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Digital field tape format standards — SEG-D[1]

SEG Subcommittee on Digital Tape Formats[2]

The evolving nature of the seismic data acquisition requires a corresponding change in the recording techniques of these data. Several recording formats have been defined in the past to accommodate the previous changes in instrumentation. They were: SEG's A, B, C, and Y. The following described format includes the best features from these previous formats plus additional characteristics.

By using this new tape format, the data may be multiplexed or demultiplexed, the multiplexed records may be gapped or gapless. The data values are recorded in one of six methods; they are: eight bits or sixteen bits using a quaternary or hexadecimal exponent, twenty bits with a binary exponent, or thirty-two bits with a hexadecimal exponent. The diversity of information to be recorded required a record header that would self-define all the recorded data. Each seismic channel can be individually identified as to its start-stop time, sampling interval, filtering and type of data information recorded.

Included are examples of the defined parameters, example calculations, a glossary, and descriptors for the abbreviations used.

INTRODUCTION

During the past 12 years, a number of recommendations have been published describing proposed tape format standards for both seismic field recording and for seismic trade data (ANSI, 1973a, b, 1976). Many of today's needs, however, were not anticipated in these designs. For example, past formats do not provide for submillisecond sampling intervals, are limited in range and slope of filters, arc restricted in the number of recording channels, and make no provisions for either multiple sampling intervals or dynamic changes in parameters such as filters or sampling intervals. This proposal's objective is to overcome these restrictions while at the same time maintaining some compatibility with the presently used formats.

We propose a family of formats all with the same header structure, encompassing both multiplexed and demultiplexcd data, with 1, 2, 2½, and 4 byte data words. It is not intended to replace SEG's A, B, C, or Y standard formats. (Northwood et al, 1967; Meiners et al, 1972; Barry et al, 1975). The family is given the designation SEG-D followed by a code number defining the type of data word, and the designation "multiplexed" or "demultiplexed." The code numbers recommended are listed in Appendix A under Bytes 3 and 4 of the general header.

GENERAL FORMAT

The following requirements have been incorporated:

(1) The nine track one-half inch tape is retained, but extension to 6250 BPI is permitted as long as it is compatible with the ANSI standard (ANSI 1973a, b, 1976).
(2) Both multiplexed and demultiplexed field tape formats are represented.
(3) Various word length formats are provided to allow trade-offs to be made when recording large numbers of channels at short sampling intervals.
(4) Multiple sets of data channels can be recorded, each operating at a different sampling interval, or each having other parameter differences (e.g., filters) during the record. The parameters can be constant throughout the record, or can be dynamically switched at some predetermined time.

[1] © 1975 Society of Exploration Geophysicist, All rights reserved.
[2] D.A. Cavers (Chairman), Gulf Research and Development, Box 36506, Houston, TX 77036; P.E. Carroll, Texas Instruments, P.O. Box 1444, M.S. 6i7, Houston, TX 77001; E.P. Meiners, Chevron Geophysical, Box 36487, Houston, TX 77036; C.W. Racer, Chevron Geophysical, 8114 Pella, Houston, TX 77036; L.E. Siems, Litton Resources, 3930 Westholme Drive, Houston, TX 77063; M.G. Sojourner, Input/Output, 8009 Harwin Drive, Houston, TX 77036; J.L. Twombly, GUS Manufacturing, 10486 Dauwood, E1 Paso, TX 79925; J.A. Weigand, Texaco Inc., 4800 Foumace Place E302, Bellaire, TX 77401.

(5) The format is self-defining. Information in the header specifies the length of the header and the length of the data record.
(6) A one's complement number system is selected for the fractional part in all binary and quaternary exponent data recording methods. A sign and magnitude number system is selected for the fractional part of all hexadecimal exponent data recording methods.
(7) A unique four byte start of scan code is used. Status bits are provided to indicate dynamic changes starting with this scan.
(8) Submillisecond timing words are incorporated to allow shorter sampling interval systems to have a unique timing word in each scan.
(9) One start of scan code followed by a timing word is utilized in all multiplexed formats in order to facilitate software and hardware synchronization.
(10) Provisions are made for recording the instrument sample skew in the header. (This does not include cable propagation delay which must be established by the user.)

FORMAT OVERVIEW

The overall tape layout is as follows:

Leader
BOT
Seismic record file 1
EOF
Seismic record file 2
EOF

•
•
•

Seismic record file n
EOF
EOF
EOT
Trailer

As shown in Figure 1, each seismic record consists of a file of two or more blocks. The first block contains the record headers. Following the header block will be one or more blocks of multiplexed data (Figure 2) or of demultiplexed data (Figure 3). Seismic records are separated by one end. of file mark (EOF). Two EOF marks indicate that there are no more seismic records on the tape.

HEADER BLOCK — FUNCTIONAL DESCRIPTION

The record header block is a single block of information separated from the data by a standard inter-block gap. The record header block is composed of a general header, one or more scan type headers and, optionally, the extended and external headers (Figure 1). All header information is packed BCD unless otherwise specified, with bit positions 0-3 being the most significant digit. Appendix A has a detailed listing of the information contained in the general and scan type headers.

General header (required)

The general header is 32 bytes long and contains information similar to SEG A, B, and C headers (Figure 4). Abbreviations (Appendix D) are as close as possible to those used in previous formats.

Scan type header (required)

The scan type header is new. It is used to describe the information of the recorded channels [filters, sampling intervals, sample skew, etc. (Figure 6)]. The scan type header is composed of one or more channel set descriptors followed by skew information. The channel set descriptors must appear in the same order as their respective channel sets will appear within a base scan interval. A channel set, which is part of a scan type, is defined as a group of channels all recorded with identical recording parameters. One or more channel sets can be recorded concurrently within one scan type. In addition, there can be multiple scan types to permit dynamic scan type changes during the record (e.g., 12 channels at ½ msec switched at about 1 sec to 48 channels at 2 msec). Where there are dynamic changes, scan type header 1 describes the first part of the record, scan type header 2 the second part, etc. Within the scan type header, each channel set descriptor is composed of a 32 byte field (Figure 5), and up to 99 channel set descriptors may be present. In addition, up to 99 scan type headers may be utilized in a record.

Following the channel set descriptors of a scan type are a number of 32 byte fields (SK, specified in Byte 30 of the general header) that specify sample skew. Sample skew (SS) is recorded in a single byte for each sample of each subscan of each channel set, in the same order as the samples are recorded in the scan. Each byte represents a fractional part of the base scan interval (Byte 23 of the general header). The resolution is 1/256 of this interval. For instance, if the base scan interval is 2 msec, the least significant bit in the sample skew byte is 1/256 of 2 msec or 7.8125 μsec. The reference point for the skew is the timing word (T) such that the timing word represents zero skew. The actual time the sample was taken is obtained by adding the timing word (T) to the product of the sample skew (SS) and the base scan interval (I). (Actual time = T + SS x I.)

The following is a list of ground roles for the scan type header:

(1) The order in which channel sets are described in the header will be the same as the order in which the data are recorded for each channel set. (See multiplexed data example 6.)
(2) In a scan type header containing multiple channel set descriptors with different sampling intervals, each channel set descriptor will appear only once in each scan type header. Within the data block, however, shorter sampling interval data are recorded more frequently (i.e., within a base scan interval, channel sets of a shorter sampling interval will appear as multiple subscans). The number of subscans of a channel set is equal to the quotient of the base scan interval divided by the channel set sampling interval [see Byte 12 of the descriptor for this channel set (Figure 5)].
(3) In the case of multiple scan type records, such as the dynamically switched sampling interval case, each scan type will contain the same number of channel sets. Any unused channel sets needed in a scan type must be so indicated by setting Bytes 9 and 10 (channels per channel set) to zero in the channel set descriptor (Appendix A).
(4) In multiple scan type records, the number of bytes per base scan interval must remain a constant for all scan types recorded.
(5) The data recording method is not permitted to change on a reel of tape. However, multiplexed and demultiplexed data may appear on the same reel. For example, one or more multiplexed or demultiplexcd records may be recorded on tape followed by a multiplexed or demultiplexed stacked record of the same data with the same word length and data recording method.
(6) Although not essential, it is suggested that the channel set order within a scan type be: auxiliary channels, long sampling interval channels, short sampling interval channels. All channel sets of the same sampling interval should be contiguous (see Example 4).

Extended header (optional)

The extended header provides additional areas to be used by equipment manufacturers to interface directly with their equipment. An example of this would be a vertical stacking unit used in conjunction with the data acquisition system (e.g., records per stack, records rejected in stack, type of stack, etc.). Since the nature of this data will depend heavily on the equipment and processes being applied, it will be the responsibility of the equipment manufacturer to establish a format and document this area. Byte 31 of the general header contains the number of 32 byte fields in the extended header.

External header (optional)

The external header provides a means of recording special user desired information in the header block. Some examples of this are roll box information, crew data, survey information, and a multiplicity of marine parameters. This data format will be defined and documented by the end user. The means of putting this information into the header has usually been provided by the equipment manufacturer. Byte 32 of the general header contains the number of 32 byte fields in the external header.

DATA BODY

Multiplexed

The multiplexed data may be gapped or gapless. A gapless multiplexed data block (Figure 2) is one continuous block of data separated from the header block by an interblock gap, and divided into an integral number of scans as defined in the header. If the multiplexed data body is gapped, each block must begin with a start-of-scan and must contain an integral number of scans. Bytes 24 and 25 of the general header indicate the number of scans in a block. Zero indicates gapless data.

In each scan the first eight bytes are dedicated to the start-of-scan code and timing word as shown in Figure 8. The sync code and timing word provide a means of recovering data that might otherwise be lost, and allow various checks to be made on the integrity of the data while it is being read during processing.

The 8 byte start-of-scan code and timing word over-head must be considered (counted) when computing the number of bytes per scan. The 8 byte start-of-scan and timing word format will remain the same in each of the different data recording methods. The start-of-scan code in each of the data recording methods described here must be maintained as a unique 4 byte code; therefore, there will be certain restrictions on the data in each of the different data recording methods which are covered in the individual format descriptions. (See general header Bytes 3 and 4.)

The 4 byte (start of scan) code as shown in Figure 8 and below is composed as follows: The first three bytes are all one's, and Bits 6 and 7 of Byte 4 must be a zero and a one, respectively, to guarantee uniqueness of the start of scan. The remaining bits (0-5) of Byte 4 are undefined (x) or are used as follows:

Start of scan

Bit	0	1	2	3	4	5	6	7
Byte 1	1	1	1	1	1	1	1	1
Byte 2	1	1	1	1	1	1	1	1
Byte 3	1	1	1	1	1	1	1	1
Byte 4	x	TWI	ITB	DP	x	x	0	1

TWI. — This bit is included as an integrity check on time break. It changes from a zero to a one at the close of the time break window. Random variations in the time of this change indicate a problem in the fire control system. The presence of a one in the TWI bit of the first start of scan of a record indicates that time break was not detected and recording commenced at the end of the time break window.

ITB. — Intemal time break is recorded as a 1 for the entire record if an abnormal condition is detected in the synchronization of the system timing with the energy source timing. Otherwise it is recorded as a zero.

DP. — The dynamic parameter change bit is recorded as a zero for the first scan of every record and remains a zero throughout the first scan type. It is switched from a zero to a one to indicate the first scan of the second scan type which contains the first data taken after a dynamic parameter change has occurred. It will remain a one throughout the second scan type until another dynamic parameter change occurs, at which time it will be switched to a zero. It is alternately switched at each subsequent scan type. For records without dynamic parameter changes, it is recorded as a zero throughout the record.

The next three bytes (Bytes 5-7 of the scan) are dedicated to a binary timing word as shown in Figure 8 and below. Byte 8 is written as all zeros. The timing word is in milliseconds and has the following bit weight assignments:

Timing word

Bit	0	1	2	3	4	5	6	7
Byte 5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
Byte 6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
Byte 7	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}
Byte 8	0	0	0	0	0	0	0	0

The timing word LSB (2^{-8}) is equal to 1/256 msec, and the MSB (2^{15}) is equal to 32,768 msec. The timing word for each scan is equal to the elapsed time from zero time to the start of that scan. Timing words of from 0 to 65,535.9961 msec are codable. For longer recordings the timing word may overflow to zero and then continue.

The first scan of data has typically started with timing word zero. However, this is not a requirement. In a sampling system, it is not always practical to resynchronize the system even though most seismic data acquisition systems have to date. Possible reasons for not wanting to resynchronize could be digital filtering, communication restrictions, etc.

Whether the system is resynchronized or not, the timing word will contain the time from the energy source event to the start of scan of interest. For example, assume the sampling interval is 2 msec, the system does not resynchronize, and the energy source event occurs 1 + 9/256 msec before the next normal start of scan. The timing word values would be:

First timing word	0 + 1 + 9/256 msec
Second	2 + 1 + 9/256 msec
Third	4 + 1 + 9/256 msec
Fourth	6 + 1 + 9/256 msec
•	
•	
•	
One-thousandth timing word	1998 + 1 + 9/256 msec

Demultiplexed

The demultiplexed data format (Figure 3) is simply an extension of the multiplexed format previously described (Figure 2). In an equivalent system, it would utilize the same header block as its multiplexed counterpart with the exception of the format code in Bytes 3 and 4 and bytes per scan in Bytes 20, 21, and 22 of the general header. The data body portion of the multiplexed format (as shown in Figure 2) is replaced with individual trace blocks (Figure 3) including a trace header (see Figure 9 and below) for all channels in each channel set of each scan type. Each trace block is separated by a standard inter block gap of erased tape and is a sequential set of points from one channel in one channel set. The data recording methods utilized within the trace blocks are described later in the section titled "Data recording method."

Trace header. — The trace header length is 20 bytes and is an identifier that precedes each channel's data. The trace header and the trace data are recorded as one block of data. A trace is restricted to one channel of data from one channel set of one scan type. All the information in the trace header is taken directly from the general header and scan type header with the exception of the channel number and the time break window end time. File number, scan type, channel set, and channel (or trace) number are recorded in packed BCD.

Bytes 7, 8, and 9 comprise the timing word that would accompany the first sample if these data were written in the multiplexed format. To obtain the exact sample time, the actual sample skew time (Byte 11 multiplied by the base scan interval) must be added to the

Trace header									
	Bit	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
File number	Byte 1	F_1	F_1	F_1	F_1	F_2	F_2	F_2	F_2
	Byte 2	F_3	F_3	F_3	F_3	F_4	F_4	F_4	F_4
Scan type	Byte 3	ST_1	ST_1	ST_1	ST_1	ST_2	ST_2	ST_2	ST_2
Channel set	Byte 4	CN_1	CN_1	CN_1	CN_1	CN_2	CN_2	CN_2	CN_2
Channel or	Byte 5	TN_1	TN_1	TN_1	TN_1	TN_2	TN_2	TN_2	TN_2
trace number	Byte 6	TN_3	TN_3	TN_3	TN_3	TN_4	TN_4	TN_4	TN_4
	Byte 7	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8
First timing	Byte 8	T_7	T_6	T_5	T_4	T_3	T_2	T_1	T_0
word	Byte 9	T_{-1}	T_{-2}	T_{-3}	T_{-4}	T_{-5}	T_{-6}	T_{-7}	T_{-8}
	Byte 10	0	0	0	0	0	0	0	0
	Byte 11	SS_{-1}	SS_{-2}	SS_{-3}	SS_{-4}	SS_{-5}	SS_{-6}	SS_{-7}	SS_{-8}
Sample skew	Byte 12	0	0	0	0	0	0	0	0
	Byte 13	TW_{15}	TW_{14}	TW_{13}	TW_{12}	TW_{11}	TW_{10}	TW_9	TW_8
Time break	Byte 14	TW_7	TW_6	TW_5	TW_4	TW_3	TW_2	TW_1	TW_0
window end	Byte 15	TW_{-1}	TW_{-2}	TW_{-3}	TW_{-4}	TW_{-5}	TW_{-6}	TW_{-7}	TW_{-8}
	Byte 16	0	0	0	0	0	0	0	0
	Byte 17	0	0	0	0	0	0	0	0
	Byte 18	0	0	0	0	0	0	0	0
	Byte 19	0	0	0	0	0	0	0	0
	Byte 20	0	0	0	0	0	0	0	0

time recorded in Bytes 7, 8, and 9.

Byte 11 contains sample skew of the first sample of this trace. This is identical to the first byte of sample skew for this channel in the scan type header.

Bytes 13, 14, and 15 are included as an integrity check on time break. They comprise the timing word of the scan in which TWI changed to a one. Thus, it represents the time from time break to the end of the time break window. Random variations in this time indicate a problem in the fire control system. The presence of a value less than the base scan interval indicates that time break was not detected and recording commenced at the end of the time break window.

DATA RECORDING METHOD

To accommodate diverse recording needs, the data recording utilizes sample sizes of 8, 16, 20, and 32 bits.

The data word is a number representation of the sign and magnitude of the instantaneous voltage presented to the system. It is not an indication of how the hardware gain system functions. The output of stepped gain systems may be represented as a binary mantissa and a binary exponent of base 2, 4, or 16 (binary, quaternary, or hexadecimal system).

Following are descriptions of each of the data recording methods permitted. The same number system is to be used on all samples in a record, including auxiliary and all other types of channels. All recording methods are valid for multiplexed and demultiplexed records. The 2½ byte binary demultiplexed method uses the LSB whereas the comparable multiplexed method does not (in order to preserve the uniqueness of the start of scan code).

1 byte quaternary exponent data recording method

The following illustrates the 8 bit word and the corresponding bit weights:

Bit	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Byte 1	S	C_2	C_1	C_0	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}

S = sign bit. — (One = negative number).

C = quaternary exponent. — This is a three bit positive binary exponent of 4 written as 4^{CCC} where CCC can assume values from 0-7.

$Q_{1\text{-}4}$-fraction. — This is a 4 bit one's complement binary fraction. The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The fraction can have values from $-1 + 2^{-4}$ to $1 - 2^{-4}$. In order to guarantee the uniqueness of the start of scan, negative zero is invalid and must be convened to positive zero.

Input signal = S.QQQQ x 4^{CCC} x 2^{MP} millivolts where 2^{MP} is the value required to descale the data sample to the recording system input level. MP is defined in Byte 8 of each channel set descriptor in the scan type header.

2 byte quaternary exponent data recording method

The following illustrated the 16-bit word and the corresponding bit weights:

Bit	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Byte 1	S	C_2	C_1	C_0	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}
Byte 2	Q_{-5}	Q_{-6}	Q_{-7}	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}

S = sign bit. — (One = negative number).

C = quaternary exponent. — This is a three bit positive binary exponent of 4 written as 4^{CCC} where CCC can assume values from 0-7.

$Q_{1\text{-}12}$ — fraction. — This is a 12 bit one's complement binary fraction. The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The fraction can have values from $-1 + 2^{-12}$ to $1 - 2^{-12}$. In order to guarantee the uniqueness of the start of scan, negative zero is invalid and must be convened to positive zero.

Input signal = S.QQQQ,QQQQ,QQQQ x 4^{CCC} x 2^{MP} millivolts where 2^{MP} is the value required to de-scale the data sample to the recording system input level. MP is defined in Byte 8 of each channel set descriptor in the scan type header.

2½ byte binary exponent data recording method —multiplexed

The following illustrates the 20-bit word and the corresponding bit weights:

Bit	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Byte 1	C_3	C_2	C_1	C_0	C_3	C_2	C_1	C_0	Exponent for
Byte 2	C_3	C_2	C_1	C_0	C_3	C_2	C_1	C_0	channels 1 thru 4[3]
Byte 3	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Channel 1

[3] In the multiplexed format, Bytes 1 and 2 contain the exponents for the following four channels of the scan. The

Byte 4	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	0	
Byte 5	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Channel 2
Byte 6	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	0	
Byte 7	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Channel 3
Byte 8	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	0	
Byte 9	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Channel 4
Byte 10	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	0	

S = sign bit. — (One = negative number).

C = binary exponents. — This is a 4 bit positive binary exponent of 2 written as 2^{CCCC} where CCCC can assume values of 0-15. The four exponents are in channel number order for the four channels starting with channel one in bits 0-3 of Byte 1.

Ql-14-fraction. — This is a 14 bit one's complement binary fraction. The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The sign and fraction can assume values from $1 - 2^{-14}$ to $-1 + 2^{-14}$. Note that bit 7 of the second byte of each sample must be zero in order to guarantee the uniqueness of the start of scan. Negative zero is invalid and must be convened to positive zero.

Input signal = S.QQQQ,QQQQ,QQQQ,QQ x 2^{CCCC} x 2^{MP} millivolts where 2^{MP} is the value required to descale the data word to the recording system input level. MP is defined in Byte 8 of each of the corresponding channel set descriptors in the scan type header.

Note that in utilizing this data recording method, the number of data channels per channel set must be exactly divisible by 4 in order to preserve the data grouping of this method.

2½ byte binary exponent data recording method—demultiplexed

The following illustrates the 20 bit word and the corresponding bit weights:

Bit	0	1	2	3	4	5	6	7	
Byte 1	C_3	C_2	C_1	C_0	C_3	C_2	C_1	C_0	Exponent for
Byte 2	C_3	C_2	C_1	C_0	C_3	C_2	C_1	C_0	samples 1 thru 4[4]
Byte 3	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Sample 1
Byte 4	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	Q_{-15}	
Byte 5	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Sample 2
Byte 6	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	Q_{-15}	
Byte 7	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Sample 3
Byte 8	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	Q_{-15}	
Byte 9	S	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Sample 4
Byte 10	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	Q_{-15}	

S = sign bit — (One = negative number).

C = binary exponent. — This is a 4 bit positive binary exponent of 2 written as 2^{CCCC} where CCCC can assume values of 0-15. The four exponents are in sample order for the four samples starting with the first sample in bits 0-3 of Byte 1.

Q_{1-15} — fraction. — This is a 15 bit one's complement binary fraction. The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The sign and fraction can assume values from $1 - 2^{-15}$ to $-1 + 2^{-15}$. Negative zero is invalid and must be convened to positive zero.

Input signal = S.Q, QQQ, QQQQ, QQQQ, QQQ 2cccc X 2^{MP} millivolts where 2^{MP} is the value required to descale the data word to the recording system input level. MP is defined in Byte 8 of each of the corresponding channel set descriptors in the scan type header.

Note that in utilizing this data recording method, the number of samples per channel must be exactly divisible by 4 in order to preserve the data grouping of this method.

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channel numbers are relative and are only to denote position in the four channel subset.

[4] In the demultiplexed format, Bytes I and 2 contain the exponents for the following four samples of the channel. The sample numbers are relative and are only to denote position in the four sample subset.

1 byte hexadecimal exponent data recording method

The following illustrates the 8-bit word and the corresponding bit weights:

Bit	0	1	2	3	4	5	6	7
Byte 1	S	C_1	C_0	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}

S = sign bit. — (One - negative number).

C = hexadecimal exponent. —This is a two bit positive binary exponent of 16 written as 16^{CC} where CC can assume values from 0-3.

Q_{1-5} — fraction. —This is a 5 bit positive binary fraction. The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The sign and fraction can have any value from $-1 + 2^{-5}$ to $1 – 2^{-5}$. In order to guarantee the uniqueness of the start of scan, an all one's representation (sign = negative, exponent = 3, and fraction = $1 – 2^{-5}$) is invalid: Thus the full range of values allowed is $-(1 - 2^{-4}) \times 16^3$ to $+ (1 - 2^{-5}) \times 16^3$.

Input signal = S.QQQQ,Q x 16^{CC} x 2^{MP} millivolts where 2^{MP} is the value required to descale the data sample to the recording system input level. MP is defined in Byte 8 of each channel set descriptor in the scan type header.

2 byte hexadecimal exponent data recording method

The following illustrates the 16-bit word and the corresponding bit weights:

Bit	0	1	2	3	4	5	6	7
Byte l	S	C_1	C_0	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}
Byte 2	Q_{-6}	Q_{-7}	Q_{-8}	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}

S = sign bit. — (One = negative number).

C = hexadecimal exponent. — This is a two bit positive binary exponent of 16 written as 16^{CC} where CC can assume values from 0-3.

Q_{1-13} — fraction. — This is a 13 bit positive binary fraction. The radix point is to the left of the most significant bit (Q_{-1} with the MSB being defined as 2^{-1} the sign and fraction can have any value from $-1 + 2^{-13}$ to $1- 2^{-13}$. In order to guarantee the uniqueness of the start of scan, an all one's representation (sign = negative, exponent = 3, and fraction = $1 – 2^{-13}$) is invalid. Thus the full range of values allowed is $-(1 – 2^{-12}) \times 16^3$ to $+ (1 – 2^{-13}) \times 16^3$

Input signal = S.QQQQ,QQQQ,QQQQ,Q x 16^{CC} X 2^{MP} millivolts where 2^{MP} is the value required to descale the data sample to the recording system input level. MP is defined in Byte 8 of each channel set descriptor in the scan type header.

4 byte hexadecimal exponent data recording method

The following illustrates the 32-bit word and the corresponding bit weights:

Bit	0	1	2	3	4	5	6	7
Byte 1	S	C_6	C_5	C_4	C_3	C_2	C_1	C_0
Byte 2	Q_{-1}	Q_{-2}	Q_{-3}	Q_{-4}	Q_{-5}	Q_{-6}	Q_{-7}	Q_{-8}
Byte 3	Q_{-9}	Q_{-10}	Q_{-11}	Q_{-12}	Q_{-13}	Q_{-14}	Q_{-15}	Q_{-16}
Byte 4	Q_{-17}	Q_{-18}	Q_{-19}	Q_{-20}	Q_{-21}	Q_{-22}	Q_{-23}	0

S = sign bit. — (One = negative number).

C = excess 64 hexadecimal exponent. — This is a binary exponent of 16. It has been biased by 64 such that it represents $16^{(CCCCCCC-64)}$ where CCCCCCC can assume values from 0 to 127.

Q_{1-23} — magnitude fraction.—This is a 23 bit positive binary fraction (i.e., the number system is sign and magnitude). The radix point is to the left of the most significant bit (Q_{-1}) with the MSB being defined as 2^{-1}. The sign and fraction can assume values from $1 – 2^{-23}$ to $-(1 + 2^{-23})$. It must always be written as a hexadecimal left justified number. If this fraction is zero, the sign and exponent must also be zero (i.e., the entire word is zero). Note that bit 7 of Byte 4 must be zero in order to guarantee the uniqueness of the start of scan.

Input signal = S. QQQQ, QQQQ, QQQQ, QQQQ, QQQQ, QQQ x $16^{(CCCCCCC-64)}$ x 2^{MP} millivolts where 2^{MP} is the value required to descale the data sample to the recording system input level. MP is defined in Byte 8 of each channel set descriptor in the scan type header. This data recording method has more than sufficient range to handle the dynamic range of a typical seismic system. Thus, MP may not be needed to account for any scaling and may be recorded as zero.

EXAMPLES

Three sets of examples are given. The header block set illustrates the header lengths for various combinations of scan types and channel sets. The multiplexed data set of examples illustrates the organization of data within scans for an example which includes multiple scan types and multiple channel sets. The demultiplexed data set of examples illustrates the order of trace blocks for most of the examples.

Header block

The following examples describe the general and scan type headers required for each case. The optional extended and external headers are not included.

Example 1 — Typical 24 channel system (Figure 6A)

4 auxiliary channels at 2-msec sampling intervals
24 seismic channels at 2-msec sampling intervals

This system would contain one scan type header because there are no parameter changes during the record. This one scan type header would contain two channel set descriptors, one for the 4 auxiliary channels and one for the 24 seismic channels. The header block in this case would be as follows, assuming no extensions for the extended and external headers:

32 bytes	General header
	Scan type header 1
32 bytes	auxiliary channel set
32 bytes	seismic channel set
32 bytes	sample skew (28 used)
128 bytes	Total header block

Example 2---24 channel system with parameter differences (Figure 6B)

4 auxiliary channels
12 seismic channels with 18-Hz low-cut filters
12 seismic channels with 36-Hz low-cut filters (2-msec sampling on all channels)

This example is similar to the previous one with the exception of needing one additional channel set descriptor, which is required because some of the seismic channels are operating at a different filter setting. The header block in this case would contain one additional 32 byte field.

32 bytes	General header
	Scan type header 1
32 bytes	auxiliary channel set
32 bytes	seismic channel set (18-Hz low cut)
32 bytes	seismic channel set (36-Hz low cut)
32 bytes	sample skew (28 used)
160 bytes	Total header block

Example 3--Large system (Figure 6C)

4 auxiliary channels
240 seismic channels(4 msec sampling on all channels)

The header block in this case will be longer than in Example 1 because it will have additional bytes of sample skew.

32 bytes	General header
	Scan type header 1
32 bytes	auxiliary channel set
32 bytes	seismic channel set
256 bytes	sample skew (244 used)
352 bytes	Total header block

Example 4---Dual sampling intervals (Figure 7A)

4 auxiliary channels at 2-msec sampling interval
48 seismic channels at 2-msec sampling interval
12 seismic channels at ½ msec sampling interval (sampled four times in each scan)

In this case there would be three channel set descriptors required to make up the scan type header. The additional channel set descriptor is required to identify the channel set operating at ½ msec.

32 bytes	General header
	Scan type header 1
32 bytes	auxiliary channel set
32 bytes	seismic channel set at 2 msec
32 bytes	seismic channel set at ½ msec
128 bytes	sample skew (100 used)
256 bytes	Total header block

Example 5---Dynamically switched sampling interval (Figure 7B)

Scan type header 1
4 auxiliary channels at 2-msec sampling interval
12 seismic channels at ½ msec sampling interval
Scan type header 2
4 auxiliary channels at 2 msec
48 seismic channels at 2 msec

This is a switched sampling interval system in which 12 of the channels will be sampled for a portion of the record at a V2-msec interval, then it will switch to 48 seismic channels at a 2-msec interval for the remainder of the record.

This system has a parameter change in mid-record and therefore requires a second scan type header to define it. Its header block would be constructed as follows:

32 bytes	General header
	Scan type header 1

32 bytes	4 auxiliary channels at 2 msec
32 bytes	12 seismic channels at V2 msec
64 bytes	Sample Skew (52 used)
	Scan type header 2
32 bytes	4 auxiliary channels at 2 msec
32 bytes	48 seismic channels at 2 msec
64 bytes	Sample skew (52 used)
288 bytes	Total header block

Example 6 — Dynamically switched sampling interval (Figure 7C)

This, as in Example 5, is a 2-msec base scan interval system that is dynamically switching sampling interval in mid-record. It starts as a 12 channel, ½ msec sampling interval system and ends as a 48 channel 2 msec sampling interval system with a common filter. The 12 channels in this example, though, are divided into 2 channel sets, with 6 channels utilizing low-cut filters and the remaining 6 without low-cut filters. The header block would be constructed in the following manner:

32 bytes	General header
	Scan type header 1
32 bytes	4 auxiliary channels at 2 msec
32 bytes	6 seismic channels with low-cut filters at ½ msec
32 bytes	6 seismic channels without low-cut filters at ½ msec
64 bytes	Sample skew (52 used)
	Scan type header 2
32 bytes	4 auxiliary channels at 2 msec
32 bytes	48 seismic channels at 2 msec
32 bytes	0 channels (dummy)
64 bytes	Sample skew (52 used)
352 bytes	Total header block

The dummy channel set descriptor is required in scan type header 2 in order to maintain its length equal to that of scan type header I. This preserves easy expandability of the format and its self-defining header length capability (see Appendix E4).

Multiplexed data

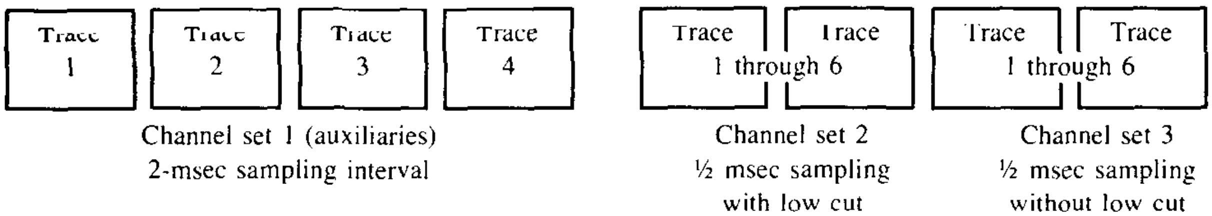
Example 6. — The multiplexed data block section of the seismic record is organized in the same order as the scan type headers and channel set descriptors they contain. Within each base scan in scan type 1, all of the data for channel set I are recorded before channel set 2. Likewise, all of the data for channel set 2 are recorded before channel set 3. Because the sampling interval for channel sets 2 and 3 is one-fourth of the base scan interval, each base scan will contain four subscans (a subscan contains one sample from each channel) of channel sets 2 and 3. Furthermore, all four subscans of channel set 2 are recorded before the four subscans of channel set 3. Thus the base scan interval is 2 msec and the data would be recorded in the following order: (I) start of scan and timing word; (2) four auxiliary channels in channel number sequence; (3a) six seismic channels with low-cut filters in channel number sequence; (3b) the second, third, and fourth set of samples of the channels in 3a; (4a) six seismic channels without low-cut filters in channel number sequence; and (4b) the second, third, and fourth sets of samples of the channels in (4a).

The pictorial representation of the multiplexed format of Example 6 as recorded on tape is shown below. Scan type 1 is:

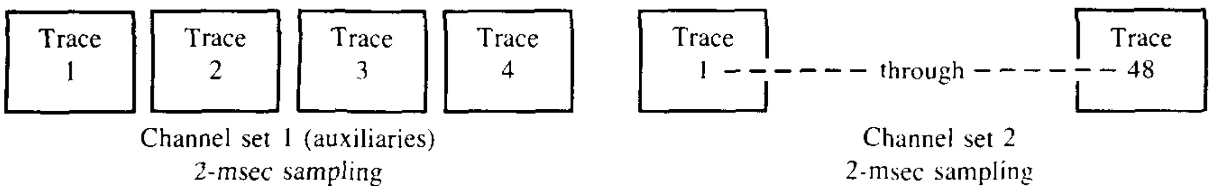
Start of scan and timing word 2 msec base scan	4 Auxiliary channels sampled once each	4 Subscans of 6 seismic channels with low-cut filters sampled at ½ msec	4 Subscans of 6 seismic channels without low- cut filters sampled at ½ msec

Note that this scan is repeated for the required number of scans until the channel set length is satisfied and the sampling interval is changed.

Scan type 1 is:



Scan type 2 is:



Note that there are no traces recorded for channel set 3 of scan type 2. There are 68 trace blocks total. Each new channel set starts with trace number 1.

Scan type 2 is:

Start of scan and timing word	4 Auxiliary channels sampled once each at 2 msec	48 Seismic channels sampled once each at 2 msec

Note that this scan type follows the recording of all of scan type 1 and repeats for the required number of scans. Scan types 1 and 2 have the same number of bytes per scan.

Demultiplexed data

The following examples are the demultiplexed versions of the previous examples given.

Example l. — Typical 24 channel system

The trace blocks in this case would be in the following order.

4 traces of auxiliary channels
24 traces of seismic data
28 trace blocks total

The channel order above is the same order in which the channel descriptions appear in the scan type header. All other examples of one scan type system follow this pattern.

Example 2. — 24 channel system with parameter differences

The trace blocks in this case would be in the following order.

4 traces of auxiliary channels
12 traces of seismic data with 18-Hz low-cut filters
12 traces of seismic data with 36-Hz low-cut filters
28 trace blocks total

Example 3.— Is similar to Example 1, but it has 240 traces of seismic data, resulting in 244 trace blocks total.

Example 4. — Dual sampling intervals

The trace blocks in this case would be in the following order.

4 traces of auxiliary channels
48 traces of seismic data recorded at a 2 msec sampling interval
12 traces of seismic data recorded at a ½ msec sampling interval
64 trace blocks total

Example 5. — Dynamically switched sampling interval

The trace blocks appear in the following order.

4 traces of auxiliary channels, recorded for the length of scan type 1
12 traces of seismic channels, recorded for the length of scan type 1
4 traces of auxiliary channels, recorded for the length of scan type 2
48 traces of seismic channels, recorded for the length of scan type 2
68 trace blocks total

Example 6. — The following is Example 6 again illustrating in graphical form the order of the trace blocks on tape. Note that even though auxiliary traces 1 to 4 are the same channels in both scan types, the data collected during the time of scan type 1 is recorded separately from those in scan type 2.

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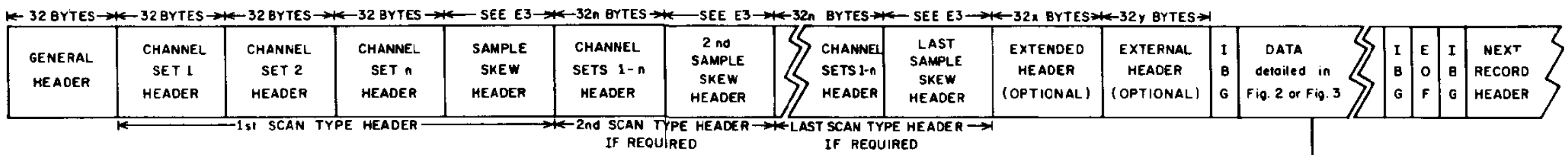

FIG. 1 Record format

SOS = START OF SCAN (4 BYTES)
T = TIMING WORD (4 BYTES)
HDR = TRACE HEADER (20 BYTES)
IBG = INTER BLOCK GAP
E3 = REFERENCE APPENDIX E3
x AND y ARE GENERAL HEADER ENTRIES

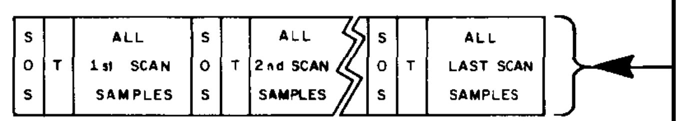

FIG. 2 Multiplexed data block

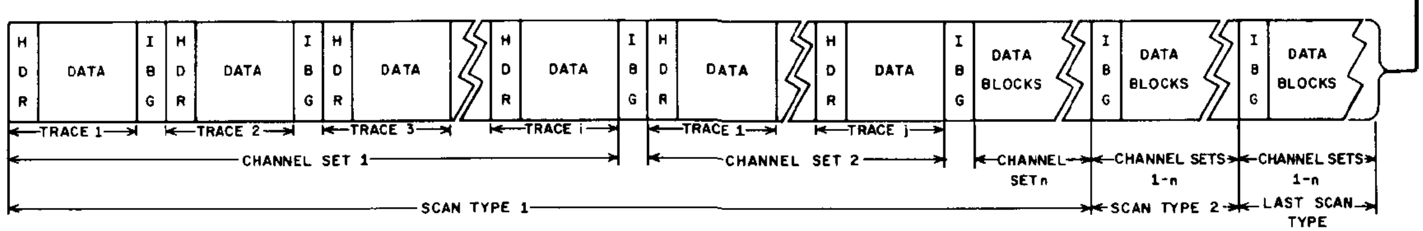

FIG. 3 Demultiplexed data blocks

TRACK NO.	4	7	6	5	3	9	1	8	2	
BIT NO.	P	0	1	2	3	4	5	6	7	
BCD VALUE MSD		8	4	2	1	8	4	2	1	LSD
BINARY VALUE MSB		128	64	32	16	8	4	2	1	LSB

FILE NUMBER	F_1	F_1	F_1	F_1	F_2	F_2	F_2	F_2	1
	F_3	F_3	F_3	F_3	F_4	F_4	F_4	F_4	2
FORMAT CODE	Y_1	Y_1	Y_1	Y_1	Y_2	Y_2	Y_2	Y_2	3
	Y_3	Y_3	Y_3	Y_3	Y_4	Y_4	Y_4	Y_4	4
GENERAL CONSTANTS	K_1	K_1	K_1	K_1	K_2	K_2	K_2	K_2	5
	K_3	K_3	K_3	K_3	K_4	K_4	K_4	K_4	6
	K_5	K_5	K_5	K_5	K_6	K_6	K_6	K_6	7
	K_7	K_7	K_7	K_7	K_8	K_8	K_8	K_8	8
	K_9	K_9	K_9	K_9	K_{10}	K_{10}	K_{10}	K_{10}	9
	K_{11}	K_{11}	K_{11}	K_{11}	K_{12}	K_{12}	K_{12}	K_{12}	10
YEAR	YR_1	YR_1	YR_1	YR_1	YR_2	YR_2	YR_2	YR_2	11
DAY (DY)	0	0	0	0	DY_1	DY_1	DY_1	DY_1	12
	DY_2	DY_2	DY_2	DY_2	DY_3	DY_3	DY_3	DY_3	13
HOUR	H_1	H_1	H_1	H_1	H_2	H_2	H_2	H_2	14
MINUTE	MI_1	MI_1	MI_1	MI_1	MI_2	MI_2	MI_2	MI_2	15
SECOND	SE_1	SE_1	SE_1	SE_1	SE_2	SE_2	SE_2	SE_2	16
MANUFACTURER'S CODE	M_1	M_1	M_1	M_1	M_2	M_2	M_2	M_2	17
MANUFACTURER'S SERIAL NUMBER	M_3	M_3	M_3	M_3	M_4	M_4	M_4	M_4	18
	M_5	M_5	M_5	M_5	M_6	M_6	M_6	M_6	19
BYTES PER SCAN	B_1	B_1	B_1	B_1	B_2	B_2	B_2	B_2	20
	B_3	B_3	B_3	B_3	B_4	B_4	B_4	B_4	21
	B_5	B_5	B_5	B_5	B_6	B_6	B_6	B_6	22
BASE SCAN INTERVAL	I_3	I_2	I_1	I_0	I_{-1}	I_{-2}	I_{-3}	I_{-4}	23
POLARITY (P) SCANS/BLOCK EXPONENT (S/Bx)	P	P	P	P	S/B_{x3}	S/B_{x2}	S/B_{x1}	S/B_{x0}	24
SCANS/BLOCK	S/B_7	S/B_6	S/B_5	S/B_4	S/B_3	S/B_2	S/B_1	S/B_0	25
RECORD TYPE (Z)	Z	Z	Z	Z	R_1	R_1	R_1	R_1	26
RECORD LENGTH (R)	R_2	R_2	R_2	R_2	R_3	R_3	R_3	R_3	27
SCAN TYPES/RECORD	ST/R_1	ST/R_1	ST/R_1	ST/R_1	ST/R_2	ST/R_2	ST/R_2	ST/R_2	28
CHANNEL SETS /SCAN TYPE	CS_1	CS_1	CS_1	CS_1	CS_2	CS_2	CS_2	CS_2	29
SKEW BLOCKS	SK_1	SK_1	SK_1	SK_1	SK_2	SK_2	SK_2	SK_2	30
EXTENDED HEADER BLOCKS	EC_1	EC_1	EC_1	EC_1	EC_2	EC_2	EC_2	EC_2	31
EXTERNAL HEADER BLOCKS	EX_1	EX_1	EX_1	EX_1	EX_2	EX_2	EX_2	EX_2	32

FIG. 4. General header

TRACK NO.	4	7	6	5	3	9	1	8	2
BIT NO.	P	0	1	2	3	4	5	6	7

BCD VALUE MSD	8	4	2	1	8	4	2	1	LSD
BINARY VALUE MSB	128	64	32	16	8	4	2	1	LSB

SCAN TYPE NUMBER	ST_1	ST_1	ST_1	ST_1	ST_2	ST_2	ST_2	ST_2	1
CHANNEL SET NUMBER	CN_1	CN_1	CN_1	CN_1	CN_2	CN_2	CN_2	CN_2	2
CHANNEL SET START TIME	TF_{16}	TF_{15}	TF_{14}	TF_{13}	TF_{12}	TF_{11}	TF_{10}	TF_9	3
	TF_8	TF_7	TF_6	TF_5	TF_4	TF_3	TF_2	TF_1	4
CHANNEL SET END TIME	TE_{16}	TE_{15}	TE_{14}	TE_{13}	TE_{12}	TE_{11}	TE_{10}	TE_9	5
	TE_8	TE_7	TE_6	TE_5	TE_4	TE_3	TE_2	TE_1	6
	0	0	0	0	0	0	0	0	7
DESCALE MULTIPLIER	MP_S	MP_4	MP_3	MP_2	MP_1	MP_0	MP_{-1}	MP_{-2}	8
NUMBER OF CHANNELS	C/S_1	C/S_1	C/S_1	C/S_1	C/S_2	C/S_2	C/S_2	C/S_2	9
	C/S_3	C/S_3	C/S_3	C/S_3	C/S_4	C/S_4	C/S_4	C/S_4	10
CHANNEL TYPE (C)	C_1	C_1	C_1	C_1	0	0	0	0	11
SAMPLES/CHANNEL (S/C) CHANNEL GAIN (J)	S/C	S/C	S/C	S/C	J	J	J	J	12
ALIAS FILTER FREQUENCY	AF_1	AF_1	AF_1	AF_1	AF_2	AF_2	AF_2	AF_2	13
	AF_3	AF_3	AF_3	AF_3	AF_4	AF_4	AF_4	AF_4	14
ALIAS FILTER SLOPE (AS)	0	0	0	0	AS_1	AS_1	AS_1	AS_1	15
	AS_2	AS_2	AS_2	AS_2	AS_3	AS_3	AS_3	AS_3	16
LOW CUT FILTER	LC_1	LC_1	LC_1	LC_1	LC_2	LC_2	LC_2	LC_2	17
	LC_3	LC_3	LC_3	LC_3	LC_4	LC_4	LC_4	LC_4	18
LOW CUT FILTER SLOPE (LS)	0	0	0	0	LS_1	LS_1	LS_1	LS_1	19
	LS_2	LS_2	LS_2	LS_2	LS_3	LS_3	LS_3	LS_3	20
FIRST NOTCH FILTER	NT_1	NT_1	NT_1	NT_1	NT_2	NT_2	NT_2	NT_2	21
	NT_3	NT_3	NT_3	NT_3	NT_4	NT_4	NT_4	NT_4	22
SECOND NOTCH FILTER	NT_1	NT_1	NT_1	NT_1	NT_2	NT_2	NT_2	NT_2	23
	NT_3	NT_3	NT_3	NT_3	NT_4	NT_4	NT_4	NT_4	24
THIRD NOTCH FILTER	NT_1	NT_1	NT_1	NT_1	NT_2	NT_2	NT_2	NT_2	25
	NT_3	NT_3	NT_3	NT_3	NT_4	NT_4	NT_4	NT_4	26
	0	0	0	0	0	0	0	0	27
	0	0	0	0	0	0	0	0	28
	0	0	0	0	0	0	0	0	29
	0	0	0	0	0	0	0	0	30
	0	0	0	0	0	0	0	0	31
	0	0	0	0	0	0	0	0	32

FIG. 5 Channel set descriptor

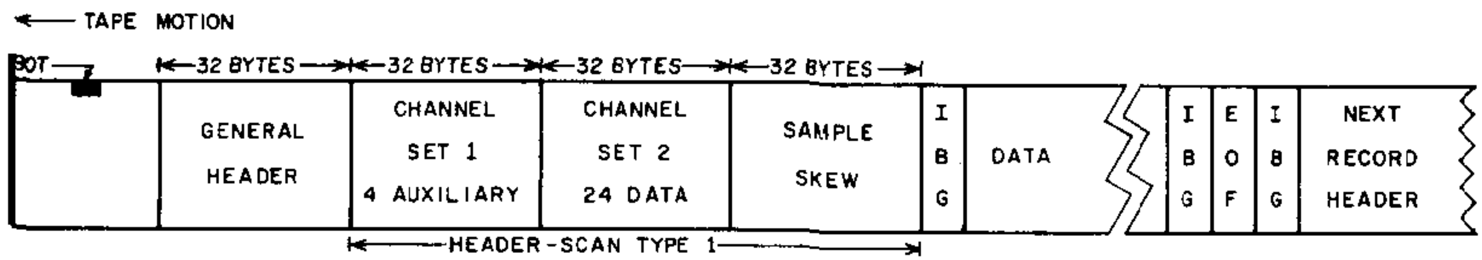

FIG. 6A Example 1

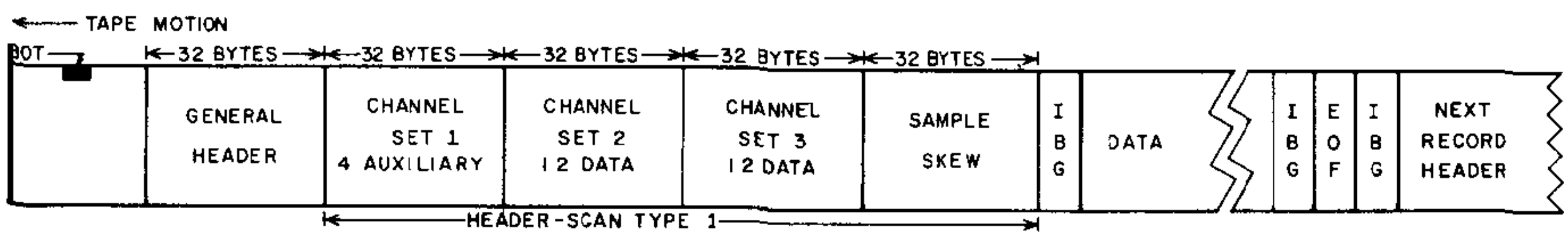

FIG. 6B Example 2

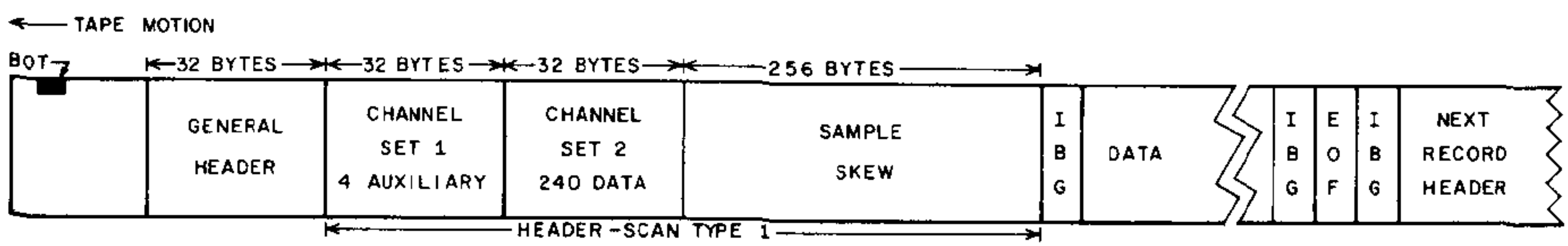

FIG. 6C Example 3

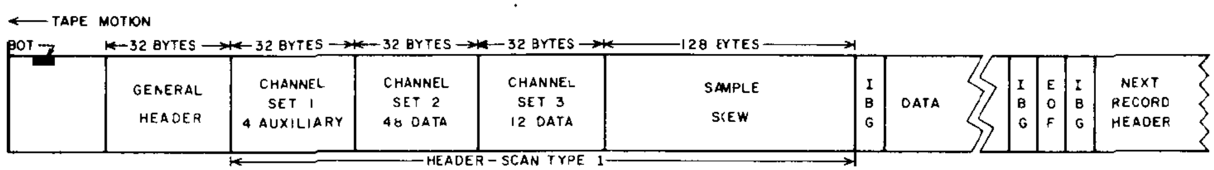

FIG. 7A Example 4

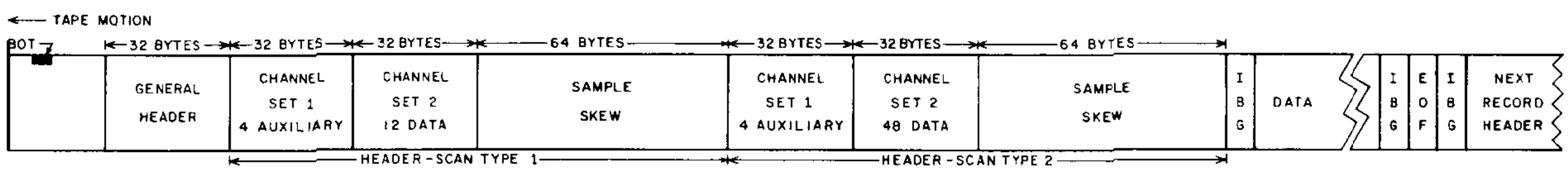

FIG. 7B Example 5

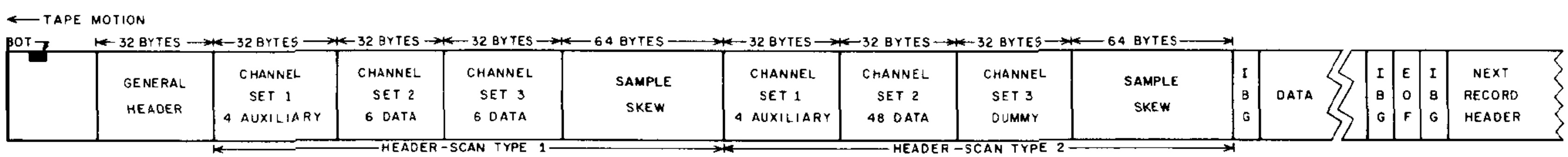

FIG. 7C Example 6

TRACK NO.	4	7	6	5	3	9	1	8	2	
BIT NO.	P	0	1	2	3	4	5	6	7	
BCD VALUE MSD		8	4	2	1	8	4	2	1	LSD
BINARY VALUE MSB		128	64	32	16	8	4	2	1	LSB
START OF SCAN		1	1	1	1	1	1	1	1	1
		1	1	1	1	1	1	1	1	2
		1	1	1	1	1	1	1	1	3
		x	TWI	ITB	DP	x	x	0	1	4
TIMING WORD		T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	5
		T_7	T_6	T_5	T_4	T_3	T_2	T_1	T_0	6
		T_{-1}	T_{-2}	T_{-3}	T_{-4}	T_{-5}	T_{-6}	T_{-7}	T_{-8}	7
		0	0	0	0	0	0	0	0	8

FIG. 8. Start of scan and timing word

FILE NUMBER	F_1	F_1	F_1	F_1	F_2	F_2	F_2	F_2	1
	F_3	F_3	F_3	F_3	F_4	F_4	F_4	F_4	2
SCAN TYPE NUMBER	ST_1	ST_1	ST_1	ST_1	ST_2	ST_2	ST_2	ST_2	3
CHANNEL SET NUMBER	CN_1	CN_1	CN_1	CN_1	CN_2	CN_2	CN_2	CN_2	4
TRACE NUMBER	TN_1	TN_1	TN_1	TN_1	TN_2	TN_2	TN_2	TN_2	5
	TN_3	TN_3	TN_3	TN_3	TN_4	TN_4	TN_4	TN_4	6
FIRST TIMING WORD	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	7
	T_7	T_6	T_5	T_4	T_3	T_2	T_1	T_0	8
	T_{-1}	T_{-2}	T_{-3}	T_{-4}	T_{-5}	T_{-6}	T_{-7}	T_{-8}	9
	0	0	0	0	0	0	0	0	10
SAMPLE SKEW	SS_{-1}	SS_{-2}	SS_{-3}	SS_{-4}	SS_{-5}	SS_{-6}	SS_{-7}	SS_{-8}	11
	0	0	0	0	0	0	0	0	12
TIME BREAK WINDOW	TW_{15}	TW_{14}	TW_{13}	TW_{12}	TW_{11}	TW_{10}	TW_9	TW_8	13
	TW_7	TW_6	TW_5	TW_4	TW_3	TW_2	TW_1	TW_0	14
	TW_{-1}	TW_{-2}	TW_{-3}	TW_{-4}	TW_{-5}	TW_{-6}	TW_{-7}	TW_{-8}	15
	0	0	0	0	0	0	0	0	16
	0	0	0	0	0	0	0	0	17
	0	0	0	0	0	0	0	0	18
	0	0	0	0	0	0	0	0	19
	0	0	0	0	0	0	0	0	20

FIG.9 Demultiplexed trace header

APPENDIX A
HEADER BLOCK PARAMETERS

General header

All values are in packed BCD unless otherwise specified.

INDEX BYTE	ABBREVIATION	DESCRIPTION
1	F_1, F_2	File number of four
2	F_3, F_4	digits (0-9999)
3	Y_1, Y_2	Format code:
4	Y_3, Y_4	0015 20 bit binary multiplexed 0022 8 bit quaternary multiplexed 0024 16 bit quaternary multiplexed 0042 8 bit hexadecimal multiplexed 0044 16 bit hexadecimal multiplexed 0048 32 bit hexadecimal multiplexed 8015 20 bit binary demultiplexed 8022 8 bit quaternary demultiplexed 8024 16 bit quaternary demultiplexed 8042 8 bit hexadecimal demultiplexed 8044 16 bit hexadecimal &multiplexed 8048 32 bit hexadecimal demultiplexed 0200 Illegal, do not use 0000 Illegal, do not use
5	K_1, K_2	General constants, 12 digits
6	K_3, K_4	
7	K_5, K_6	
8	K_7, K_8	
9	K_9 K_{10}	
10	K_{11}, K_{12}	
11	YR_1, YR_2	Last two digits of year (0-99)
12	$0, DY_1$	Julian day 3 digits (1-366)
13	DY_2, DY_3	
14	H_1, H_2	Hour of day 2 digits (0-23) (Greenwich Mean Time)
1:5	MI_1, MI_2	Minute of hour 2 digits (0-59)
16	SE_1, SE_2	Second of minute 2 digits (0-59)
17	M_1, M_2	Manufacturer's code 2 digits Note: See Appendix B for the current assignments
18	M_3, M_4	Manufacturer's serial number, 4 digits
19	M_5, M_6	
20	B_1, B_2	Bytes per scan 6 digits (1-999,999) are utilized in
21	B_3, B_4	the multiplexed formats to identify the number of
22	B_5, B_6	bytes (including data, auxiliary, sync, and timing bytes, etc.) required to make up a complete scan. In a demultiplexed record, this field is not used and is recorded as zeros. (See Appendix E2)
23	I_3 thru I_{-4}	Base scan interval — This is coded as a binary number with the LSB equal to 1/16 msec. This will allow sampling intervals from 1/16 through 8 msec

INDEX BYTE	ABBREVIATION	DESCRIPTION
		in binary steps. Thus, the allowable base scan intervals are 1/16, 1/8, 1/4, 1/2, 1, 2, 4, and 8 msec. The base scan interval is always the difference between successive timing words. Each channel used will be sampled one or more times per base scan interval.
24	P,	Polarity. — These 4 binary bits are measured on the sensors, cables, instrument, and source combination and are set into the system manually. The codes are: 0000 Untested 0001 Zero 0010 45 degrees 0011 90 degrees 0100 135 degrees 0101 180 degrees 0110 225 degrees 0111 270 degrees 1000 315 degrees 1001 1010 1011 1100 unassigned 1101 1110 1111[5]
	, S/BX_7 thru S/BX_0	This binary number (range 0 to 15) is an exponent of 2 and is used in conjunction with S/B (Byte 25).
25	S/B_7 thru S/B_0	This binary number (range 0 to 255) is used in conjunction with S/BX (see Byte 24) to indicate the number of scans in a block. If it is 0, the data body is one continuous block. Otherwise, the data body is composed of multiple blocks, each block containing $S/B \times 2^{S/BX}$ scans. It is valid only for multiplexed data.
26	Z,	Record type Bits 0 1 2 3 0 0 1 0 Test record 0 1 0 0 Parallel channel test 0 1 1 0 Direct channel test 1 0 0 0 Normal record 0 0 0 1 Other
	, R_1	Record length from time zero (in increments of 0.5
27	R_2, R_3	times 1.024 sec). This value can be set from 00.5 to 99.5 representing times from 0.512 sec. to 101.888 sec. A setting of 00.0 indicates the record length is indeterminate.

[5] Details of polarity codes and test methods are listed in the following reference: Thigpen, B. B., Dalby, A. E., Landrum, R., 1975, Special report of the subcommittee on polarity standards' Geophysics, v. 40, p. 694.

APPENDIX A
GENERAL HEADER

INDEX BYTE	ABBREVIATION	DESCRIPTION
28	ST/R_1, ST/R_2	Scan types per record. This 2 digit code is the number of scan types per record (1-99). (Zero is invalid.)
29	CS_1, CS_2	Number of channel sets per scan type (1-99). (Zero is invalid.) This 2 digit code is the number of channel sets per scan. If multiple scan types are used (such as in a switching sampling interval environment), this number is equal to the number of channel sets contained in the scan type with the largest number of channel sets. If scan types also exist with less than this maximum number of channel sets per scan type, dummy channel set descriptors will have to be recorded in the scan type header. This can be done by setting the number of channels in the dummy channel set descriptor to zero (reference Bytes 9 and 10 of the scan type header description). Example 6 illustrates this requirement.
30	SK_1, SK_2	Number of 32 byte fields added to the end of each scan type header in order to record the sample skew of all channels (0-99). (See Appendix E3). Zero indicates that skew is not recorded.
31	EC_1, EC_2	Extended header length. The extended header is used to record additional equipment parameters. An example of this would be parameters generated by the addition of a field stacker to the system. The two digits (0-99) in this field specify the number of 32 byte extensions.
32	EX_1, EX_2	External header length. The external header is used to record additional user supplied information in the header. The two digits (0-99) in this field specify the number of 32 byte extensions.

Scan type header (channel set descriptor)

The scan type header is determined by the system configuration and consists of one or more channel set descriptors each of 32 bytes followed by a series of 32 byte sample skew fields. A channel set is defined as a group of channels operating with the same set of parameters and being sampled as part of a scan of data. A scan type header can be composed of from I to 99 channel set descriptors. If dynamic parameter changes are required during the recording, additional scan type headers must be added, each containing the channel set descriptors necessary to define the new parameters. Each scan type header must have the same number of channel set descriptors (see Appendix E4 for header length calculation).

APPENDIX A
CHANNEL SET DESCRIPTOR

INDEX BYTE	ABBREVIATION	DESCRIPTION
1	ST_1, ST_2	These two digits (1-99) identify the number of the scan type header to be described by the subsequent bytes. The first scan type header is I and the last scan type header number is the same value as Byte 28 (ST/R) of the general header. If a scan type header contains more than one channel set descriptor, the scan type header number will be repeated in each of its channel set descriptors. If the system does not have dynamic parameter changes during the record, such as switched sampling intervals, there will only be one scan type header required.
2	CN_1, CN_2	These two digits (1-99) identify the channel set to be described in the next 30 bytes within this scan type header. The first channel set is "1" and the last channel set number is the same number as Byte 29 (CS) of the general header. If the scan actually contains fewer channel sets than CS, then dummy channel set descriptors are included as specified in Byte 29 of general header.
3 4	TF_{16} thru TF_9 TF_8 thru TF_1	Channel set starting time. This is a binary number where $TF_1 = 2^1$ msec (2-msec increments). This number identifies the timing word of the first scan of data in this channel set. In a single scan type record, this would typically be recorded as a zero (an exception might be deep water recording). In multiple scan type records, this number represents the starting time, in milliseconds, of the channel set. Start times from 0 to 131,070 msec (in 2-msec increments) can be recorded.
5 6	TE_{16} thru TE_9 TE_8 thru TE_1	Channel set end time. This is a binary number where $TE_1 = 2^1$ milliseconds (2 millisecond increments). These two bytes represent the record end time of the channel set in milliseconds. In a multiplexed record, all channels of a channel set must be of the same length. TE may be used in a demultiplexed record to allow the termination of a particular channel set shorter than other channel sets within its scan type. In a single scan type record, Bytes 5 and 6 would be the length of the record. End times up to 131,070 msec (in 2-msec increments) can be recorded.
7	0,0	
8	MP_S, MP_4 thru MP_{-2}	This sign magnitude binary number is the exponent of the base 2 multiplier to be used to descale the data on tape to obtain input voltage in millivolts. The radix point is between MP_0 and MP_{-1}. This multiplier has a range of $2^{31.75}$ to $2^{-31.75}$. (See Appendix E7.)
9 10	C/S_1, C/S_2 C/S_3, C/S_4	This is the number of channels in this channel set. It can assume a number from 0-9999.

INDEX BYTE	ABBREVIATION	DESCRIPTION
11	C_1, 0	Channel type identification: Bit 0 1 2 3 0 1 1 1 Other 0 1 1 0 Extemaldata 0 1 0 1 Timecounter[6] 0 1 0 0 Water break 0 0 1 1 Up hole 0 0 1 0 Time break 0 0 0 1 Seis 0 0 0 0 Unused 1 0 0 0 Signature, unfiltered 1 0 0 1 Signature, filtered
12	S/C,	This packed BCD number is an exponent of 2. The number ($2^{s/c}$) represents the number of subscans of this channel set in the base scan. Possible values for this parameter ($2^{s/c}$) are 1 to 512 (2^0 to 2^9). Reference Byte 23 of the general header.)
12	, J	Channel gain control method Bits 4 5 6 7 Gain mode 0 0 0 1 - (1) Individual AGC 0 0 1 0 - (2) Ganged AGC 0 0 1 1 - (3) Fixed gain 0 1 0 0 - (4) Programmed gain 1 0 0 0 - (8) Binary gain control 1 0 0 1 - (9) IFP gain control
13	AF_1, AF_2	Alias filter frequency. It can be coded for any
14	AF_3, AF_4	frequency from 0 to 9999 Hz.
15	0, AS_1	Alias filter slope in dB per octave. It can be coded
16	AS_2, AS_3	from 0 to 999 dB in 1-dB steps. A zero indicates the filter is out (see Appendix E5 for definition).
17	LC_1, LC_2	Low-cut filter setting. It can be coded for any
18	LC_3, LC_4	frequency from 0 to 9999 Hz.
19	0, LS_1	Low-cut filter slope. It can be coded for any slope
20	LS_2, LS_3	from 0 to 999 dB per octave. A zero slope indicates the filter is out. (See Appendix E5 for definition.)
21	NT_1, NT_2	Notch frequency setting. It can be coded for any
22	NT_3, NT_4	frequency from 0 to 999.9 Hz. The out filter is written as 000.0 Hz.

The following notch filters are coded in a similar manner:

23	NT_1, NT_2	Second notch frequency
24	NT_3, NT_4	
25	NT_1, NT_2	Third notch frequency
26	NT_3, NT_4	
27		
28		
29		Unused. Written as zeros.
30		
31		
32		

[6] Illegal code for this format because the timing counter is part of the start of scan and cannot be identified as part of a channel.

APPENDIX B
MANUFACTURERS OF SEISMIC DIGITAL FIELD RECORDERS

Code No.

01 Alpine Geophysical Associates, Inc.
(Obsolete) *
65 Oak Street
Norwood, New Jersey

02 Applied Magnetics Corporation (See 09)
75 Robin Hill Rd.
Goleta, California 93017

05 Dyna-Tronics Mfg. Corporation (Obsolete) *
5820 Star Lane
Box 22202
Houston, Texas 77027

06 Electronic Instrumentation, Inc. (Obsolete) *
601 Dooley Road
Box 34046
Dallas, Texas 75234

07 Electro-Technical Labs
Div. of Geosource, Inc.
6909 Southwest Freeway
Box 36827
Houston, Texas 77036

08 Fortune Electronics, Inc. (Obsolete) *
5606 Parkersburg Drive
Houston, Texas 77036

09 Geo Space Corporation
(Subsidiary of Applied Magnetics Company)
5803 Glenmont Drive
Box 36374
Houston, Texas 77036

17 GUS Manufacturing, Inc.
P.O. Box 10013
El Paso, Texas 79991

18 Input/Output, Inc.
8009 Harwin Dr.
Houston, Texas 77036

10 Leach Corporation (Obsolete) *
405 Huntington Drive
San Marino, California

03 Litton Resources Systems, Inc.
3930 Westholme Dr.
Houston, Texas 77063

11 Metrix Instrument Co. (Obsolete) *
8200 Westglen
Box 36501
Houston, Texas 77063

12 Redcor Corporation (Obsolete) *
7800 Deering Avenue
Box 1031
Canoga Park, California 91304

14 Scientific Data Systems (SDS) (Obsolete) *
1649 Seventeenth Street
Santa Monica, California 90404

13 Sercel (Societe d'Etudes, Recherches Et
Constructions Electroniques)
25 X, 44040 Nantes Cedex,
France

04 SIE, Inc.
5110 Ashbrook
Box 36293
Houston, Texas 77036

15 Texas Instruments, Inc.
P.O. Box 1444
Houston, Texas 77001

* This was originally extracted from Geophysics, v. 32. The ones marked obsolete do not appear in the latest edition of the Geophysical Directory (1979). Should additional manufacturer code numbers be required, contact the SEG Standards Committee for the assignment of these numbers.

APPENDIX C
GLOSSARY

Base scan interval The time between timing words. A base scan interval usually contains one scan but under some conditions may contain multiple subscans.

Block The data between gaps on tape.

Channel set One or more channels sampled at the same sampling interval and containing the same filter, fixed gain, and other fixed parameter information.

Channel set descriptor A unit of the scan type header describing the parameters of a channel set.

Data recording method The arrangement of bits to represent samples on tape.

File All data recorded from a single energy impulse or sweep. It may also be the sum of a number of energy impulses or sweeps. Literally, it is all of the blocks between file marks.

Format Data recording method combined with a multiplexed/demultiplexed indicator (see general header Bytes 3 and 4).

General header The first header in the header block. It contains information common to the entire record. Index byte The byte number of some particular parameter within the general or scan type header.

Packed BCD Binary coded decimal digits represented by four data bits.

Sample skew The fraction of the base scan interval between the timing word and the actual time the sample was taken in a base scan interval (not related to position on tape).

Sampling interval The interval between readings such as the time between successive samples of a digital seismic trace.

Scan One complete sequence of events, such as sampling all channels. Data recorded during a base scan interval.

Scan interval The interval between readings of all samples contained in a scan type. Scan type One complete set of channel sets which make up a scan. A seismic record contains multiple scans, and may or may not contain more than one scan type.

Scan type header A header containing one or more channel set descriptors and the skew information.

Subscan A set of samples containing one sample for each channel in a channel set.

Time break window Time interval in which time break is expected. If time break does not occur by the end of the window, internal time break is generated.

Trace A record of one seismic channel within a scan type. A collection of a sequential set of points from one seismic channel.

Trace block A block containing the data of one trace or a part of a trace with constant parameters.

APPENDIX D
HEADER DESCRIPTORS

G = general header S = scan type header (channel set descriptor)

ABBREVIATION	HEADER	BYTE NO.	DESCRIPTION
AF	S	13, 14	ALIAS FILTER FREQUENCY
AS	S	15, 16	ALIAS FILTER SLOPE
B	G	20, 21,22	BYTES PER SCAN (MULTIPLEXED ONLY)
BCD	—		BINARY CODED DECIMAL
BOY			BEGINNING OF TAPE MARK
C	S	11	CHANNEL TYPE IDENTIFICATION
CN	S	2	CHANNEL SET NUMBER
CS	G	29	CHANNEL SETS PER SCAN TYPE
C/S	S	9, 10	CHANNELS IN THIS CHANNEL SET
DP	—		DYNAMIC PARAMETER CHANGE BIT (SEE THE MULTIPLEXED DATA BLOCK, SOS BYTE 4)
DY	G	12, 13	DAY OF YEAR
EC	G	31	EXTENDED HEADER LENGTH
EOF	—		END OF FILE MARK
EOT			END OF TAPE MARK
EX	G	32	EXTERNAL HEADER LENGTH
F	G	1, 2	FILE NUMBER
H	G	14	HOUR OF DAY
HDR	—		HEADER FOR DEMULTIPLEXED TRACE
HL	—		HEADER LENGTH (SEE APPENDIX E4)
I	G	23	BASE SCAN INTERVAL
IBG	—		INTERBLOCK GAP (ALSO GAP)
ITB			INTERNAL TIME BREAK (SEE THE MULTI-PLEXED DATA BLOCK, SOS BYTE 4)
J	S	12	GAIN CONTROL METHOD
K	G	5 THRU 10	GENERAL CONSTANTS
LC	S	17, 18	LOW CUT FILTER FREQUENCY
LS	S	19, 20	LOW CUT FILTER SLOPE
LSB	—		LEAST SIGNIFICANT BIT
LSD	—		LEAST SIGNIFICANT DIGIT
M	G	17 THRU 19	MANUFACTURER'S CODE AND SERIAL NUMBER
MI	G	15	MINUTE OF HOUR
MP	S	8	DESCALING EXPONENT
MSB	—		MOST SIGNIFICANT BIT
MSD			MOST SIGNIFICANT DIGIT
NT	S	21 THRU 26	NOTCH FILTER FREQUENCY
P	G	24	POLARITY
R	G	26, 27	RECORD LENGTH
S	—		SIGN BIT
S/B, S/BX	G	24, 25	NUMBER OF SCANS PER BLOCK

S/C	S	12	EXPONENT OF SAMPLES PER CHANNEL IN THE BASE SCAN
SE	G	16	SECOND OF MINUTE
SK	G	30	NUMBER OF 32 BYTE SKEW FIELDS
SOS	—		START OF SCAN (MULTIPLEXED DATA BLOCK)
SS	—		SAMPLE SKEW
S/S	—		SAMPLES/SCAN
ST	S	1	SCAN TYPE NUMBER
ST/R	G	28	SCAN TYPES PER RECORD
T	—		TIMING WORD (MULTIPLEXED DATA BLOCK)
TF	S	3, 4	FIRST TIMING WORD IN THIS CHANNEL SET
TE	S	5, 6	END TIME OF THIS CHANNEL SET
TN	—		DEMULTIPLEXED TRACE NO. (SEE TRACE HEADER)
TW	—		TIME BREAK WINDOW (SEE DEMULTI-PLEXED DATA BLOCK, TRACE HEADER BYTES 13, 14 AND 15)
TWI	—		TIME BREAK WINDOW INDICATOR (SEE MULTIPLEXED DATA BLOCK, SOS BYTE 4)
Y	G	3, 4	FORMAT CODE (DATA RECORDING METHOD)
YR	G	11	YEAR (LAST TWO DIGITS)
Z	G	26	RECORD TYPE

APPENDIX E
SAMPLE CALCULATIONS

E1 Samples per scan type

$$S/S = \sum_{1}^{CS} C/S \times 2^{s/c}$$

where

S/S = samples per scan type
C/S = channels in this channel set (channel set descriptor Bytes 9 and 10)
$2^{s/c}$ = samples per channel (in this channel set) (channel set descriptor Byte 12)
CS = number of channel sets in this scan type (general header Byte 29)

For example, for a 2-msec base scan interval with 4 auxiliary channels at 2 msec, 96 channels at 2 msec and 12 channels at V2 msec. There are three channel sets, so CS = 3.

$$S/S = C/S \times 2^{s/c} \Big|_{CS = 1} + C/S \times 2^{s/c} \Big|_{CS = 2} + \dots$$

S/S = 4 x 1 + 96 x 1 + 12 x 4
S/S = 4 + 96 + 48 = 148

Note that all scan types must have the same number of data samples.

E2 Bytes per scan

$$B = 8 + \sum_{1}^{CS} C/S \times 2^{s/c} \times \text{bytes/sample}$$

where

B = bytes per scan
8 = start of scan plus timing word
C/S = channels in this channel set (channel set descriptor Bytes 9 and 10)
$2^{s/c}$ = samples per channel (in this channel set) (channel set descriptor header Byte 12)
CS = number of channel sets in this scan type (general header Byte 29)

Bytes/sample	format code (general header Bytes 3 and 4)
1.0	0042, 0022
2.0	0024, 0044
2.5	0015
4.0	0048

For example, for a 2-msec base scan with a 2.5 byte format that contains 4 auxiliary channels, 96 channels at 2 msec and 12 channels at ½ msec.

B = 8+(4 x 1 x 2.5) + (96 x 1 x 2.5) + (12 x 4 x 2.5)
B = 8 + (4 + 96 + 48) x 2.5
B = 8+ 148 x 2.5 = 378 bytes

E3 Skew fields per scan type

$$SK = \frac{S/S}{32}$$

(If the quotient is not a whole number, round up to the next largest whole number.)

where

SK = skew fields (of 32 bytes each) per scan type (general header Byte 30)
S/S = samples per scan (Appendix E1) Substituting for S/S from Appendix El:

$$SK = \frac{\sum_{1}^{CS} C/S \times 2^{s/c}}{32}$$ (If the quotient is not a whole number, round up to the next largest whole number.)

where

CS = the number of channel sets in each scan type (general header Byte 29)

C/S = channels in this channel set (channel set descriptor Bytes 9 and 10)

$2^{s/c}$ = samples per channel in this channel set (channel set descriptor Byte 12).

For example, for a 2-msec base scan with 4 auxiliary channels at 2 msec, 96 channels at 2 msec and 12 channels at ~,6 msec

$$SK = \frac{4 \times 1 + 96 \times 1 + 12 \times 4}{32}$$

$$SK = \frac{148}{32} = 4\,\frac{20}{32}$$ roundup = 5 fields of 32 bytes each

E4 Total header length

HL = 32 x [ST/R (CS + SK)+ 1 + EC + EX],

where

HL = header length (bytes)

ST/R = number of scan types per record (general header Byte 28)

CS = number of channel sets per scan type (general header Byte 29)

SK = skew fields per scan type (general header Byte 30)

EC = extended header length (general header Byte 31)

EX = external header length (general header Byte 32)

Example 1: For a system with a 2-msec base scan, 4 auxiliary channels at 2 msec, 96 channels at 2 msec, and 12 channels at Y2 msec

HL = 32 x (1 x (3+5) + 1 + EC + EX)

ST/R = 1 since there is only one scan type in this example,

= 32 x (9) = 288 bytes + extended header + external header

E5 Filter slope calculation

Modern filters may not have a constant slope, so it is necessary to define this parameter. The slope is defined as the asymptote of effective performance as it would be in a constant slope filter. This slope is zero dB attenuation at the cut-off frequency and a specific attenuation at the beginning of the stop band. The chosen values are 40 dB for a low-cut filter and 60 dB for an anti-alias filter.

Low-cut filter slope calculation. —

$$LS = \frac{40}{\log_2 f_{LCO}/f_{40}} = \frac{40}{3.322 \log_{10} f_{LCO}/f_{40}} = \frac{12.04}{\log_{10} f_{LCO}/f_{40}}$$

LS = low-cut filter slope (channel set descriptor Bytes 19 and 20),

F_{40} = the frequency of 40 dB low-cut filter attenuation,

f_{LCO} = low-cut filter cut-off frequency usually 6 or 12 dB attenuation.

Alias-filter slope calculation. —

$$AS = \frac{60}{\log_2 f6o/f_{ACO}} = \frac{60}{3.322 \log_{10} f60/f_{ACO}} = \frac{18.06}{\log_{10} f_{60}/f_{ACO}}$$

AS = alias filter slope (channel set descriptor Bytes 15 and 16)
F_{60} = the frequency of 60 dB alias-filter attenuation
f_{ACO} = alias-filter cut-off frequency usually 3 or 6 dB attenuation

The resultant slope in the above calculations is rounded to the nearest whole number and is written in the channel set descriptor.

E6 Calculation of byte offset from the beginning of the header block to a specific byte index in channel set descriptor i of scan type header j

Byte no. = 32 + index byte + 32 (CN_i - l) + 32 (ST_j - l) (CS + SK)

where

CN_i = channel set number of interest
index byte = byte number of interest in the channel set descriptor
CS = number of channel sets per scan type (general header Byte 29).

ST_j = scan type of interest
SK -skew fields per scan type (Appendix E3)

$1 \leq CN_i \leq CS$

$1 \leq ST_j \leq ST/R$; i = 1, 2,...,ST/R

Example: For a 2 msec base scan system having 2 scan types: (1) 4 auxiliary channels at 2 msec plus 12 channels at ½ msec, and in the second scan type (2) 4 auxiliary channels at 2 msec plus 48 channels at 2 msec.

First calculate the samples per scan (S/S) per Appendix El and skew field (SK) per Appendix E3.

$$S/S = \sum_{1}^{CS} C/S \times 2^{sic}$$

$$S/S = C/S \times 2^{s/c} + C/S \times 2^{s/c}$$

$$CS = 1 \quad CS = 2$$

$$= 4 \times 1 + 12 \times 4$$

$$S/S = 4 + 48 = 52.$$

Note: It is not necessary to evaluate the samples per scan in the second scan type because all scan types must have the same number of samples.

Second, evaluate the skew fields per scan per Example 3.

$$SK = \frac{\sum_{1}^{CS} S/S}{32}$$ (round up to the next largest whole number),

$$SK = \frac{52}{32} = 1 \frac{20}{32}$$

Now, compute the header byte number of index Byte 11 of the second channel set in the second scan type.

Byte no. = 32 + 11 + 32 (2- 1) +32 (2 - 1) (2 + 2)
Byte no. = 43 + 32 (1) + 32 (4)
Byte no. = 203.

E7 Calculation and use of MP

The MP parameter is provided to allow the dimensionless numbers recorded on tape to be "descaled" back to the instantaneous sample values in millivolts at the system inputs. MP is encoded in Byte 8 of each channel set descriptor in the scan type header. It is a sign and magnitude binary exponent. It can have any value between -31.75 and +31.75 in increments of 0.25.

In general, recording systems scale the input signal level in order to match the useful range of input levels to the gain-ranging amplifier. MP must account for all scaling (unless, as in the 4 byte hexadecimal case, the data recording method has sufficient range).

MP CALCULATION

The calculation of MP for a data recording method is given by one of the following equations:

(1) MP = FS - PA - Cmax; for binary exponents,
(2) MP = FS- PA – 2 x Cmax; for quaternary exponents,
(3) MP = FS - PA – 4 x Cmax; for hexadecimal exponents (except the 4 byte excess 64 method),
(4) MP = FS – PA - 4 (Cmax - 64); for excess 64 hexadecimal exponents,

where

2^{FS} = Converter full scale (millivolts),
$2^{PA=}$ Minimum system gain,

and

Cmax = maximum value of the data exponent.
Cmax = 15 for binary exponents,
= 7 for quaternary exponents,
= 3 for hexadecimal exponents except excess 64; and
= 127 for excess 64 exponents.

The term "minimum system gain" includes preamplifier gain and the minimum floating point amplifier gain. For example, one system may use a preamplifier gain of 256 and a minimum floating point amplifier gain of one. The minimum system gain is 256 x 1 = 2^8, so PA=8. Another system may use a preamplifier gain of 320 and a minimum floating point amplifier gain of 0.8. In this case, the minimum system gain is 320 x 0.8 = 256 or 2^8 Again PA = 8.

PA may also account for any amplification needed to accommodate an analog to digital converter with a full scale value that is not a power of 2 in millivolts. For example, a 10 V (10,000 mV) converter may be preceded by an amplifier with a gain of 1.221 (10,000/8,192). This gain may be accounted for in PA. Alternatively, it could be considered part of the converter, making it appear to have a binary full scale. In either case, FS - PA must be a multiple of 0.25.

JUSTIFICATIONS FOR THE EQUATIONS

The output of the analog-to-digital converter is written as the fractional portion of the data value. This is equivalent to dividing the value by the full scale of the converter. In order to compensate for this, the data value recorded on tape must be multiplied by the full scale value of the converter (2^{FS}). Thus FS appears in equations (1)-(4) with a positive sign.

The input signal was multiplied by the minimum system gain (2^{PA}) which, as mentioned, includes any preamplification gain, minimum floating point amplifier gain, or analog-to-digital converter adjustment gain. The data recorded on tape must be divided by this minimum system gain; thus, PA appears in the equations with a negative sign.

Large input signals converted at minimum floating point amplifier gain are written on tape with the maximum exponent for the data recording method used. Likewise, small signals converted at full gain are written with the minimum exponent. The data as written have been multiplied by the exponent base raised to Cmax (or Cmax -64 in the excess 64 case). Thus Cmax appears in the equations with a negative sign. MP is a power of 2 so the quaternary and hexadecimal Cmax values are multiplied by 2 and 4, respectively ($4^C = 2^{2C}$ and $16^C = 2^{4C}$).

EXAMPLES

Note: In the following examples, all logarithms are base 10.

Example 1

Assume: quaternary data recording method, converter full scale = 8192 m V, preamplifier gain = 320, and minimum floating point amplifier gain = 0.8. Then

Cmax = 7,

FS = log 8192 / log $_2$ = 13,

PA = log (320 x 0.8) / log $_2$ = 8.

and

MP = 13 - 8 - 2 x 7 = -9.

Example 2

Assume: binary data recording method, convener full scale = 10 volts, preamplifier gain = 128, and minimum floating point amplifier gain = 1.0. Then

Cmax = 15,

FS = log 10000 / log $_2$ = 13.287 ....

PA = log 128 / log $_2$ = 7,

and

MP = 13.287... - 7 – 15 = -8.712 ....

But MP must be a multiple of 0.25. This can be achieved by changing the preamplifier gain to 131.39. Then

PA = log 131.39 / 1og $_2$ = 7.037 and

MP = 13.287 . . . -7.037 . . . -15 = -8.75.

MP could be made a whole number by changing the preamplifier gain to 156.25. Then

PA = log 156.25/log $_2$ = 7.287 and

MP= 13.287 . . .-7.287 . . . -15 = -9.

Note that this is equivalent to preceding the conventer with an amplifier of gain 1.220... thus making the converter appear to have a full scale value of 8192 mV. Then

FS = log 8192 / 1og $_2$ = 13,

PA = log 128 / log$_2$ = 7,

and

MP = 13 – 7 – 15 = -9.

Example 3

Assume: hexadecimal (1 or 2 byte) data recording method, convener full scale - 8192 mV, preamplifier gain = 256, and minimum floating point amplifier gain = 1.0. Then

Cmax = 3,

FS = log 8192 / 1og $_2$ = 13,

PA = log 256 / log$_2$ = 8,

and

MP = 13 - 8 - 4 x 3 = -7.

Note: In the 4 byte hexadecimal case, it is expected that MP will generally be recorded as zero because of the large range of the number system of this data recording method. Nonetheless, equation 4 must still be valid:

MP = FS - PA – 4 x (Cmax – 64).

If MP = 0, then

FS- PA = 4 (Cmax- 64).

Since Cmax is always an integer, FS - PA must be a multiple of 4.

Note: The data recording method (binary, quaternary, or hexadecimal) does not indicate the type of floating point amplifier used. Any gain ranging amplifier and converter outputs can be convened to any of the data recording methods.

USE OF MP

As indicated in the descriptions of the data recording formats, MP is applied by multiplying the recorded data by 2^{MP}.

E8 Calculation of the byte offset from the beginning of the header block to the skew information byte for channel k of channel set i of scan typej

For clarity, the equation is given on several lines. The terms on each line are explained.

SS OFFSET = 32	(general header)
+ 32(STj- 1) (CS + SK)	(all previous scan type headers)
+ 32 (CS)	(channel set descriptors in scan type header j)
$+\sum_{1}^{CNi-1} C/S \times 2^{s/c}$	(samples in the base scan for all previous channel sets in this scan type)
+ k	(position of channel in this channel set)

Where

STj = scan type of interest,
CS = number of channel sets per scan type (general header Byte 29),
SK = number of skew fields per scan type (Appendix E3),
CN_i = channel set number of interest,
C/S = channels in this channel set (channel set descriptor Bytes 9 and 10), and
$2^{s/c}$ = samples per channel of this channel set in a base scan (channel set descriptor Byte 12).

Note that if there are multiple subscans of a channel set within a base scan (i.e., $2^{s/c}$ greater than one), a skew information byte is written for each sample in each subscan.

The above equation accounts for multiple subscans of previous channel sets, but it determines the location of the skew information byte of channel k in the first subscan only of channel set i. Skew information for subsequent subscans can be obtained in two ways:

(1) Add multiples of C/S to the computed offset to obtain the offset to the byte of interest; or
(2) Add multiples of $2^{-s/c}$ to the value of the skew information byte obtained for the first sub-scan.

For example, assume there are two .scan types with three channel sets, as follows:
Scan type 1:
channel set 1 — 4 channels at 4 msec (1 subscan per base scan)
channel set 2 — 24 channels at 2 msec (2 subscans per base scan)
channel set 3 — 12 channels at l msec (4 subscans per base scan)
Scan type 2:
Channel set 1 — 4 channels at 4 msec (1 subscan per base scan)
Channel set 2 — 48 channels at 2 msec (2 subscans per base scan)
Channel set 3 — 0 channels (dummy).

The offset to the skew information byte for channel 11 of channel set 2 in scan type 2 is computed below. The number of skew fields (Appendix E3) is:

$$\frac{\sum_{1}^{CS} C/S \times 2^{s/c}}{32} = \frac{4 + 24 \times 2 + 12 \times 4}{} = \frac{100}{32}$$

or 4 (rounded up).

$$SS\ offset = 32 + 32(STj-1)(CS + SK) + 32(CS) + \sum_{1}^{CNi-1} C/S \times 2^{S/C} + k$$

$$= 32 + 32(2 - 1)(3 + 4) + 32(3) + 4 + 11$$
$$= 367.$$

The position of the skew information byte for the second subscan of channel 11 in this scan is: 367 + 48 = 415.

E9 Calculation of the number of bytes per block for a gapped multiplexed record

$$\text{Bytes per block} = (S/B \times 2^{S/BX}) \times B$$

where

$S/B \times 2^{S/BX}$ = scans per block (general header Bytes 24 and 25)
B = bytes per scan (general header Bytes 20, 21, and 22).

Note: S/B and S/BX are written in the header as binary numbers; whereas B is represented as 6 packed BCD digits. Assume, as in example E2, that there are 378 bytes per scan. Further assume that S/BX is 2 and S/B is 173. Then $(S/B \times 2^{S/BX}) \times B = 173 \times 2^2 \times 378$, and bytes per block = 261,576.

E10 Determination of scans per block subject to block size limits

S/B and S/BX will normally be chosen to result in the largest block (fewest gaps) possible without exceeding a predetermined limit. This is accomplished by selecting S/BX to be just large enough that $2^{S/BX}$ is within a factor of 256 of the maximum number of scans allowed. Maximum number of scans = integer portion of block limit per bytes per scan.

$$S/BX = \log_2 \frac{\text{Max number}}{256} \quad \text{rounded up,}$$

$$S/B = \frac{\text{Max number of scans}}{2^{S/BX}} \quad \text{rounded down.}$$

For example, assume that there are 378 bytes per scan and the block size may not exceed 250,000 bytes.

$$\text{Max scans} = \frac{\text{Int of } 250{,}000}{378} = 661$$

$$S/BX = \mathrm{Log}_2 \frac{661}{256} \quad \text{rounded up,} \quad =2;$$

$$S/B = \frac{661}{2^2} \quad \text{rounded down} \quad = 165;$$

$$\text{Block length} = 165 \times 22 \times 378, = 249{,}480 \text{ bytes.}$$