

SEGMENTED TAPE FORMAT VIDEO TAPE SYSTEM

Although many different recording formats are known for use in video tape systems which include record and/or replay units, each such system is designed to utilize only one format. Therefore, no compatibility exists between systems having different recording formats because a tape recorded by one system cannot be replayed in another system. If high quality performance is to be attained, a recording format requiring extensive tape consumption and complex signal processing circuitry must be utilized, which then becomes very cumbersome in portable recording equipment. However, simplification of recording format to gain enhanced compactness in portable record equipment by reducing tape consumption and the amount of circuitry, results in reduce performance.

It has been proposed to use a hierarchy of digital television standards wherein a higher data rate system would be available to attain the high quality performance required for studio equipment, and a lower data rate system would be available to attain compactness in portable equipment. One such hierarchy for the Y, I and Q components of a television signal provides for the higher data rate system by sampling the components in the ratio of 4:2:2 respectively, and provides for the lower data rate system by sampling the components in the ratio of 2:1:1 respectively. For example, one currently contemplated standard utilizes a sampling frequency of 13.5 MHz corresponding to the level of 4 in the hierarchy, and therefore the levels of 2 and 1 would represent frequencies of 6.75 and 3.375 MHz, respectively. Although such hierarchies do provide for greater flexibility between studio and portable recording equipment, the individual recording formats for higher and lower data rate systems

are not readily interchangeable in that a tape recorded by one system cannot be replayed directly in the other system. To convert the recording format of one system to the recording format of the other system, recorded information
5 sampled at one hierarchy level must be replayed, transcoded into the other hierarchy level and re-recorded or otherwise transmitted around the studio.

A multiple recording format for a video tape record and replay system is provided wherein the tape
10 is laterally divided into a plurality of longitudinal segments with a given segment being assigned to tracks in which full raster information is recorded at a fractional resolution so different data rates or formats are available for different aspects of the system such as the studio and
15 portable recording equipments respectively.

In the drawings:

FIGURE 1 illustrates an embodiment of a multiple recording format in accordance with the principles of the invention;

20 FIGURE 2 illustrates the sequence of Y, I and Q samples that are to be recorded in the tracks of each longitudinal segment of a magnetic tape having the multiple recording format illustrated in FIGURE 1;

FIGURE 3 schematically illustrates scanner
25 apparatus used to scan tracks in accordance with the multiple recording format illustrated in FIGURE 1;

FIGURE 4 illustrates schematically an arrangement for directing the Y, I and Q component pixels to each of the transducers of FIGURE 3;

30 FIGURE 5 illustrates a multiple recording format in accordance with an aspect of the invention that is adapted for use by a portable tape unit;

FIGURE 6 schematically illustrates the arrangement of transducers on a scanner of a portable unit
35 adapted for use with a multiple recording format in accordance with an aspect of the invention;

FIGURE 7A illustrates a tape wrap and FIGURE 7B illustrates the locations of transducers on a scanner so as

to scan tracks in accordance with the multiple recording format illustrated in FIGURE 7C;

FIGURE 8A illustrates a tape wrap and FIGURE 8B illustrates the locations of transducers on a scanner so as to scan tracks in accordance with the multiple recording format illustrated in FIGURE 8C;

FIGURES 9 and 10 illustrate record and replay pixel reformatting systems, respectively, adapted for use with the recording formats of FIGURES 1, 5, 7C and 8C;

FIGURE 11 illustrates another embodiment of a multiple recording format in accordance with an aspect of the invention;

FIGURE 12 illustrates, in block diagram form, a record/playback system capable of recording and playing back a television signal in accordance with the format illustrated in FIGURE 11; and

FIGURE 13A-13I illustrate a timing diagram useful in explaining the operation of the system of FIGURE 12.

In digital video tape record and replay systems, the recorded information is commonly related to each picture (e.g. television field or frame) by a grid of samples that are to be displayed in a raster. To provide for greater compactness in portable equipment while allowing for quality performance with studio equipment, a multiple recording format is disclosed for a digital video tape record and replay system. In this multiple recording format, the tape is laterally divided into a plurality of longitudinal segments with each segment being assigned to record full raster information at a partial or fractional pixel resolution equal to the quotient of one divided by the number of the plurality of longitudinal tape segments. The video is first digitized by sampling pixels (picture elements or samples) at some predetermined frequency and these pixels may relate to either composite or component video information. Each pixel is directed through a transducer to a particular track in one of the longitudinal segments and such tracks may be disposed in each segment along the

- 1 direction of tape travel or at some angle across the
direction of tape travel.

One preferred embodiment of a multiple recording
format in accordance with the invention is illustrated
5 by FIGURE 1 wherein Y, I and Q components of the video
information are being recorded. The longitudinal tracks
8, 9 containing e.g. audio and cue in FIGURE 1 are scanned
on tape 5 by fixed transducer head 310 in FIGURE 3. The
Y, I, and Q components are sampled in a conventional
10 ratio of 4:2:2 respectively, as illustrated in FIGURE 2
for one raster scan line. Furthermore, the tape 5 is
divided into just two longitudinal segments 6 and 7 and
full raster information at one-half resolution is
recorded in each longitudinal tape segment. Therefore,
15 two Y tracks, one I track, and one Q track are disposed
in 4-track sections of each longitudinal segment and each
of these tracks are scanned across the direction of tape
travel in a helical pattern. As shown in FIGURE 3, each
track in the 4-track sections is scanned simultaneously
20 by separate transducers Y_1 , Y_2 , Y_3 , Y_4 , I_1 , I_2 , Q_1 , and
 Q_2 on a rotating scanner 300 driven by a motor 312 and
drive 314. The tape is translated across the face of
headwheel 300 by a drive including capstan 316 in an
arrangement familiar to those skilled in the art.
25 Because the transducers are located under the tape 5 in
FIGURE 3, they should be represented with discontinuous
or dash lines but due to their small size, they are
represented with continuous lines in the interest of
clarity. A tape wrap of approximately 270° is shown in
30 FIGURE 3. However, any wrap angle could be utilized,
even an omega wrap of substantially 360° . Furthermore,
each 4-track section could include information relating
to a field or frame in a format familiar to those skilled
in the art. For every raster scan line of video informa-
35 tion, track Y_1 contains Y pixels 1, 5, 9, 13 and so on;
track Y_2 contains Y pixels 2, 6, 10, 14, and so on;
track Y_3 contains Y pixels 3, 7, 11, 15, and so on; track
 Y_4 contains Y pixels 4, 8, 12, 16, and so on; track I_1

1 contains I pixels 1, 3, 5, 7, and so on; track I_2
contains I pixels 2, 4, 6, 8, and so on; track Q_1 contains
Q pixels, 1, 3, 5, 7, and so on; track Q_2 contains
Q pixels, 2, 4, 6, 8, and so on. With this recording
5 format, the video information can be recorded at full
resolution on both longitudinal segments of the tape with
a studio record unit for which compactness and
portability are not a primary concern or at one-half
resolution on only one longitudinal segment of the tape
10 with a portable record unit for which compactness and
portability are a primary concern.

To record the video information at half
resolution in the separate longitudinal tape segments,
the Y, I and Q components could be organized in many
15 ways other than the way described above regarding FIGURE 1.
For example, the video information relating only to the
odd numbered raster scan lines could be recorded in one
longitudinal tape segment while the video information
relating only to the even numbered raster scan lines could
20 be recorded in the other longitudinal tape segment. Also,
the video information relating only to the odd numbered
fields could be recorded in one longitudinal tape segment
while the video information relating only to the even
numbered fields could be recorded in the other
25 longitudinal tape segments. Furthermore, the inventive
concept disclosed in U. S. Patent 4,393,414,
issued July 12, 1983, and entitled
"Interleaved Recording Format for Digital Video" could be
utilized along with the concept of this invention by
30 recording each of the interleaved checkerboard pixel patterns
illustrated in FIGURE 1 of that patent, in the
separate longitudinal tape segments in FIGURE 1 of this
application.

As explained previously in regard to FIGURE 3,
35 those skilled in the art will readily understand that
transducer means are provided on the rotating
scanner 300 for each of the Y_1 , Y_2 , Y_3 , Y_4 , I_1 , I_2 , Q_1 ,
and Q_2 tracks in the helical pattern of FIGURE 1. An
arrangement for directing the Y, I and Q component pixels

1 to each of the transducers on this scanner 300 is shown
in FIGURE 4. Because the particular recording format
selected could have any number of tracks allotted to each
of the Y, I and Q components, this arrangement will be
5 described for both the 4:2:2 recording format of
FIGURE 1 and the general situation wherein the number of
different tracks is not limited. The pixels of each
signal component are directed to individual switches 10,
12 and 14 which relate to the Q, I and Y components
10 respectively. While the switches 10, 12 and 14 are
illustrated as mechanical switches, it will be readily
understood that equivalent electronic switches would
be utilized in practice. Each switch 10, 12 and 14
has a number of output throw positions equal to the
15 number of format tracks that are allotted to its signal
component. Each output from the switches 10, 12 and 14
is directed in known fashion to a track on the recording
medium through one of the transducers shown in FIGURE 3.
The throw positions of switches 10, 12 and 14 are each
20 controlled individually by the output count of modulo
counters 16, 18 and 20 respectively. Each modulo counter
16, 18 and 20 has a number of count outputs equal to
the number of format tracks that are allotted to the signal
component of the switch 10, 12 or 14 it controls and
25 also, a programmable starting count output when the nature
of the particular format selected so requires. Because
the Q and I components are each allotted only one track
in the 4-track sections of each longitudinal tape segment
in the FIGURE 1 recording format, the modulo counters
30 16 and 18 could be flip flops in this hardware arrangement.
Each modulo counter 16, 18 and 20 is driven by the pixel
rate clock of the signal component to which its switch 10,
12 or 14 respectively, relates. As an example, a clock
22 representative of the frequency (13.5 MHz)
35 corresponding to the "4" hierarchy level, is directly
applied to drive modulo counter 20. Clock 22 is applied
through a divide-by-2 unit 24 thus deriving the "2"
level frequency required to drive modulo counters 16 and 18.

1 Modulo counter 20 is of the programmable starting count
type. The horizontal sync signal is applied to the starting
count input of each modulo counter 16, 18 and 20, so
that the recording of each raster scan line will start
5 with the first Y pixel in that line. Each switch 10,
12 or 14 is set to a different track position for each
output count of its respective modulo counter 16, 18 or
20 and the Y, I and Q component pixels are thereby
directed to their designated tracks in the different
10 longitudinal tape segments. It will also be readily
understood by those skilled in the art that the switching
arrangement for replaying a particular recording format
embodiment is essentially the inverse of the particular
switching arrangement selected for recording that format
15 and therefore, such replay switching is not shown in the
interest of brevity. Consequently, the replay switching
arrangement for the record switching arrangement of
FIGURE 4 would include a separate switch to receive each
of the Y, I and Q component pixels through a transducer
20 from the tape tracks and a modulo counter to control
each switch in reconstructing the appropriate replay
signal therefrom. Of course, the modulo counters would
be driven by the horizontal sync signal and clocking
arrangement in a manner similar to that shown in FIGURE 4.
25 Of course, the replay unit of the system must
be capable of reproducing the video information as a
signal for display from either the full or half resolution
recording formats on the tape in FIGURE 1. Certainly
those skilled in the art will understand that the full
30 resolution format presents no problem because the replay
unit would only perform the inverse functions of the
record unit in reverse order. Therefore, transducers in
the replay unit would pick up all of the video information
from the tracks in both longitudinal segments of the tape
35 and process that information in a well known conventional
manner to derive the display signal. With this invention,
the replay unit can also reproduce the one-half resolution
format from one longitudinal segment of the tape in this

1 same way where the picture obtained from the display
signal would be acceptable, such as in ENG*applications,
even though it would not be of suitable quality for most
studio purposes. However, in the concept of a digital
5 video hierarchy, the lower quality level signal may be
transcoded to a higher quality level by using well known
error compensation or concealment techniques such as the
interpolation scheme disclosed in U. S. Patent 4,041,453.
Thus, a hierarchy transcoder could be incorporated into
10 the replay unit (either separately or as part of the
concealment system) to process the one-half resolution
video information in deriving a display signal of suitable
quality for most studio purposes. Other design approaches
to such a hierarchy transcoder are discussed in John P.
15 Rossi's article entitled "A Simple Family of Digital
Filters For A Binary Hierarchy" in the October 1981
SMPTE Journal, pages 956-959.

When a portable unit is utilized to record the
video information at one-half resolution on only one
20 longitudinal segment located toward one side of the tape
in FIGURE 1, the other longitudinal segment located toward
the other side of the tape remains blank. To fully utilize
the tape deck and thereby enhance the functional aspect
of the portable record unit, this blank portion of the
25 tape deck is also recorded with video information at one-
half resolution in another preferred embodiment of the
invention which is illustrated in FIGURE 5. Each
longitudinal segment of the tape is independently recorded
or replayed in this embodiment while the tape travels
30 through its full length and after the longitudinal segment
located toward one side of the tape has been recorded or
replayed, the tape is "flipped" and fed in the reverse
direction to record or replay the video information in the
longitudinal segment located toward the other side of the
35 tape. Therefore, the tracks in each longitudinal segment
of FIGURE 5 recording format traverse the tape in
different directions. However, the tape deck could be
rewound between the recording or replaying of the video

[*electronic news gathering]

1 information in each of its longitudinal segments as still
another embodiment of the invention, so that the tracks
in each longitudinal segment would traverse the tape in
the same direction. Furthermore, component video
5 information is also illustrated in the recording format
of FIGURE 5 for illustrative purposes only and composite
video information at one-half resolution could readily
have been recorded or replayed in substantially the same
format.

10 Since recording format embodiments of the
invention, such as that shown in FIGURE 5, only relate to
partial raster resolution, the number of transducers on the
scanner can be reduced in the equipment of the record and
replay system that operates with only those recording
15 formats. An example of such equipment would be a portable
record unit or an electronic news gathering (ENG)
television recorder and a scanner for either recording or
replaying the format of FIGURE 5 in such equipment, is
illustrated in FIGURE 6. Of course, a switching
20 arrangement in accordance with the previous discussion
regarding FIGURE 4 would be utilized to direct the Y,
I and Q component pixels to or from each of the transducers
on the scanner during the record or replay modes,
respectively.

25 Although only two longitudinal tape segments are
included in the multiple recording formats of FIGURES 1
and 5, more of such segments could be included in other
formats within the scope of this invention. The
transducers can also be arranged in different ways on the
30 scanner to derive the various formats and the video
information may be arranged in different ways for each
such format. Examples of some of the other formats within
the scope of the invention are illustrated in FIGURES 7
and 8 wherein only one of the possible tape wraps around
35 the scanner and the transducer arrangement on the scanner
is shown for each format. For the format of FIGURE 7C, tandem
transducer pairs A, B and C, D are disposed at a single loca-
tion on the circumference of the scanner as shown in FIGURE
7A and are separated across the axial length of the scanner

1 by a distance equal to approximately half that length as
shown in FIGURE 7B. The transducers of each tandem pair
scan separate tracks in the longitudinal tape segments
on the tape which is wrapped around the scanner for
5 approximately 346°. For each revolution of the scanner,
each tandem transducer pair scans tracks in a separate
longitudinal track segment with tracks A and B disposed
in one longitudinal tape segment and tracks C and D
disposed in another longitudinal tape segment. For the
10 format of FIGURE 8C, tandem transducer pairs A, B and C, D
are disposed at a first location on the circumference of
the scanner, while tandem transducer pairs E, F and G, H
are disposed at a second location on the circumference of
the scanner that is 180° from the first location, as shown
15 in FIGURE 8A. Tandem transducer pair A, B is separated
across the axial length of the scanner from tandem
transducer pair C, D by a distance equal to approximately
one-half of that axial length, while tandem transducer
pair E, F is separated across the axial length of the
20 scanner from tandem transducer pair G, H by a distance
equal to approximately one-half of that axial length,
as shown in FIGURE 8B. Tandem transducer pairs E, F and
G, H should be shown with dotted lines however, due to their
small size they are shown with solid lines for the sake
25 of clarity. The transducers of each tandem pair scan
individual tracks in 2 longitudinal segments on the tape
which is wrapped around the scanner for 180°. During the
initial 180° of each scanner revolution, tandem transducer
AB first scans tracks A and B in the lower longitudinal
30 tape segment and thereafter tandem transducer CD scans
tracks C and D in the upper longitudinal tape segment, as
shown in FIGURE 8C. Then during the final 180° of each
scanner revolution, tandem transducer EF first scans tracks
E and F in the lower longitudinal tape segment and
35 thereafter tandem transducer GH scans tracks G and H in
the upper longitudinal tape segment.

The recording formats of this invention could be
utilized in otherwise conventional record and/or replay
systems, such as the record system shown in FIGURE 9 and

1 the replay system shown in FIGURE 10. Both of these
systems could have any desired number of track channels,
however two track channels 1 and 2 were selected for
purposes of illustrative convenience.

5 In the record system of FIGURE 9, the digitized
Y, I and Q components of the video signal
are each applied to the individual inputs of a pixel
formatter 20 arranged in accordance with FIGURE 10 of U.S.
Patent 4,393,414.

10 The Y clock in formatter 20 is 13.5 MHz while
the I and Q clocks are 6.75 MHz. For illustrative
purposes only, an 8 bit parallel format is utilized
at each input to the formatter 20. The hardware
arrangement illustrated in FIGURE 4 could serve as a
15 pixel formatter having individual inputs for each of the
Y, I and Q components in a record system with 4 track
channels directed to each longitudinal tape segment.
However, it should also be understood that the record
system of FIGURE 9 could only have 2 inputs with the
20 Y components applied at one input and both the I and Q
components applied at the other input. In such a system,
multiplexing circuitry in the pixel formatter would
provide the necessary interface standard. The pixel
formatter 20 distributes preselected combinations of
25 Y and/or I and/or Q pixels to a tape scan formatter 22
in each track channel. Control signals including 13.5
MHz clock at the input, horizontal and vertical sync, a
vertical field portion signal V/5 or V/6 (intended to
accommodate 5 revolutions/field in 525 line TV systems
30 and 6 revolutions/field in 625 line TV systems respectively),
and a video data rate (11.8 MHz) clock at the output
are applied to each tape scan formatter 22 which functions
to convert from the video rate to the tape data rate,
while leaving appropriate "blanks" for digital video
35 tape recorder control and synchronizing information.
For purposes of illustrative convenience, all such control
signals are only shown to be applied in track channel 2
and it should be realized that such signals would also
be applied in track channel 1. As is well known in the

1 art, the video data rate (11.8 MHz) clock is determined
in accordance with the information rate of the active
picture, plus the rate of the digital sync, plus the
parity rate; and the horizontal and vertical sync
5 redundancies are removed therefrom. The pixel
combinations pass from the scan formatter 22 in each
track channel to an error detection and correction (EDAC)/
parity insert unit 24 which inserts computer redundancy
for purposes of correcting or detecting errors in the
10 recording or playback process, thus accounting for some
of the DVTR overhead. The data rate clock is applied
to control the passage of pixel combinations through the
EDAC/parity insert unit 24. Then in each track channel,
the pixel combinations pass from the EDAC/parity insert
15 unit 24 to a flutter buffer 26 which accommodates or
corrects any time-base error (TBE) in the mechanics of
the record system relative to the video information
being recorded. As is known to those skilled in the art,
the flutter buffer 26 includes a memory of sufficient
20 capacity to accommodate the TBE. This memory has
the data rate (11.8 MHz) clock which is synchronous with
the incoming video, controlling its input and a mechanical
rate (11.8 MHz) clock which is synchronous with the tape
transport, controlling its output. The parallel format
25 of the pixel combinations in each track channel is then
changed to serial format through a converter 28 having
the mechanical rate clock applied both directly to control
its input and through a multiply by 8 unit 29 as a
record rate clock to control its output. From the converter
30 28, the pixel combinations pass to a preamble and sync
insert unit 30 which functions to establish both the
start of scan information and a digital sync occupying
some number of blocks per line. The record rate clock is
applied to control the passage of pixel combinations
35 through the preamble and sync insert unit 30. The pixel
combinations in each channel pass from the preamble and
sync insert unit 30 to a track channel coder 32 which
functions to organize the raw digital information in

1 accordance with the tape recording code to be utilized. The
record rate clock is applied to control the passage of
information through the track channel coder 32. This
information in each channel then passes from the coder 32
5 through a conventional recording amplifier 34 to a trans-
ducer switching unit 36 to which a position signal is applied
from a rotating headwheel within a tape transport 38. Some
number of transducers (such as 4 single transducers at the
same locations as the 4 tandem transducer pairs in FIGURE 8B
10 to only scan tracks A, E, C, G in FIGURE 8C) are disposed on
the headwheel for directing the information to the tape
traveling through an ^{appropriate} wrap angle about the headwheel
in the transport 38. A servo reference signal is
applied to the transport 38 by a timing unit 40 to which
15 the video sync and headwheel position signals are
applied and from which all of the clocks, sync signals
and vertical field portion signals are supplied.

As mentioned previously, the replay system
performs the inverse functions of the record system in
20 reverse order. Therefore, in the replay system of
FIGURE 10, the recorded information on the tape traveling
about a headwheel in a tape transport 50 is picked up
in serial format by some number of transducers (four
as in the record system of FIGURE 9) which are disposed
25 on the headwheel. A transducer switching unit 52
distributes this information to a playback amplifier
54 in track channels 1 and 2. A position signal is
applied from the headwheel to the switching unit 52.
Each amplifier 54 passes the information in each track
30 channel to a track channel decoder 56 which functions
to derive raw digital information and generate a
mechanical rate clock synchronous with the transport 50.
The raw digital information (still in serial format) in each
track channel then pass to a preamble and sync extractor 58
35 wherein the start of scan information and digital sync
information is removed. The mechanical rate clock is
applied to control the passage of information through the
preamble and sync extractor 58. In each channel, a converter
60 then receives the serial bit stream and changes the serial

1 format to pixel combinations in an 8 bit parallel format.
The mechanical rate clock is applied to converter 60
both directly and through a divide by 8 unit 61 as a
replay rate (11.8 MHz) clock. The pixel combinations in
5 each channel pass from the converter 60 to a flutter
buffer 62 which accommodates or corrects any time-base
error (TBE) in the mechanics of the replay system
relative to the video information being replayed. This
is accomplished by clocking the pixel combinations into
10 the buffer 62 with the replay rate (11.8 MHz) clock
and out with a video data rate (11.8 MHz) clock. Also,
differential signals from a time comparator 64 are
individually applied to each flutter buffer 62. In
addition to accommodating the TBE, the flutter buffers 62
15 respond to the differential signals as programmable delays
which accommodate for any timing or mechanical error that
may occur between track channels. A sync signal from
each preamble and sync extractor 58 is applied to the
time comparator 64 and utilized therein to derive the
20 differential signals. The pixel combinations in each
track channel pass from the flutter buffer 62 to an
EDAC unit 66 which functions to rectify the correctable
errors and flag the detectable errors. The data rate
clock is applied to control the passage of pixel
25 combinations through the EDAC unit 66. The pixel
combinations in each track channel pass from the EDAC
66 to a tape scan deformatter 68 with the detectable
error flag being passed in a separate path, such as by
using an added bit. The deformatter 68 functions to
30 exclude the overhead "blanks" and convert from the tape
rate to the video rate. Control signals including the
data rate clock at the input, horizontal and vertical
sync, a vertical field portion signal V/5 or V/6, and a
13.5 MHz clock at the output are applied to each deformatter
35 68. The pixel combinations from the deformatter 68 in
each channel pass to a pixel deformatter 70 with the
detectable error flag again being passed through a
separate path. The deformatter 70 is controlled by the

13.5 MHz clock and functions to collect the pixel combinations from both track channels and directs Y, I and Q pixels to individual video outputs through separate error concealment means 72, such as that disclosed in U.S. Patent No. 4,376,455 for composite pixel recording and similar techniques to those disclosed therein, could be utilized for component pixel recording. Between the deformatter 70 and each concealment means 72, the detectable error flag also passes through a separate path and the 13.5 MHz clock controls the passage of pixels through each concealment means 72. A servo reference signal is applied from a timing unit 74 to the tape transport 50 and except for the mechanical rate clock and the replay rate (11.8 MHz) clock extracted from the track channel decoder 56, the clocks, sync signals, and field portion signals are also derived from a timing section 74 to which the video sync and headwheel position signals are applied. The pixel deformatter 70 would include identical hardware to that of the pixel formatter 20 in the record system of FIGURE 9 however, the switches therein would be connected with multiple inputs from the deformatter 68 and with a single output directed to the video outputs.

FIGURE 11 illustrates a multiple segment recording format for recording on a magnetic tape a progressively scanned television signal. The format separates the noninterlaced video lines 1, 2, 3, ...n... of each frame of the progressively scanned television signal into A and B interlaced fields prior to their being recorded in different longitudinal segments. By reversing on a frame-by-frame basis, the recording sequence of noninterlaced video lines that are adjacent in time, the progressively scanned television signal is converted, in each longitudinal segment, into a recorded television signal having interlaced fields that provides a recorded picture scene that is representative of the full picture or the entire area, top and bottom, left and right, of the picture scene contained in the original noninterlaced

television signal. Thus in each longitudinal segment of Figure 11, a frame of the recorded interlaced television signal is comprised of two interlaced fields A and B, recorded in adjacently located helical tracks, with field A being derived from a first frame of the noninterlaced television signal and field B being derived from a nearby, adjacent in time, second frame. Field A, for example, will contain the odd numbered lines 1, 3, 5, ...n,...593, 595,..., where n is an odd integer, whereas field B will contain the even numbered lines 2, 4, 6,...n+1,...594, 596.... The recorded pixel resolution in each longitudinal segment is, for example, one-half or a lesser fraction of the pixel resolution of the original picture scene.

FIGURE 12 illustrates a record/playback system 120, embodying an aspect of the invention, that may be used to record or playback a magnetic tape formatted in accordance with the format illustrated in FIGURE 11. In the record mode of operation, for example, a noninterlaced video signal V_{PR} is coupled to a terminal 130. Video signal V_{PR} may be developed, in a conventional manner, by a progressively scanned camera system to develop, illustratively, 625 noninterlaced video lines per picture frame, at a frame repetition rate of 50 frames per second. Thus, the total number of video lines per frame of noninterlaced video signal V_{PR} is similar to that in a frame of video lines for the PAL standard. However, because video signal V_{PR} is noninterlaced, the frame rate, f_V , is at twice that of the PAL standard, whereas the line rate is $2f_H$, also twice the line rate f_H of the PAL standard.

Video signal V_{PR} may be either analog or digital in form, be either a monochrome or a color signal, and if a color signal, may be in either composite or component form. Furthermore, if video signal V_{PR} is in component form, the components may be time-multiplexed in a single channel, such as in a MAC format, or may be in separate channel component form, where, for each longitudinal segment, separate transducers are assigned to each of the Y, I and Q

component signals, in a scanner arrangement similar to that of FIGURE 3. If video signal V_{PR} is of the separate channel component form, then the processing stages shown in FIGURE 12 are duplicated in each component channel.

5 In the record mode of record/playback system 120 of FIGURE 12, the arms of record/playback switches RP1 and RP2 make contact with their respective record terminals R. Noninterlaced video signal V_{PS} is passed through to a terminal 128.

10 FIGURE 13A illustrates the video line number sequence for noninterlaced video signal V_{PS} , beginning with an arbitrary video line number n which is the same line number associated with the odd integer line number n in FIGURE 11. Because of the noninterlaced nature of video
15 signal V_{PS} , the duration of a given video line is $1/2f_H$.

Noninterlaced video signal V_{PS} is applied to the pole of a single-pole, triple-throw switch S1, clocked in a modulo-3 manner by a clock signal $2f_{H,ck}$, where the clock rate of $2f_{H,ck}$ equals $2f_H$. FIGURE 13A illustrates the
20 contact dwell positions and durations of arm A_r of modulo-3 switch S1, referenced to the video line number of the video signal V_{PS} being developed at terminal 128. Thus, for example, when video line n appears at terminal 128, arm A_r is in contact with terminal D1; when video line $n+1$ appears
25 at terminal 128, arm A_r is in contact with terminal D2; and when video line $n+2$ appears at terminal 128, arm A_r is in contact with terminal D3. This contact sequence repeats on a modulo-3 basis.

Contacts D1-D3 are coupled to respective first
30 ends of memories M1-M3, each memory having a memory capacity for storing a line's worth of pixels in accordance with a given desired pixel resolution. The respective other ends of memories M1-M3 are coupled to respective contacts C1-C3 of a double-pole switch S2 that includes an
35 arm A_p coupled to a pole P and an arm A_q coupled to a pole Q. The arms of switch S2 are rotated in a counterclockwise direction in a modulo-3 manner by means of the clock signal $f_{H,ck}$ provided by timing unit 122.

A double-pole, double-throw switch S3 has a pole R coupled to pole P of switch S2 and a pole S coupled to pole Q of switch S2. The arms of switch S3 cycle between their solid line contact positions and dotted line contact positions at the frame rate of noninterlaced video signal V_{ps} in accordance with the clock $f_{v,ck}$. Thus, for example, during the appearance of the video lines of Frame 1 of noninterlaced video signal V_{ps} , the arms of switch S3 are in their solid line contact position; whereas in the next frame, Frame 2, the arms are in their dotted line contact position. Therefore, during Frame 1, the video signal V_1 , developed at contact terminal B1 of switch S3, equals video signal V_p developed at pole P of switch S2, and video signal V_2 , developed at contact terminal B2, equals video signal V_q developed at pole Q of switch S2. The opposite situation holds true during the next frame, Frame 2.

Each of memories M1-M3 may be organized as a first-in-first-out (FIFO) memory. Each memory is capable of either-direction signal flow with respect to input/output functioning, depending upon the particular internal memory read/write clocking configuration. For example, each of the memories may comprise two parallel delay lines operated in a ping-pong manner between read and write functions by means of multiplexer steering stages coupled at both ends of each delay line. In the record mode of operation of the system of FIGURE 12, the ends of memories M1-M3 coupled to respective terminals D1-D3 function as signal inputs, whereas the other ends of the memories coupled to respective terminals C1-C3 serve as memory outputs.

To write signal samples into memories M1-M3, a timing unit 122 provides a write clock $WR1,ck$ to memory M1, a write clock $WR2,ck$ to memory M2 and a write clock $WR3,ck$ to memory M3. To read signal samples out of memories M1-M3, timing unit 122 provides a read clock $R1,ck$ to memory M1, a read clock $R2,ck$ to memory M2 and a read clock $R3,ck$ to memory M3. The noninterlaced video signal V_{ps} developed at terminal 128 is coupled in the record mode of

operation, to timing unit 122 to synchronize the generation of the write and read clocks to the sequence of video lines 1,2,3...n,... of noninterlaced video signal V_{PS} , and to synchronize in frequency and phase the $2f_H,ck$ signal, an f_H,ck signal and an f_V,ck signal to the horizontal and vertical blanking intervals associated with noninterlaced video signal V_{PS} .

FIGURES 13C-13E illustrate the contents of memories M1-M3 as a function of the video line number in noninterlaced video signal V_{PS} . When line n of video signal V_{PS} appears at terminal 128 and arm A_r of switch S1 dwells at contact D1, line n is written into memory M1. Line n remains in memory M1 for the next two noninterlaced lines, when arm A_r sequentially dwells at contact terminals D2 and D3. When line n+1 of video signal V_{PS} appears at terminal 128, arm A_r dwells at contact terminal D2, and line n+1 is written into memory M2 by its respective write clock. Line n+1 remains in memory for the next two noninterlaced lines, as arm A_r sequentially dwells at contact terminals D3 and D1. When line n+2 of video signal V_{PS} appears at terminal 128, arm A_r dwells at contact terminal D3, and line n+2 is written into memory M3 by its respective write clock. Line n+2 remains in memory M3 for the next two noninterlaced lines, when arm A_r sequentially dwells at contact terminals D1 and D2. The modulo-3 cycling of switch S1 repeats, with line n+3 being written into memory M1, when arm A_r dwells at contact terminal D1.

The signals stored in memories M1-M3 are sequentially read-out of the memories in coordination with the rotation of arms A_p and A_q between contacts C1-C3 of switch S2. The read-out rate from each memory is half that of the write-in rate, and a line's worth of memory is read-out in an interval $1/f_H$, an interval that equals the dwell time at each of contact terminals C1-C3 of each arm, A_p and A_q , as indicated in FIGURES 13F and 13G.

In the synchronized read-out of memories M1-M3, stored line n in memory M1 and stored line n+1 in memory M2 are read out by their respective read clocks when arm A_p

dwells at contact terminal C1 and arm A_q dwells at contact terminal C2, as indicated in FIGURES 13F-13I. For proper read-out, the synchronized operation is such that the dwell times at contacts C1 and C2, for reading out stored lines n and $n+1$, occur during the sequential appearance at terminal 128 of lines $n+2$ and $n+3$ of noninterlaced video signal V_{PS} of FIGURE 13A.

In the next sequential arm position of switch S2, arm A_p dwells at contact terminal C3 and arm A_q dwells at contact terminal C1. In this contact position, stored line $n+2$ is read out of memory M3 and stored line $n+3$ is read out of memory M1. In the final sequential contact position of switch S2, for a given modulo-3 cycle of operation, arm A_p dwells at contact terminal C2 and arm A_q dwells at contact terminal C3. Stored line $n+4$ is thereby read out of memory M2 and stored line $n+5$ is read out of memory M3.

As a result of the above described synchronous operation of switches S1-S3 and memories M1-M3, noninterlaced video signal V_{PS} is converted into two separated, interlaced video signals V1 and V2. In Frame 1 of noninterlaced video signal V_{PS} , interlaced video signal V1 contains the odd numbered lines of the frame, namely, Field A, and interlaced video signal V2 contains the even numbered lines, namely, Field B. For Frame 2 of noninterlaced video V_{PS} , when the arms of switch S3 are in the dotted line contact positions shown in FIGURE 12, interlaced video signal V1 contains the video lines of Field B and interlaced video signal V2 contains the lines of Field A.

Interlaced video signal V1 is applied to a record/playback electronics stage 126, and video signal V2 is applied to a record/playback electronics stage 127, both operated in the record mode, to develop interlaced video signal V_{i1} and interlaced video signal V_{i2} , respectively. Video signals V_{i1} and V_{i2} are properly conditioned for recording onto respective longitudinal segments 1 and 2 of the magnetic tape of FIGURE 11 by means of a scanner

apparatus comprising respective scanner transducer stages 123 and 124.

The construction of scanner apparatus 129 is similar to that of the scanner apparatus illustrated in
5 FIGURE 3, with the lower level transducers Y_1 , Y_3 , I_1 , Q_1 being associated with transducer stage 123 of FIGURE 12 and the upper level transducers, Y_2 , Y_4 , I_2 , Q_2 being associated with transducer stage 124. The tape wrap angle for scanner apparatus 129 may be similar to the nearly 360°
10 wrap angle, omega-wrap shown in FIGURE 3 or may be a complete 360° wrap angle that is provided by an alpha-wrap configuration.

Bidirectional flow of control signals is provided between timing element 122 of FIGURE 12 and a scanner and
15 capstan servo control stage 125 that controls the recording and playback of cue and headwheel control track pulses that may be associated in a conventional manner with scanner apparatus 129, the tracks of which are not illustrated in FIGURE 11. Also not illustrated in FIGURE 11 are any
20 separate audio tracks, if used.

To replay or playback the noninterlaced video signal V_{ps} that is recorded on the magnetic tape of FIGURE 11, record/playback system 120 of FIGURE 12 is operated in the playback mode with the arms of switches RP1 and RP2
25 making contact with their respective playback terminals PB. The heads of transducer stages 123 and 124 of scanner apparatus 129 pick-up the signal in the recorded tracks of each of their respective longitudinal segments 1 and 2 to produce a signal flow from scanner apparatus 129 to
30 terminal 128 that is essentially the inverse of the signal flow described when record/playback system 120 was in the record mode. The synchronized operation of switches S1-S3 and memories M1-M3 is essentially the same in the playback mode as in the previously described record mode and thus a
35 description of the operation will not be repeated.

Interlaced video signal V_{i1} and V_{i2} , sensed from their respective longitudinal segment tracks by transducer stages 123 and 124, are combined into sequential

noninterlaced video lines of a noninterlaced reconstructed video signal V_{PS} that appears at terminal 128. Vertical and horizontal synchronization components are inserted into the noninterlaced video signal developed at terminal 128 by a sync generator 121 that receives vertical and horizontal timing information from timing unit 122, in accordance with the control track and/or cue track information provided by control stage 125. In this manner a reconstructed noninterlaced video signal V_{PS} with full horizontal and vertical synchronization information is developed by record/playback system 120 at the now output signal line 130 from the recorded tracks of both longitudinal segments 1 and 2 in FIGURE 11.

When a portable unit is used to replay the recorded magnetic tape of FIGURE 11, a record/playback system may be used that has a scanner apparatus that is capable of and scans the tracks in only one of the longitudinal segments, such as Longitudinal Segment 1 of FIGURE 11. The scanner apparatus in the portable playback unit may be equipped with a lesser number of transducers that is required to playback only one of the longitudinal segments in a scanner transducer arrangement similar to that illustrated in FIGURE 6. The playback unit will provide an interlaced video signal such as interlaced video signal V_I of FIGURE 12, which may then be applied directly to a sync generator for insertion of synchronization information to develop an interlaced playback television signal. The interlaced playback television signal contains interlaced video lines that are representative of the entire area of the picture scene contained in the recorded noninterlaced video signal, as represented by the totality of all the tracks in both segments of the magnetic tape of FIGURE 11.

The playback unit, therefore, advantageously provides a ready conversion from a progressively scanned television format to an interlaced scan television format without the use of field store sized memories. As a trade off, the resolution of the interlaced video signal,

provided when playing back only one longitudinal segment of the magnetic tape of FIGURE 11, is a coarser one, since the resolution is one-half the pixel resolution of the original noninterlaced video signal, in the vertical direction.



CLAIMS:

1. A recording system for recording on magnetic tape a television signal representing a picture scene made up of pixels of information and having a certain pixel resolution, comprising:

a plurality of transducers disposed to scan a plurality of helical tracks on said tape in a plurality of longitudinal tape segments which divide the width of the tape along its length,

a plurality of control switches coupled between a source of said television signal and said transducers, and

a control circuit coupled to said switches and responsive to synchronizing information from said television signal for selectively directing to said transducers via said switches different portions of said television signal each representing a plurality of said pixels regularly distributed over the entire area of said scene, whereby the portion of the television signal thereby recorded in each segment by the associated transducer will be representative of substantially the whole area of the scene but at a lower pixel resolution.

2. A recording system as claimed in claim 1 wherein said control circuit is effective for controlling said switches to direct successive pixels of said television signal sequentially to said transducers for recording in different ones of said segments, whereby the pixels thereby recorded in each said segment will be representative of substantially the whole area of said scene but at a reduced resolution in a line scan direction.

3. A recording system as claimed in claim 1 wherein said control circuit is effective for controlling said switches to direct successive video lines of said television signal sequentially to said transducers for



recording in different ones of said segments, whereby the pixels thereby recorded in said segment will be representative of substantially the whole area of said scene but at a reduced resolution transversely to the line direction.

4. A recording system according to claim 1 for recording a television signal made up of pixels relating to each of a plurality of signal components, wherein said control circuit is effective for directing the pixels of each signal component to respective ones of said transducers through a respective one of said plurality of switches, and wherein said control circuit includes a plurality of modulo counters for controlling the switching operation of said respective ones of said switches in accordance with the sampling rate of the signal component associated therewith

5. A recording system for recording a television signal representing in a progressive-scan (non-field-interlaced) format a picture scene made up of pixels of information, comprising:

a plurality of transducers disposed to scan a plurality of helical tracks on said tape in a plurality of longitudinal tape segments which divide the width of the tape along its length,

a plurality of control switches coupled between a source of said progressive scan television signal and said transducers, and

a control circuit coupled to said switches and responsive to synchronizing information from said television signal for selectively directing to said transducers via said switches different portions of said television signal wherein, considering each frame of said television signal to comprise a first plurality of video lines notionally constituting a first field in said frame



and a second plurality of video lines notionally constituting a second field in said frame interlaced with the first field, said control circuit is effective for controlling the switching operation of said plurality of switches to record said notional fields of said television signal separately in said plurality of longitudinal tape segments in a manner such that in a given segment is recorded a television signal having recorded frames of said recorded television signal each containing first and second recorded fields that correspond to respective ones of said first and second notional fields of said progressive-scan television signal.

6. A recording system as claimed in Claim 5 wherein said control circuit is effective for controlling said switches to direct successive video lines of a first frame of said television signal sequentially to first and second of said transducers for recording in first and second ones of said tape segments, whereby said notional interlaced fields of said first frame will be recorded in said first and second segments respectively, and to direct successive video lines of a second frame of said television signal sequentially to said second and first transducers, respectively, whereby said notional fields of said second frame will be recorded in said second and first segments respectively, with each segment thereby containing successive fields alternating between a first notional field of one frame of said television signal and a second notional field of another such frame.

7. A playback tape machine for generating a playback television signal from a magnetic tape on which a television signal, representative of a picture scene made



up of pixels of information, is recorded in a plurality of helical tracks on said tape in a plurality of longitudinal tape segments which divide the width of the tape along the length, with each segment having recorded therein a plurality of pixels corresponding to a proportion of the pixels of said scene regularly distributed over the entire area of the scene at a lower pixel resolution than the pixel resolution of the scene, said machine comprising:

means including a scanner for scanning said recorded magnetic tape;

means including a transducer arrangement disposed on said scanner for transducing, from the recorded tracks in a given one but not all of said tape segments, video signal lines composed of pixels obtained from only said given segment; and

means coupled to said transducer arrangement and responsive to said transduced video lines for generating said playback television signal as representative of the entire area of said picture scene but at said lower pixel resolution.

8. A playback tape machine according to claim 7 for generating a playback signal from a said tape on which the recorded pixels in each segment are recorded in video lines each composed of a plurality of recorded pixels having said lower pixel resolution within each line, wherein said transducer arrangement is effective for transducing from said given segment said video lines of reduced pixel resolution in the line direction for the generation of said playback television signal of lower pixel resolution.

9. A playback tape machine according to claim 7 for generating a playback signal from a said tape on which the recorded pixels are recorded as video lines of such pixels with successive video lines as recorded in each tape



segment corresponding to non-adjacent scan-lines of said picture scene, wherein said transducer arrangement is effective for transducing said video lines from said given segment for the generation of said playback television signal as representative of said picture scene but with lower resolution transversely to the line direction.

10. A playback tape machine for generating a playback television signal from magnetic tape having recorded thereon, in a plurality of helical tracks in a plurality of longitudinal tape segments which divide the width of said tape along its length, video lines of a progressive scan television signal recorded such that a given frame of said progressive-scan television signal is recorded as a plurality of fields in different ones of said plurality of longitudinal tape segments to provide in a given segment a succession of recorded fields successive ones of which respectively correspond to notional fields of said progressively scanned television signal that form an interlaced line pattern with each other, said playback tape machine including:

a scanner for scanning said recorded magnetic tape; means including a transducer arrangement located on said scanner for transducing from the recorded tracks in said given segment the fields recorded therein, and means coupled to said transducer arrangement and responsive to the transduced fields for generating said playback television signal as a field-interlaced playback television signal.

11. A playback tape machine for generating a playback television signal from a magnetic tape on which a television signal, representative of a picture scene made up of pixels of information, is recorded in a plurality of helical tracks on said tape in a plurality of longitudinal tape segments which divide the width of the tape along the length, with each segment having recorded therein a



plurality of pixels corresponding to a proportion of the pixels of said scene regularly distributed over the entire area of the scene at a lower pixel resolution than the pixel resolution of the scene, said machine comprising:

means including a scanner for scanning said recorded magnetic tape;

means including a transducer arrangement disposed on said scanner for transducing, from the recorded tracks in each of said tape segments, video lines composed of pixels obtained from the respective segment; and

means coupled to said transducer arrangement and responsive to said transduced video lines from said segments for generating said playback television signal as representative of the entire area of said picture scene at its original resolution.

12. A playback tape machine according to claim 11 for generating a playback signal from a said tape on which the recorded pixels in each segment are recorded in video lines each composed of a plurality of recorded pixels having said lower pixel resolution within each line, wherein said transducer arrangement is effective for transducing said recorded video lines from each of said segments for the generation of said playback television signal from said transduced video lines.

13. A playback tape machine according to claim 11 for generating a playback signal from a said tape on which the recorded pixels are recorded as video lines of such pixels with successive video lines as recorded in each tape segment corresponding to non-adjacent scan-lines of said picture scene, wherein said transducer arrangement is effective for transducing said recorded video lines from each of said segments for the generation of said playback television signal from said transduced video lines.



14. A playback tape machine for generating a playback television signal from magnetic tape having recorded thereon, in a plurality of helical tracks in a plurality of longitudinal tape segments which divide the width of said tape along its length, video lines of a progressive scan television signal recorded such that a given frame of said progressive-scan television signal is recorded as a plurality of fields in different ones of said plurality of longitudinal tape segments to provide in a given segment a succession of recorded fields successive ones of which respectively correspond to notional fields of said progressively scanned television signal that form an interlaced line pattern with each other, said playback tape machine including:

a scanner for scanning said recorded magnetic tape;
means including a transducer arrangement located on said scanner for transducing from the recorded tracks in each of said segments the fields recorded therein, and
means coupled to said transducer arrangement and responsive to the fields transduced from said segments for generating said playback television signal as a progressive scan playback television signal.

15. A recording system, or playback machine substantially in accordance with any of the alternatives hereinbefore described with reference to the accompanying drawings.
