of the encoded PAL or NTSC signals can be separated into two parts: pulse timing and subcarrier phasing. First the path differences through all cameras and machine chains, including all the amplifier delays, should be made less than 50ns. This does not mean a very critical cutting of cables as 50ns is equivalent to a coaxial cable length of about 33ft. Cables between colour encoders and mixers should, of course, be as short as possible to avoid the problem of cable equalization; cables of 25ft or less need not be equalized. Having timed the pulses, the subcarrier phase shifters on source encoders are adjusted to obtain phase coincidence within 1ns. Cables between machines and all mixers must be made exactly equal because there is only a single phase adjustment per machine. The inputs to mixers are now properly timed.

The operational procedure adopted in presentation (or MCR switching) may require mixing, wiping, etc between studio outputs and the machines fed directly to presentation. In this case a different time coincidence level has to be established at the input to the presentation mixer. From figure 1 it can easily be seen that the delay of a machine connected to presentation via a studio is longer than that of a machine fed directly to presentation by the delay of a studio mixer. At first sight the easiest solution appears to be to insert into the machine feeds to presentation a delay D1 equivalent to the studio mixer delay. But such a delay of about 1μs inserted into an encoded signal path must be stable to less than 1ns and the delays in all machine feeds to presentation must be equalized to within a fraction of 1ns. It is preferable to avoid large video delays and to use instead delays in the pulse feeds to the machines. These delays, of the same magnitude as D1 (equivalent to the studio mixer delay), inserted into sync, blanking, line drive and burst gating feeds to each machine need not be so accurate or stable, but they must be shorted out when any machine is used with a studio mixer. Therefore a rudimentary assignment switcher is needed to allocate correctly timed pulses to machines according to their use.[1] Together with the delays a subcarrier phase shifter can be switched into the subcarrier feed so that the phases of machines at the input of presentation can be matched to the studio outputs.

MONOSYNC PULSE CODING

In a very small studio centre employing only one sync pulse generator, pulse coding into a single waveform, instead of distribution of separate pulses, can give only marginal economic advantages. But in a bigger centre using more sync pulse generators pulse coding is not only more economical but it also makes the task of timing the station much easier.[2]

The basic principles of the Monosync pulse coding system[3] are shown in figure 2. All pulses from the generator are first encoded into a single waveform. The coder has two outputs: undelayed for use in studios and delayed for presentation. The subcarriers after passing through a phase shifter, is gated into the waveform. The subcarrier is added after the delay; this method improves subcarrier stability and

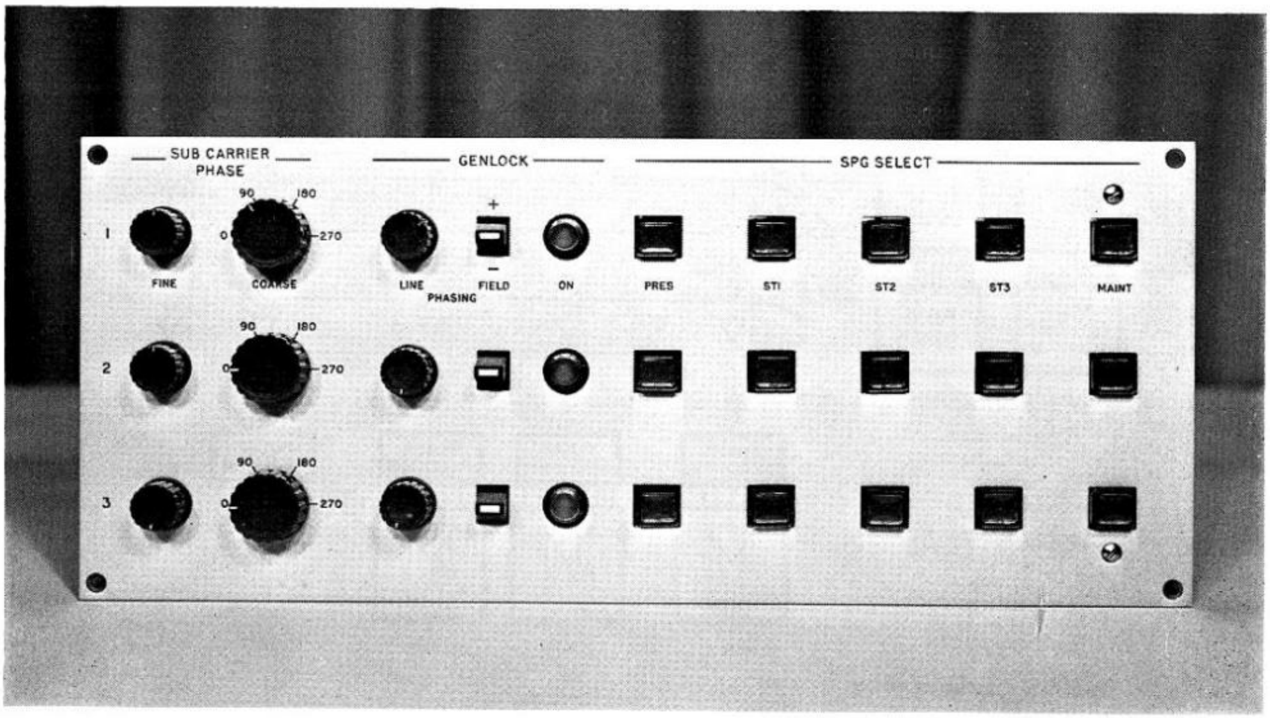

Fig.6 Manual SPG assignment panel.

ensures that the delay adjustment does not affect the subcarrier phase. The phase shifter is used in genlocking to match the phase of all local sources to that of the remote input on the input to a vision mixer.

In the Monosync decoder the subcarrier is first separated and regenerated and then the waveform is fed via an adjustable delay to a pulse decoder where all pulses are reconstituted. The delays and phase shifters are optional and their use depends on the requirements of the centre. There is a choice of two delays which can be fitted either in the coder or the decoder: up to 3·15μs or up to 375ns both adjustable in 25ns steps. The subcarrier phase shifter covers 360° and can be remotely controlled.

In the Monosync waveform shown underneath, all pulse edges are transmitted by means of sine squared pulses; (only the back edge of line and field drives are set in the decoder) and there are two bursts of subcarrier per line. In this way the original sync pulse generator timings are preserved.

An alternative arrangement of the Monosync coder is shown in figure 3 and this is used whenever it is necessary to establish a second time coincidence level, e.g when it is necessary to mix on the presentation mixer between the output of a studio and a machine fed directly to presentation. Two separate subcarrier gates are employed on the two coder outputs. The subcarrier, after passing through the first phase shifter and looping through the input of the second shifter, is added to the delayed pulses feeding presentation; the output of the second phase shifter is added to the undelayed studio pulses. The first phase shifter affects both outputs and is used as before for genlocking. The second phase shifter permits differential phase adjustment between studios and presentation.

PULSE DISTRIBUTION SYSTEMS

In bigger television centres which have to produce an on-air programme and make video tape recordings simultaneously it is essential to provide more than one SPG. There are two basic pulse distribution systems: an SPG per area and SPG assignment. In both these systems pulse coding is employed to simplify the pulse switching matrices and to ease timing.

In the SPG per area system, shown in figure 4, an SPG with a coder is provided for each studio and for presentation. An additional spare generator (usually without a genlock) is distributed in coded form to each area to provide an alternative source of pulses in case of a breakdown. Each area is completely independent and can genlock without disturbing other areas (which may be recording). If it is desired to have a studio output synchronous with other sources connected to presentation, the studio SPG can genlock to presentation. All the crosspoints of the matrices switching pulses to machines are operated by a machine assignment switcher, i e when a machine is assigned to a studio it automatically receives the correct studio pulses.

The SPG assignment system uses less SPG's but their use must be carefully scheduled. Two or three SPG's are manually assigned to production areas as and when required. This method permits the output of the studios to appear properly timed at the input of presentation without the need for genlocking. Alternatively a 'slave' studio can be fed correctly timed to the vision mixer of a 'master' studio, but in this case the 'master' studio has to be treated as a remote input in presentation.

A typical SPG assignment system using three generators is shown in figure 5. The first two generators are equipped with genlock and colour lock[4] and the third SPG, without locking facilities, is used for recording and for feeding the machines which are not assigned anywhere. Outputs of all generators are first coded into a single waveform. Two outputs of the first two generators are utilized: undelayed to studios and to all machines assigned to studios and the delayed output to presentation or MCR and the machines assigned to presentation. The studio part of the switching matrix is controlled manually from an SPG assignment panel. The rest of the cross-points are operated automatically by the machine assignment switcher. At each destination a pulse decoder reconstitutes the original pulses. At the more important destinations, such as studios, a dual decoder with a changeover unit may be employed.

The manual SPG assignment panel designed for Southern Television in Southampton, controlling a system similar to the one described, is shown in figure 6. In this case all three generators are fitted with genlock. At the left-hand side are fine and coarse subcarrier phase adjustments, line and field phasing, genlock ON light and buttons to select any of the three SPG's to presentation, three studios and maintenance. In most studio systems the selection of inputs for genlocking and the actual action of genlocking are carried out from the studio control rooms. With the SPG assignment system several studios can be connected to the same SPG and it is therefore necessary to provide a genlock assignment. In Southern Television a manual patch is employed. In other stations remote control of genlock assignment from buttons mounted on the SPG assignment panel has been provided.

TIMING A STUDIO CENTRE

Each studio centre has its own peculiar timing problems depending on the physical layout of technical areas, methods of pulse and vision distribution and the types of picture generating equipment. But certain basic principles apply to all centres. To obtain the best results, adjustment of delays should be carried out on pulse feeds and large video delays avoided. Sufficient subcarrier phase shifters should be provided so that trimming of coaxial cables to achieve phase coincidence is made unnecessary.

To illustrate how the timing of a studio centre can be carried out consider one using an SPG assignment system with pulse coding as shown in figure 5. Assume that a single SPG is assigned to two studios and presentation and that it is required for all sources including studios to be in phase at the input of the presentation mixer (Fig.7). Such a requirement can arise during the production of more complicated programmes such as election results.

Both studios are driven from the undelayed output of the pulse coder. Each studio complex consists of camera chains which include pulse switching, a pulse decoder with pulse delay and phase shifter, camera control units and colour coders and machine chains (telecines and VTR's); only one machine is shown for simplicity. The outputs of machines are assigned to the studio mixers or the presentation mixer by a machine assignment switcher. It must be remembered that any machine can be assigned to any studio or to presentation; therefore to avoid readjustment of subcarrier phase

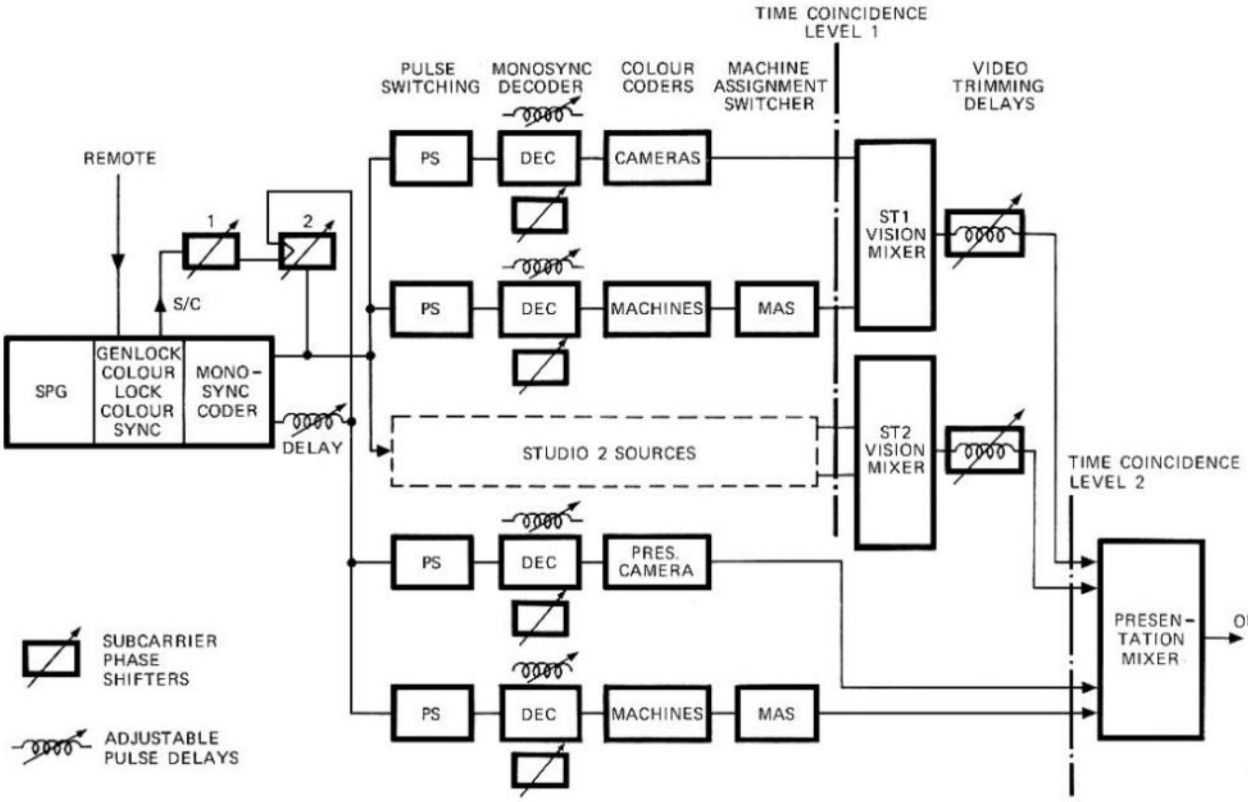

Fig.7 System timing diagram of a studio centre.

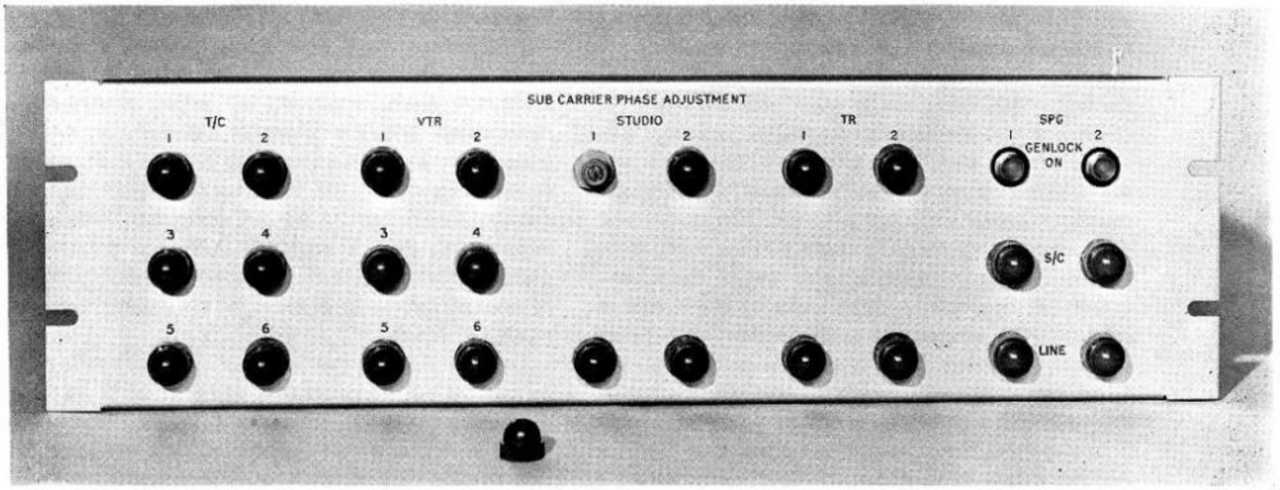

Fig.8 Subcarrier phase shifter adjustment panel.

every time a machine is reassigned the coaxial cables between the machine assignment switcher and the inputs of all mixers should be made exactly equal. The presentation complex may consist of a presentation camera chain and a number of machines assigned directly to the presentation mixer.

Timing of the station could be started with Studio 1 for example. One of the machine paths, be it a VTR or a telecine, is probably the longest and it should be chosen as a reference. Each machine in turn is selected to the input of the vision mixer and its pulse timing is adjusted by means of the delay in its pulse decoder to be within 25ns of the reference chain. Now the delays of the live cameras are adjusted to match the machines. There is a single pulse decoder driving all the camera chains in a studio and therefore the signal path through all cameras should be kept equal. Once the black-and-white timing has been adjusted subcarrier phase can be tackled. Again one machine can be chosen as a reference and the phase shifters on the machine pulse decoders adjusted in turn to the highest accuracy which the measuring gear employed will permit – certainly to better than 1ns. Camera colour coders are usually equipped with subcarrier phase shifters; these can be used to match the phases of cameras against each other and then a common phase shifter on the pulse decoder can be used to phase all cameras to the machines. Studio 1 is now properly timed. Adjusting Studio 2 is simpler because the machines are already timed and all that remains to be done is to match the pulse delay and subcarrier phase of Studio 2 cameras to the machines.

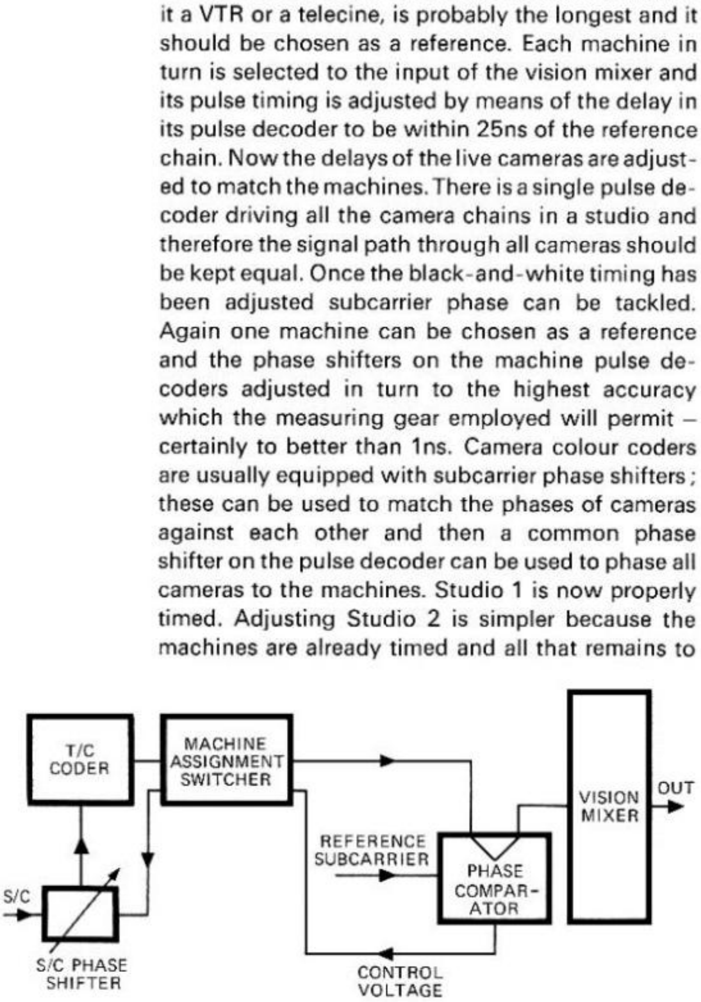

Fig.9 Automatic phase adjustment.

Next the timing of presentation can be carried out. The delays of the two studio vision mixers, being rather large (about 1μs), may not be exactly the same. Thus it may be necessary to use small trimming delays on the mixer outputs to match the subcarrier phase at the input to the presentation mixer. The machines have already been timed with respect to each other, therefore only the pulse delay and subcarrier phase of the presentation camera have to be adjusted to match the machines. Looking at the presentation paths it is obvious that they are shorter than the studio paths by roughly the delay of the studio mixer. To compensate, the delay in the Monosync pulse coder is adjusted selecting a machine first via a studio mixer and then directly to presentation. Similarly to obtain phase coincidence between studios and sources connected directly to presentation the second phase shifter on the Monosync coder is adjusted. This shifts the phase of both studios with respect to presentation.

To simplify the task of phasing the subcarrier of all the sources it is convenient to have a central adjustment position. Figure 8 shows a panel designed for Independent Television News in London giving access to all variable phase shifters on the station: telecines, VTRs, studios, a few spares and subcarrier and line phasing for genlocking. Near this panel there are located control panels to select the inputs to all mixers and a measuring instrument – a Vectorscope or a phase comparator.

Once the phasing of a station has been carried out initially it will have to be checked only periodically. To achieve such stability the design of the station must be very compact with all the vision and pulse equipment concentrated in a Central Apparatus Room maintained at a reasonably constant temperature. The delay characteristics of the amplifiers employed must be stable against time and the video chains designed very simply with the minimum number of tandem connected amplifiers.

Such an ideal can be achieved provided that the station is planned as an integral whole. But sometimes the architects have an upper hand over the engineers and the station is split into several very attractive but separate buildings surrounded by landscaped gardens: telecine building, central facilities building and a studio block. Under such conditions it is difficult, if not impossible, to maintain phase to within a few nanoseconds without some automatic means of phase adjustment. One of the possible solutions is shown in figure 9. Every input to a vision mixer which is likely to vary in phase is looped through a phase comparator where its phase is compared with a subcarrier reference such as a colour black generator or a local camera. A d.c voltage proportional to the phase difference is fed back to the source where it is used to control the subcarrier phase shifter.

CONCLUSIONS

The design of colour television centres presents a whole host of interdependent problems which cannot be solved in isolation from each other. The timing of a centre is a problem which has to be faced in the early stages of planning. The choice of a pulse and subcarrier distribution system with easily adjustable pulse delays and subcarrier phase shifters will not only simplify the initial timing of the station but will also provide the necessary flexibility for future expansion or changes.

REFERENCES

1 H. Mirzwinski: Assignment Switchers; *Sound and Vision broadcasting*, Vol.10, No.1, Spring 1969.

2 A. N. Heightman and G. D. Iles: Design Considerations in Transmission of Television Timing Pulses along a Single Distribution Cable; I.E.E. Conference Publication No.46, Part 1, Paper 3/21 – I.B.C. 1968.

3 H. D. Kitchin and A. Tucker: Monosync Pulse Coding; *Sound and Vision broadcasting*, Vol.9, No.3, Winter 1968.

4 A. N. Heightman and D. V. Ryley: Colour Synchronization and Genlocking for PAL and NTSC; *Sound and Vision broadcasting*, Vol.9, No.2, Summer 1968.