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MILITARY STANDARD

HELICAL DIGITAL RECORDING FORMAT

FOR 19-MM MAGNETIC TAPE CASSETTE

RECORDER/REPRODUCERS

AMSC N/A FSC 6625

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DEPARTMENT OF DEFENSE
WASHINGTON, DC 20301

Helical Digital Recording Format for 19-mm Magnetic Tape Cassette Recorder/Reproducers

1. This military standard is approved for use by the Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this standard should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 5313), Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this standard or by letter.

FOREWORD

This standard was established to provide a means for operational military platforms to exchange digital data in the anti-submarine warfare, reconnaissance, intelligence and training communities. The standard defines the minimum requirements for compatibility and exchange of data and also allows designers to use one of several different approaches to implement compatible hardware that will reproduce data which was recorded on another manufacturer's equipment conforming to this standard.

Future growth to higher linear density and higher track density was given high priority in the development of this format. Recording techniques judged to restrict different concepts of hardware implementation, compatibility with new recording media, or backward compatibility with this format were rejected. This format shall provide the basis for future growth.

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1. SCOPE

1.1 Purpose. The purpose of this standard is to ensure the ability to exchange digital data within the appropriate community of users in the Department of Defense, to standardize the cassettes and the format of the data for 19-mm magnetic tape and to ensure that a recording made on one machine can be replayed on any other machine that conforms to this standard.

1.2 Scope. This standard establishes the format of the data as recorded on the tape, the principal properties of the tape, and the dimensions and physical properties of three sizes of cassettes.

1.3 Applicability. This standard defines requirements for the purchase of magnetic tape recorder/reproducers which record and reproduce or reproduce digital data using a rotary helical scan on 19-mm tape cassettes.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Standards. Unless otherwise specified, the following standard of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation forms a part of this standard to the extent specified herein.

INTER-RANGE INSTRUMENTATION GROUP (IRIG)

200-70	IRIG RCC Time Code Standards

(Application for copies should be addressed to Defense Logistics Agency, Defense Documentation Center, Cameron Station, Alexandria, VA 22314.)

(Copies of standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

SMPTE 224M	Component Digital Video Recording - 19mm Type D-1 Cassette - Tape Record
SMPTE 225M	Component Digital Video Recording - 19mm Type D-1 Cassette - Magnetic Tape
SMPTE 226M	Component Digital Video Recording - 19mm Type D-1 Cassette - Tape Cassette
SMPTE 227M	Component Digital Video Recording - 19mm Type D-1 Cassette - Helical Data and Control Records

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS (Continued)

SMPTE 228M — Component Digital Video Recording - 19mm Type D-1 Cassette - Cue and Time and Control Records

(Application for copies should be addressed to the Society of Motion Picture and Television Engineers, 595 West Hartsdale Avenue, White Plains, NY 10607.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the text of references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 8/9 encoding. A method of encoding whereby an 8-bit data word is converted to a 9-bit code word in accordance with a conversion table.

3.2 Basic dimension. A fundamental dimension to which no tolerance is applied.

3.3 Byte. A byte consists of eight binary digits.

3.4 Channel coding. The process by which binary data obtained from the digital logic circuits is converted to a waveform suitable for recording on magnetic tape.

3.5 Codeword. An 8/9 codeword consists of 9 binary digits.

3.6 Codeword Digital Sum (CDS). The digital sum variation from the beginning to the end of a codeword. CDS is calculated assuming that the codeword polarity begins with a negative level and that the binary levels are +1 and -1 and the transitions are centered in the bit cell.

3.7 Derived dimension. A derived dimension is obtained from other fundamental dimensions by computation and is given for informational purposes only.

3.8 Digital Sum Variation (DSV). The running integral of the charge of the binary bit stream which will result in the coded NRZI(1) recording waveform. DSV is calculated assuming the binary levels are +1 and -1.

3.9 Error correction. The use of mathematically related check data, recorded with the digital data, to derive the error symbols location and enable the correction of errors in the digital data.

3.10 Galois field. Denoted by GF (2) is a finite field of Q elements. It is also a polyonomial denoted by GF (2) is a finite field of Q element.

3.11 Helical digital recorder. A helical-scan digital cassette tape recorder/reproducer using 19mm type D-1 cassettes to record and/or reproduce digital data.

3.12 Identification pattern. Specific patterns used to identify sectors and array rows as described below.

3.13 Inner code block. An inner code block (horizontal in Figure 9) consists of 1 byte of block ID, 153 bytes of digital data followed by eight bytes of inner code check data for each row of each Error Correction Code (ECC) array.

3.14 Interleaving. The systematic reordering of data so that originally adjacent bytes are separated, thus reducing the effect of burst errors on the error correcting capability.

3.15 Longitudinal track modulation method. The modulation method for recording digital data on the longitudinal track shall be Manchester encoding. This method results in a transition occurring at the beginning of every bit period. "One" is represented by a second transition one-half a period from the start of a bit. "Zero" is represented when there is no transition within the bit.

3.16 Non-Return to Zero Inverse, Version 1, NRZI(1). A coding method where "1" is denoted by a waveform transition in the center of a bit cell and a "0" is denoted by no change.

3.17 Outer code block. An outer code block (vertical in Figure 9) consists of 118 bytes of digital data followed by ten bytes of outer code check data.

3.18 Postamble. A postamble consists of a sync pattern followed by an identification pattern.

3.19 Preamble. A preamble is the bit pattern recorded at the beginning of each helical track. A preamble consists of a runup sequence, a sync pattern, an identification pattern and auxiliary data.

3.20 Randomization. The reduction of correlation in a serial bit sequence so that it statistically approximates a random sequence.

3.21 Reference dimension. A dimension, usually without tolerances, used for information purposes.

3.22 Row identification pattern. The row identification pattern consists of one nine bit word which identifies each row of each data array within one sector.

3.23 Runup sequence. A runup sequence is a bit pattern chosen to facilitate the synchronization of data extraction circuits.

3.24 Scrambling. An alternate term for randomization.

3.25 Sector identification pattern. The sector preamble and postamble identification pattern consists of four consecutive 9 bit symbols which provide unique labeling of each sector recorded on tape.

3.26 Sync pattern. A sync pattern consists of four consecutive 9-bit words whose bit pattern is chosen to be a unique, compared to data.

3.27 Waveform polarity. The state of the codeword waveform at any specific time as denoted by "-" when the waveform is low and "+" when the waveform is high.

3.28 Waveform polarity inversion. The polarity at the end of codeword waveform that is opposite the polarity at the beginning of the codeword waveform. A waveform polarity inversion is caused by an odd number of "1"s in the nine-bit NRZI codeword.

4. GENERAL REQUIREMENTS

4.1 General. This section covers the general requirements for digital data recordings made on 19-mm magnetic tape cassettes.

4.1.1 Cassettes. Recorder/reproducers that conform to this standard shall be capable of using 19-mm cassettes that conform to the physical dimensions of small, medium, or large cassettes specified in 5.3. The cassettes are based on, and are compatible with small, medium, and large cassettes defined in SMPTE 226M.

4.1.1.1 Magnetic tape. The magnetic tape shall meet the requirements for 850 Oersted class (68,000 A/m) magnetic tape in accordance with SMPTE 225M.

4.1.2 Performance of helical tracks. Recorder/reproducers shall record and/or reproduce a single serial digital bit stream.

4.1.2.1 Bit-Error-Rate (BER). Error correction codes (ECC) shall be employed. The reproduced BER shall be not greater than $1X10^{-10}$ when error correction is used. The required BER is based on the media model with a random raw bit error rate of 10^{-4} and a maximum burst error of three Kilo codewords long. The BER requirement shall apply to data recorded and reproduced on the same machine and it shall also apply to data recorded on one machine and reproduced on another.

4.1.2.2 Data rate. The recorder/reproducers shall record and/or reproduce serial data streams proportional to input clock rate. As a minimum, this technology shall accommodate user data rates within the range of 10 megabits per second to 480 megabits per second. Although the data rate will normally remain constant during a recording mission, it shall be possible to select a new data rate during the recording of a single cassette tape and maintain the specified packing density and format on tape at any speed.

4.1.2.3 Read after write. It is intended that recorders built to this format standard shall support "read-after-write" capability for the purpose of on-the-spot verification of the record process. The read after write function is defined as reproducing recorded data with a separate head immediately after having recorded it.

4.1.2.4 Tape speed. The tape speed shall be variable and proportional to the input data rate.

4.1.3 Signal flow. Figure 1 is a conceptual flow diagram of the recording process. The Serial NRZL data and the row ID is read into an array generator where two arrays of 8 bit data symbols are formed. The Error Correction Code symbols are generated based on the data and the row ID and then added to the array. The row ID data ECC symbols set are then added to the preamble ID and auxiliary data and postamble ID. This symbol set is then transferred to the 8/9 encoder where each symbol is converted from an 8 bit symbol to a 9 bit symbol. This conversion incorporates the sync charge in the calculation of DSV. The 9 bit symbol set is then transferred to the multiplexer where the synchronization patterns for row sync and sector sync are inserted in their proper positions and the preamble run-up sequence is added. The NRZL representation of the bit stream is then converted to NRZI(1) and transferred to the head buffer/interface for recording on tape.

4.1.4 Input data format. The input data representation for the purpose of defining the signal flow is a serial NRZL bit stream and an in phase, coherent clock. The clock zero crossing jitter shall not exceed ±10% of the bit period about the data zero crossing at any input data rate.

5. DETAILED REQUIREMENTS

5.1 Tape record. Tape recordings shall consist of single serial digital data, recorded in a helical-scan format, plus three tracks of auxiliary data recorded in a longitudinal format. The first longitudinal track shall be used for annotation data, the second shall be used for servo control, and the third shall be used for time code/voice. The dimensions and location of the helical and auxiliary track records for 19mm helical-scan digital cassette tape recorder/reproducers shall be as specified herein.

5.1.1 Record location and dimensions. Record location and dimensions shall be as specified in Figures 2 and 3, and Table I.

5.1.2 Tape reference edge. The reference edge of the tape, for dimensions specified in this standard, shall be the lower edge, as shown in Figure 2. The magnetic coating is on the side facing the observer when the direction of tape travel is as shown in Figure 2.

5.1.3 Longitudinal tracks.

5.1.3.1 Longitudinal head gap azimuth. The azimuth angle of the head gaps used to produce longitudinal track records shall be perpendicular to the track record, plus or minus 2 minutes of arc.

5.1.3.2 Longitudinal head location. The longitudinal heads for the annotation and time code tracks shall be located in a single stack, centered as specified in Figure 3 and Table I. The control track head shall be located not greater than +119mm or minus 92mm, from the helical data reference point. The centerline of the longitudinal head stack and the control track head shall be perpendicular to the reference edge of the tape, plus or minus 2 minutes of arc.

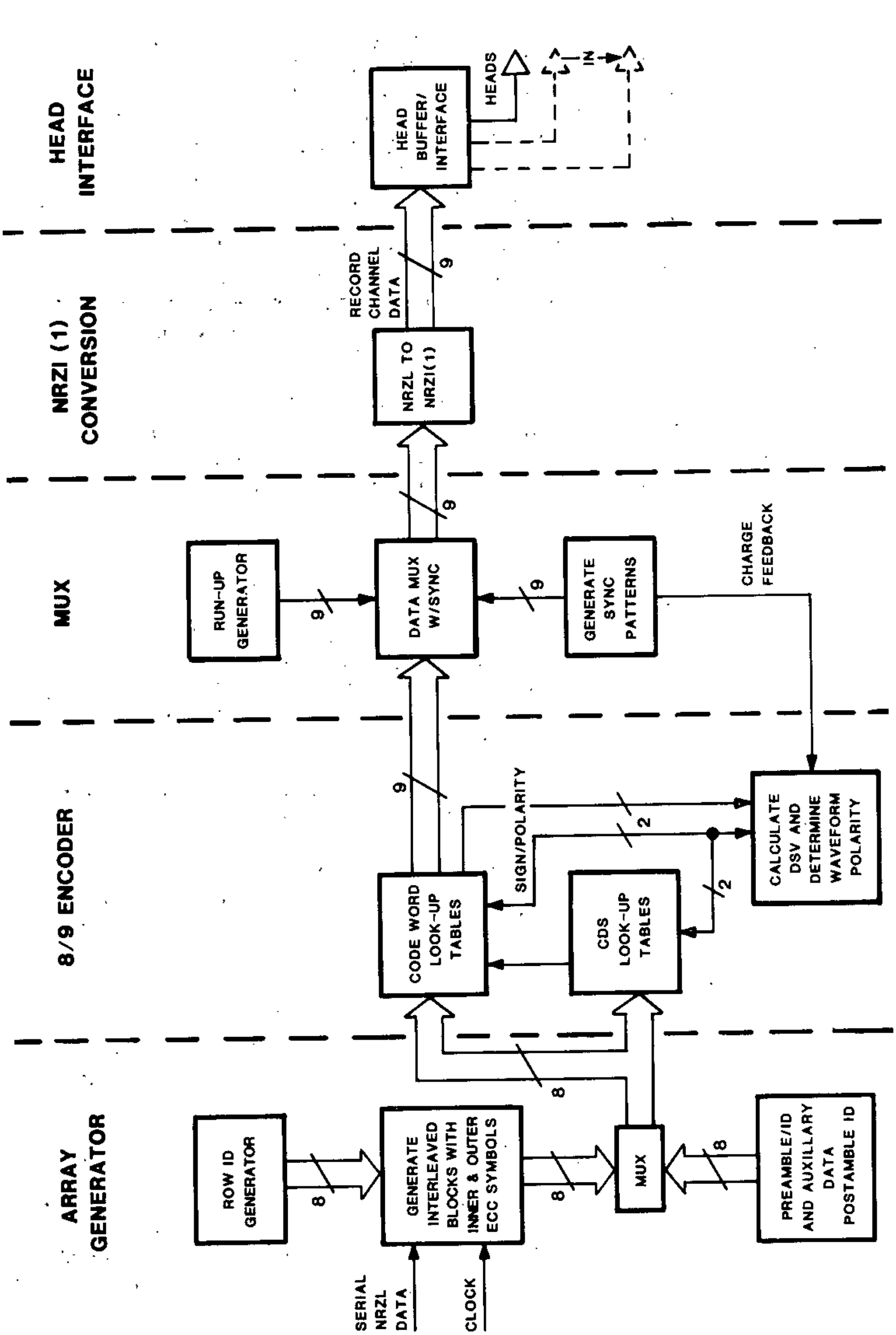


FIGURE 1. Record process signal flow (conceptual).

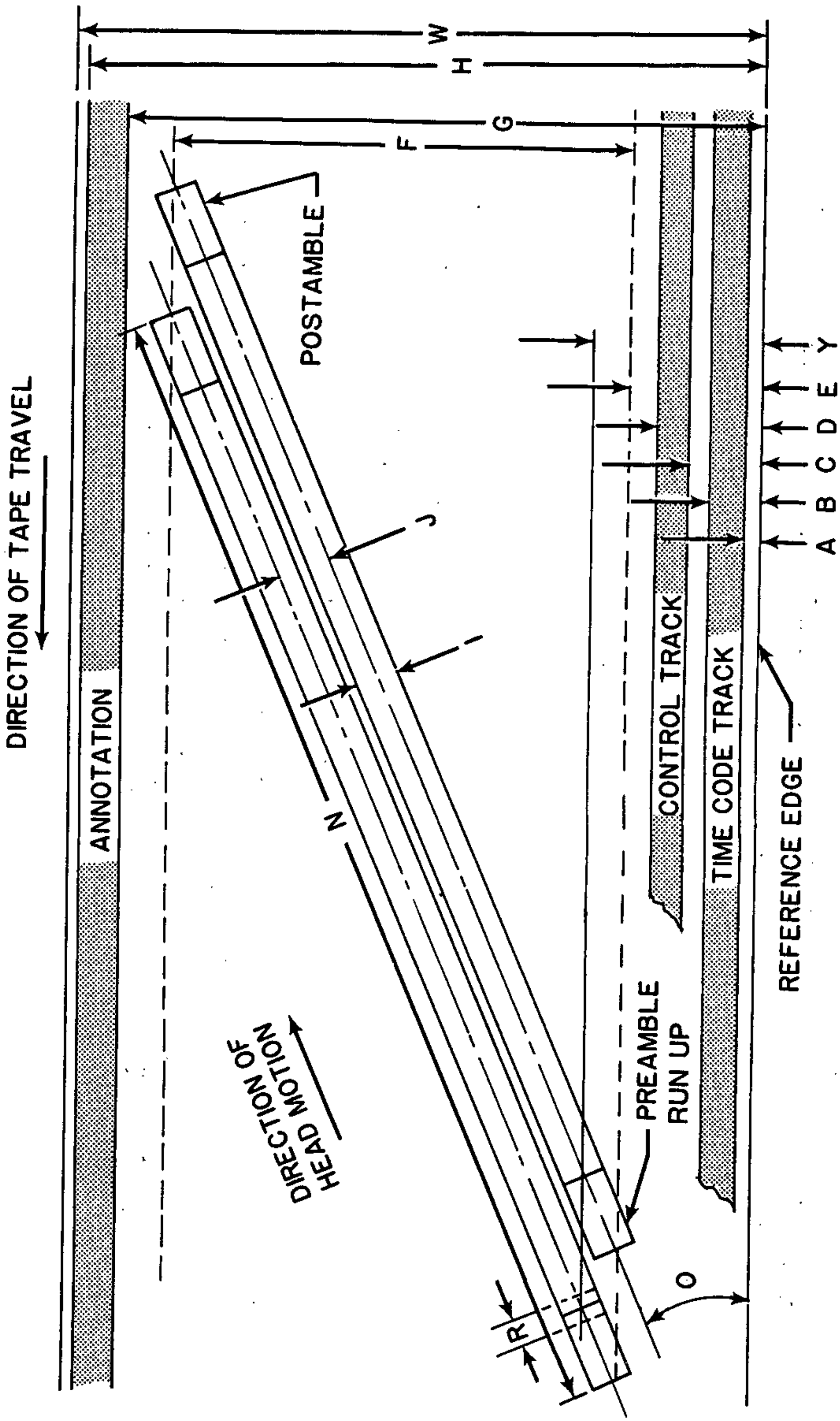


FIGURE 2. Location and dimensions of record track.

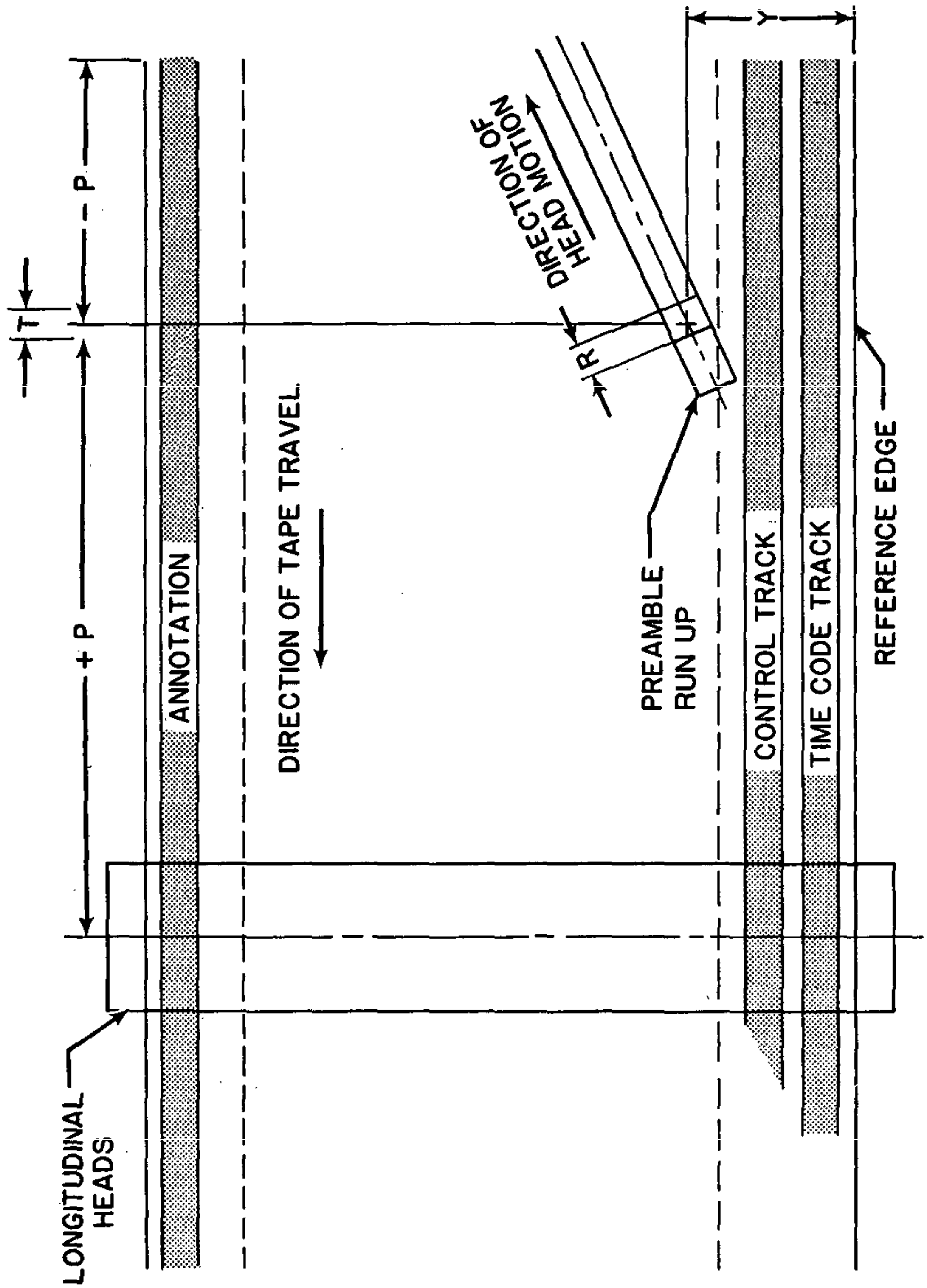


FIGURE 3. Longitudinal heads location.

TABLE I. Record location and dimensions.

		Dimensions (Millimeters)	
		Nominal	Tolerance
A	Time code track lower edge	0.2	(+0.1)
B	Time code track upper edge	0.7	(+0.1)
C	Control track lower edge	1.0	(+0.1)
D	Control track upper edge	1.5	(+0.05)
E	Digital data area lower edge	1.8	(Derived)
F	Digital data area width	16	(Derived)
G	Auxiliary track lower edge	18.1	(+0.15)
H	Auxiliary track upper edge	18.8	(+0.2)
I	Helical track width	0.04	(+0/-0.005)
J	Helical track pitch	0.045	(basic)
N	Helical track total length	170	(basic)
P	Servo control head location	-92 to +119	(±0.3)
R	Sector Recording Tolerance		(±0.1)
T	Longitudinal track sync tolerance		(±0.1)
O	Track angle	Arc Sine 16/170	(basic)
W	Tape width	19.01	(+0.015)
Y	Reference point	1.8075	(basic)

5.1.3.3 Recording method. When digital data is recorded on the longitudinal tracks, this data shall be recorded using the direct, saturate (no bias) recording method and Manchester coding rules. If voice is used for annotation on one longitudinal track bias shall be used. If analog time code is recorded on one longitudinal track, IRIG B time code shall be recorded with bias.

5.1.3.4 Flux level. The recorded peak-to-peak flux shall correspond to a magnetic short circuit flux level of 185 ± 20nWb/m of track width.

5.1.3.5 Packing density. The minimum encoded packing density shall be 5.5 KBPI.

5.1.3.6 Annotation. The system specification shall define the data format, data protocol and the interface requirements.

5.1.3.7 Servo control. The servo control record shall be a series of 32 bits recorded on the control track, as specified in Figure 4, and shall allow for identification and location of each four scan set and provide for multiple transport synchronization.

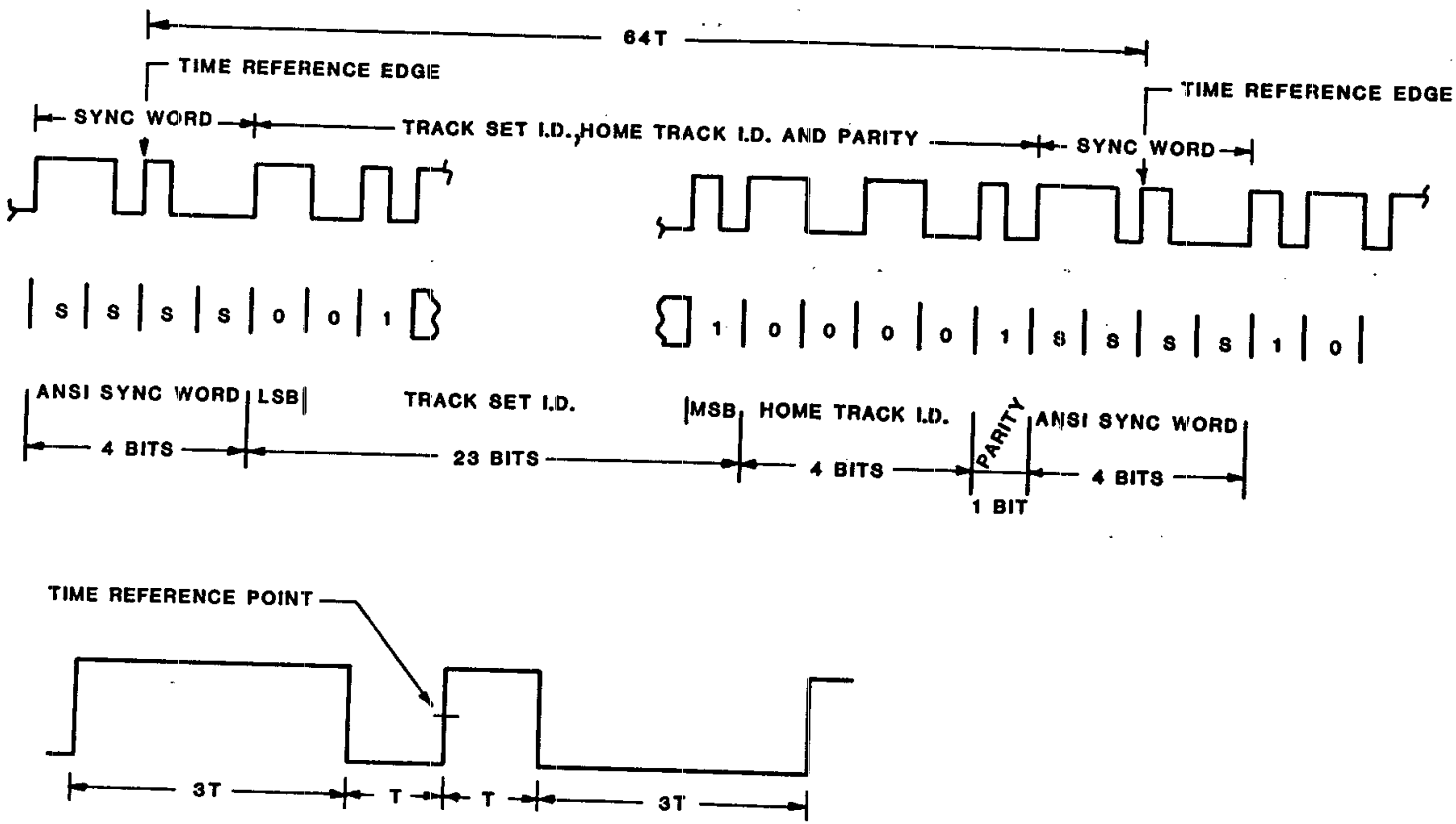
5.1.3.7.1 Servo sync and ID. The sync signal shall be four bit periods long and shall be an NRZL signal as defined in Figure 5. The track set ID shall be a 23 bit sequence which will identify each track set. The Home Track Identification shall be a 4-bit sequence which will allow systems with other than four heads per scanner to use track location data more effectively. The last bit before the next servo sync shall be an even parity bit calculated over the previous 27 bits. When home track ID is not required for a specific application, 0s shall be recorded for this sequence.

5.1.3.7.2 Servo reference signals. Servo control signal for the transport shall be derived from the servo reference on the control track. This signal shall be made up of an ANSI sync word, track set ID and Home Track Identification. This control track data block shall be repeated with an updated track set ID for each four scan track sets.

5.1.3.7.3 ANSI sync pattern polarity. During the first bit period of the ANSI sync pattern, the polarity of the control track magnetization shall be such that the south pole of the magnetic domain points in the direction of normal tape travel. The fourth bit period shall be of opposite polarity.

5.1.3.7.4 Pulse width. Each bit period of the control track code word shall occupy approximately 60 micrometers. Each control track word shall occupy a linear span of tape defined by four helical data tracks as shown in Figure 6.

5.1.3.7.5 Pulse separation. The center zero crossing of the control track sync word shall be coincident with the end of the preamble runup of every fourth track. Control track sync words are separated by the linear tape span of four helical tracks.



SYNC WORD DETAIL

NOTES:

1. T IS 1/64 THE PERIOD OF 4 HELICAL TRACKS.
2. RISE/FALL TIME IS <15 μs.

FIGURE 4. Servo control track format.

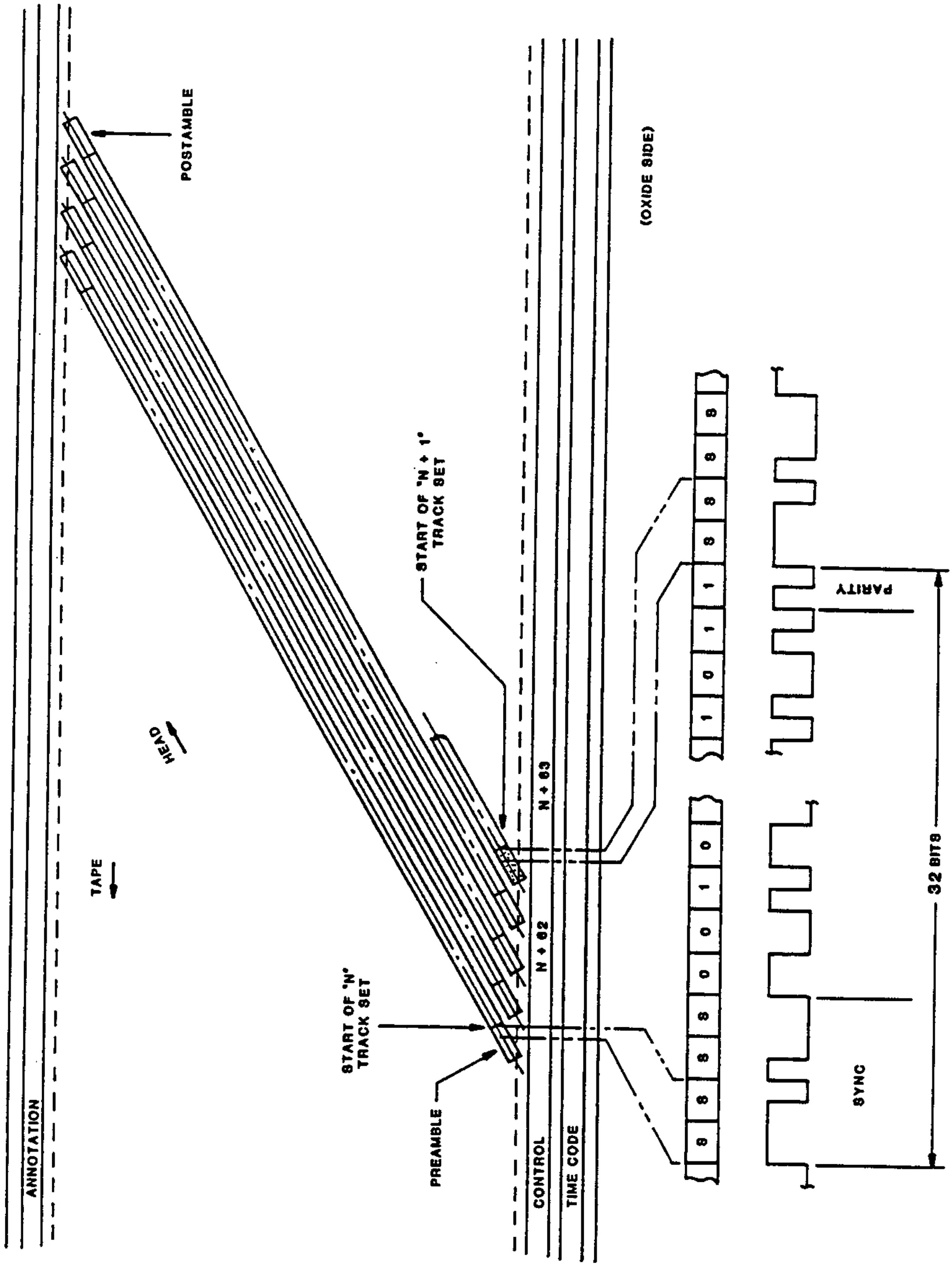


FIGURE 6. Servo reference signals.

5.1.3.7.6 Relative positions of recorded signals. The spatial relationship between the center zero crossing of the sync on the control track record and helical tracks is specified in Figure 3. The reference point is defined by a line parallel to the reference edge of the tape, 1.81 mm basic from the reference edge, intersecting the track center line at the end of the preamble as shown in Figure 3. The distance between the centerline of the control track head and the reference point shall be in accordance with Table I.

5.1.3.8 Voice/time code. If analog time code is recorded, it shall be IRIG B, as shown in Figure 7, specified in IRIG Standard Time Formats, B120 or B123, RCC Document 200-70. When required, time code shall be recorded on the longitudinal time code track with AC bias. Otherwise, this track can be used for voice or other system data.

5.1.4 Helical record. The helical track which is defined physically in 5.1.1 and 5.1.2 is continuously recorded. This segment of digital data, as defined by Figure 8, shall be recorded on one track, as a continuous serial bit stream and shall contain a contiguous sequence of the data. The next track written shall contain the next contiguous sequence of a segment of the data, i.e., there shall be no intertrack shuffling of the data. Data is arranged in one sector per track as shown in Figures 2 and 8. Each sector is divided into the following elements:

a. Preamble containing a clock run-up sequence, sync pattern, helical track identification pattern and auxiliary data.

b. Data of a fixed length sequence with error correcting code, sync patterns, and row identification patterns.

c. Postamble containing channel sync pattern and helical track identification pattern.

5.1.4.1 Labeling convention. The most significant bit is written on the left and is the first recorded to tape. The lowest numbered byte is shown at left/top and is the first encountered in the input data stream. Byte values are expressed in hexadecimal notation unless otherwise noted.

5.1.4.2 Sector details. The sector details shall be as shown in Figure 8 and described below. A sector is the digital data recorded on one helical track.

5.1.4.2.1 Sector preamble. Each sector shall commence with a preamble sequence.

(a) Length 34 codewords

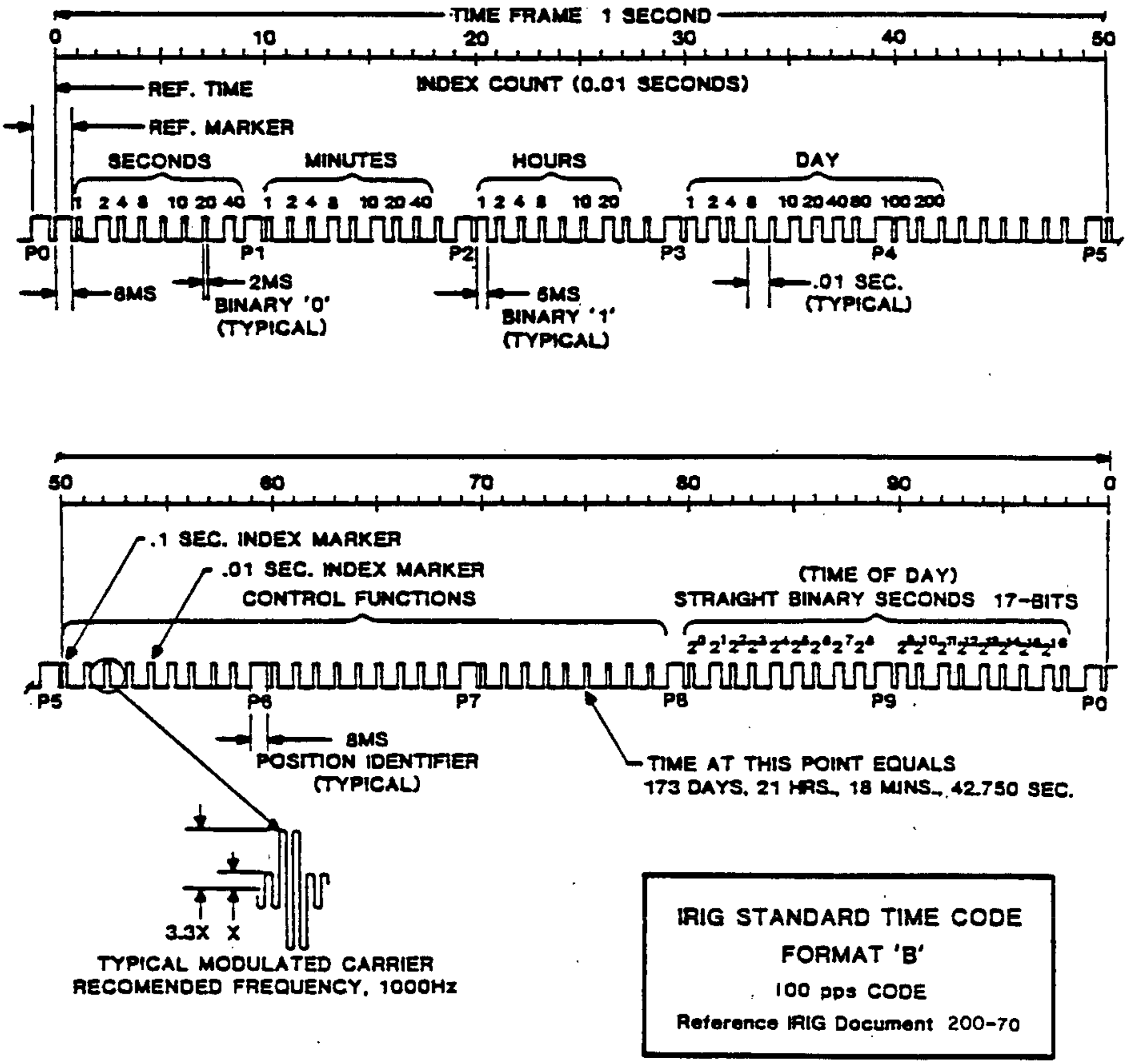


FIGURE 7. Time code.

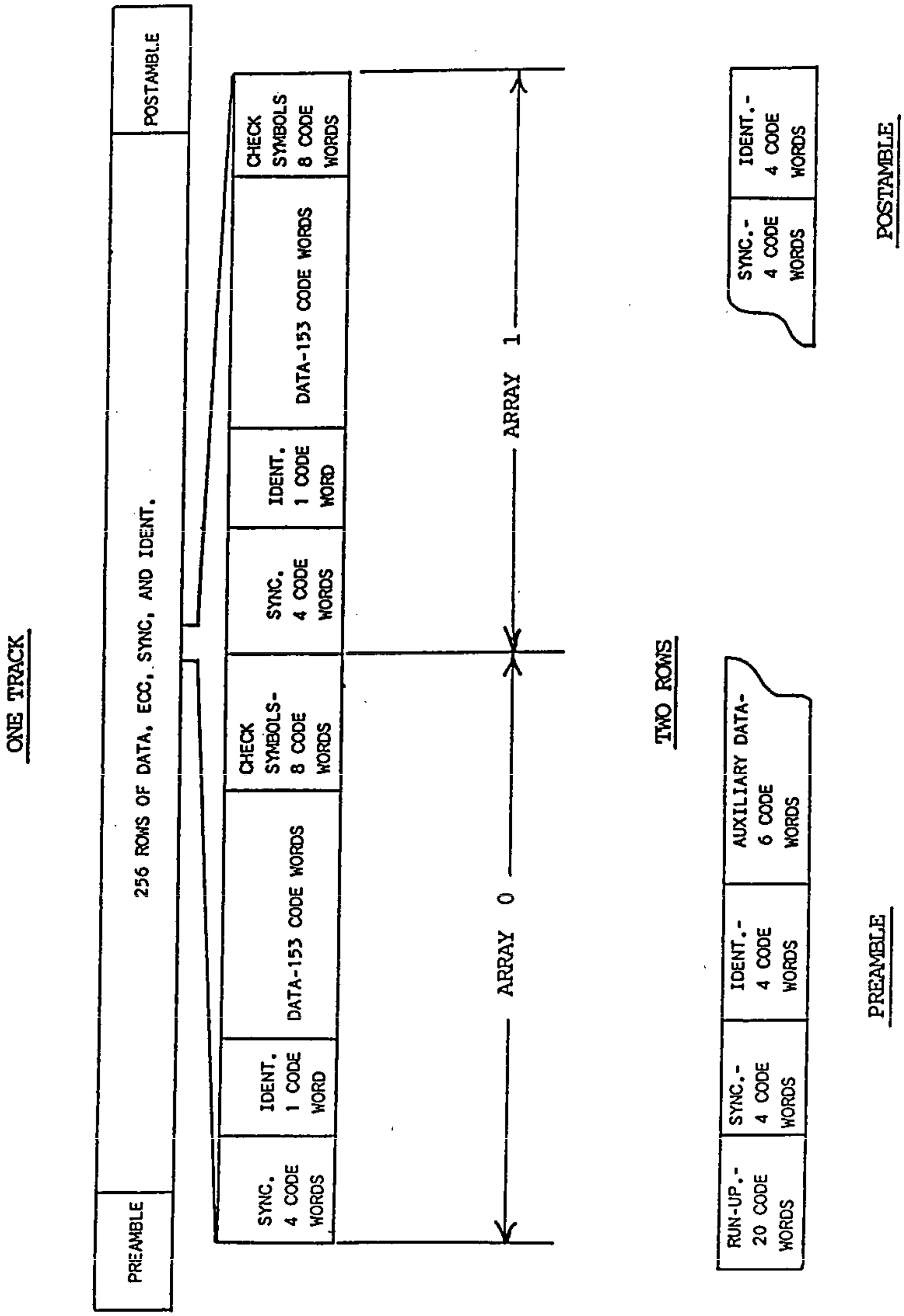
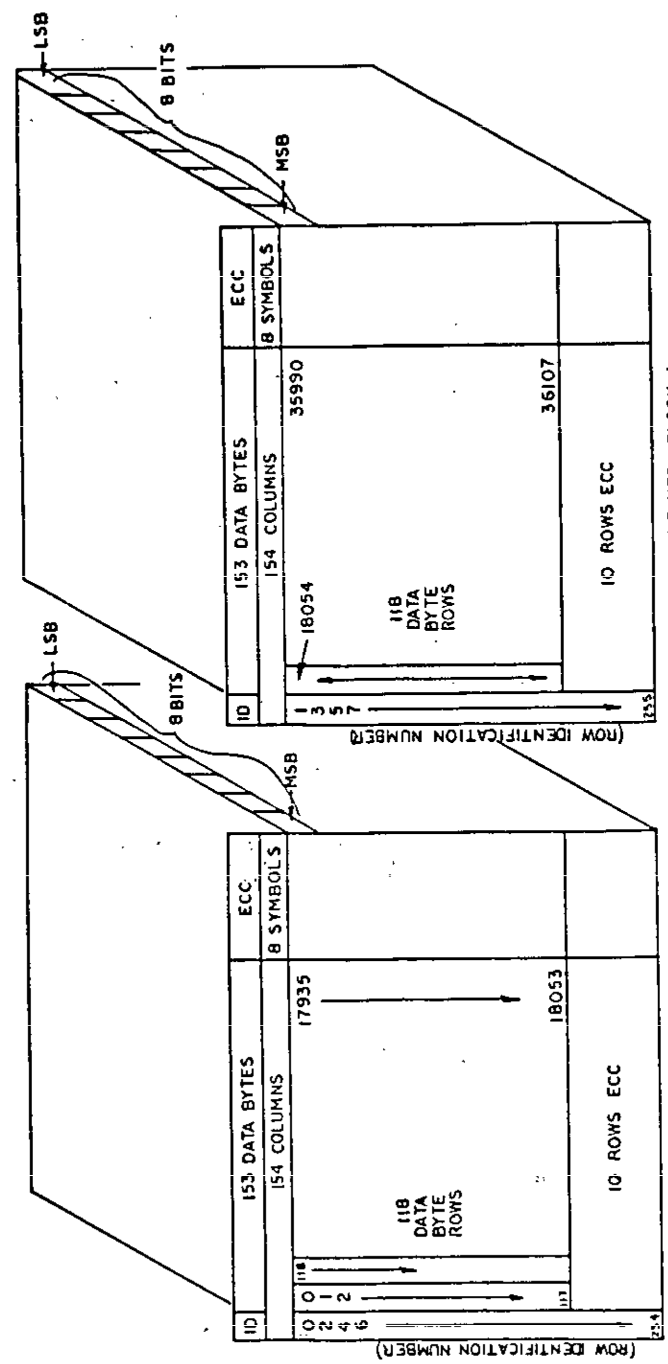


FIGURE 8. Sector details.

(b)	Arrangement	See Figure 8	
		Run-up	20 codewords minimum for clock reference Magnetization pattern as follows: LSB 001110001 11 110001110 . . . 001110001 110001110 MSB
	Sync Pattern	4 codewords	
		Identification pattern	4 codewords
		Auxiliary data	6 codewords
(c)	Protection	None	
(d)	Randomization	None	
(e)	Interleaving	None	

5.1.4.2.2 Data field. This field is used for the row ID, all data and the associated error correction data.

(a)	Length	2 arrays of data bytes; 1 row ID column and 153 columns by 118 rows. Ten error-code check symbols are appended to each column; 8 error-code check symbols are appended to each row in that order per 5.1.5.2.6 Array Generation.
(b)	Arrangement	See Figure 9
(c)	Protection (Inner Code)	
	Type	Reed-Solomon
	Galois Field	8 bits, (GF 2^8)
	Field Generator Polynomial	$x^8+x^4+x^3+x^2+x^0$
	Order of use	Left-most term is most significant, "oldest" in time computationally, and first written to tape.
	Code Generator Polynomial	$G(x)=(x+\sigma^0)(x+\sigma^1)(x+\sigma^2)(x+\sigma^3)(x+\sigma^4)(x+\sigma^5)(x+\sigma^6)(x+\sigma^7)$



NOTE: Input data bytes are sequential from 0 through 36107 and are read into the arrays in columns.

FIGURE 9. Data and ECC blocks.

(in GF(2^8)) where

σ 0 = 0000 0001
σ 1 = 0000 0010
σ 2 = 0000 0100
σ 3 = 0000 1000
σ 4 = 0001 0000
σ 5 = 0010 0000
σ 6 = 0100 0000
σ 7 = 1000 0000

Check Characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7+K_6x^6\ K_5x^5+K_4x^4+K_3x^3+K_2x^2+K_1x^1+K_0x^1$ obtained as the remainder after dividing $x^8.D(x)$ by G(x) where $D(x)=B_{152}x^{152}+\ldots+B_1x^1+B_0x^0$

Equation of Full Code: $B_{153}x^{161}+\ldots B_0x^8+K_7x^7+K_6x^6\ldots K_0x^0$

An example of three possible patterns is shown in Table II, where pattern 1 is the impulse function and the values in the check locations represent the expansion of the code generator polynomial. The values are given in hex.

TABLE II. Data field patterns.

	Data Symbols							Check Symbols							
Symbol Position	0	1	2	...	151	152	153	154	155	156	157	158	159	160	161
Pattern 1	00	00	00	...	00	00	01	FF	0B	51	36	EF	AD	C8	18
Pattern 2	00	01	02	...	97	98	99	A1	93	20	86	F9	5B	B7	D0
Pattern 3	CC	CC	CC	...	CC	CC	CC	24	4B	05	22	ED	70	0C	D9
Symbol Identity	B_{153}	B_{152}	B_{151}	...	B_2	B_1	B_0	K_7	K_6	K_5	K_4	K_3	K_2	K_1	K_0

5.1.4.2.3 Outer error protection. Ten rows of each array contain the error correction check data associated with each column of 8-bit bytes.

Type -- Reed-Solomon
Galois Field -- GF(2^8)

Field Generator polynomial $x^8+x^4+x^3+x^2+x^0$

Order of Use left-most term is the most significant, "oldest" in time computationally, and first written to tape.

Code Generator polynomial

$$G(x)=(x+\ ^{0})(x+\ ^{1})(x+\ ^{2})(x+\ ^{3})(x+\ ^{4})$$
$$(x+\ ^{5})(x+\ ^{6})(x+\ ^{7})(x+\ ^{8})(x+\ ^{9})$$

where σ^{0} = 0000 0001

σ^{1} = 0000 0010

σ^{2} = 0000 0100

σ^{3} = 0000 1000

σ^{4} = 0001 0000

σ^{5} = 0010 0000

σ^{6} = 0100 0000

σ^{7} = 1000 0000

σ^{8} = 0001 1101

σ^{9} = 0011 1010

Check Characters

$K_9, K_8, K_7 \ldots K_1, K_0$ in $K_9x^9+K_8x^8+K_7x^7+\ldots+K_1x^1+K_0x^0$ obtained as the remainder after dividing $x^{10}\,D(x)$ by $G(x)$ where

$$D(x)=B_{117}x^{117}+B_{116}x^{116}+\ldots+B_1x^1+B_0x^0$$

Equation of Full Code

$$B_{117}x^{127}+B_{116}x^{126}+\ldots+B_1x^{11}+B_0x^{10}+K_9x^9+K_8x^8+K_7x^7+\ldots+K_1x^1+K_0x^0$$

Table III shows an example of three possible patterns, where pattern 1 is the impulse function and the values in the check location represent the expansion of the code generator polynomial.

TABLE III. Outer error protection patterns.

	Data Symbols					Check Symbols									
Symbol Position	0	1	2	116	117	118	119	120	121	122	123	124	125	126	127
Pattern 1	00	00	00	00	01	D8	C2	9F	6F	C7	5E	5F	71	9D	C1
Pattern 2	00	01	02	74	75	5B	78	59	23	8A	14	AA	DD	EF	5E
Pattern 3	CC	CC	CC	CC	CC	33	32	4A	DD	AE	EB	E7	AF	24	BF
Symbol Identity	B_{117}	B_{116}	B_{115}	B_1	B_0	K_9	K_8	K_7	K_6	K_5	K_4	K_3	K_2	K_1	K_0

5.1.4.2.4 Synchronization patterns. The synchronization patterns for the row and sector shall be defined below. The NRZI(1) definition implies that one is defined as having the polarity of its flux pattern with a north pole pointing in the direction of head travel. A zero is defined as having a south pole pointing in the direction of head travel.

5.1.4.2.4.1 Row synchronization. The synchronization pattern in binary for each row of an interleaved block shall consist of four 9 bit words in NRZI(1) as follows:

111100110000000001101000111111110010

The sync may be recorded using the NRZL to NRZI encoder and a simple rule. The NRZL codewords in hexidecimal are as follows:

@15 001 0E4 00B

Where @ is determined by:

@ = 0 if previous polarity is high

@ = 1 if previous polarity is low

5.1.4.2.4.2 Sector synchronization. The sync pattern in binary, in NRZI(1) for the sector, is as follows:

000011001111111110010111000000001101

The sync may be recorded using the NRZL to NRZI(1) encoder and a simple rule. The NRZL codewords in hexidecimal are as follows:

@15 001 0E4 00B

Where @ is determined by:

@ = 0 if previous polarity is low

@ = 1 if previous polarity is high

This row synchronization signal CDS/DSV shall be used by the 8/9 encoder when determining the selection of the next 9 bit codeword selected to minimize DSV.

5.1.4.2.5 Row identification. The row identification pattern shall consist of a 8-bit representation of the row number in the interleaved block. Row synchronization and identification patterns shall be as shown in Figure 10. The row identification pattern shall be included in the calculation of the ECC check symbols.

5.1.4.2.6 Array generation. The data field is formatted in two arrays as shown in Figure 9. Each data array consists of one ID column plus 153 columns by 118 rows. Ten error correcting code symbols are appended to each data column as per Table III. The arrays are filled by columns. The byte is

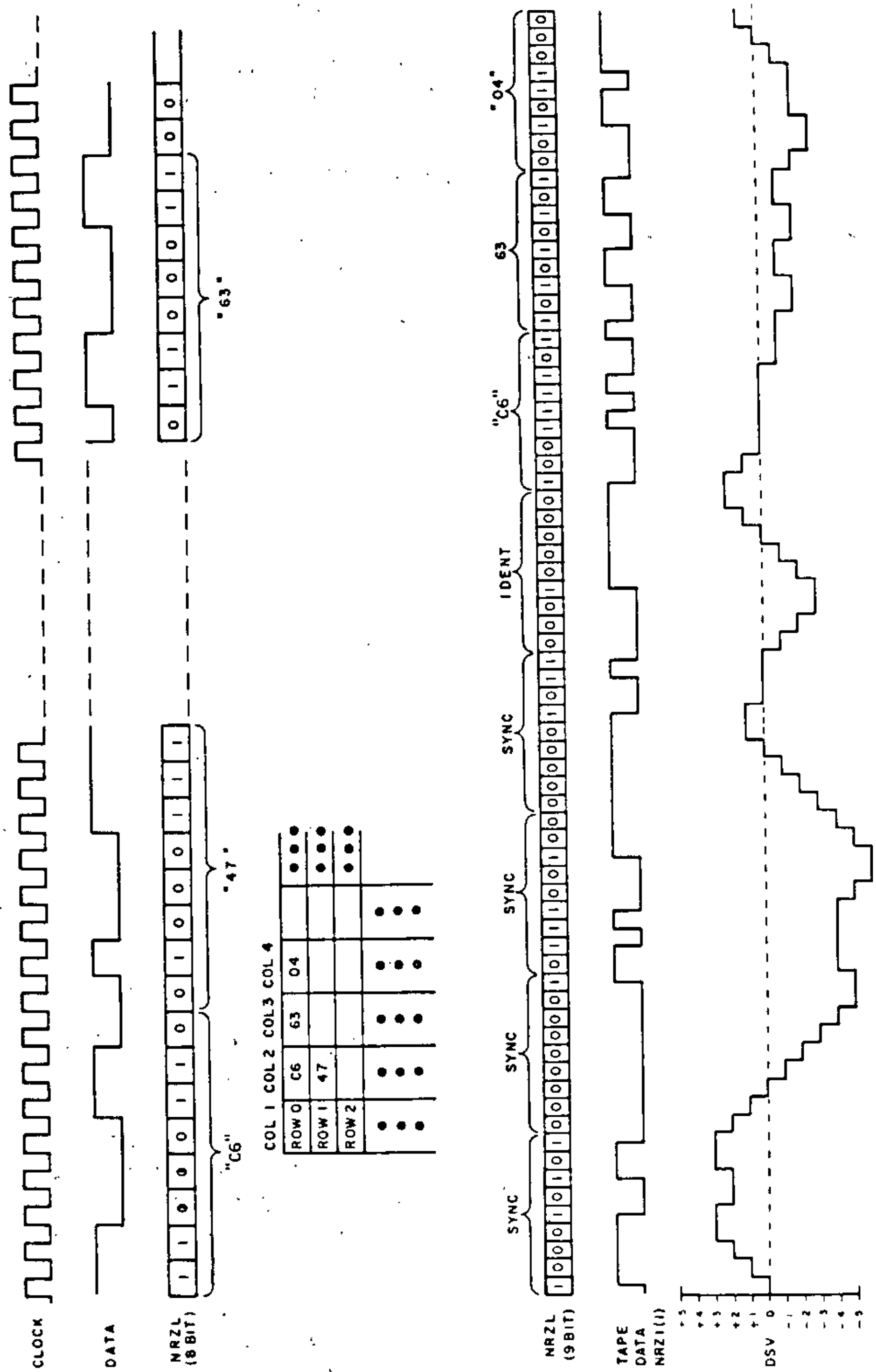


FIGURE 10. Row synchronization and identification.

read into the upper left-most column of array 0 (column 0, row 0). The second ID byte is read into the left-most column of the next row of array 0 (column 0, row 2). (The rows of array 0 are even numbers 0, 2, 4, etc., and the rows of array 1 are the odd numbers.) The first column of each array is filled with row ID numbers. The first data byte is read into row 0 column 1 of array. The process continues until the first 118 data bytes are read into column 1 of array 0. The ten error correcting code symbols for column 1 are calculated "on the fly" and then read into column 1 (rows 118 to 127). The 119th data byte is read into column 2 of row 0, array 0 and the process of filling column 2 of array 0 continues in a manner similar to the process used to fill column 0. The process of filling interleaved block 0 by columns continues until the 154th column is filled. When the 154th column of row 0 is filled the eight error correcting code symbols for row 0 may be calculated based on the row ID through the 154th column of the row, and appended to that row as per Table II. The error correcting symbols for each subsequent row in array 0 are processed in a similar manner. After array 0 has been filled, array 1 is filled by columns in the same manner. When data is transferred to the 8/9 encoder it is read out of the arrays by interleaved rows.

5.1.4.2.7 Interleaving. The sequence in which data is recorded on tape is as follows: A 36-bit sync word, 1 byte of ID for row 0, 153 data bytes 8 check symbols for row 0, array 0, beginning with column 0. Then a 36-bit sync word, 1 byte of ID for row 1, 153 data bytes and 8 check symbols for row 1, array 1. This sequence is repeated for each subsequent pair of rows in array 0 and 1.

5.1.4.2.8 Channel coding. The NRZL 8-bit byte data stream, which is read out of the two arrays (interleaved blocks), shall be coded in accordance with the coding rules specified below and use the 8/9 block code conversion described in 5.1.5.2.8.1. The preamble and postamble and synchronization pattern are added and the combined stream shall be generated as depicted in Figure 8. This data stream shall then be converted from NRZL to NRZI(1) for recording on tape.

5.1.4.2.8.1 8/9 code conversion. In order to properly effect the DC free encoding of data, the channel coding system shall actively maintain a DSV, calculated from the CDS of each 9-bit symbol chosen during the 8 to 9-bit mapping operation. This mapping shall include both a one to one ("0 CDS" 9-bit code word) selection and one to two (+ or - CDS 9-bit word) selection from Table IV. Each one to two 9-bit word mapping shall be chosen to create a DC free data stream through the choice of the 9-bit word which brings the DSV back to 0. Each one to one 9-bit word mapping maintains the DSV by using a 9-bit word with a CDS of 0. The positive or negative CDS words are chosen from Table IV, based on the DSV and the waveform polarity at the end of the previous word in accordance with Table V. The CDS listed in Table IV assumes a negative waveform polarity at the end of the preceding word. When this is true, the DSV is calculated by adding the CDS listed in Table IV to the previous DSV. If the waveform polarity at the end of the preceding word is positive, then the DSV is calculated by subtracting the CDS listed in Table IV from the previous DSV. The DSV calculation shall incorporate the CDS of the synchronization patterns, sector ID # and the Auxiliary Data in order to maintain a DC free data stream.

TABLE IV. 8- to 9-bit map.

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
	msb lsb		
0	000100000	+2	Y
	010011100	-1	N
1	001000011	+2	Y
	001000100	-1	N
2	001000110	+2	Y
	001001110	-1	N
3	001001100	+2	Y
	001011010	-1	N
4	001011000	+2	Y
	000100101	-2	Y
5	001110000	+2	Y
	000101010	-2	Y
6	010000101	+2	Y
	000101111	-2	Y
7	010001010	+2	Y
	000110100	-2	Y
8	010001111	+2	Y
	000111011	-2	Y
9	010010100	+2	Y
	000111110	-2	Y
10	010011011	+2	Y
	001001001	-2	Y
11	010011110	+2	Y
	001010010	-2	Y
12	010101000	+2	Y
	001010111	-2	Y
13	010110011	+2	Y
	001011101	-2	Y
14	010110110	+2	Y
	001100100	-2	Y
15	010111100	+2	Y
	001101011	-2	Y
16	011010000	+2	Y
	001101110	-2	Y
17	011100011	+2	Y
	001110101	-2	Y
18	011100110	+2	Y
	001111010	-2	Y
19	011101100	+2	Y
	001111111	-2	Y
20	011111000	+2	Y
	010010001	-2	Y
21	100001001	+2	Y
	010100010	-2	Y
22	100010010	+2	Y
	010100111	-2	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
23	100010111	+2	Y
	010101101	-2	Y
24	100011101	+2	Y
	010111001	-2	Y
25	100100100	+2	Y
	011000100	-2	Y
26	100101011	+2	Y
	011001011	-2	Y
27	100101110	+2	Y
	011001110	-2	Y
28	100110101	+2	Y
	011010101	-2	Y
29	100111010	+2	Y
	011011010	-2	Y
30	100111111	+2	Y
	011011111	-2	Y
31	101001000	+2	Y
	011101001	-2	Y
32	101010011	+2	Y
	011110010	-2	Y
33	101010110	+2	Y
	011110111	-2	Y
34	101011100	+2	Y
	011111101	-2	Y
35	101100101	+2	Y
	100100001	-2	Y
36	101101010	+2	Y
	101000010	-2	Y
37	101101111	+2	Y
	101000111	-2	Y
38	101110100	+2	Y
	101001101	-2	Y
39	101111011	+2	Y
	101011001	-2	Y
40	101111110	+2	Y
	101110001	-2	Y
41	110010000	+2	Y
	110000100	-2	Y
42	110100011	+2	Y
	110001011	-2	Y
43	110100110	+2	Y
	110001110	-2	Y
44	110101100	+2	Y
	110010101	-2	Y
45	110111000	+2	Y
	110011010	-2	Y
46	111000101	+2	Y
	110011111	-2	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
47	111001010	+2	Y
	110101001	-2	Y
48	111001111	+2	Y
	110110010	-2	Y
49	111010100	+2	Y
	110110111	-2	Y
50	111011011	+2	Y
	110111101	-2	Y
51	111011110	+2	Y
	111010001	-2	Y
52	111101000	+2	Y
	111100010	-2	Y
53	111110011	+2	Y
	111100111	-2	Y
54	111110110	+2	Y
	111101101	-2	Y
55	111111100	+2	Y
	111111001	-2	Y
56	000010000	0	Y
	000010000	0	Y
57	000100011	0	Y
	000100011	0	Y
58	000100110	0	Y
	000100110	0	Y
59	000101100	0	Y
	000101100	0	Y
60	000111000	0	Y
	000111000	0	Y
61	001000101	0	Y
	001000101	0	Y
62	001001010	0	Y
	001001010	0	Y
63	001001111	0	Y
	001001111	0	Y
64	001010100	0	Y
	001010100	0	Y
65	001011011	0	Y
	001011011	0	Y
66	001011110	0	Y
	001011110	0	Y
67	001101000	0	Y
	001101000	0	Y
68	001110011	0	Y
	001110011	0	Y
69	001110110	0	Y
	001110110	0	Y
70	001111100	0	Y
	001111100	0	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
71	010001001	0	Y
	010001001	0	Y
72	010010010	0	Y
	010010010	0	Y
73	010010111	0	Y
	010010111	0	Y
74	010011101	0	Y
	010011101	0	Y
75	010100100	0	Y
	010100100	0	Y
76	010101011	0	Y
	010101011	0	Y
77	010101110	0	Y
	010101110	0	Y
78	010110101	0	Y
	010110101	0	Y
79	010111010	0	Y
	010111010	0	Y
80	010111111	0	Y
	010111111	0	Y
81	011001000	0	Y
	011001000	0	Y
82	011010011	0	Y
	011010011	0	Y
83	011010110	0	Y
	011010110	0	Y
84	011011100	0	Y
	011011100	0	Y
85	011100101	0	Y
	011100101	0	Y
86	011101010	0	Y
	011101010	0	Y
87	011101111	0	Y
	011101111	0	Y
88	011110100	0	Y
	011110100	0	Y
89	011111011	0	Y
	011111011	0	Y
90	011111110	0	Y
	011111110	0	Y
91	100010001	0	Y
	100010001	0	Y
92	100100010	0	Y
	100100010	0	Y
93	100100111	0	Y
	100100111	0	Y
94	100101101	0	Y
	100101101	0	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
95	100111001	0	Y
	100111001	0	Y
96	101000100	0	Y
	101000100	0	Y
97	101001011	0	Y
	101001011	0	Y
98	101001110	0	Y
	101001110	0	Y
99	101010101	0	Y
	101010101	0	Y
100	101011010	0	Y
	101011010	0	Y
101	101011111	0	Y
	101011111	0	Y
102	101101001	0	Y
	101101001	0	Y
103	101110010	0	Y
	101110010	0	Y
104	101110111	0	Y
	101110111	0	Y
105	101111101	0	Y
	101111101	0	Y
106	110001000	0	Y
	110001000	0	Y
107	110010011	0	Y
	110010011	0	Y
108	110010110	0	Y
	110010110	0	Y
109	110011100	0	Y
	110011100	0	Y
110	110100101	0	Y
	110100101	0	Y
111	110101010	0	Y
	110101010	0	Y
112	110101111	0	Y
	110101111	0	Y
113	110110100	0	Y
	110110100	0	Y
114	110111011	0	Y
	110111011	0	Y
115	110111110	0	Y
	110111110	0	Y
116	111001001	0	Y
	111001001	0	Y
117	111010010	0	Y
	111010010	0	Y
118	111010111	0	Y
	111010111	0	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
119	111011101	0	Y
	111011101	0	Y
120	111100100	0	Y
	111100100	0	Y
121	111101011	0	Y
	111101011	0	Y
122	111101110	0	Y
	111101110	0	Y
123	111110101	0	Y
	111110101	0	Y
124	111111010	0	Y
	111111010	0	Y
125	111111111	0	Y
	000111001	-1	N
126	000100001	+1	N
	001001011	-1	N
127	001000010	+1	N
	001010101	-1	N
128	001000111	+1	N
	001011111	-1	N
129	001001101	+1	N
	001101001	-1	N
130	001011001	+1	N
	001110010	-1	N
131	001110001	+1	N
	001110111	-1	N
132	010000100	+1	N
	001111101	-1	N
133	010001011	+1	N
	010010011	-1	N
134	010001110	+1	N
	010010110	-1	N
135	010010101	+1	N
	010100101	-1	N
136	010011010	+1	N
	010101010	-1	N
137	010011111	+1	N
	010101111	-1	N
138	010101001	+1	N
	010110100	-1	N
139	010110010	+1	N
	010111011	-1	N
140	010111101	+1	N
	010111110	-1	N
141	011010001	+1	N
	011001001	-1	N
142	011100010	+1	N
	011010010	-1	N

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
143	011100111	+1	N
	011010111	-1	N
144	011101101	+1	N
	011011101	-1	N
145	011111001	+1	N
	011100100	-1	N
146	100001000	+1	N
	011101011	-1	N
147	100010011	+1	N
	011101110	-1	N
148	100010110	+1	N
	011110101	-1	N
149	100011100	+1	N
	011111010	-1	N
150	100100101	+1	N
	011111111	-1	N
151	100101010	+1	N
	100100011	-1	N
152	100101111	+1	N
	100100110	-1	N
153	100110100	+1	N
	100101100	-1	N
154	100111011	+1	N
	101000101	-1	N
155	100111110	+1	N
	101001010	-1	N
156	101001001	+1	N
	101001111	-1	N
157	101010010	+1	N
	101010100	-1	N
158	101010111	+1	N
	101011011	-1	N
159	101011101	+1	N
	101011110	-1	N
160	101100100	+1	N
	101110011	-1	N
161	101101011	+1	N
	101110110	-1	N
162	101101110	+1	N
	101111100	-1	N
163	101110101	+1	N
	110001001	-1	N
164	101111010	+1	N
	110010010	-1	N
165	101111111	+1	N
	110010111	-1	N

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
166	110010001	+1	N
	110011101	-1	N
167	110100010	+1	N
	110100100	-1	N
168	110100111	+1	N
	110101011	-1	N
169	110101101	+1	N
	110101110	-1	N
170	110111001	+1	N
	110110101	-1	N
171	111000100	+1	N
	110111010	-1	N
172	111001011	+1	N
	110111111	-1	N
173	111001110	+1	N
	111010011	-1	N
174	111010101	+1	N
	111010110	-1	N
175	111011010	+1	N
	111011100	-1	N
176	111011111	+1	N
	111100101	-1	N
177	111101001	+1	N
	111101010	-1	N
178	111110010	+1	N
	111101111	-1	N
179	111110111	+1	N
	111110100	-1	N
180	111111101	+1	N
	111111011	-1	N
181	010110111	+1	N
	111111110	-1	N
182	001000001	+3	N
	001010011	-3	N
183	010000010	+3	N
	001010110	-3	N
184	010000111	+3	N
	001111011	-3	N
185	010001101	+3	N
	001111110	-3	N
186	010011001	+3	N
	010100011	-3	N
187	010110001	+3	N
	010100110	-3	N
188	011100001	+3	N
	011000101	-3	N

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
189	100000100	+3	N
	011001010	-3	N
190	100001011	+3	N
	011001111	-3	N
191	100001110	+3	N
	011011011	-3	N
192	100010101	+3	N
	011011110	-3	N
193	100011010	+3	N
	011110011	-3	N
194	100011111	+3	N
	011110110	-3	N
195	100101001	+3	N
	101000011	-3	N
196	100110010	+3	N
	101000110	-3	N
197	100110111	+3	N
	101001100	-3	N
198	100111101	+3	N
	110000101	-3	N
199	101010001	+3	N
	110001010	-3	N
200	101100010	+3	N
	110001111	-3	N
201	101100111	+3	N
	110010100	-3	N
202	101101101	+3	N
	110011011	-3	N
203	101111001	+3	N
	110011110	-3	N
204	110100001	+3	N
	110110011	-3	N
205	111000010	+3	N
	110110110	-3	N
206	111000111	+3	N
	110111100	-3	N
207	111001101	+3	N
	111100011	-3	N
208	111011001	+3	N
	111100110	-3	N
209	111110001	+3	N
	111101100	-3	N
210	010000011	+4	Y
	001100101	-3	N
211	010000110	+4	Y
	001101010	-3	N

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
212	010001100	+4	Y
	001101111	-3	N
213	010011000	+4	Y
	000101001	-4	Y
214	010110000	+4	Y
	000110010	-4	Y
215	100000101	+4	Y
	000110111	-4	Y
216	100001010	+4	Y
	000111101	-4	Y
217	100001111	+4	Y
	001010001	-4	Y
218	100010100	+4	Y
	001100010	-4	Y
219	100011011	+4	Y
	001100111	-4	Y
220	100011110	+4	Y
	001101101	-4	Y
221	100101000	+4	Y
	001111001	-4	Y
222	100110011	+4	Y
	010100001	-4	Y
223	100110110	+4	Y
	011000010	-4	Y
224	100111100	+4	Y
	011000111	-4	Y
225	101010000	+4	Y
	011001101	-4	Y
226	101100011	+4	Y
	011011001	-4	Y
227	101100110	+4	Y
	011110001	-4	Y
228	101101100	+4	Y
	101000001	-4	Y
229	101111000	+4	Y
	110000010	-4	Y
230	111000011	+4	Y
	110000111	-4	Y
231	111000110	+4	Y
	110001101	-4	Y
232	111001100	+4	Y
	110011001	-4	Y
233	111011000	+4	Y
	110110001	-4	Y
234	111110000	+4	Y
	111100001	-4	Y

TABLE IV. 8- to 9-bit map (Continued).

8-Bit Data (Decimal)	9-Bit Codeword (Binary)	Codeword Digital Sum	Polarity Inversion Y=Yes N=No
235	001000000	+4	Y
	010101100	-3	N
236	011100000	+4	Y
	011010100	-3	N
237	110100000	+4	Y
	011111100	-3	N
238	010000001	+5	N
	001100011	-5	N
239	100000010	+5	N
	001100110	-5	N
240	100000111	+5	N
	001101100	-5	N
241	100001101	+5	N
	011000011	-5	N
242	100011001	+5	N
	011000110	-5	N
243	100110001	+5	N
	110000011	-5	N
244	101100001	+5	N
	110000110	-5	N
245	111000001	+5	N
	110001100	-5	N
246	010000000	+6	Y
	110000001	-6	Y
247	100000011	+6	Y
	001100001	-6	Y
248	100000110	+6	Y
	011000001	-6	Y
249	100001100	+6	Y
	000110001	-6	Y
250	100011000	+6	Y
	000110011	-5	N
251	100110000	+6	Y
	000110110	-5	N
252	101100000	+6	Y
	000111100	-5	N
253	111000000	+6	Y
	011001100	-5	N
254	100000001	+7	N
	001111000	-5	N
255	100000000	+8	Y
	110011000	-5	N

TABLE V. Code word mapping table.

DSV	Waveform Polarity	Positive CDS	Negative CDS
+	+	chosen	
+	-		chosen
- or 0	+		chosen
- or 0	-	chosen	

NOTES:

1. Digital Sum Variation (DSV) - The DSV is determined from the start of data and is a running integral of the charge which results in a DSV value at the end of each codeword. DSV calculation shall be in accordance with 5.1.4.2.8, based on the DSV determined at the end of the previous codeword.

2. Waveform polarity is the position (+ or -) of the waveform at the end of the previous codeword.

5.1.4.2.8.2 Recording waveform. Figure 1 is a conceptual block diagram of the recording process and is not meant to imply a hardware implementation. Due to the lack of any 0 CDS words in the 9-bit NRZL signal, the waveform recorded shall be NRZI (1). The NRZL waveform shall be converted to NRZI (1) such that each "1" in the data stream shall create a transition in the center of the bit cell and each "0" shall create no transition. This NRZI (1) data signal shall be provided to the heads with no pre-emphasis, encoding, randomization or conversion. A waveform polarity inversion indication is included in Table IV. This is for convenience in determining waveform inversion polarity for any chosen 9-bit word from the table.

5.1.4.2.8.3 Head interface. Due to the wide variation in data rate and hardware implementations, the output of the NRZI(1) converter may be buffered for single or multiple heads. A number of heads may be used in order to maintain the physical format on tape. The data's serial nature shall be maintained from track to track.

5.1.4.2.9 Sector postamble. All sectors shall terminate with the postamble sequence.

(a) Length	8 codewords	
(b) Arrangement	See Figure 8	
	Sync Pattern	4 codewords (same as preamble)
	Ident Pattern	4 codewords (same as preamble)
(c) Protection	None	
(d) Randomization	None	
(e) Interleaving	None	

5.1.4.2.10 Magnetization. During the time interval of a recorded "+" level of NRZI(1), the polarity of data flux shall be such that the north pole of the magnetic domain shall point in the direction of head motion. During the time interval of a recorded "-" level of NRZI(1) the polarity of data flux shall be such that the south pole of the magnetic domain shall point in the direction of head motion. Magnetization shall bring the tape to saturation at maximum transition density.

5.1.4.2.11 Gap azimuth. The azimuth angle of the head gaps used for the helical track recording shall be perpendicular to the helical track record within a tolerance of ±10 minutes.

5.1.4.2.12 Helical track record curvature. The center lines of any six consecutive tracks shall be contained within the pattern of the six tolerance zones specified in Figure 11. Each zone is defined by two parallel lines that are inclined at an angle of arc-sine (16/170) basic with respect to the tape reference edge. The center lines of all tracks shall be spaced 0.045 mm basic apart at any point along the length of the track. The width of the first zone shall be 0.01 mm basic. The width of zones 2 through 6 shall be 0.015 mm basic. These zones are established to contain track angle errors, track straightness errors, and track pitch errors.

5.1.4.2.13 Transport start-up and stop. During the time period when the transport is transitioning from no tape motion to phase lock, no data shall be written on the helical tracks. This time period shall not exceed 1.0 second.

5.2 Principal magnetic tape properties. Magnetic tape used in 19-mm cassette recorders shall have properties as specified in SMPTE 225M. Improvements to SMPTE 225M and 226M, which do not affect form, fit, function and performance of the tape/cartridge system are acceptable.

5.2.1 Base material. The base material shall be polyester or equivalent.

5.2.2 Magnetic coating. The magnetic tape shall have a coating of improved metal oxide or equivalent.

5.2.2.1 Coercivity. The coating coercivity shall be a class 850 oersted (68,000 A/m), as measured by a 50- or 60-Hz BH meter.

5.2.2.2 Orientation. The oxide particles shall be longitudinally oriented.

5.2.3 Tape size.

5.2.3.1 Tape thickness. Nominal 16 um tape shall have a thickness of 13.5 to 16.0 um. Nominal 13 um tape shall have a thickness of 11.0 to 13.0 um.

5.2.3.2 Tape width. The tape width shall be 19.010 + 0.015 mm.

5.2.3.3 Delta width. Minor variations in tape width (delta width) about the measured value shall not exceed 6 um peak-to-peak.

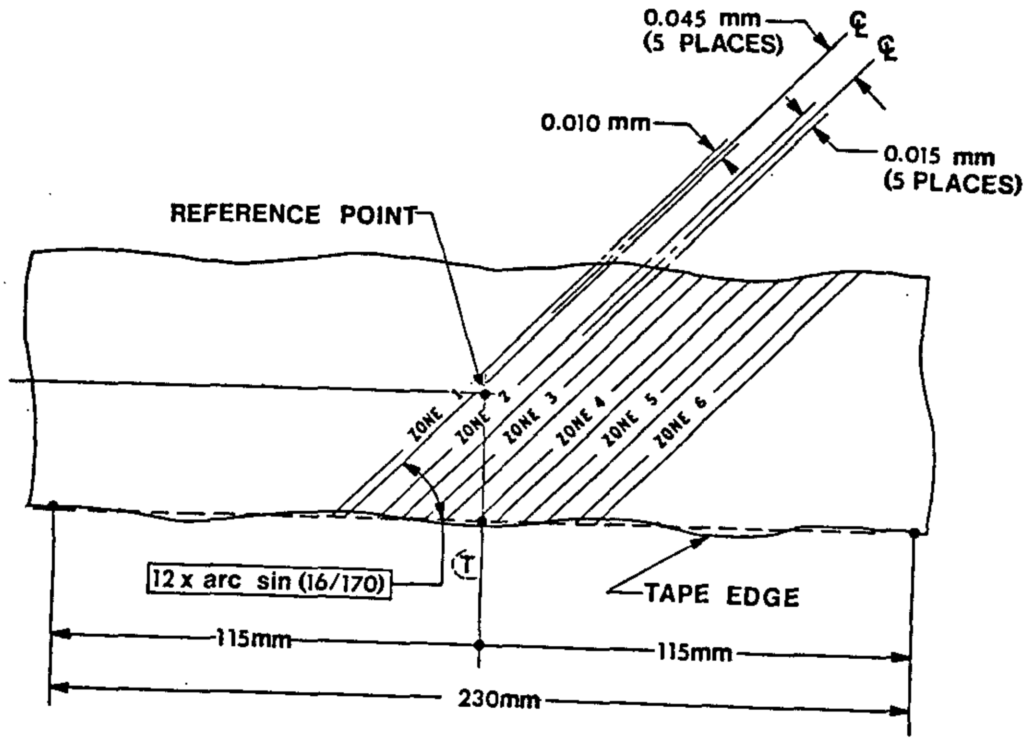


FIGURE 11. Locations and dimensions of tolerance zones.

5.2.4 Reference edge straightness. The maximum deviation of the tape reference edge shall not exceed 6 micrometers peak-to-peak when measured at the edge of a moving tape guided by three guides having contact to the same edge and having a distance of 115 mm from the first guide to the second and 115 mm from the second guide to the third. Edge measurements are averaged over 10-mm lengths and are made at the mid-point between the first and second guide.

5.2.5 Transmissivity. The tape transmissivity shall be less that five percent over the wavelength range of 700 to 900 nanometers.

5.2.6 Offset yield strength. The offset yield strength of the tape shall be greater than 15 N.

5.3 Tape cassettes. Tape cassettes shall be small, medium or large sizes, corresponding to SMPTE small (D-1.S), SMPTE medium (DS-1.M), and SMPTE large (D-1.L), respectively, as defined in SMPTE 226 M. Characteristics specified in 5.3.1 through 5.3.7 are given for reference only. Cassette details shall be controlled by the SMPTE cassette specification in their current version.

5.3.1 Magnetic tape. The magnetic coating on the tape shall face out of the cassette. The minimum tape length (and nominal play time) for a fully loaded cassette shall be as specified in Table VI.

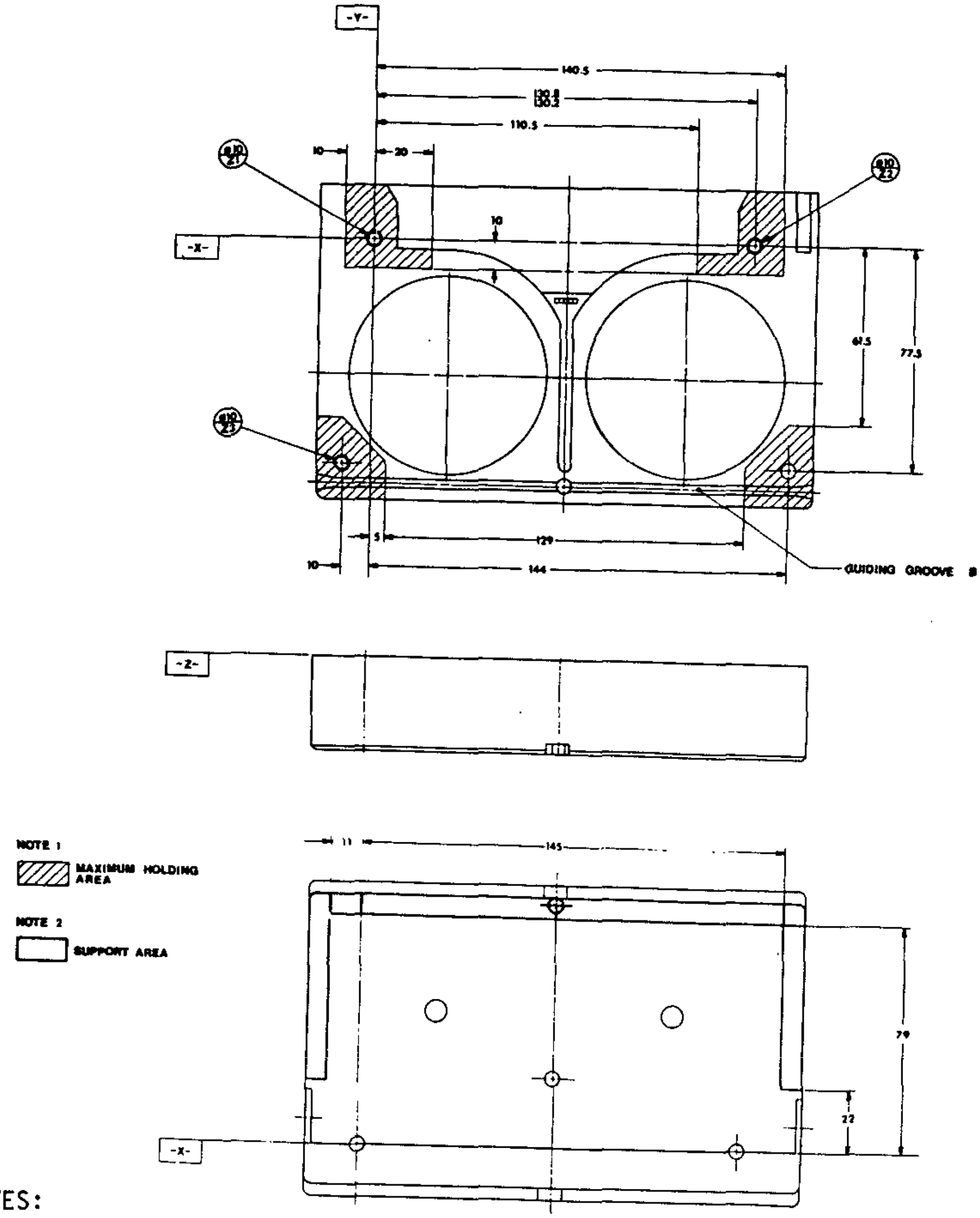
TABLE VI. Minimum tape length and nominal play time (at 240m bits/s user data rate).

Cassette	Tape Thickness (micrometers)	Tape Length (meters)	Play Time (minutes)
Small	16 13	190 225	8 9
Medium	16 13	587 708	24 24
Large	16 13	1311 1622	55 68

5.3.2 Datum planes.

5.3.2.1 Datum plane Z. The datum plane Z is determined by datum areas A, B, and C, as specified in Figures 12, 13, and 14. Datum C need not correspond to a fastener.

5.3.2.2 Datum plane X. The datum plane X shall be orthogonal to the datum plane Z and shall run through the center of datum holes (a) and (b), as specified in Figures 15, 16, and 17.



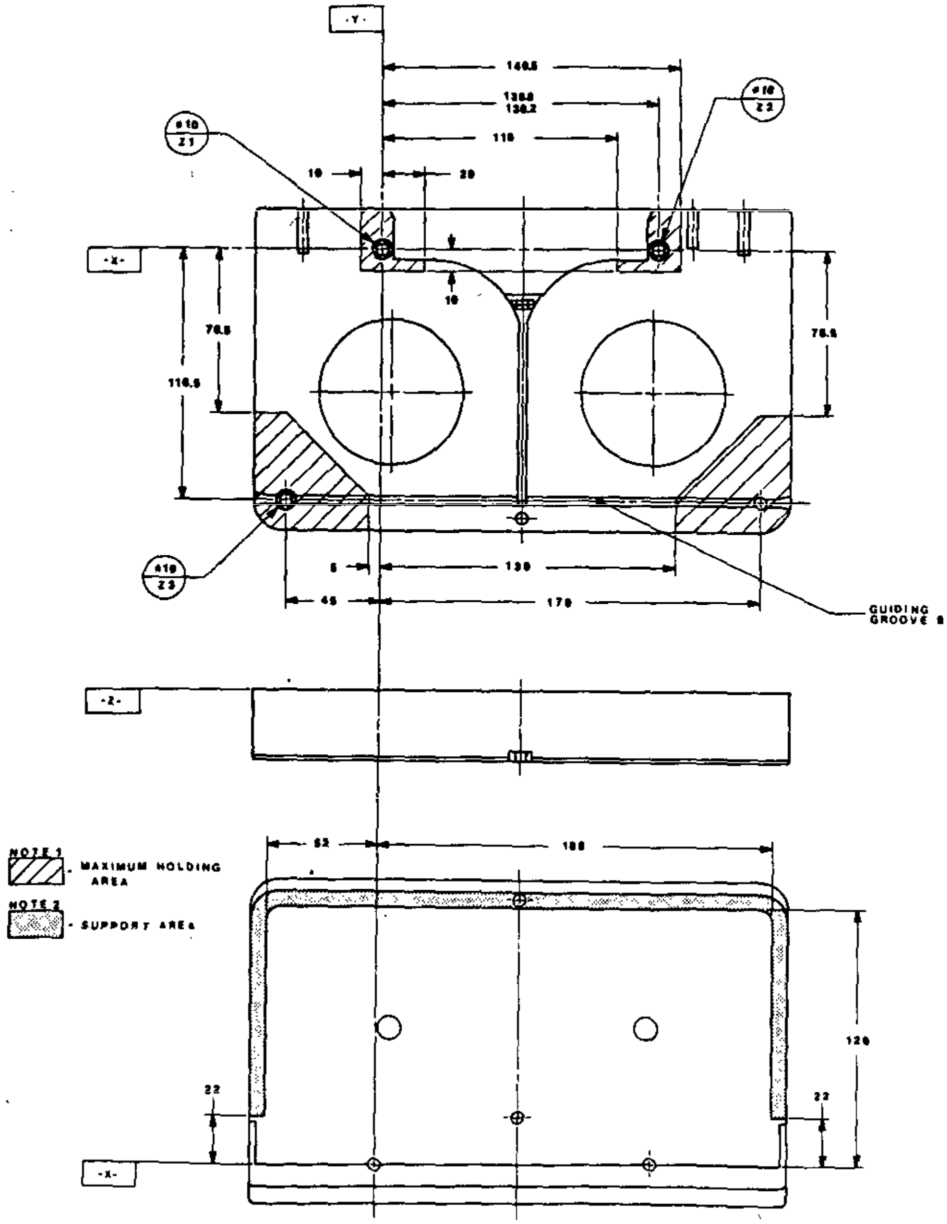
NOTES:

The cassette shall be secured by the recorder and/or player unit on the dotted area.

The periphery within 1.0 mm from the edge of guiding groove B and from the edge of the cassette shall be removed from the support area. The cassette shall be supported by the recorder and/or player unit on the hatched area.

Datum plane Z shall be determined by datum areas A, B and C.

FIGURE 12. Datum, support and holding areas of small cassette.

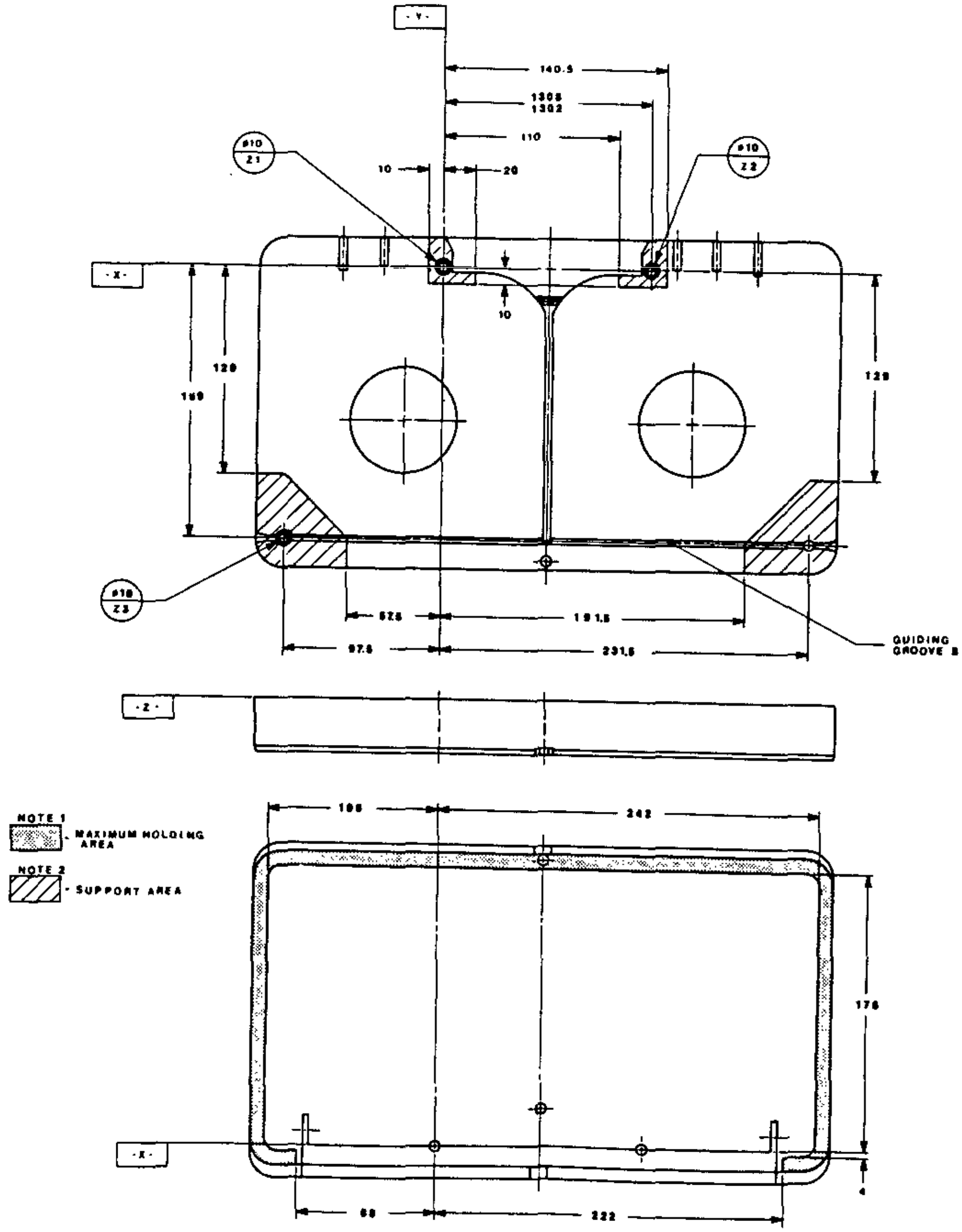


NOTES:

The cassette shall be secured by the recorder and/or player unit on the dotted area.

The periphery within 1.0 mm from the edge of the guiding groove B and from the edge of the cassette shall be supported by the recorder/reproducer on the hatched area.

FIGURE 13. Datum, support and holding areas of medium cassette.

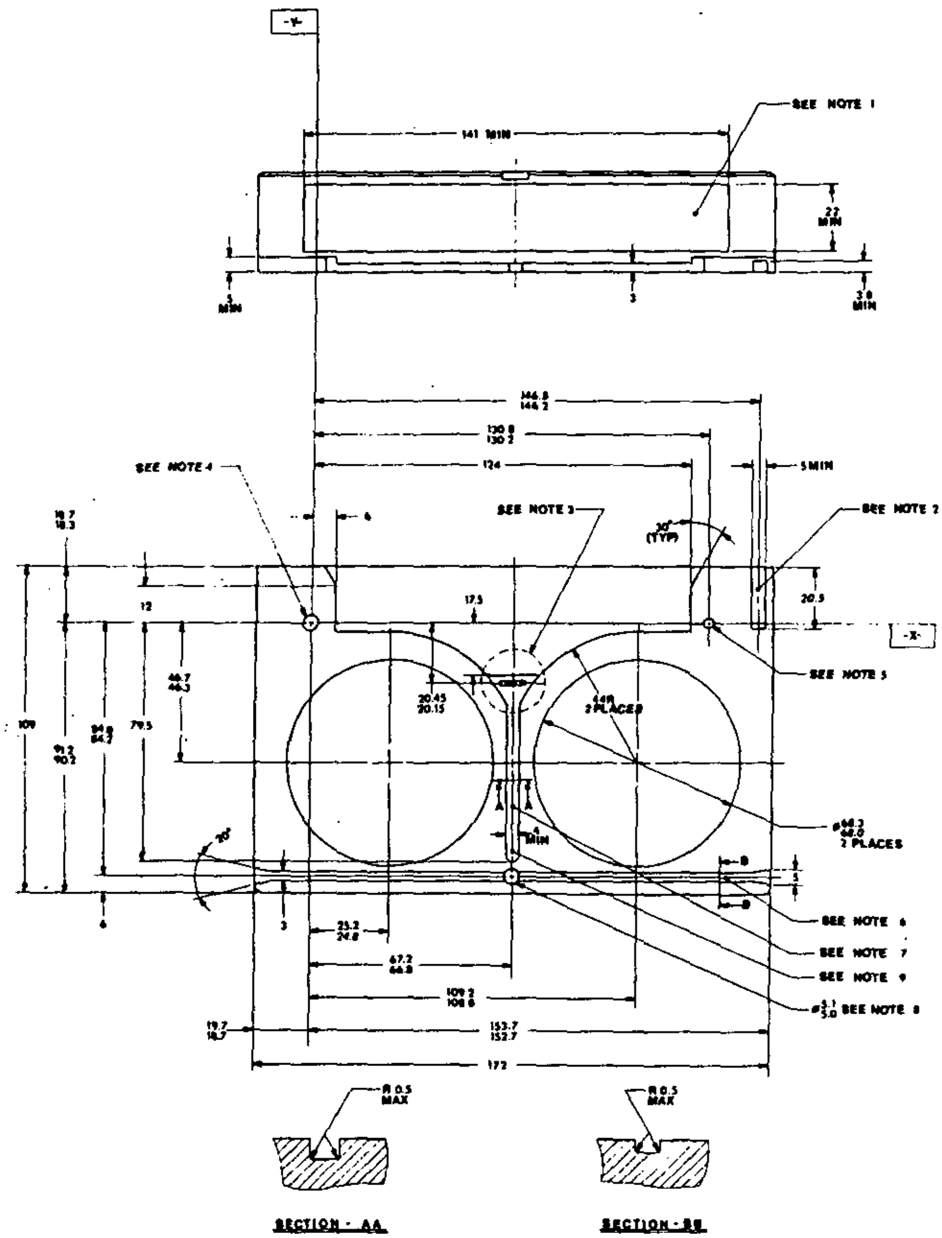


NOTES:

The cassette shall be secured by the recorder and/or player unit on the dotted area.

The periphery within 1.0 mm from the edge of the guiding groove B and from the edge of the cassette shall be supported by the recorder/reproducer on the hatched area.

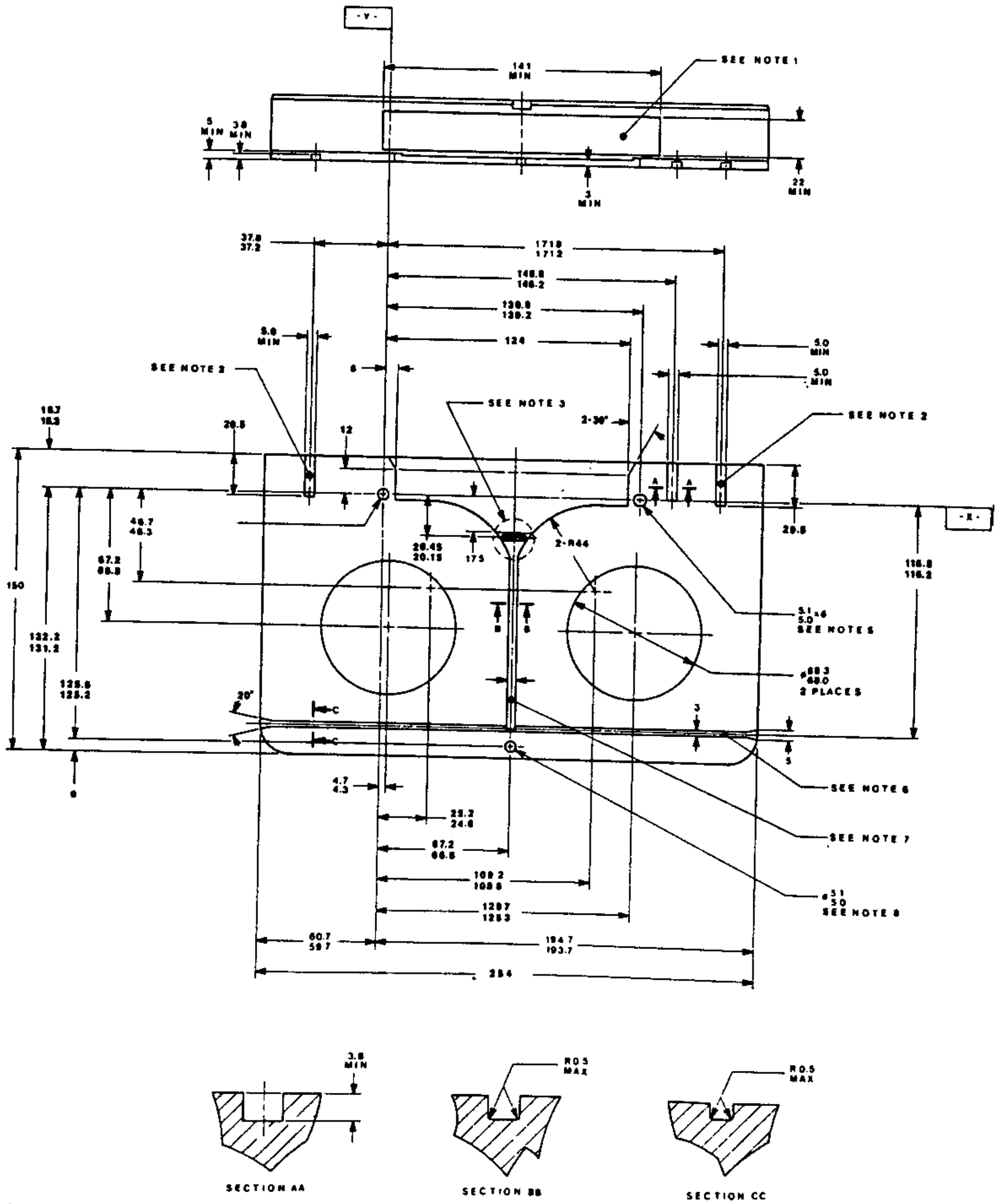
FIGURE 14. Datum, support and holding areas of large cassette.



NOTES:

1. Lid label may be attached to this recessed area, depth: 0.2 - 0.3.
2. Lid lock and release, see Figure 29.
3. Coding hole, user-hole, see Figure 20.
4. Datum hole 1, user-hole, see Figure 20.
5. Datum hole 2, user-hole, see Figure 20.
6. Guiding groove B, depth: 1.5 - 2.0.
7. Guiding groove A, depth: 2.9 - 3.1.
8. User-hole, see Figure 20.
9. Reel lock and release, see Figure 26.

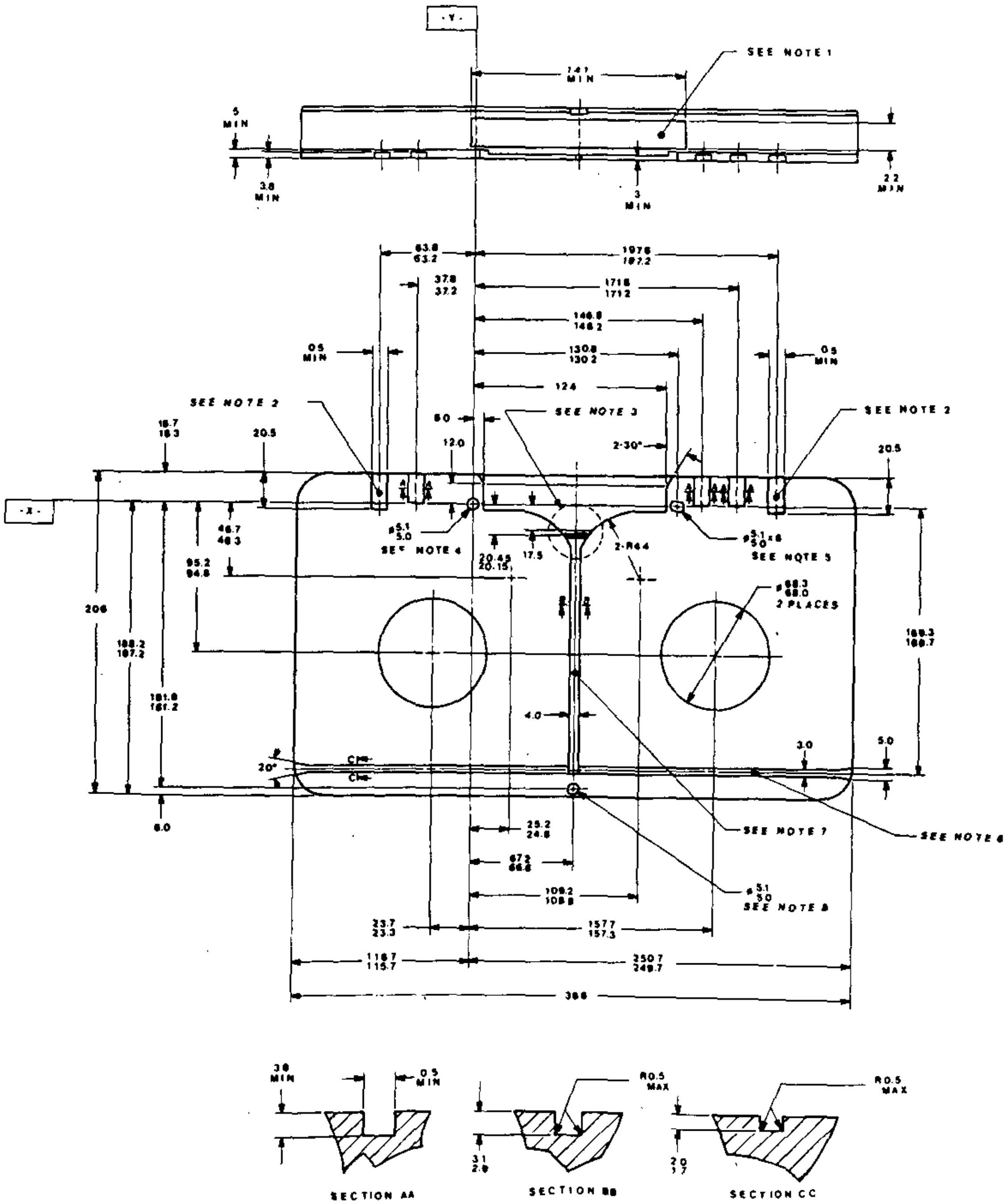
FIGURE 15. Bottom view of small cassette.



NOTES:

1. Lid label may be attached to this recessed area, depth: 0.2 - 0.3.
2. Lid lock and release, see Figure 29.
3. Coding hole, user-hole, see Figure 21.
4. Datum hole 1, user-hole, see Figure 21.
5. Datum hole 2, user-hole, see Figure 21.
6. Guiding groove B, depth: 1.5 - 2.0.
7. Guiding groove A, depth: 2.9 - 3.1.
8. User-hole, see Figure 21.

FIGURE 16. Medium cassette, bottom and front views.



NOTES:

1. Lid label may be attached to this recessed area, depth: 0.2 - 0.3.
2. Lid lock and release, see Figure 29.
3. Coding hole, user-hole, see Figure 22.
4. Datum hole 1, user-hole, see Figure 22.
5. Datum hole 2, user-hole, see Figure 22.
6. Guiding groove B, depth: 1.5 - 2.0.
7. Guiding groove A, depth: 2.9 - 3.1.
8. User-hole, see Figure 22.

FIGURE 17. Large cassette, bottom and front views.

5.3.2.3 Datum plane Y. The datum plane Y shall be orthogonal to both datum planes X and datum plane Z and shall run through the center of datum hole (a), as specified in Figures 15, 16, and 17.

5.3.3 Window and labels. The window and label areas shall be as specified in Figures 18 and 19.

5.3.3.1 Label dimensions. Labels attached to the cassette shall not extend beyond the external dimensions as shown in Figures 18 and 19.

5.3.3.2 Label location. Labels shall not interfere with users' or manufacturers' identification holes. Labels shall not interfere with the hub drive and support mechanism.

5.3.4 Identification holes. Each cassette shall have two sets of four identification holes. One set shall be set by the manufacturer; the second set shall be for the user.

5.3.4.1 Purpose. The purpose of the identification holes is to provide a means whereby the recorder/reproducer can automatically sense pertinent characteristics of the cassette.

5.3.4.2 Logical sense. The logical sense of the information contained in the identification holes shall be determined by the relative depth of the holes. The shallower depth (measured from datum plane Z) is logical "1." The deeper depth is a logical "0."

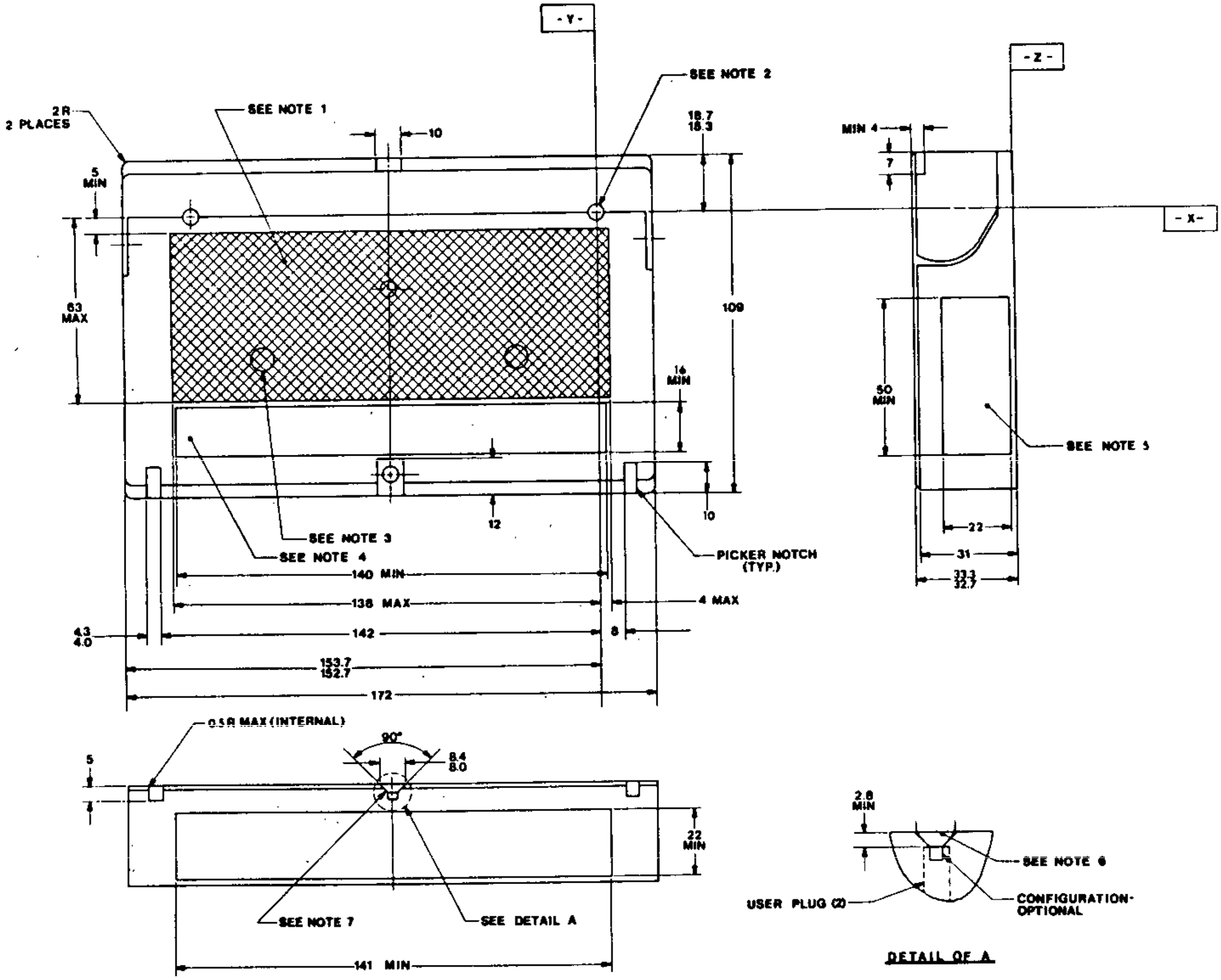
5.3.4.3 Manufacturers' holes. The information contained in the manufacturers' holes shall be as follows:

Hole numbers 1 and 2 shall be used in combination to indicate tape thickness as specified in Table VII.

TABLE VII. Tape thickness.

Hole number 1	Hole number 2	Tape thickness
0	0	16 um
0	1	13 um
1	0	Undefined/Reserved
1	1	Undefined/Reserved

Hole numbers 3 and 4 shall be used to indicate the coercivity of the magnetic recording tape as specified in Table VIII.



NOTES:

1. The crosshatched area is available for the window/labels.
2. Four user plugs, see Figure 20.
3. See Figure 25.
4. The top label may be attached to this cross hatched area, depth: 0.2 - 0.3.
5. The side or rear label may be attached to this recessed area, depth: 0.2 - 0.3.

FIGURE 18. Top and side view of small cassette.

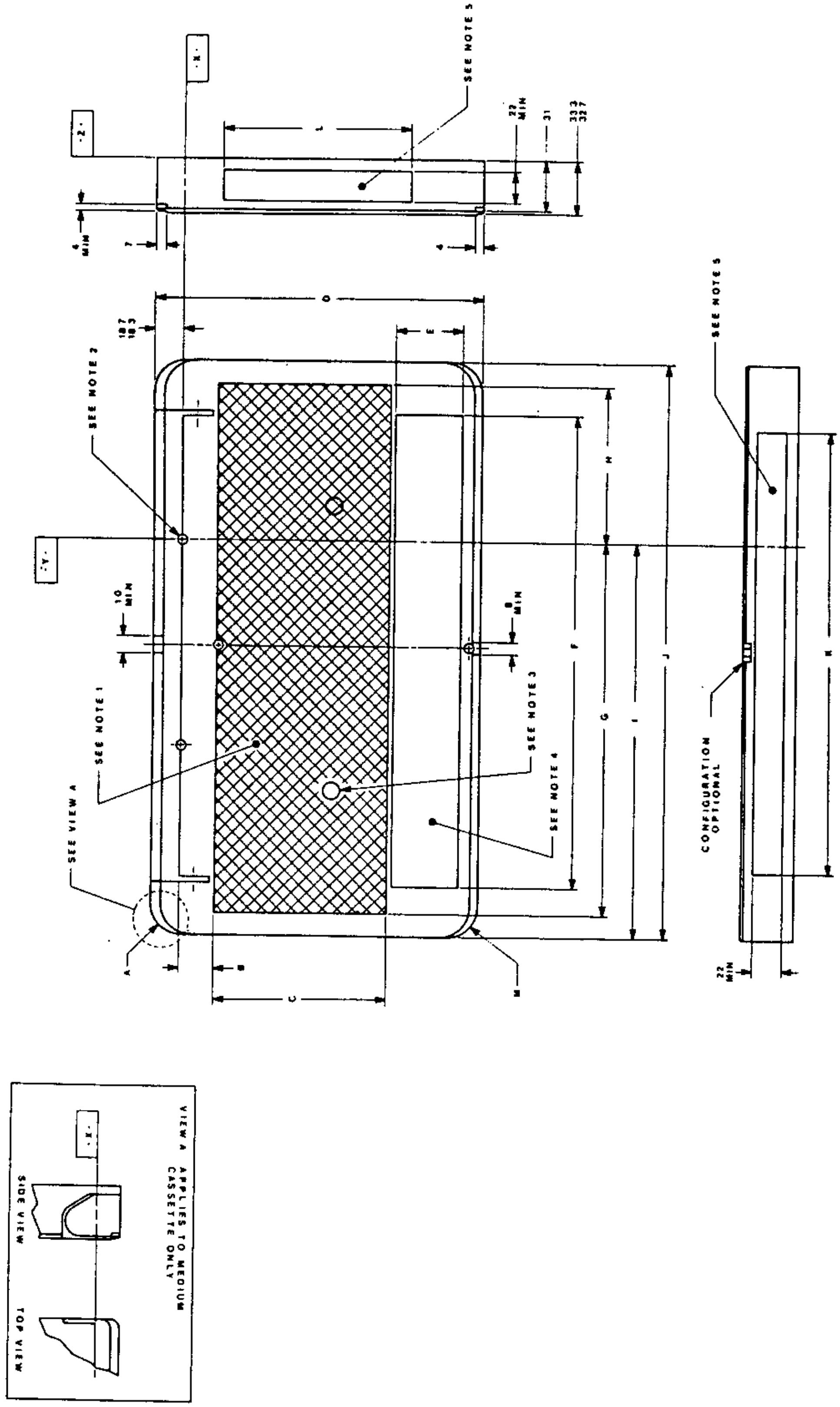
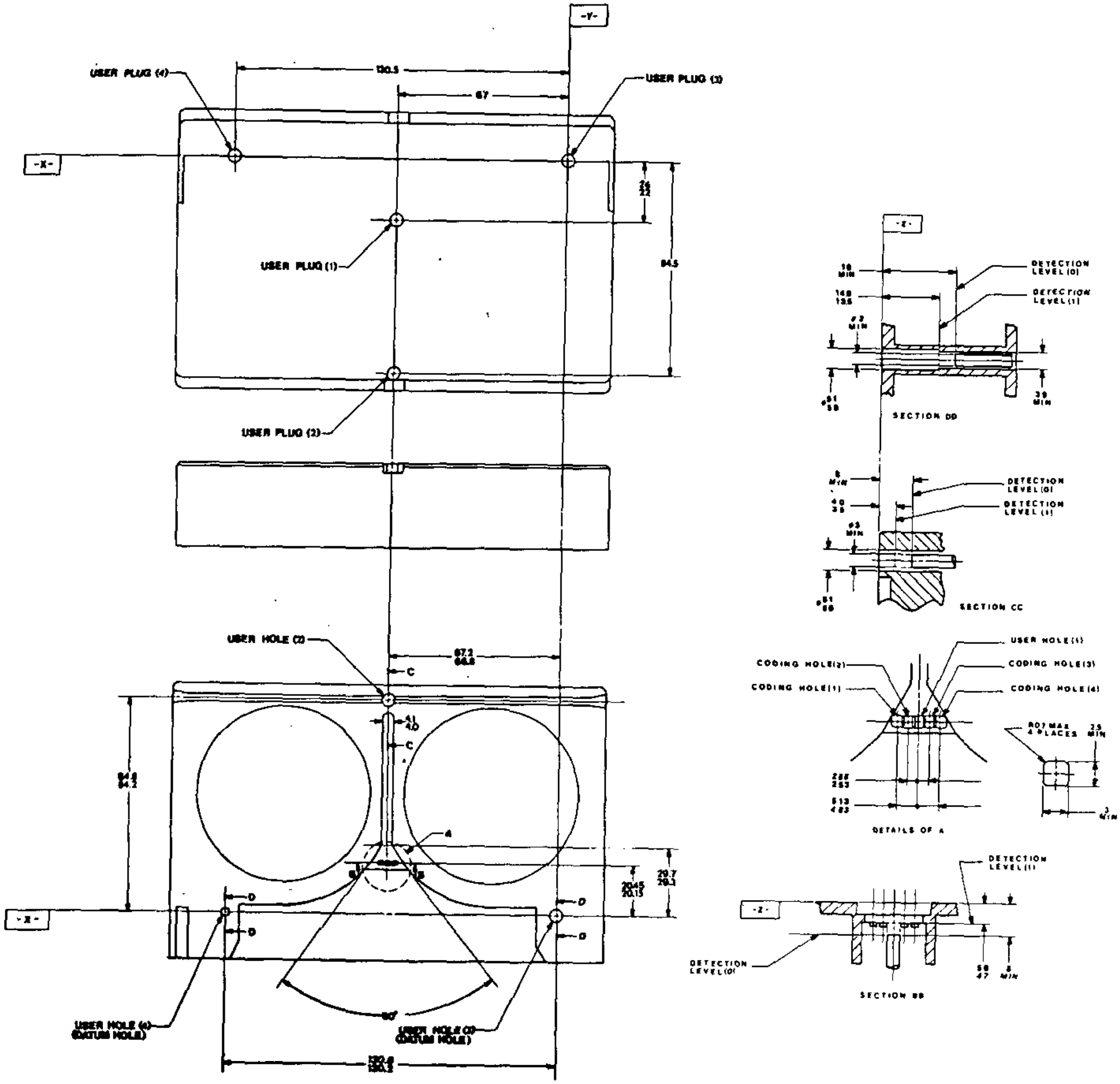


FIGURE 19. Top, rear, and end view of medium and large cassette.



NOTES:

1. The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4). When any plug is removed, the opening shall be as shown in detail A. The user plug (1) shall be green.
2. User holes (3) and (4) on the upper shell shall be opened when user plugs are removed.
3. All cassettes shall be provided with holes as defined by section DD and CC.

FIGURE 20. Small cassette coding holes and user holes.

TABLE VIII. Tape coercivity.

Hole number 3	Hole number 4	Coercivity class
0	0	Class 850
0	1	Undefined/Reserved
1	0	Undefined/Reserved
1	1	Undefined/Reserved

A "0" in Tables VII or VIII signifies the removal or opening of the indicator tab. The recorder/reproducer sensor mechanism interprets the absence of an indicator tab as a nondetected state.

5.3.4.4 User holes. When a "0" state exists, the user holes shall identify the following conditions:

1. Total record lock out (data, control track, time code, annotations).
2. Reserved and undefined.
3. Reserved and undefined.
4. Reserved and undefined.

5.3.4.4.1 User plug. The user plug mechanism shall not move when subjected to an axial force of 0.5 N.

5.3.4.5 Dimensions and location. The dimensions and locations of the user holes shall be as specified in Figures 20, 21, and 22.

5.3.5 Leader/trailer tape. The cassette shall include leader and trailer tape.

5.3.5.1 Length. When attached to the hub, a length of 240 mm + 30 mm shall exist between the splice point and the outside of the cassette shell.

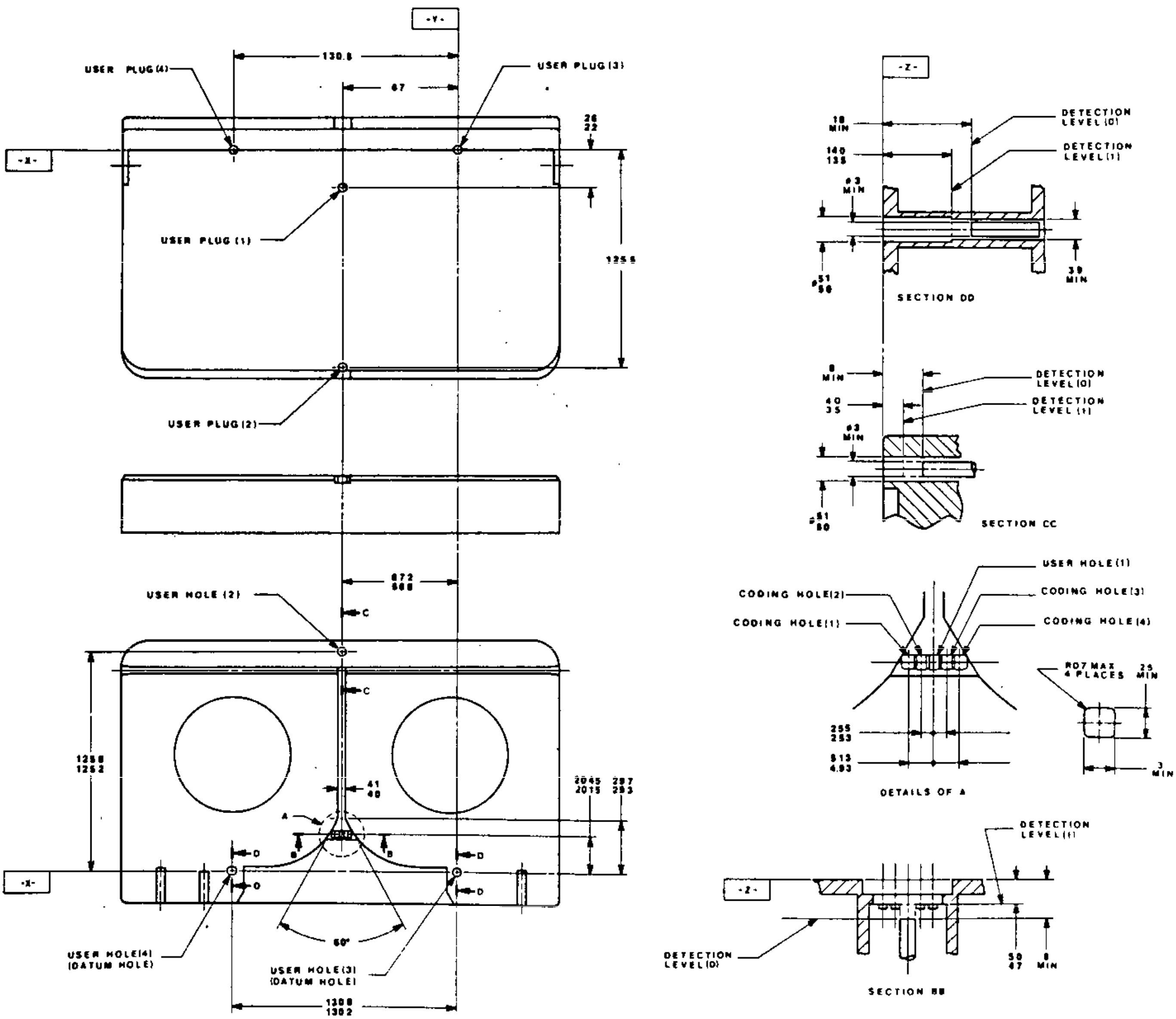
5.3.5.2 Material. The leader/trailer tape material shall be polyester or equivalent, with a transmissivity of at least 60 percent when measured with a 700 to 900 nm light source.

5.3.5.3 Attachment. When attached to the hub, the leader/trailer tape shall not separate from the magnetic tape when subjected to a force of 22 N.

5.3.5.4 Width. The width of the leader/trailer tape shall be 19 mm + 0.025 mm.

5.3.5.5 Thickness. The thickness of the leader/trailer tape shall be 20 um + 10 um.

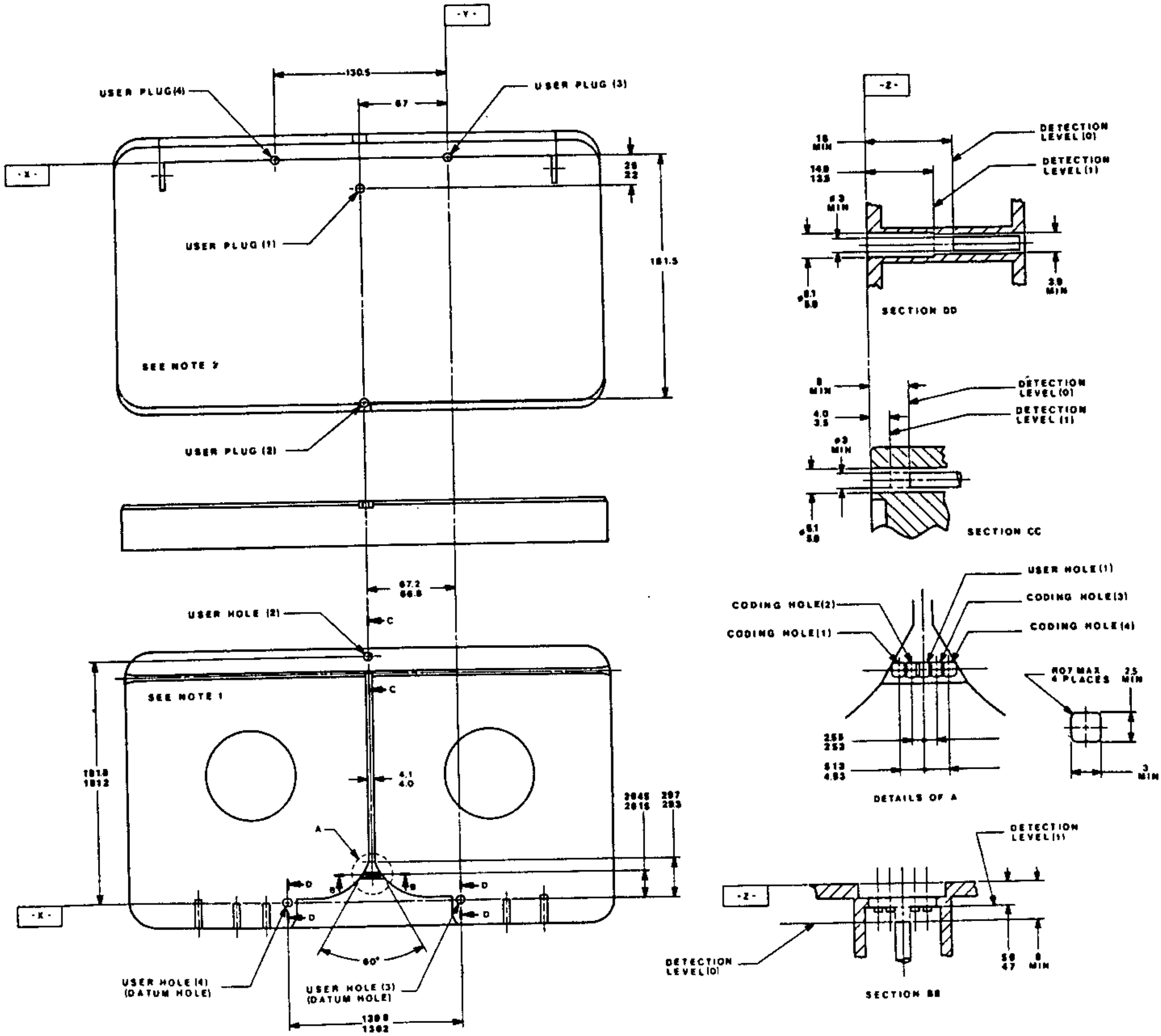
5.3.6 Reels. The dimensions of the reels and the relationship between the reels and reel tables shall be as specified in Figures 23 and 24.



NOTES:

1. The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4). When any plug is removed, the opening shall be as shown in detail A. The user plug (1) shall be green.
2. User holes (3) and (4) on the upper shell shall be opened when user plugs are removed.
3. All cassettes shall be provided with holes as defined by section DD and CC.

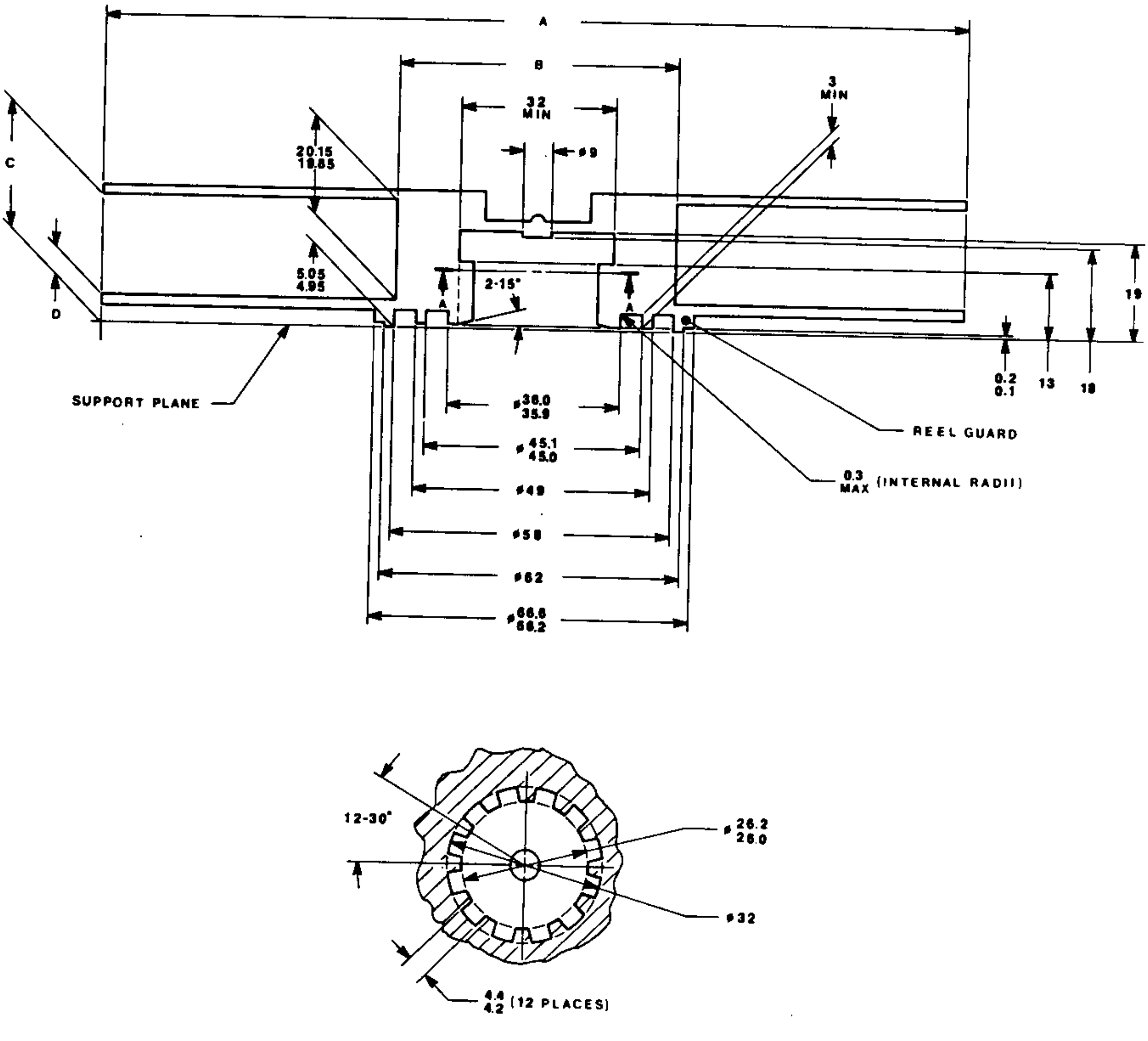
FIGURE 21. Medium cassette coding holes and user holes.



NOTES:

1. The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4).
2. User hole (3) and (4) on the upper shell shall be opened, when user plugs are removed.
3. All cassettes shall be provided with holes as defined by sections DD and CC.

FIGURE 22. Large cassette coding holes and user holes.

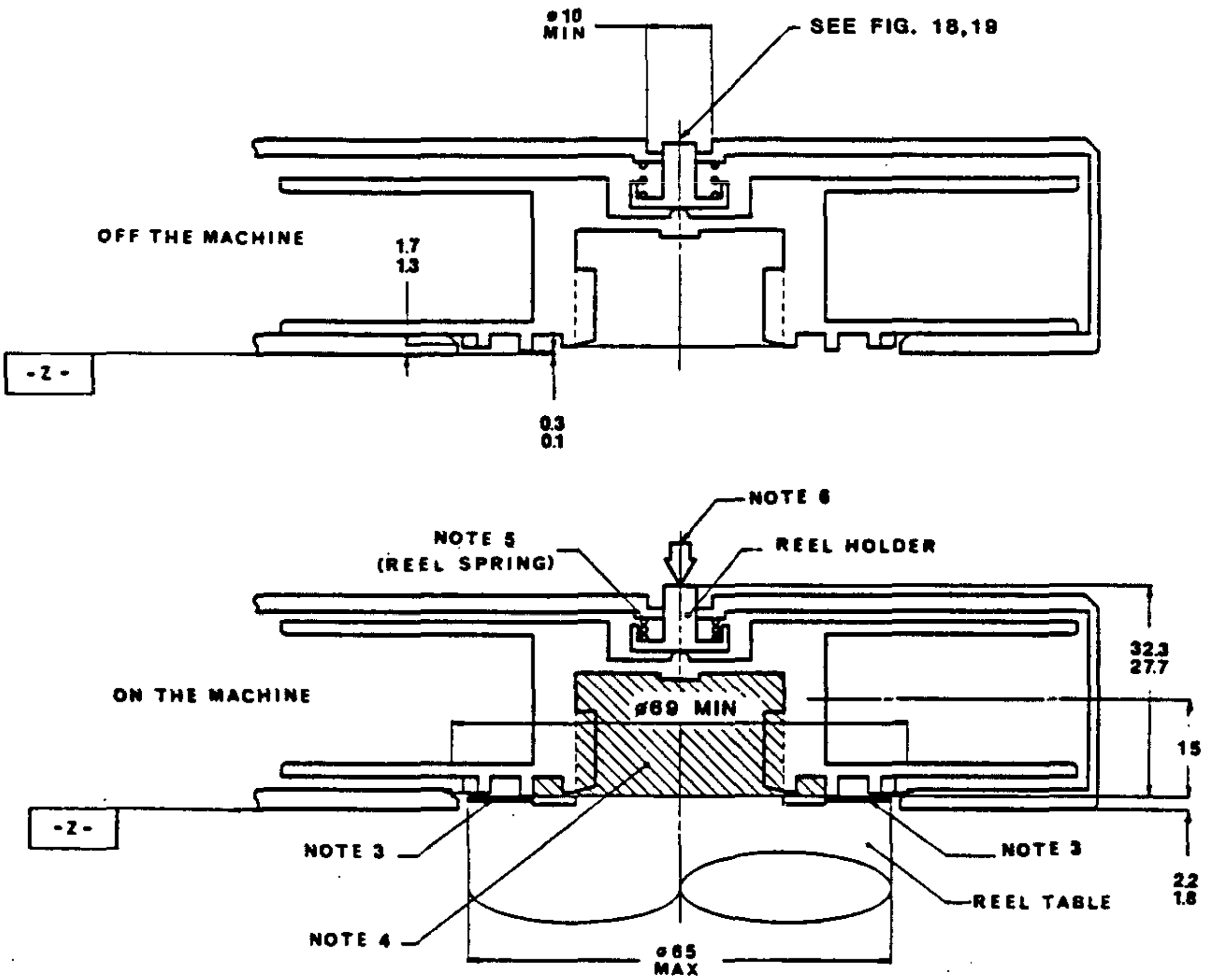


SECTION AA

NOTE:

The center of the reel and the reel table shall be positioned on either the center of the area 36.1 - 36.0 or the center of the area 45.1 - 45.0 in diameter.

FIGURE 23. Small, medium and large cassette reel.



NOTES:

1. Distance between the support area of the reel table and the datum plane Z.
2. Distance between the support area of the reel table and tape center.
3. Support area of the reel table.
4. Hatched area shows the maximum reel table area.
5. Reel spring pressure shall be as specified in 5.3.6.3.
6. If necessary, more reel spring pressure shall be applied to this portion from the outside.
7. The reel spring structure is at manufacturer's option.

FIGURE 24. Relationship between reel and reel table.

TABLE IX. Dimensions for bottom and side views of the medium and large cassette.

DIMENSIONS (millimeters)

Label	Medium Cassette	Large Cassette
A	R 2 (2 places)	R 18.5 (2 places)
B	5 min	22 min
C	88 max	130 max
D	150	206
E	30 min	40 min
F	200 min	300 min
G	179 max	235 max
H	45 max	101 max
I	193.7 - 194.7	249.7 - 250.7
J	254	366
K	200 min	280 min
L	80 min	120 min
M	R 15 (2 places)	R 18.5 (2 places)

TABLE X. Dimensions for figure 24 (small, medium and large cassette).

DIMENSIONS (millimeters)

Label	Small Cassette	Medium Cassette	Large Cassette
A	0 81.5 (reference)	0 122.5 (reference)	0 178.5 (reference)
B	0 45.0 44.7	0 45.0 44.7	0 58.0 57.7
C	24.85 min	24.9 min	24.95 min
D	5.15 max	5.1 max	5.05 max

5.3.6.1 Locking. The reels shall be automatically locked when the cassette is removed from the recorder/reproducer.

5.3.6.2 Unlocking. When a small (D-1.S), medium (D-1.M), or large (D-1.L) cassette is inserted into a recorder/reproducer, the reels shall be automatically unlocked by the process of opening the lid, as specified in Figures 25, 26, and 27.

5.3.6.3 Reel spring. The reels shall be held in position by a reel spring. The small reel spring shall exert a force of 3N and the medium and large reel springs shall exert a force of 8N when the height of the reel support table is 2.0 + 0.2 mm from datum plane Z. (See Figure 24.)

5.3.7 Lid. The lid shall be unlocked and opened by the recorder/reproducer when the cassette is inserted.

5.3.7.1 Unlocking. The lid shall be unlocked by a force of 0.5 + 0.1 N exerted on the release pin. (See Figure 28.)

5.3.7.2 Opening. The force required to open the lid shall not be greater than 1.5 N. The recorder/reproducer shall lift the inner door to the position shown in Figure 29.

5.3.7.3 Closing. When the cassette is removed from the recorder/reproducer, the lid shall automatically close and lock.

5.3.8 Tape path. Figures 30, 31, and 32 show the tape path and maximum area for tape guides for the small, medium, and large cassettes, respectively. Figures 30, 31, and 32 are included for reference only.

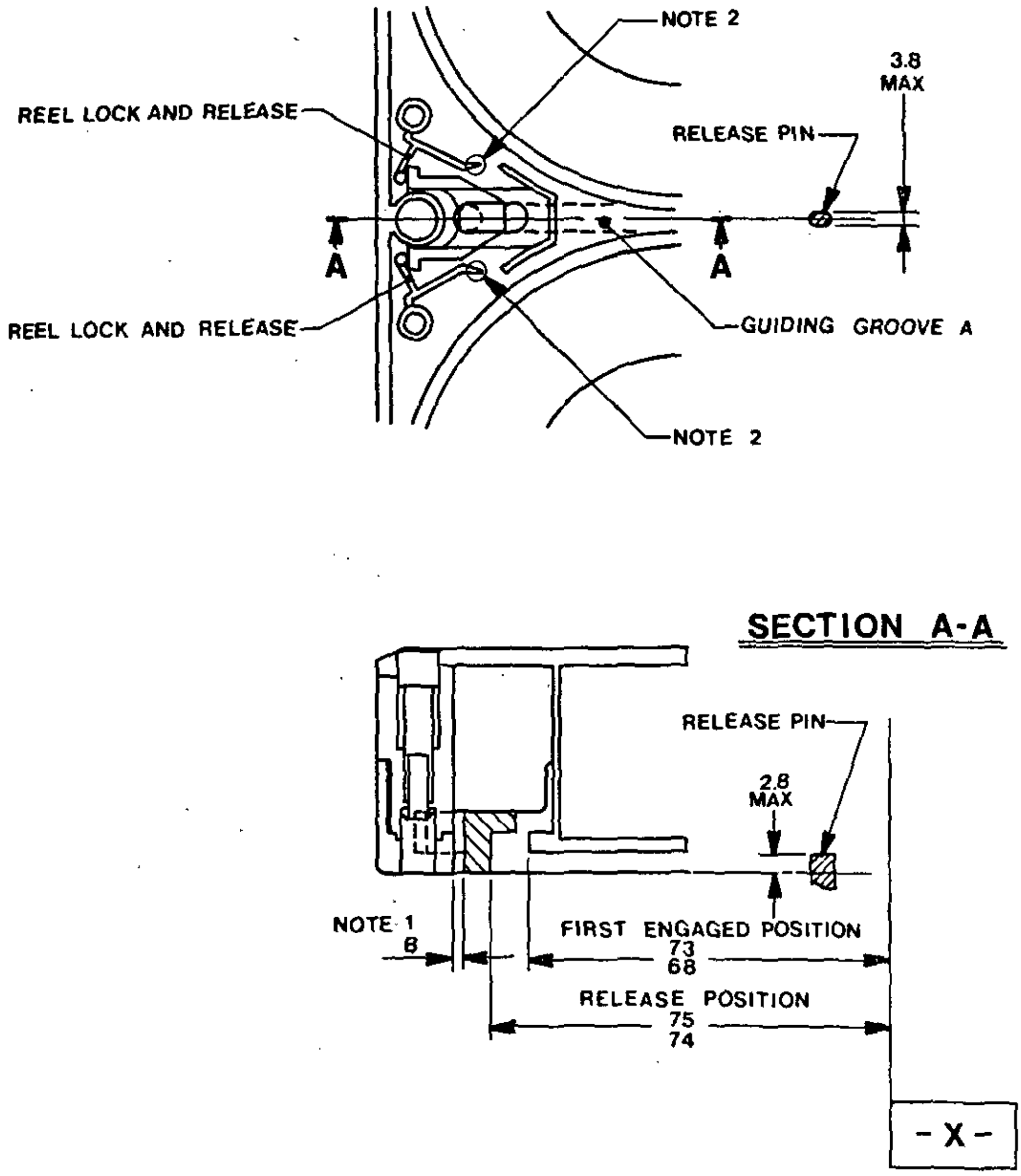
5.3.9 Loading mechanism. The minimum space for the recorder/reproducer loading mechanism shall be as specified in Figure 33.

6. NOTES

6.1 Intended use. This standard is intended to insure the capability to exchange data between members of the various DOD user communities. Data recorded by one recorder shall be capable of being reproduced on any other recorder/reproducer that conforms to this standard. The standard allows the designer of tape transport mechanisms to use one of several different combinations of tape scanner diameters and data head arrangements to achieve standard format recording. The designer may make different design choices for different applications provided the format is identical.

6.2 Subject term (key word) listing.

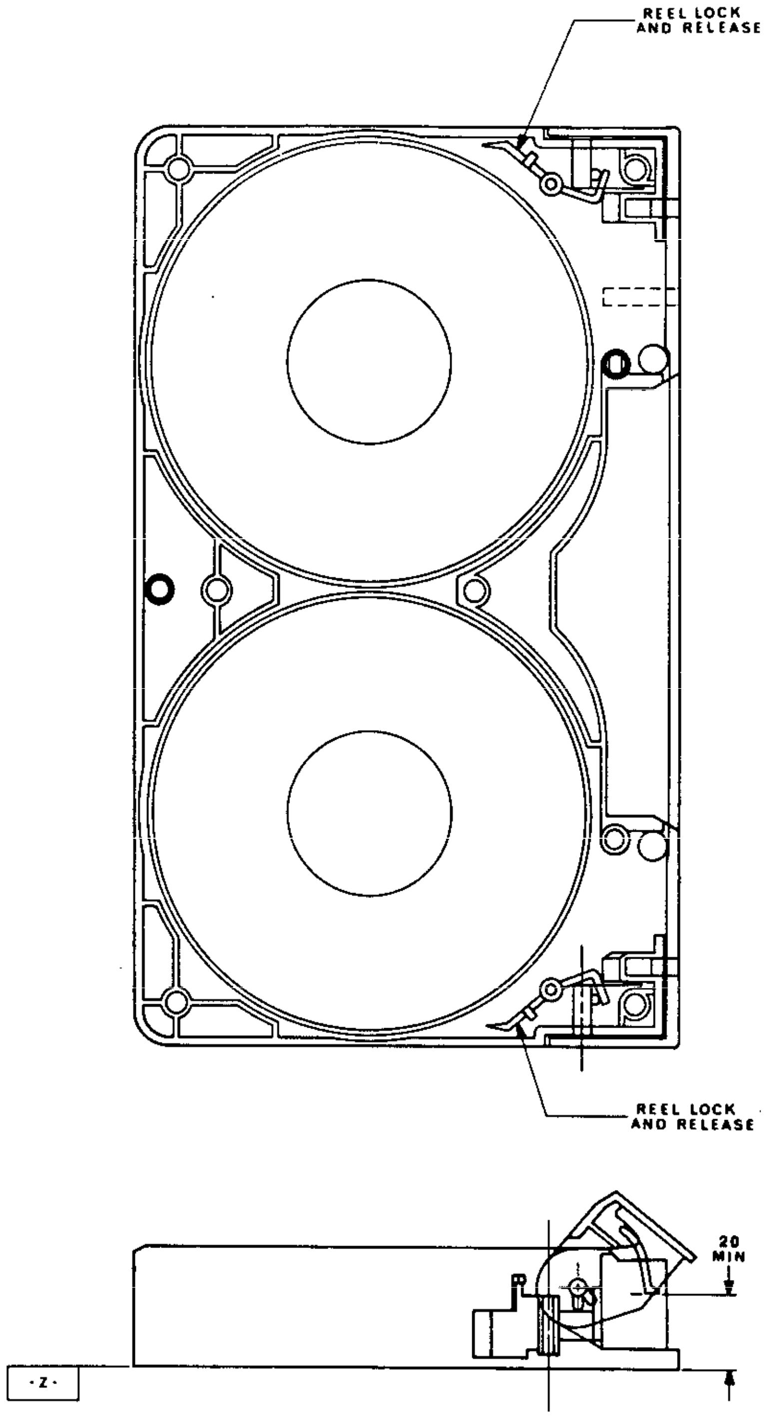
Cassettes, magnetic tape
Magnetic tape
Recording, digital data
Recording, helical
Recording, magnetic tape
Recording, rotary



NOTES:

1. Clearance B shall be 0.5 mm at a minimum when the release pin is located 75 mm away from datum plane X.
2. The end of the reel lock shall be outside the reel area 84 mm min in diameter, when the release pin is located 74 mm away from datum plane X.

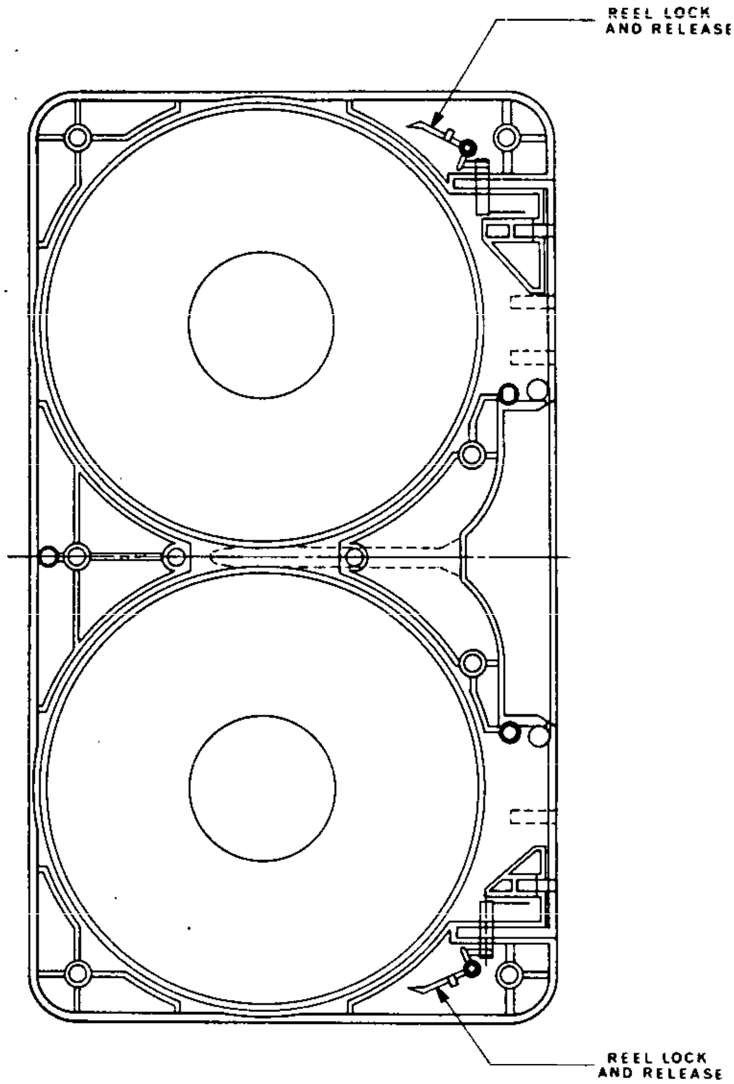
FIGURE 25. Small cassette reel lock and release.

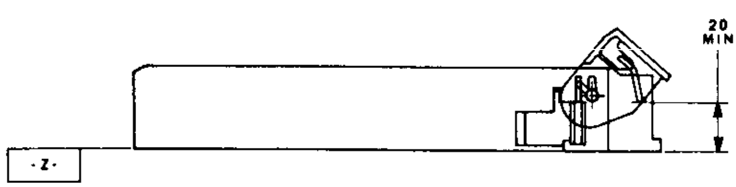


NOTE:

The end of the reel lock shall be outside the reel area (Ø 125 mm min.), when the lid is opened 20 mm above the datum plane Z.

FIGURE 26. Medium cassette reel lock and release.

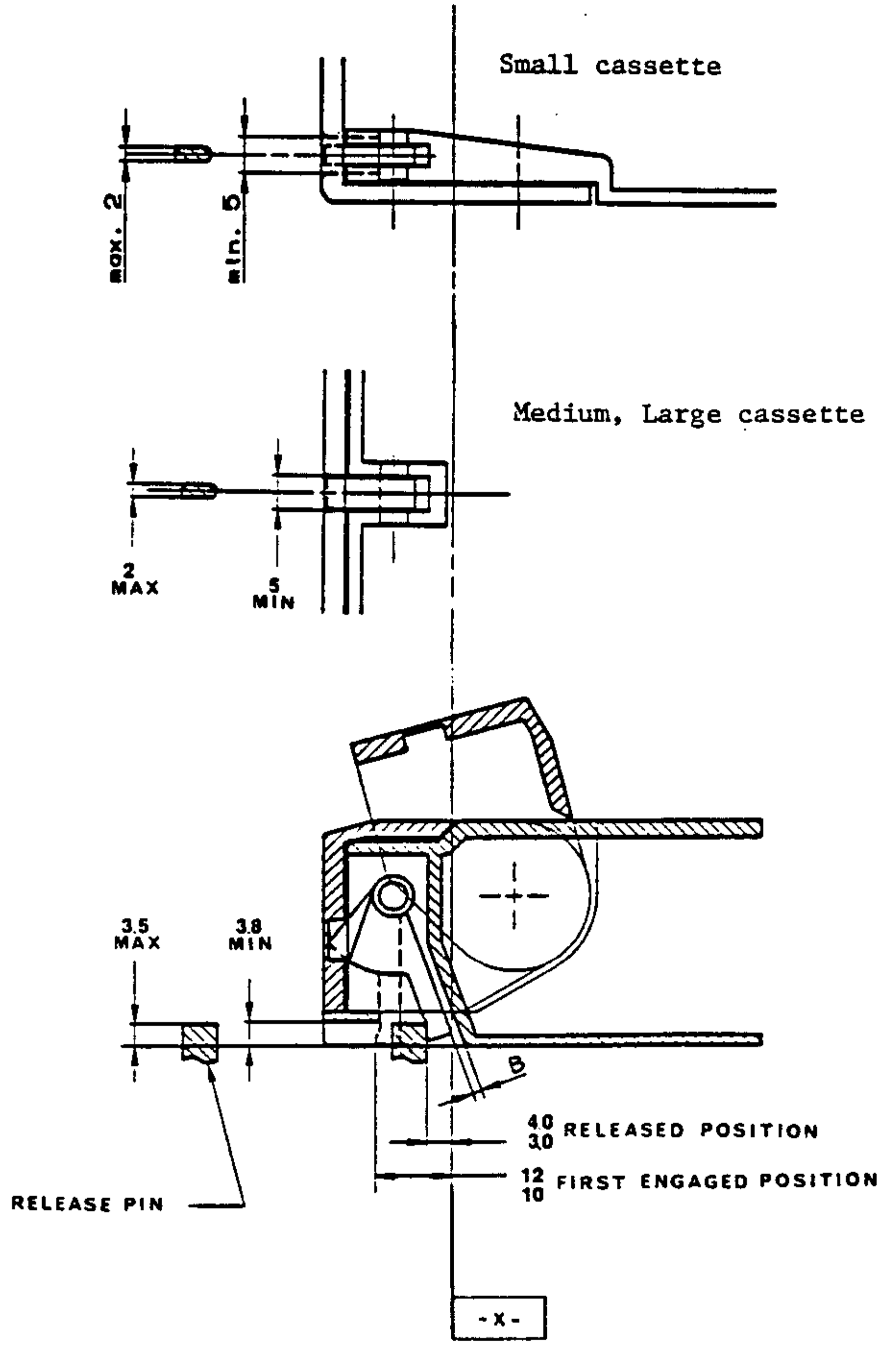




NOTE:

The end of the reel lock shall be outside the reel area (Ø 181 mm min.), when the lid is opened 20 mm above the datum plane Z.

FIGURE 27. Large cassette reel lock and release.

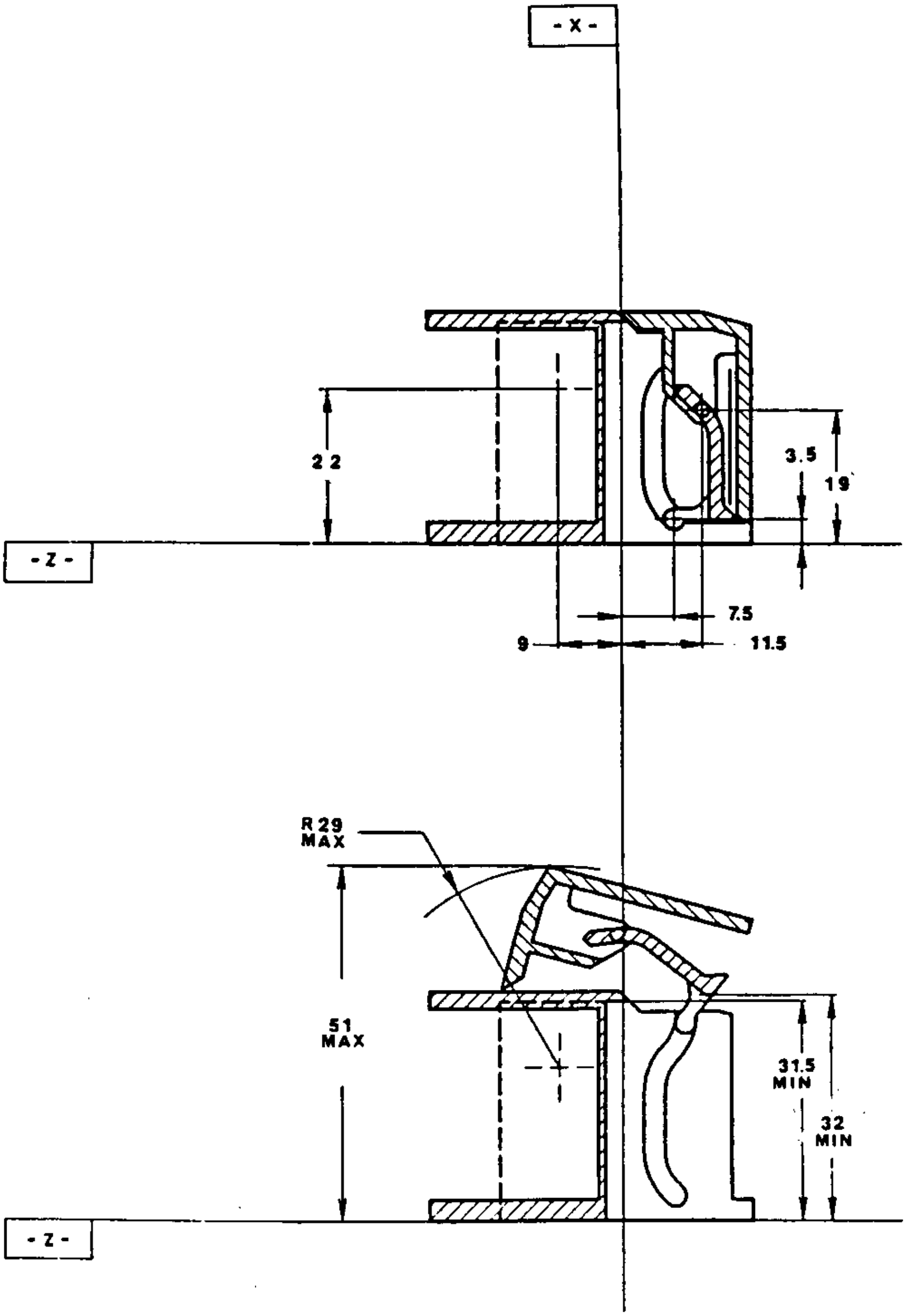


NOTES:

Clearance B shall be 0.5 mm at a minimum when the release pin is located 3 mm away from datum plane X.

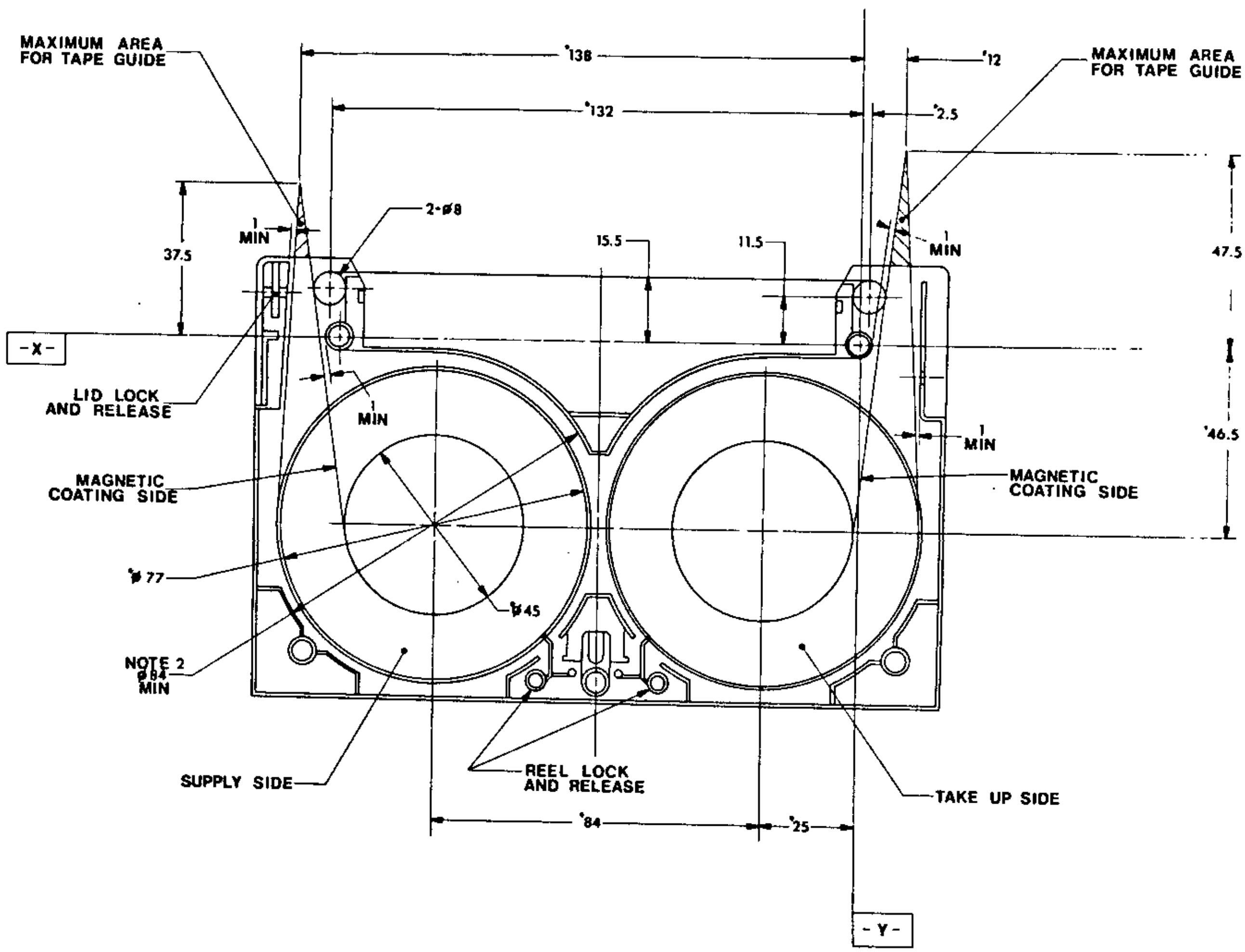
The lid lock shall be released when the release pin is located 4 mm away from datum plane X.

FIGURE 28. Lid lock and release.



NOTE: Lid shall open to a height of at least 32 mm.

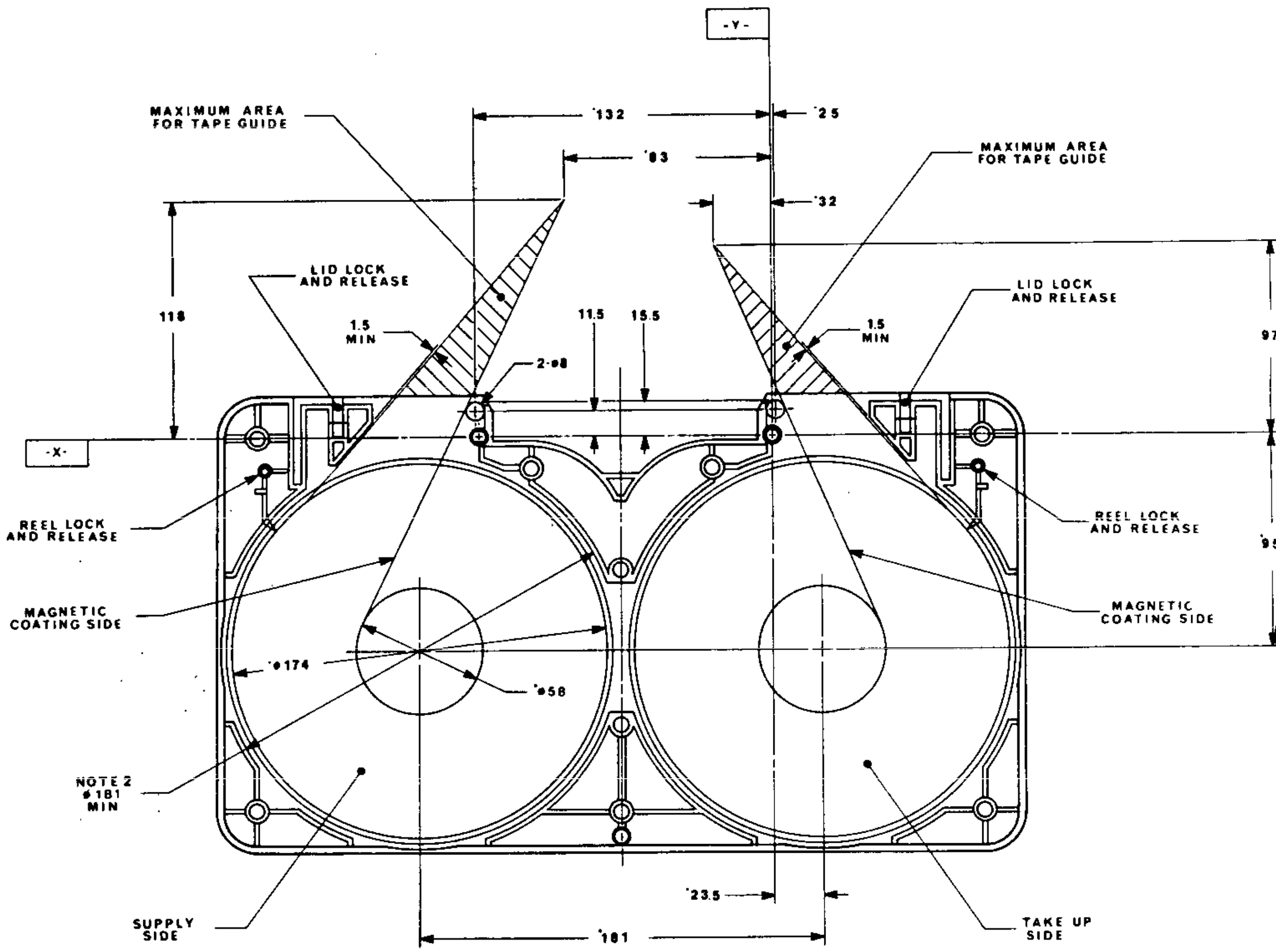
FIGURE 29. Lid structure.



NOTES:

1. Dimensions marked with an asterisk are nominal values specifying the tape path.
2. Area for the reel.

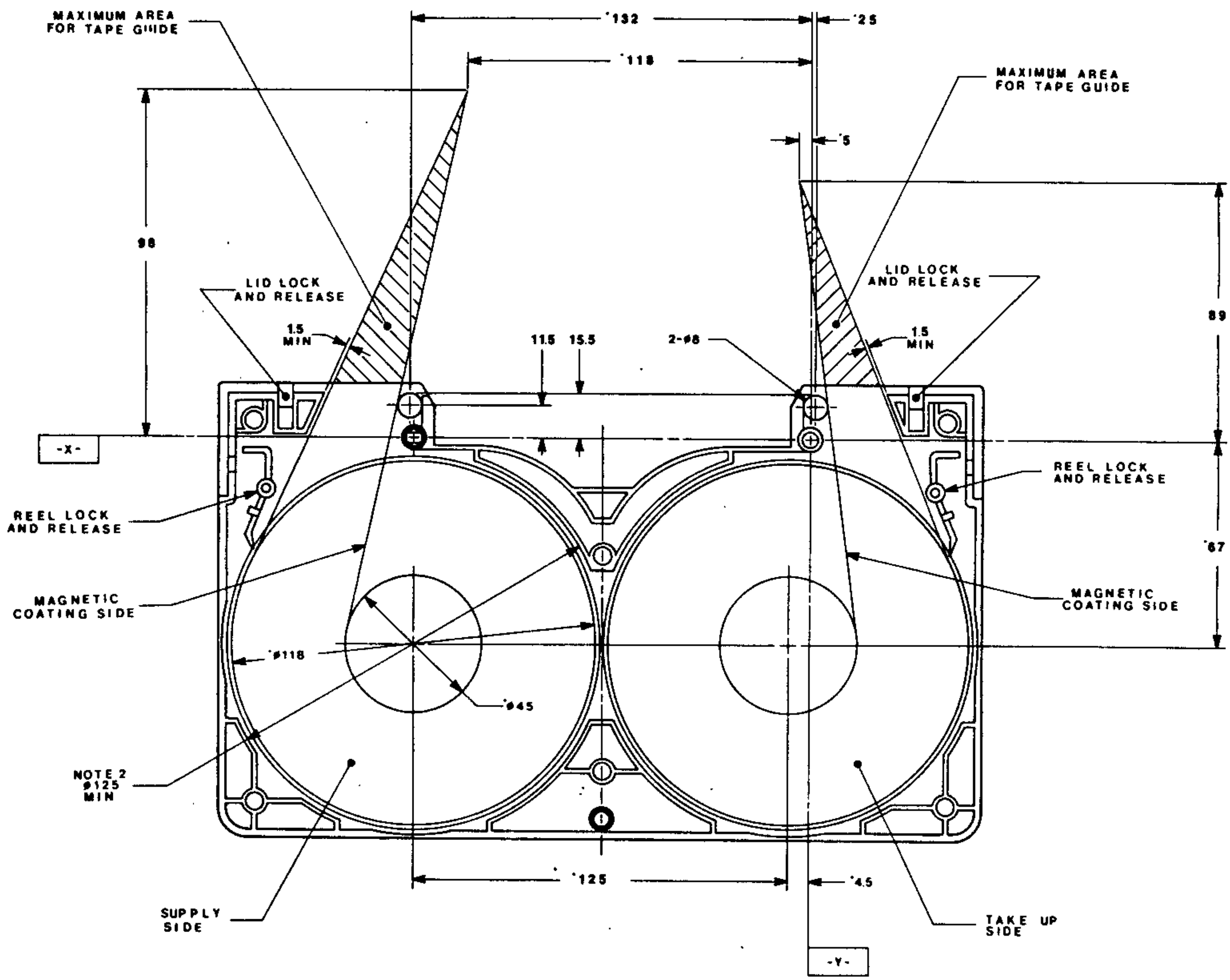
FIGURE 30. Internal structure and tape path of small cassette (top view) for reference only).



NOTES:

1. Dimensions marked with an asterisk are nominal values specifying the tape path.
2. Area for the reel.

FIGURE 31. Internal structure and tape path of medium cassette (top view) (for reference only).



NOTES:

1. Dimensions marked with an asterisk are nominal values specifying the tape path.
2. Area for the reel.

FIGURE 32. Internal structure and tape path of large cassette (top view) (for reference only).

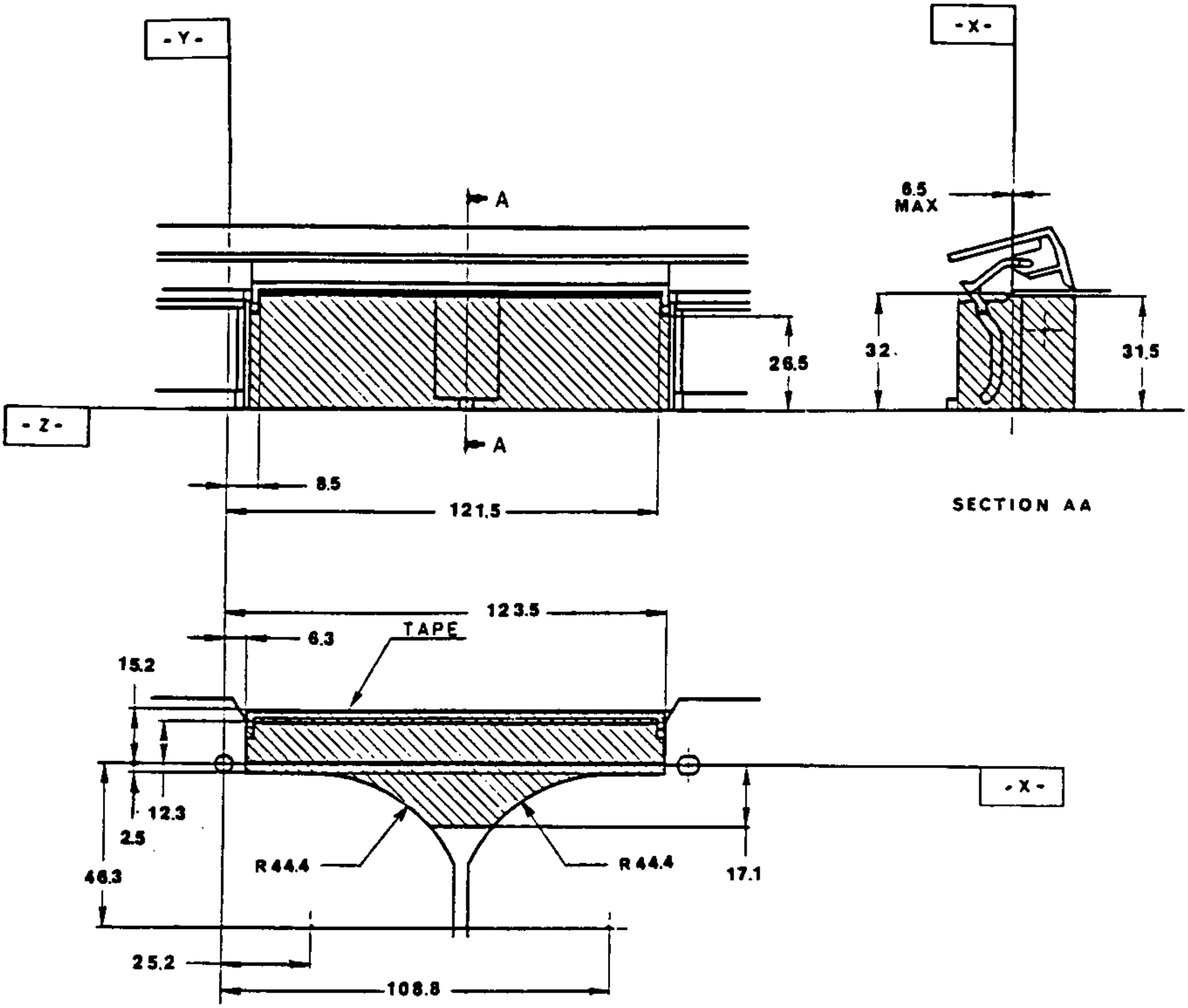


FIGURE 33. Minimum space for recorder/reproducer loading mechanism.

6.3 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to previous issues due to the extensiveness of the changes.

Custodians:
Army - CR
Navy - AS
Air Force - 99

Review activities:
Navy - EC, SH, MC
NSA - NS

Preparing activity:
Navy - AS
(Project No. 6625-0690)

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-2179A	HELICAL DIGITAL RECORDING FORMAT FOR 19-MM MAGNETIC TAPE CASSETTE RECORDER/REPRODUCERS

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS (Street, City, State, ZIP Code)

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: ______

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

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