

SMPTE Time Code Recording  
on 1/4" Tape  
TI Nb 67/82

TECHNICAL ASPECTS AND  
APPLICATIONS

By: A. Bourget  
STUDER INTERNATIONAL AG  
Regensdorf/Zürich - Switzerland

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## 1. INTRODUCTION

- The S.M.P.T.E. Time-Code has been defined many years ago, and it is now accepted as an universal standard which enables two or more Audio/Video/Data units to be fully interlocked.
- Until now it has been used mainly in Video Recording Studios, Video Editing Rooms and to a less extent in Sound Recording Studios with Multitrack Recorders.
- The key unit for optimal Time-Code utilisation is obviously the SYNCHRONIZER. In the past, Synchronizers either were relatively cumbersome and expensive, or had poor specs. Today, thanks to technological improvements in semi-conductor manufacture, the specs/price ratio of units processing time code signals has greatly increased.
- In other words, yesterday it was reasonable to introduce time-code processing equipment only in large or very expensive systems. Today time-code can be used to lock or drive any kind of equipment (from portable Audio or Video Recorder up to Stationary Multichannel Tape Recorder or Video Editing System) without affecting significantly its basic price.
- In the Audio Field, Tape Recorders using conventional 1/4" magnetic tape are now brought on the market with SMPTE Time-Code Record/Replay facility at an affordable price.
- In view of today's situation and considering future needs, it is of prime importance that standards have to be clearly defined prior to any wild development of fancy equipment, and this in the interest of both, manufacturers and professional users.
- The purpose of this paper is to make a clear and simple proposal defining all the parameters that have to be taken into consideration as far as Record/Replay compatibility is concerned.
- Also described are some solutions worked out by STUDER to meet the requirements outlined in this standard proposal.
- Finally, some practical examples of utilisation are shortly described.

## 2. TECHNICAL ASPECTS

- To ensure full exchange compatibility between time coded 1/4" tapes there are 5 basic parameters that have to be precisely defined:

1) Tracks Configuration:

- Figure 1 shows a well known layout.

Advantages: - Full compatibility with tape recorders that do not include time-code Record/Replay facility.

- Same amount of cross-talk (if any) in both channels, reducing annoying side noise in stereo recording.

2) Tracks Dimensions:

- Figure 2 shows the actual dimensions of recorded tracks, i.e.

{	Audio Tracks width	=	2.00 mm	(0.08")
	Separation Track	=	2.00 mm	(0.08")
	Time-Code Track width	=	$0.35 \begin{matrix} + 0.05 \\ - 0.00 \end{matrix}$ mm	$(13.78 \begin{matrix} + 2.0 \\ - 0.0 \end{matrix} \text{ mil})$

Advantage: 2.00 mm Audio Tracks together with 2.00 mm separation track is exactly today's standard for so called two-track recording.

- However, as usual, erase heads have gap lengths that are a little longer than the recorded track widths; see Figure 3.

{	Audio Erase width	=	3.25 mm	(0.125")
	Distance between both Audio Erase Tracks	=	$0.5 \begin{matrix} + 0.1 \\ - 0.0 \end{matrix}$ mm	(20.0 mil)
	Time-Code Erase width	=	$0.6 \begin{matrix} + 0.1 \\ - 0.0 \end{matrix}$ mm	(23.6 mil)

Advantage: Thanks to a slight erase overlapping it is possible to eliminate cross talk when performing sel-sync or time code re-recording operations.

3) Modulation Type:

- BI-PHASE MARK Modulation Mode has proven to be extremely reliable and easy to synthesize. Its coding key is shown on Figure 4.

- The "one" transition occurring at  $0.5 \text{ bit} \pm 5 \%$ .

- The shape of the signal is to be kept within the following values:

- Rise time (10 - 90 %) =  $65 \mu\text{s} \pm 10 \mu\text{s}$
- Fall time (90 - 10 %) =  $65 \mu\text{s} \pm 10 \mu\text{s}$
- Overshoot or tilt < 5 % (ref. peak value)

Advantage: - Easy to produce modulation with very low DC biasing risk.

#### 4) Magnetic Flux:

- The chosen value lies at:

707 nWb/m, peak-peak  $\pm 3$  dB

i.e. 350 nWb/m, equivalent sinus RMS  $\pm 3$  dB  
without frequency dependant pre-emphasis.

Advantage: This value (relatively high for a time-code signal) is very interesting because it enables the signal to be easily read at very low speed, i.e. = 1/50 of nominal speed or even slower.

Drawback: To minimize cross talk, special care has to be brought to head design, e.g. magnetic short circuit of time code track on the audio reproduce head.

N.B. The advantage of recording without preemphasis is that in fast wind or rewind mode no variable frequency dependant de-emphasis (according to actual tape speed) has to be provided.

#### 5) Coincidence of Audio Signal and Time-Code Signal:

- For many and obvious reasons, it is proposed that the offset between Audio Signal and Time-Code Signal should be Zero. In other words: Exact alignment of the Audio and Time-Code Signals on the tape is thus achieved.

Advantages: - Tape can be cut and spliced without problems as usually performed with 1/4" tapes.

- When using synchronizers: No jamming possible with spliced tapes.
- When using synchronizers: No basic offset to introduce and thus no offset correction (according to the speed) has to be performed.

Drawbacks: - Some internal compensation circuitry has to be built in the tape recorder.

These 5 parameters have been carefully studied and we tried to find an optimum solution to each of them.

When carefully designed, recorders with built-in time-code record/reproduce circuitry have the same audio specs as today's best two-track recorders. However, great care has to be taken to minimize cross-talk in replay mode from time-code channel into audio channels. Unfortunately, the main components of time-code frequency spectrum are exactly positioned where the human ear is the most sensitive, i.e. 2 to 6 kHz. In this case, the cross-talk value should not be as low as the noise floor of the reproduce chain, but it should be much lower by 10 to 15 dB, i.e. cross-talk has to be deeply buried in the reproduce chain noise.

### 3. THE STUDER SOLUTION

- On Figure 5 a solution proposed by STUDER is depicted.
- It is based on two principles:
  - a) The use of two combi-heads.
    - The first with a time-code repro gap and two audio erase gaps
    - The second with a time-code erase gap and a time code record gap.
  - b) The use of a self clocked digital delay-line to compensate for the distance between
    - 1) Audio record and time-code record heads
    - 2) Time-code repro and audio repro heads.

N.B. Note the double switch-over at both ends of the delay-line.

- Advantages:
- Full compensation in record and repro mode  
⇒ Zero Offset.
  - Can be programmed to compensate for tapes which are not recorded with a zero offset.
  - Can be used for nulling offset on an old tape recorded with an original offset different from zero (time code re-recording).
  - Low cost electronics.
  - Can be used either with vari-speed or in fast wind or rewind mode.

#### 4. APPLICATIONS

##### a) Video-Audio full interlock Figure 6

- The 1/4" Tape Recorders are housed in 19" racks together with simple synchronizers. Slaving from an editing system can then be achieved since machines receive their own time code already including an offset which is chosen by the operator for editing effects.
- A Multitrack Recorder can be used to store the different time registered sound pre-mixes.
- Master code signal would usually be generated by one of the V-T-R's.
- Advantages:
  - Tracks can be time-aligned: Each respective to each other.
  - Low cost system.
  - Very high quality audio system.
  - Unlimited number of tracks.

##### b) Film-Audio Editing System Figure 7

- Here again the 1/4" Tape Recorders are housed in 19" racks with synchronizers where individual offset can be preset.
- Slaving is then achieved by a single time code signal coming from either a film editing table or a movie projector.
- However, usually, films do not carry a full S.M.P.T.E. time code on each frame, i.e.: 80 bits/frame; but they are encoded with 4 bits/frame and 25 frames are needed to generate a complete time-code word (= 100 bits). This is known as E.B.U. film four-bit code.

- Due to the lack of editing systems that could handle this 4-bit code, this system had little success in the past. But now, E.B.U (4-bit) → SMPTE (80-bit) time-code converters are to appear on the market very soon. This will together with 1/4" Tape Recorders create a very elegant alternative to sprocket machines (mags) using magnetic film.
- For films which are not time-coded, it would be possible to drive the time-code converter with tacho pulses generated by a tacho generator attached to either a movie projector or a flat bed editing table. In this way, the whole system would operate in full interlock as older magnetic film/sprocket machine systems.
- Advantages:
  - Perfect time-code registration of picture and sound.
  - No more clapper needed.
  - Highest audio quality.
  - No more tape to magnetic film transfer.
  - Low cost in comparison to magnetic film/sprocket machine system.
  - Programmable time squeeze/expand with synchronizer.

c) TV Simulcasting Figure 8

- The diagram is self explanatory.
- Advantages:
  - Uncritical distance between V.T.R. and A.T.R.
  - Single video master can be used with different languages tracks
  - Lower cost than multi-track Tape Recorder

d) Broadcasting Automation Figure 9

- The whole radio program can be composed on the keyboard of the central programmer, then: REPEAT, INSERT and other key functions can be easily actuated.
- E.G: Short-wave service of governmental broadcasting corporations which are transmitting the same program at different times of the day and in different languages.

e) Logging Figure 10

- Self explanatory.

f) Audio-Audio Interlock Figure 11

- The 1/4" Tape Recorders are housed in 19" racks together with synchronizers. Each synchronizer received its own time-code signal generated by the "Audio full-electronic editing controller".
- The main audio program sources are of course normal multi-track Recorders where original signals have been recorded as usual.

g) Mixing Console Automation Figure 12

- Automated Mixing Consoles which are driven by time-code signal can now be used also with individual 1/4" Tape Recorders which are also locked to the Mixing Console Program.

- Advantages:
- Loops can be programmed without any problems.
  - Time related effects can be programmed and rehearsed with reliability until desired effect is achieved.
  - Increased freedom of artist in relation to Tape Machine problems.

h) Audio Visual Systems Control Figure 13

- By mean of a time code decoder/programmer it is possible to drive many different visual units like: Slide projectors, coloured flashes, laser rays, etc. The number of combinations being unlimited.

5. CONCLUSION

- It is shown that: With only 5 standardized parameters perfect compatibility can be ensured when exchanging time-coded 1/4" tapes. In addition, solutions meeting the standard specs are relatively simple to be realized. This is opening a field of possible applications of which some practical examples have been described above.



TRACKS CONFIGURATION

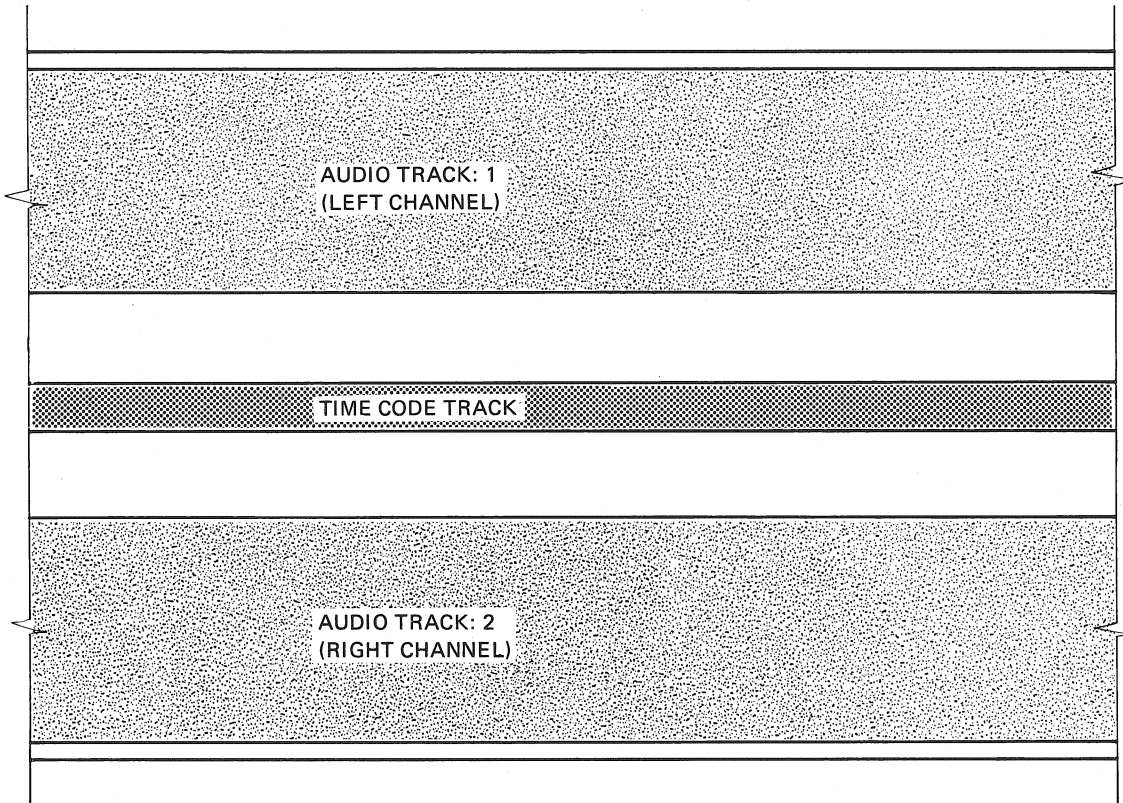


FIG 1

TIME CODE AND AUDIO  
RECORD/REPRO TRACK WIDTH

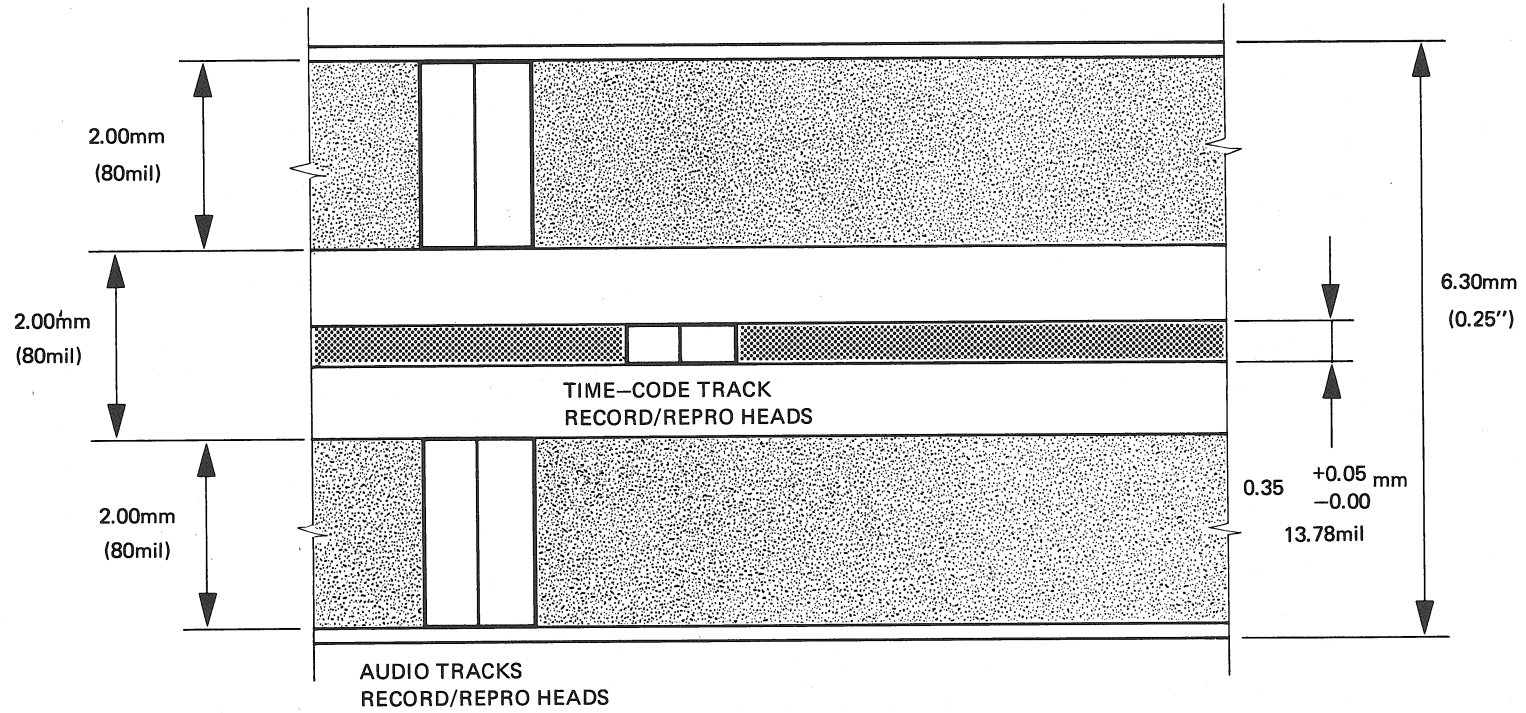


FIG 2

TIME CODE AND AUDIO  
ERASE TRACK WIDTH

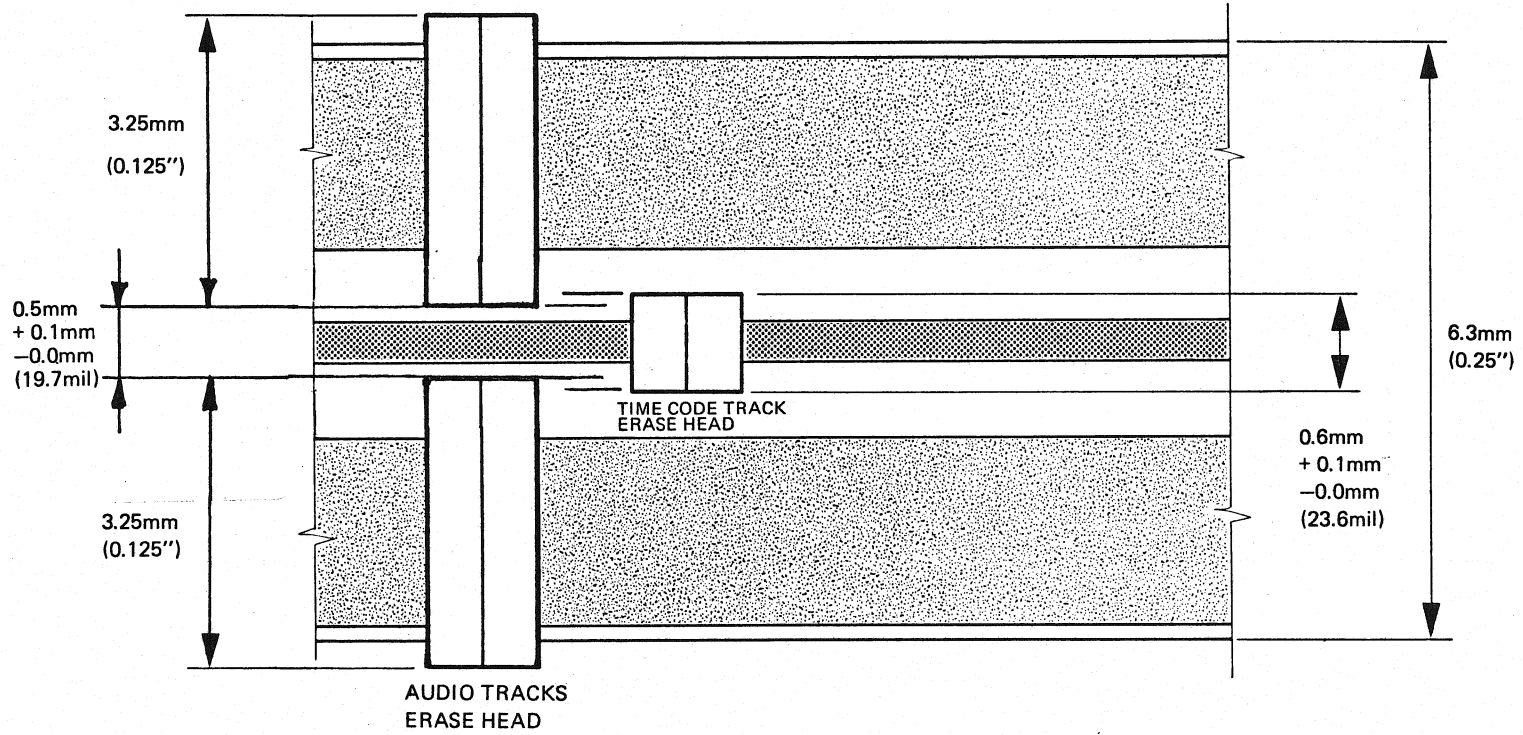


FIG 3

MODULATION

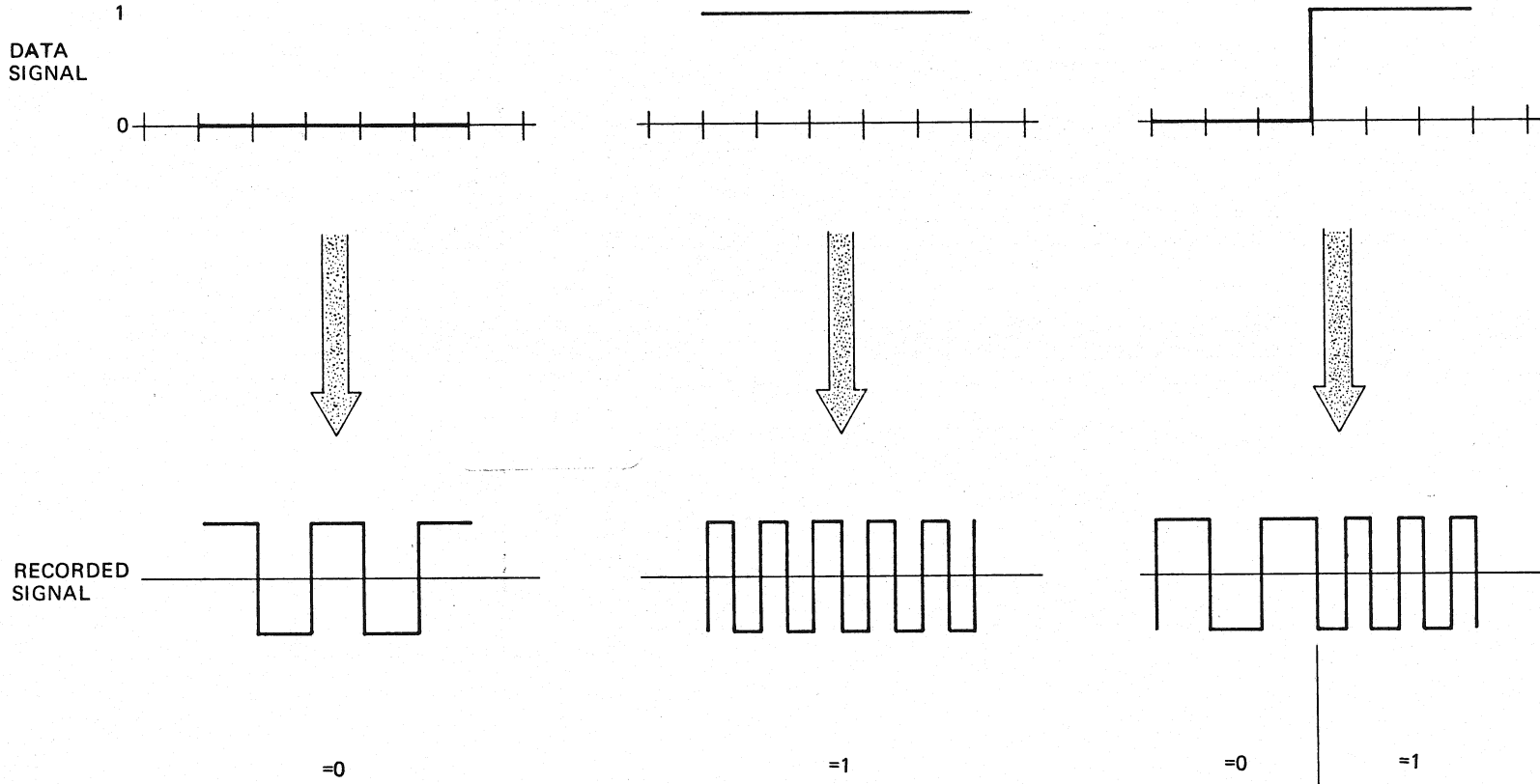


FIG 4

STUDER SOLUTION

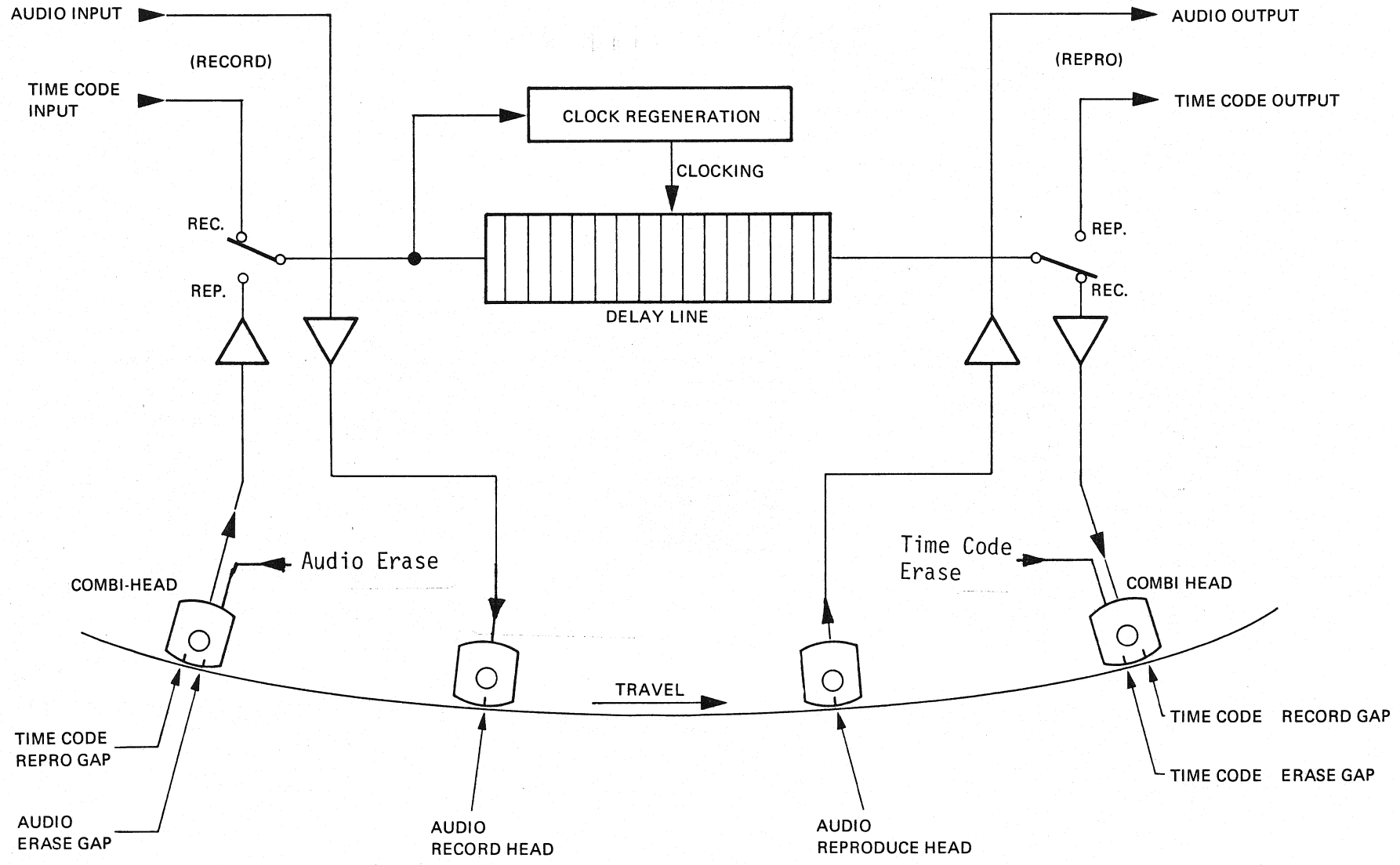


FIG 5

VIDEO-AUDIO EDITING SYSTEM

VIDEO RECORDERS

1/4" TAPE RECORDERS

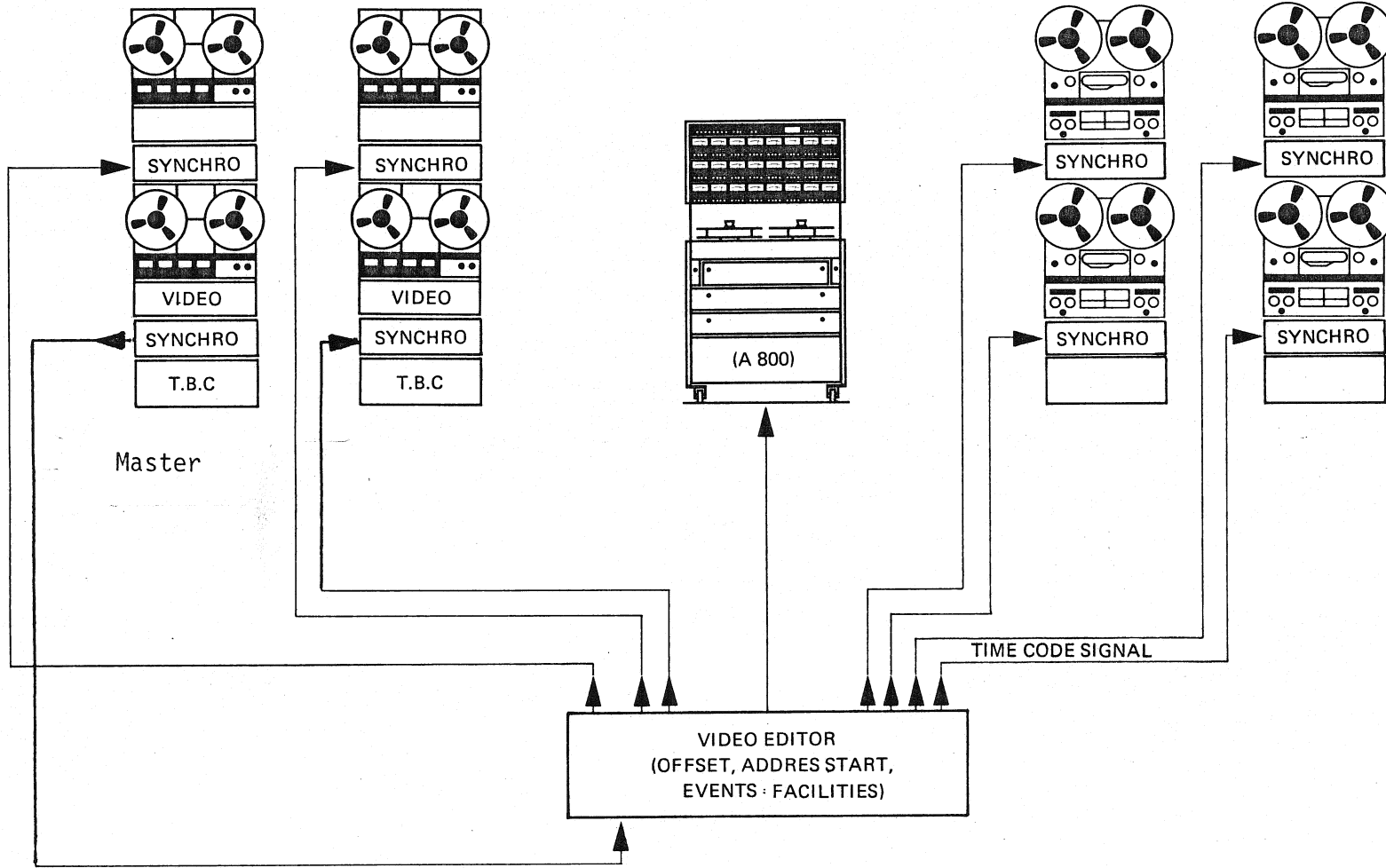


FIG 6

FILM-AUDIO EDITING SYSTEM

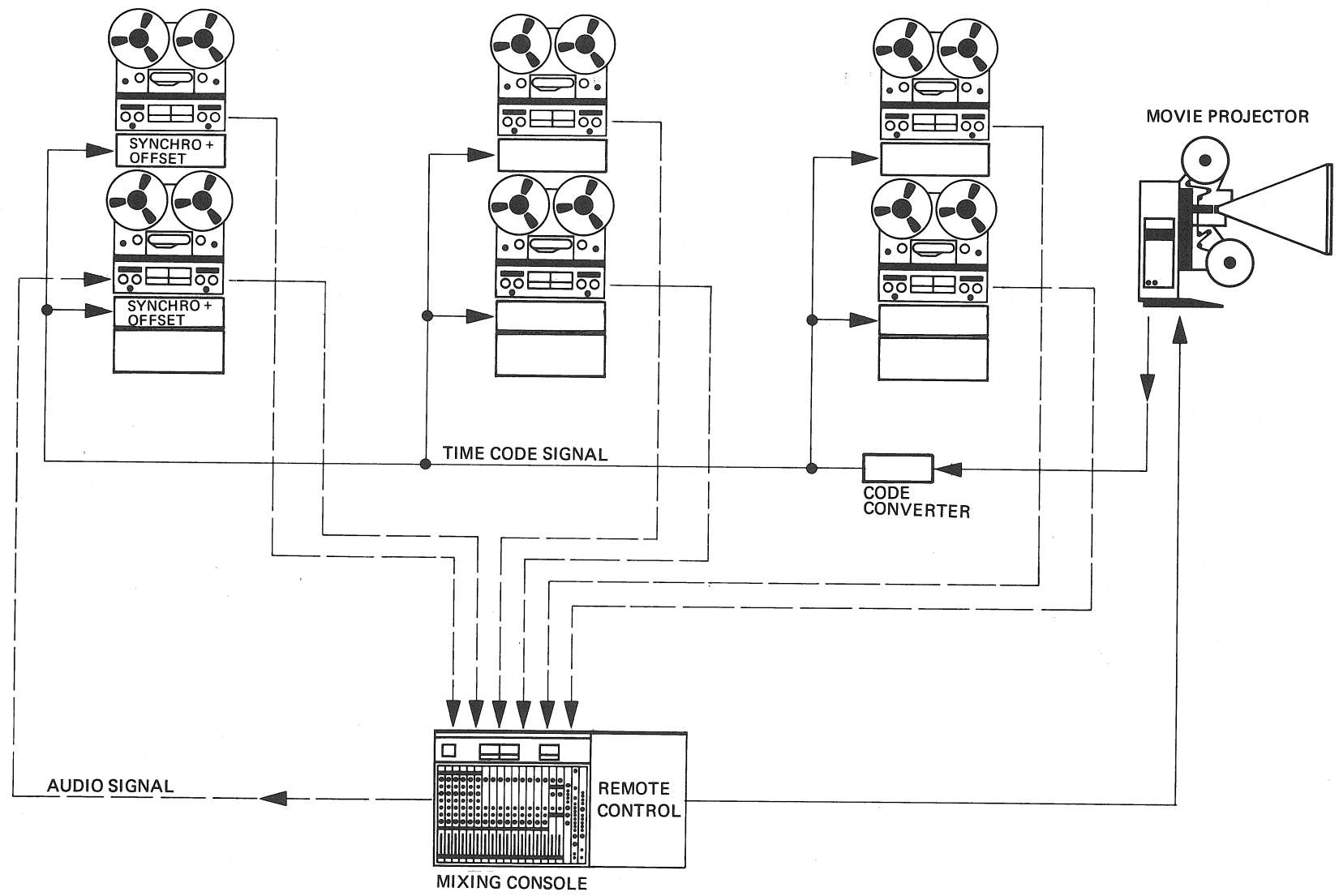


FIG 7

TV SIMULCASTING

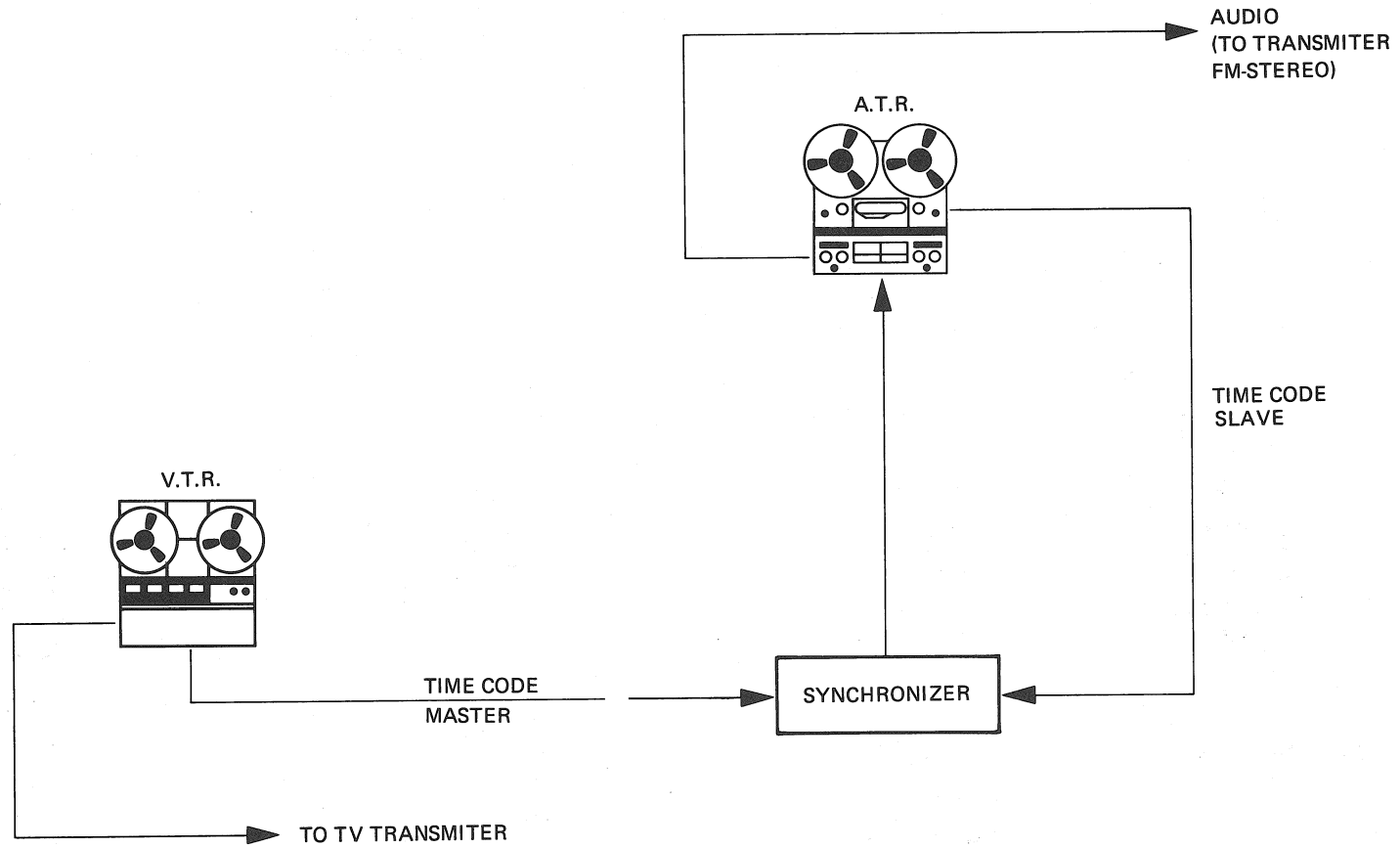


FIG 8



BROADCASTING AUTOMATION

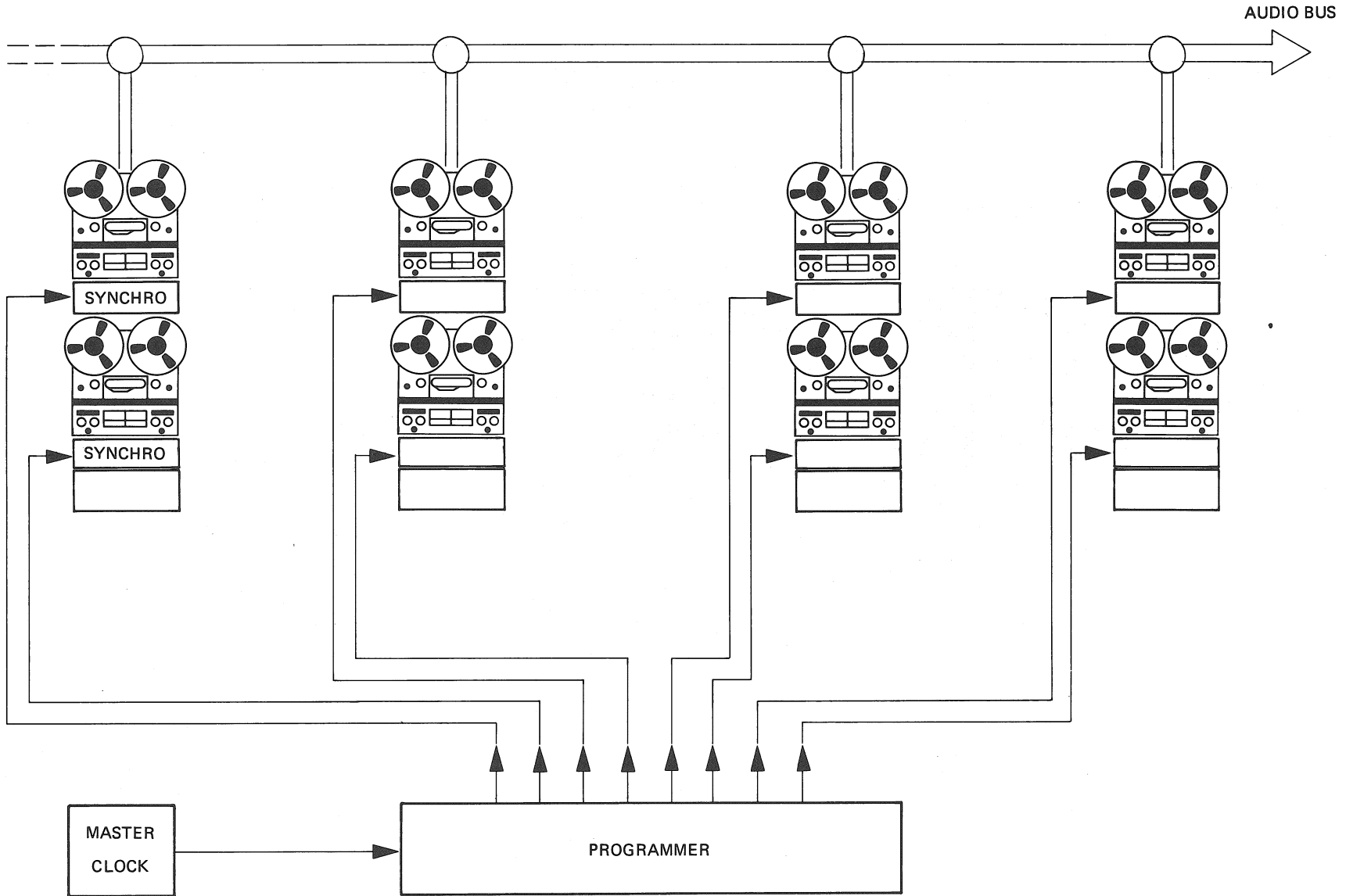


FIG 9

LOGGING

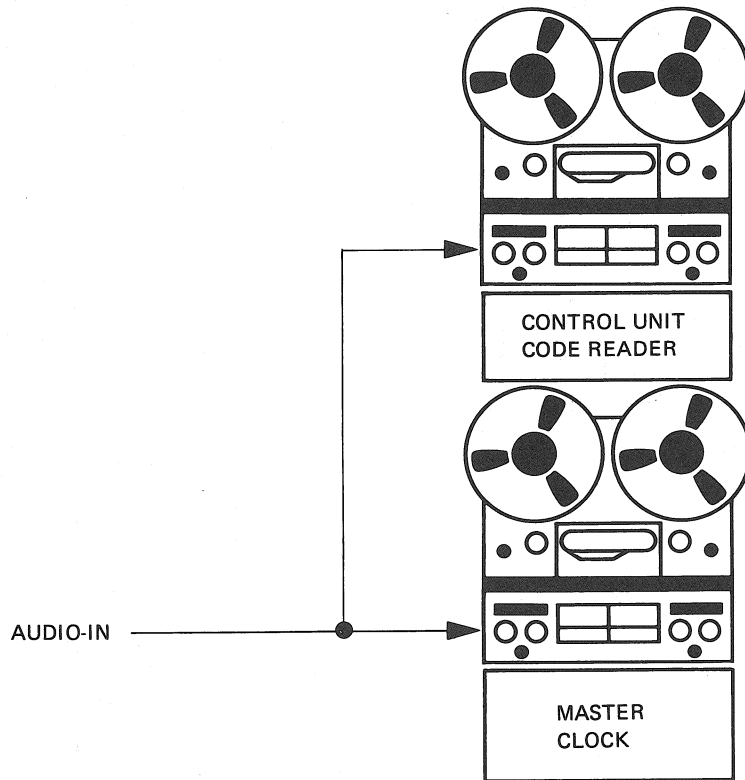


FIG 10

AUDIO-AUDIO  
FULL INTERLOCK

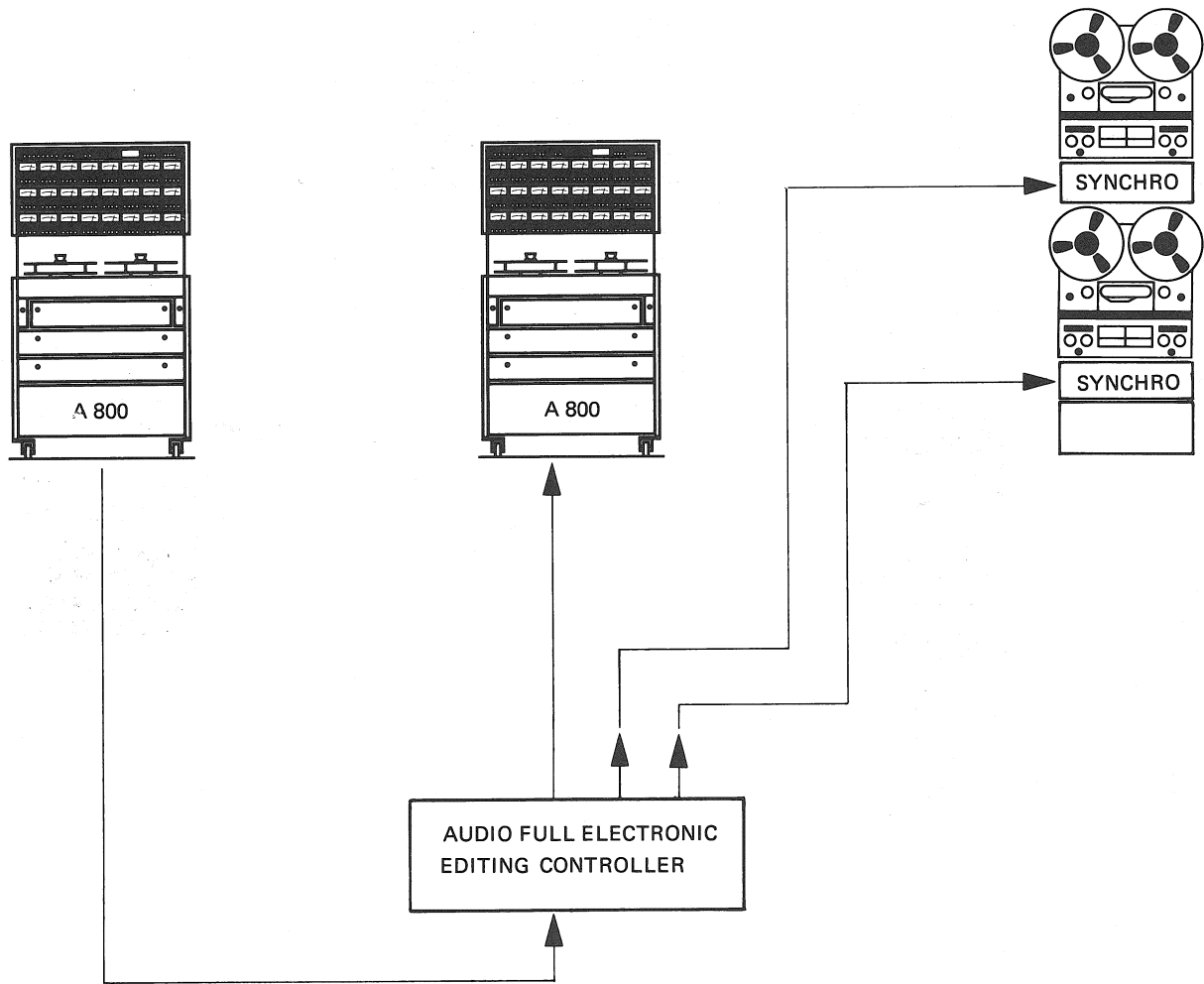


FIG 11

MIXING CONSOLE AUTOMATION

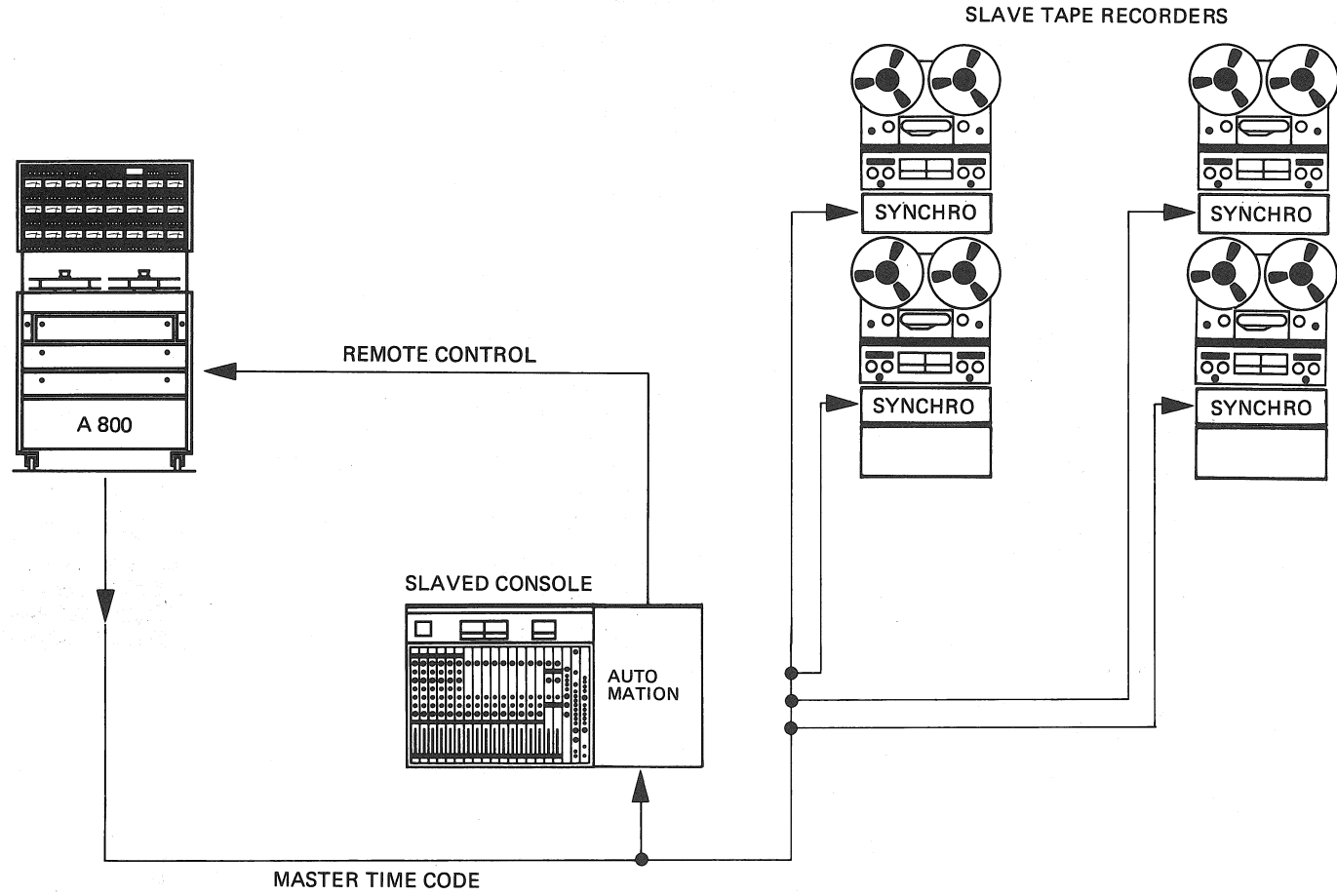


FIG 12

AUDIO VISUAL SYSTEM CONTROL

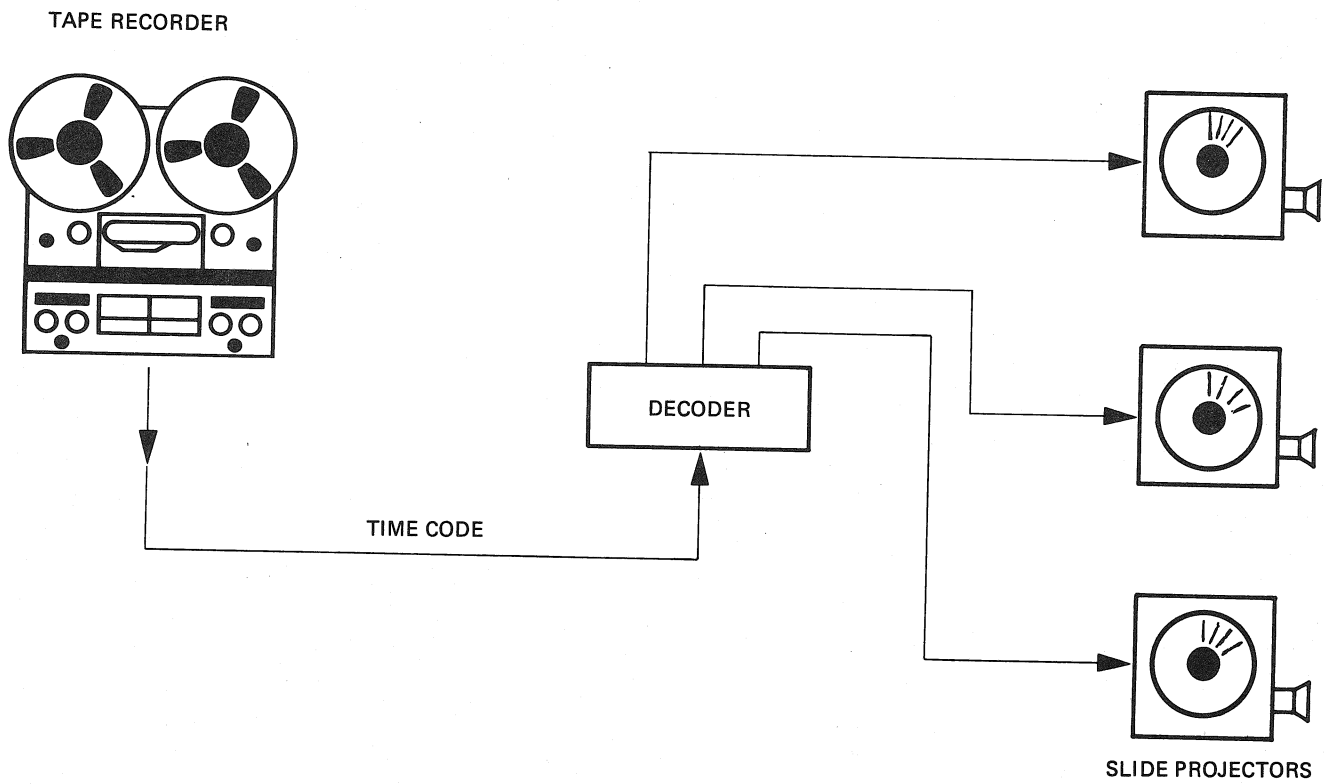


FIG 13