Chapter 6

VERTICAL OBSERVATION (VERT OBS) DATA

INTRODUCTION

The purpose of this chapter is to provide detailed specifications and instructions for the coding and keying of the observation data set of a vertical control job. As was explained in Chapter 5, a vertical control job consists of two distinct data sets which must be submitted together. The companion data set to the vertical observation (VERT OBS) data set treated in this chapter is the data set containing original descriptions and/or recovery descriptions for the control points which occur in the vertical control job. This descriptive (VERT DESC) data set is treated in Chapter 7.

VERT OBS DATA SET RECORDS

The data which constitute a VERT OBS data set are organized into four categories:

        1.   Line Identification Data
        2.   Survey Equipment Data
        3.   Field Abstract Data
        4.   Observation Data

Within these categories, the respective data have been grouped into one or more logical units called "records." A record is a string of characters containing data coded according to a specific format. Every record in a VERT OBS data set consists of 80 characters or "columns" (standard punched card image). Within each record, the 80 columns are divided into fixed-length "character fields," each field being the space reserved for a specific data item. Accordingly, for every desired data item, there exists a field of appropriate length into which the data item in question is to be entered after it is converted into a string of alphanumeric characters. The set of rules according to which specific data items are converted into strings of alphanumeric characters to be entered in the fields of a record is known as the "format" of that record.

The types of records which may appear in a VERT OBS data set are listed in Table 6-1. Each type of record has been given a name, and a block diagram illustrating the respective format has been prepared to serve as a model for that record - see FORMAT DIAGRAMS.

Except for the first and last records of the data set, the second character field of each record (columns 7-10) contains a two-digit numerical data code, preceded and followed by an asterisk, which specifies the type of that record (*10*, *11*, ..., *43* - see Table 6-1). The first and last records of the data set (the Data Set Identification Record and the Data Set Termination Record) display the two-character alphanumeric job code assigned by the submitting agency in this field (*A1*, *A2*, ..., *ZZ* - see Chapter 5). The first character field of every record (columns 1-6) is reserved for the respective record sequence number - see Chapter 5. The remaining portion of each record(columns 11-80) contains character fields which are peculiar to each individual record type.

TABLE 6-1
VERTICAL OBSERVATION DATA SET RECORDS

FIRST RECORD
AA - Data Set Identification Record

LINE IDENTIFICATION DATA
10 - Line Information Record
11 - Line Title Record (Optional)
12 - Line Title Continuation Record (Optional)
13 - Line Title Continuation Record (Optional)
14 - Line Title Continuation Record (Optional)
15 - Comment Record (Optional)

SURVEY EQUIPMENT DATA
20 - Instrument Information Record
21 - Rod Information Record
22 - Rod Standardization Record
23 - Rod Calibration Record

FIELD ABSTRACT DATA
30 - Field Abstract Record

OBSERVATION DATA
40 - Survey Equipment Record
41 - Running Record
42 - River/Valley Crossing Record
43 - Correction/Rejection Record
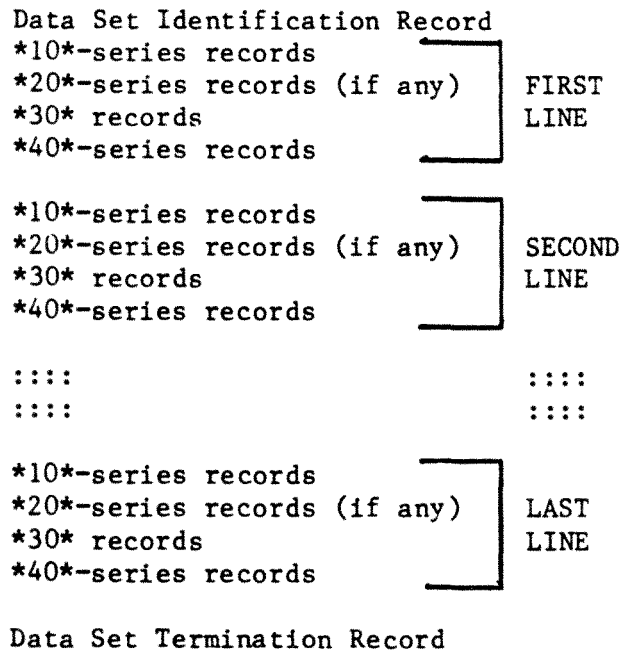
LAST RECORD
AA - Data Set Termination Record

Note: The symbol *AA* denotes the two-character job code assigned by the submitting agency - see Chapter 5.

STRUCTURE OF THE VERT OBS DATA SET

The first record of a VERT OBS data set must be the Data Set
Identification Record which contains the required information to
identify the data set and to correlate it with its companion VERT DESC
data set – job code, data type (VERT OBS), name of submitting agency,
and date the data set was created. The last record of the data set must
be the Data Set Termination Record. It is the only other record in the
data set on which the respective job code appears in the same field
(columns 7-10) as on the Data Set Identification Record.

The VERT OBS data set records which are bracketed by these two
delimiting records may pertain to one or more units of field work;
i.e., field observation data for several leveling lines may by submitted
in one VERT OBS data set under the same job code, provided that the
total number of survey points (bench marks and temporary bench marks) in
the job does not exceed 9,999 (see Chapter 5). When two or more
leveling lines are included in a vertical control job, each line must
appear as a complete unit in the respective VERT OBS data set, i.e., as
a block of records which contains all information pertinent to that
line (see table 6-2). Each line must begin with a *10* record, contain
any appropriate number of the other types of records in proper sequence,
followed by one or more *40 – series records.

TABLE 6-2
STRUCTURE OF THE VERT OBS DATA SET

Data Set Identification Record
10-series records
20-series records (if any)   FIRST
30 records   LINE
40-series records

10-series records
20-series records (if any)   SECOND
30 records   LINE
40-series records

::::   ::::
::::   ::::

10-series records
20-series records (if any)   LAST
30 records   LINE
40-series records

Data Set Termination Record

A leveling line is a unit of field work consisting of a number of
survey points (bench marks and temporary bench marks - see Chapter 5)
which are connected by chains of differential leveling observations
called "runnings." When coded as part of a VERT OBS data set, a
leveling line is a block of records comprising record groups arranged
in the following order:

1. Line Identification Data (*10*-Series) Records:

    10 record
    11 record (optional; possibly *12*, *13*, and *14* records as
            well)
    15 records (optional, any number allowed)

2. Survey Equipment Data (*20*-Series) Records:

    20 records (at least one if instrument not previously reported;
            in general, one for each previously unreported stadia factor
            determination) for the first instrument used
    20 records (at least one if instrument not previously reported;
            in general, one for each previously unreported stadia factor
            determination) for the second instrument used
    ::::
    20 records (at least one if instrument not previously reported; in
            general, one for each previously unreported stadia factor
            determination) for the last instrument used
    21, *22*, and/or *23* record(s) - *21* record alone if rod not
            previously reported and no standardization or calibration
            data are available; in general, one *21* record followed by
            one or more *22* records (one for each previously unreported
            rod standardization), one or more *22*, *23*,..., *23* record
            sets (one such set for each previously unreported
            single-temperature rod calibration), and/or one or more *23*,
            23,..., *23* record sets (one such set for each previously
            unreported multiple-temperature rod calibration with one or
            more *23* record(s) for each calibration temperature) -
            for the first rod used
    21, *22*, and/or *23* record(s) - *21* record alone if rod not
            previously reported and no standardization or calibration
            data are available; in general, one *21* record followed by
            one or more *22* records (one for each previously unreported
            rod standardization), one or more *22*, *23*,..., *23* record
            sets (one such set for each previously unreported
            single-temperature rod calibration), and/or one or more *23*,
            23,..., *23* record sets (one such set for each previously
            unreported multiple-temperature rod calibration with one or
            more *23* record(s) for each calibration temperature) -
            for the second rod used
    ::::
    21, *22*, and/or *23* record(s) - *21* record alone if rod not

previously reported and no standardization or calibration
data are available; in general, one *21* record followed by
one or more *22* records (one for each previously unreported
rod standardization), one or more *22*, *23*,..., *23* record
sets (one such set for each previously reported
single-temperature rod calibration), and/or one or more *23*,
23,..., *23* record sets (one such set for each previously
unreported multiple-temperature rod calibration with one or
more *23* record(s) for each calibration temperature) –
for the last rod used

Note that for instruments and/or rods which are used in more than one
leveling line submitted in the same or in different vertical control
jobs, it is not necessary to repeat the same *20*-series records in
each such line or each such VERT OBS data set. It is sufficient to
submit the respective *20*-series records once as part of the first line
submitted in which such instruments and/or rods appear, and thereafter
only if the stadia factor is redetermined for an instrument and/or if a
rod is restandardized or recalibrated – see SURVEY EQUIPMENT DATA
RECORDS.

3. Field Abstract Data (*30*) Records:

   30 records – one for the first (starting) survey point (bench
        mark or temporary bench mark) followed by one *30* record
        for each elevation carried forward to a survey point along
        the leveling line.

The order of the *30* records is important; normally they should follow
in sequence as the respective survey points (bench marks and temporary
bench marks) occur along the leveling line. However, one or more spurs
may emanate from any given survey point – in which case, after the *30*
record for such a "base" point, the *30* records for all survey points
along the longest spur must follow first, then those along the
next-longest spur, etc. Only when all spurs emanating from that base
point have thus been exhausted, should the *30* record for the
elevation carried forward to the next survey point along the main route
be given – see example in Figure 6-1.

In the absence of any closed loops, there will be as many *30* records
as there are survey points along the leveling line. However, if a loop
is closed (as in the case of a spur loop or if the line itself forms a
closed loop), an additional *30* record must appear in proper sequence
(see above) for the endpoint of every such loop, reflecting the
elevation carried forward to that bench mark or temporary bench mark
via the loop.

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4. Observation Data (*40*-Series) Records:

40 record giving the date, instrument/rod combination, and
        collimation error data <u>for the first set of runnings</u>
41 record for the first running in the first set
43 record (if needed) for the first running in the first set
41 record for the second running in the first set
43 record (if needed) for the second running in the first set
::::
41 record for the last running in the first set
43 record (if needed) for the last running in the first set
40 record giving the date, instrument/rod combination, and collimation
        error data <u>for the second set of runnings</u>
41 record for the first running in the second set
43 record (if needed) for the first running in the second set
41 record for the second running in the second set
43 record (if needed) for the second running in the second set
::::
41 record for the last running in the second set
43 record (if needed) for the last running in the second set

::::

40 record giving the data, instrument/rod combination, and collimation
        error data <u>for the last set of runnings</u>
41 record for the first running in the last set
43 record (if needed) for the first running in the last set
41 record for the second running in the last set
43 record (if needed) for the second running in the last set
::::
41 record for the last running in the last set
43 record (if needed) for the last running in the last set
42 record for the first river/valley crossing along the line
43 record (if needed) for the first river/valley crossing along line
42 record for the second river/valley crossing along the line
43 record (if needed) for the second river/valley crossing along line
::::
42 record for the last river/valley crossing along the line
43 record (if needed) for the last river/valley crossing along line

<u>LINE IDENTIFICATION DATA RECORDS</u>
        10 Line Information Record
        11 Line Title Record (Optional)
        12 Line Title Continuation Record (Optional)
        13 Line Title Continuation Record (Optional)
        14 Line Title Continuation Record (Optional)
        15 Comment Record (Optional)

The line identification data records, bearing the *10*-series data codes, are listed above; the block diagrams illustrating the respective formats will be found under FORMAT DIAGRAMS.

The *10* record contains essential line identification data and is always required. The *11* record is optional; however, it is highly desirable that a line title (reflecting the geographic location of the line - see below) be given. The line title should be concise so as to fit on the *11* record (up to 70 characters); however, one, two, or three continuation records (the *12*, *13*, and *14* records) may be appended if the title is lengthy or if a main title followed by subtitle(s) is called for. Following the *11* record (or else the last title continuation record), there may appear as many *15* records as appropriate to give comments pertinent to the leveling line (e.g., significant problems encountered, deviations from standard procedures, etc.), if any.

The entries on these records (see FORMAT DIAGRAMS) are for the most part self-explanatory; however, the following data items will be explained in greater detail:

Leveling Line: As was stated in the preceding section, a leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks) which are connected by chains of differential leveling observations called "runnings." Each segment of a leveling line consisting of two neighboring survey points connected by a running is called a "section" of the leveling line.

The objective of differential leveling is the extension of vertical control by precise determination of differences of elevation between successive survey points along the leveling line. The end product is a string of permanently marked vertical control points or bench marks (BMs).

Tolerance Factor: To control the accumulation of error in the differential leveling process, each section of a leveling line is normally "double-run," i.e., observed twice by runnings in opposite directions, and the disagreement between the respective differences of elevation as determined by the two runnings must not exceed a tolerance limit computed as the product of the appropriate tolerance factor and the square root of the section length.

Aside from the units of measurement involved, the numerical value of the tolerance factor used for this purpose depends on the type and intended accuracy of the vertical control survey in question; it is one of the specification parameters which characterizes a given order and class of vertical control survey (see below).

Note that the tolerance factor is expressed in mixed units, i.e., in "Units of Elevation Difference Disagreement Per Square-Root of Units of Section Length." For the purposes of this publication two such unit combinations are allowed (must be specified by the respective units code given as part of the tolerance factor data group on the *10* record):

1. Millimeters per square-root of kilometers (units code MM), and
2. Feet per square-root of statute miles (units code FT).

Order and Class of Survey: A two-digit code is provided on the *10* record to specify the order of accuracy of the survey. The first digit of this code reflects the order and the second digit the class of the survey in accordance with the "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys," prepared by the Federal Geodetic Control Committee (FGCC), and published by the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, Rockville, MD (February 1974). In addition to the five vertical control survey categories defined in this publication, three other survey categories need to be considered - old vertical control surveys of first or second order for which no class is specified, and surveys of lower-than-third-order accuracy. The respective two-digit codes are as follows:

              10 - First-Order (Class Unspecified)
              11 - First-Order, Class I
              12 - First-Order, Class II
              20 - Second-Order (Class Unspecified)
              21 - Second-Order, Class I
              22 - Second-Order, Class II
              30 - Third-Order
              40 - Lower-Than-Third-Order   noT used

Remove this Classification in next revision

The order-and-class code assigned to a leveling line should reflect the procedures and specifications according to which that entire line has been observed. When well-defined segments of a leveling line fall into different order-and-class categories, the line must be divided accordingly and the respective parts submitted as separate lines.

State or Country Code: Provision is made on the *10* record to indicate the political unit(s) and/or geographic area(s) in which the leveling line is located using the two-letter state or country codes given in ANNEX A. Up to three such codes may be entered, in the order of progress along the line in question. In the United States or in Canada, enter the appropriate code for the respective state, commonwealth, province, or territory; elsewhere enter the appropriate code for the respective country, island group, or geographic area - see ANNEX A.

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Line Title: The desired elements of information in the title of a leveling line are (1) the respective line number or other identification symbol, (2) the order of accuracy of the survey, (3) whether original leveling or releveling, and (4) the geographic locality (or localities) of the survey. Since the first three elements are explicitly coded on the *10* Line Information Record (see FORMAT DIAGRAMS), it would be superfluous to repeat them in the line title, and hence only the geographic location needs to be specified. The use of geographic location alone as the title of a leveling line has traditionally been the practice of the NGS and its predecessors.

In general, the title by which the leveling line is known to the submitting agency should be given, supplemented to reflect geographic location, as required. Omit punctuation marks (periods, commas, etc.) and parentheses whenever their omission can be tolerated, and use ANNEX A state and country codes whenever reference to a state or country is necessary. Furthermore, edit and/or abbreviate the line title in the interest of fitting the entire title on the *11* Line Title Record, if at all possible. However, up to three additional records (the *12*, *13*, and *14* Line Title Continuation Records) may follow the *11* Line Title Record if the title must be lengthy or when a main title followed by one or more subtitles is desired.

The geographic location of the leveling line should be descriptive of the route followed, i.e., the starting locality, any prominent "via" points, and the ending locality should be specified in the order of progress of the survey (Example: ALBANY GA VIA MORVEN TO CALLAHAN FL). If the leveling line is a member of a special project or of an area network to which a specific name or title has been assigned, such a name or title should be carried as a main title on the *11* record and the title of the line proper should follow as a subtitle on one or more of the continuation records. Example:

     11 Record: TULARE-VASCO ARVIN-MARICOPA AREA CA
     12 Record: 9.1 KM SE OF KETTLEMAN CITY TO PIXLEY ·

DATE AND TIME

Date of the VERT OBS data set creation must appear on the Data Set Identification Record, and the dates on which survey operations commenced and terminated are to be entered on the *10* Line Information Record. In addition, character fields are reserved for the date and/or time on several other records of the VERT OBS data set. Throughout the VERT OBS data set, date and time are to be coded as follows:

     Date: Full date is coded as an eight-digit integer number consisting of four two-digit groups denoting (from left to right) the last whole century, number of full years since the turn of century, month of the year, and day of the month (CCYYMMDD). For the 20th

century, the "century" columns may by omitted, and the date coded as a six-digit integer number denoting the year, month, and day (YYMMDD). If the day is not known (e.g., in connection with old data extracted from archives for which the date is not fully specified), leave the last two columns of the field blank; if the month is not known, leave the last four columns of the field blank. For example, February 8, 1970, would be coded as follows:

1. Full date is known: 19700208 or 700208
2. Day of the month is not known: 197002   or 7002
3. Month of the year is not known: 1970   or 70

Time: The time of day is, coded as a four-digit integer number consisting of two two-digit groups denoting (from left to right) the hours and minutes (HHMM) of a 24-hour clock. Each four-character time field or pair of (beginning and ending) time fields is preceded by a one-character field reserved for the appropriate one-letter U.S. Navy time zone designation (see below). In every case, the local zone time is to be used; in this manner ambiguities are avoided concerning the date, which is always assumed to be the "local" date (i.e., the date changes at local midnight).

Time Zone: A time zone is a geographic region in which uniform time differing by an integer number of hours from Greenwich Mean Time (GMT) is maintained by law. In theory, a time zone extends 7-1/2 degrees in longitude east and west of a "time meridian" whose longitude is a multiple of 15 degrees (since the Earth rotates 360 degrees in 24 hours, 15 degrees of longitude difference equals one hour of time difference). In practice, the lines which separate adjacent time zones often follow political boundaries and are therefore irregular. Associated with every time zone is a "time zone description" - an integer number positive west of Greenwich and negative east of Greenwich - which represents the number of hours which must be added (algebraically) to the local zone time in order to obtain the corresponding GMT. The time zone description is reduced by one hour when the standard zone time is changed to daylight-saving time.

Instead of the numeric time zone description, it is more convenient to use the U.S. Navy one-letter codes which uniquely identify each time zone. In this system, GMT is the "Z" (Zulu) Time Zone. Time zones east of Greenwich are identified by letters A, B, C, etc., through L, with the letter J omitted. Time zones west of Greenwich are identified by letters N, O, P, etc., through X. The letter Y is used to designate the western half of the time zone centered on the meridian of longitude 180 degrees (International Date Line), and the letter M is used to designate the eastern half of this zone.

The world-wide use of the time zone descriptions and the U.S. Navy one-letter designations is illustrated in ANNEX H. In the continental

United States, Alaska (AK), and Hawaii (HI) the time zones are as given
in Table 6-3:

TABLE 6-3 - U.S. NAVY TIME ZONE DESIGNATIONS

STANDARD TIME		DAYLIGHT TIME		TIME MERIDIAN	TIME ZONE DESCIRP'N	U.S. NAVY DEISGNATION
Atlantic	AST	Eastern	EDT	60W	+4	Q (Quebec)
Eastern	EST	Central	CDT	75W	+5	R (Romeo)
Central	CST	Mountain	MDT	90W	+6	S (Sierra)
Mountain	MST	Pacific	PDT	105W	+7	T (Tango)
Pacific	PST	Yukon	YDT	120W	+8	U (Uniform)
Yukon	YST	AK/HI	HDT	135W	+9	V (Victor)
AK/HI	HST	Bering	BDT	150W	+10	W (Whiskey)

If the time zone cannot be reliably ascertained, leave the time zone field
blank. In this case, the time given will be interpreted as the standard
time in a zone determined on the basis of the longitude of the vertical
control point from which the respective leveling observations (running)
originate. As of this printing, Arizona, Hawaii, eastern Indiana, Puerto
Rico, the Virgin Islands, and American Samoa do not observe daylight
savings time. Verify locally (during the time of observations) whether
or not daylight savings time is in effect.

SURVEY EQUIPMENT DATA RECORDS

    20 Instrument Information Record
    21 Rod Information Record
    22 Rod Standardization Record
    23 Rod Calibration Record

The survey equipment data records, identified by *20*-series data codes,
are listed above; the block diagrams illustrating the respective formats
are given in the FORMAT DIAGRAMS. The survey equipment data records
contain identification and calibration data pertaining to the leveling
instruments and rods used to carry out the differential leveling obser-
vations. See STRUCTURE OF THE VERT OBS DATA SET for the proper sequence
in which the *20*-series records must appear in the block of records
which constitutes a leveling line in a VERT OBS data set.

The *20* Instrument Information Record contains the data required to
identify a leveling instrument (the appropriate NGS survey equipment code
and the instrument serial number), date of stadia factor determination,
and the stadia factor itself. This stadia factor will be used in the
computation of the lengths of sights made with that instrument subsequent
to the respective stadia factor determination date. Several *20* records
may be submitted as a group for a leveling instrument; one for each past
stadia factor determination.

The *21* Rod Information Record contains analogous data (the appropriate NGS survey equipment code and the rod serial number) required to identify a leveling rod; however, it does not contain any calibration data. Rod calibration data, which are required only for rods used in first- and second-order differential leveling work, must follow the *21* record in the form of a *22* record, a record set consisting of a *22* record and one or more *23* record(s), or a record set consisting of two or more *23* records, all bearing the same standardization/calibration date.

Again, several such *22* records, *22*, *23*,..., *23* record sets, and/or record sets of the form *23*, *23*,..., *23*, as appropriate, may be submitted as a group for a leveling rod following the respective *21* Rod Information Record; one such *22* record, *22*, *23*,..., *23* record set, or *23, *23*,..., *23* record set for each past calibration of the leveling rod in question.

The *22* Rod Standardization Record contains the summary of a rod calibration. For the purposes of this chapter, the term "standardization" will be used to denote a group of data which is the end product of a rod calibration (i.e., the respective coefficient of thermal expansion, rod excess, and index error - see below). The *22* Rod Standardization Record may appear alone, or it may be followed by one or more *23* Rod Calibration Record(s) containing the (single-temperature) calibration data on which the standardization summary is based. Optionally, a *22* record may also precede a set of two or more *23* records of a multiple-temperature calibration; in this case, however, all data contained on the leading *22* record are inferable from the accompanying *23* records.

The *23* Rod Calibration Record contains data pertaining to the calibration of a leveling rod at one temperature. For single-temperature calibrations, submit one or more *23* record(s) following the corresponding *22* record (see above) - as many as required to accommodate all calibration intervals (three per *23* record - see FORMAT DIAGRAMS). For multiple-temperature calibrations, submit a set of *23* records (one or more per calibration temperature), with or without a preceding *22* record, which is optional in this case. In general, *23* Rod Calibration Records should be submitted whenever rhe respective data are available.

NGS Leveling Instrument and Rod File: The purpose of the *20*-series records is to provide input to a permanent computer file in which a historic record is maintained for each leveling instrument and leveling rod ever used in a VERT OBS data set submitted to the National Geodetic Survey. A record is established in this file for an instrument or rod at the first time it is encountered in the processing of a VERT OBS data set. Thereafter, the file is updated by adding new information to the respective instrument and/or rod records whenever

standardization or calibration data not previously available are encountered among the *20*-series records of a subsequently processed leveling line in the same or different VERT OBS data set.

Accordingly, it is not necessary to repeat identical *20* Instrument Information Records among the *20*-series records of every leveling line in which that instrument appears. It is sufficient, for any instrument, to submit one or more such records (one for each past determination of the respective stadia factor) once initially, and thereafter only when a new stadia factor is determined (e.g., following the installation of a new reticle). Of course, for each leveling line, care must be taken to insure that any omitted *20* Instrument Information Records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

Analogously, it is not necessary to repeat identical *21* Rod Information Records, *22* Rod Standardization Records, and/or *23* Rod Calibration Records among the *20*-series records of every leveling line in which the respective rod appears. It is sufficient, for any rod, to submit an appropriate grouping of these records (covering all past calibrations) only once initialy, and thereafter only when the leveling rod in question is recalibrated. Again, in connection with every leveling line, care must be taken to insure that any omitted *21*, *22*, and/or *23* records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

To summarize, submit a *20* record for every previously unreported leveling instrument and/or previously unreported stadia factor determination. For every leveling rod, submit a *21* record alone if the rod has not previously been reported and no calibration data follow (e.g., a rod used in third- or lower-order differential leveling work exclusively). Otherwise, submit (as a group) one *21* record followed by one or more *22* records, one or more *22*, *23*,..., *23* record sets, and/or one or more *23*, *23*,..., *23* record sets, as appropriate; one such *22* record, *22*, *23*,..., *23* record set, or *23*, *23*,..., *23* record set for each previously unreported calibration of the leveling rod in question.

NGS Survey Equipment Code: A three-digit numeric identification code assigned to each category of survey equipment, and within each category to specific instruments or other commonly used items. In particular, leveling instruments are assigned 200-series survey equipment codes, while leveling rods and staves are assigned 300-series survey equipment codes (see ANNEX F).

Instrument/Rod Serial Number: Assigned by the manufacturer, the serial number is the ultimate identifier of a specific leveling instrument or leveling rod. Serial numbers are normally numeric;

however, alphabetic characters are often used as prefixes, suffixes, etc., and special characters such as a blank (space), hyphen (minus sign), slash (solidus), etc., may appear imbedded in the respective alphanumeric character group. For this reason, a serial number must be treated as alphanumeric information to be entered in the respective character field left-justified and blank-filled on the right.

The instrument or rod serial number will be used together with the respective survey equipment code (see above) to create appropriate entries in the NGS Leveling Instrument and Rod File, to maintain these entries up to date, and to access this file for the retrieval of the respective stadia factor and/or rod calibration data in the course of routine processing of VERT OBS data sets. It is therefore of utmost importance that the respective serial number be faithfully reproduced as given by the manufacturer, character for character, including any leading zeros, imbedded blanks, etc., and that identical serial number representation be used consistently whenever reference is made to that specific instrument or rod in any VERT OBS data set.

Stadia Factor: An instrument-specific constant numerically equal to the ratio of the focal length of the instrument to the respective stadia interval, i.e., to the distance which separates the stadia lines (two horizontal lines spaced equally above and below the level line) in the reticle of the leveling instrument. By design, the stadia interval is chosen so that the stadia factor is a convenient integer number such as 100.

The stadia factor is used to obtain the distance between the leveling instrument and a rod as the product of the stadia factor multiplied by the respective (full) stadia intercept - see OBSERVATION DATA RECORDS. Note that a sight length so obtained is in the same units as the stadia intercept, i.e., in rod units, and hence must be further multiplied by a conversion factor to obtain the sight length in other units.

Rod Units: The units in which the respective rod scale is graduated. Four different rod units are acceptable, each identified by a two-letter code. They are as follows:

        CF - centifeet (0.01 ft)
        CM - centimeters (0.01 m = 1 cm)
        CY - centiyards (0.01 yd = 0.03 ft)
        HC - half-centimeters (0.005 m = 0.5 cm = 5 mm)

Rod Graduation Code: A one-digit code denoting the type of graduation of the respective leveling rod:

        1 - line graduation (single scale)
        2 - line graduation (double scale)
        3 - block graduation (including checkerboard)
        4 - other

Temperature Scale: The temperature at which the leveling rod was calibrated must be given on both the *22* Rod Standardization Record (Standardization Temperature) and the *23* Rod Calibration Record (Calibration Temperature). On either record, provision is made to indicate which of the two possible temperature scales applies by means of a one-letter code immediately preceding the respective temperature field:

C - Celsius Temperature Scale
F - Fahrenheit Temperature Scale

Coefficient of Expansion: The relative change in linear dimension (expansion or contraction) per unit of temperature change peculiar to the material of the respective leveling rod scale (these include INVAR or other low-expansion metal alloys for modern rods, and specially treated wood for rods used in older differential leveling work of high precision). Aside from the scale factor 10,000 mentioned below, the coefficient of expansion given on the *22* Rod Standardization Record must be in units which are compatible with the respective temperature scale and rod units (see above), as specified in Table 6-4.

TABLE 6-4
UNITS OF COEFFICIENT OF EXPANSION

ROD UNITS	TEMPERATURE SCALE	
	C	F
CF	feet per degree Celsius	feet per degree Fahrenheit
CM	meters per degree Celsius	meters per degree Fahrenheit
CY	feet per degree Celsius	feet per degree Fahrenheit
HC	meters per degree Celsius	meters per degree Fahrenheit

The coefficient of expansion expressed in either one of the four possible unit combinations (see above) is always a very small decimal fraction. To avoid the keying of a long string of zeros preceding the first significant digit, enter the respective coefficient of expansion multiplied by 10,000, i.e., with the decimal point moved four places to the right (Example: A coefficient of expansion of 0.00000079 is entered as 0.0079 or .0079).

A-Flag: Enter 'A' if the coefficient of expansion (see above) is an "assumed" value (i.e., as given by the manufacturer, or a standard value for the material in question). Leave the field blank if the coefficient of expansion has been determined by means of a multiple-temperature calibration of the respective leveling rod.

Rod Excess: A factor used to compute the rod correction for a single running of a section of a leveling line. The rod calibration process precisely determines the actual length of the respective rod (or of a representative segment thereof). Rod excess is the ratio of the difference between the actual and nominal length (actual minus nominal) to the nominal length of the rod (or calibrated segment thereof).

Note that the rod excess is a unitless number; however, since it is always a small (positive or negative) decimal fraction, it is convenient to express rod excess as the aforementioned ratio multiplied by 1,000 (i.e., as millimeters per meter, if metric units are being used). Accordingly, regardless of the respective rod units, enter the rod excess with the decimal point moved three places to the right.

Index Error: The distance above or below the bottom surface (foot) of the leveling rod at which the nominal origin (zero) of the respective graduated scale is located (the origin of the low scale of a rod with a double-scale graduation). The index error is positive when the scale origin falls below the foot of the rod; it is negative when the scale origin falls above the foot of the rod. Note that the index error is expressed in rod units (see above) of the leveling rod in question.

FIELD ABSTRACT DATA RECORDS

30 Field Abstract Record

The purpose of the *30* record is to provide cross-reference between the primary identifier (i.e., the designation) of a vertical control point and the corresponding job-specific survey point serial number (SPSN). In addition, the accumulated distance along the leveling line and the respective "field" elevation (see below) are given on this record. Following established practice, these latter two data items are computed from the detailed differential leveling field notes as the work progresses and are normally recorded on a form called the "Field Abstract" - hence the name "Field Abstract Record." The block diagram illustrating the respective format will be found with the FORMAT DIAGRAMS.

Submit a *30* record for the first (starting) survey point (bench mark or temporary bench mark), followed by a *30* record for each elevation carried forward to a survey point by the differential leveling process. Normally, in the absence of any closed loops, there will be as many

30 records as there are survey points along the leveling line.
However, if a loop is closed (as in the case of a spur loop or if the
line itself forms a closed loop), an additional *30* record must appear
in proper sequence (see below) for the endpoint of each such loop,
reflecting the elevation carried forward to that bench mark or
temporary bench mark via the loop.

Order of the *30* Records: As was previously covered in the section
on the STRUCTURE OF THE VERT OBS DATA SET, the order of the *30* records
is crucial. This is because the *30* records, as a group, define the
leveling line in question, i.e., they define the nominal sequence of
bench marks and temporary bench marks along the leveling line.

Normally, the *30* records should follow the same sequence as the
respective survey points occur along the leveling line. However, one
or more spurs may emanate from any survey point - in which case, after
the *30* record for such a "base" point, the *30* records for all
survey points along the longest spur must follow first, then those
along the next-longest spur, etc. Only when all spurs emanating from
that base point have thus been exhausted should the *30* record for the
elevation carried forward to the next survey point along the main route
of the leveling line be given - see example in Figure 6-1.

Survey Point Serial Number: For the purpose of identifying the
initial and terminal points of each section of the leveling line in a
concise and unique manner (e.g., on the respective *41* and *42*
records - see OBSERVATION DATA RECORDS), each survey point that is
leveled to in a vertical control job (bench mark or temporary bench
mark) is assigned a job-specific serial number in the range 0001 to
9999. All survey points for which recovery descriptions are written,
but which were not leveled to in the current project, are to be
assigned the SPSN code 0000. See Chapter 5 for a detailed explanation
of the survey point numbering system.

The survey point serial number (SPSN) is also used in the correlation
of the data pertaining to the bench marks and temporary bench marks
which appear in the VERT OBS data set with the corresponding
descriptive data contained in the companion VERT DESC data set of the
vertical control job. For this reason, special care must be taken to
insure that the identical survey point serial number assigned to a
bench mark or temporary bench mark in the VERT OBS data set is also
used to identify the same survey point in the respective companion VERT
DESC data set.

Designation: A vertical control point or bench mark is normally
identified by a numeric or alphanumeric symbol which is stamped on the
disk marker (or is otherwise inscribed on the bench mark monument) to
which is appended the abbreviation or acronym (see Annex C) of the
agency whose name is precast in the monument - if other than the
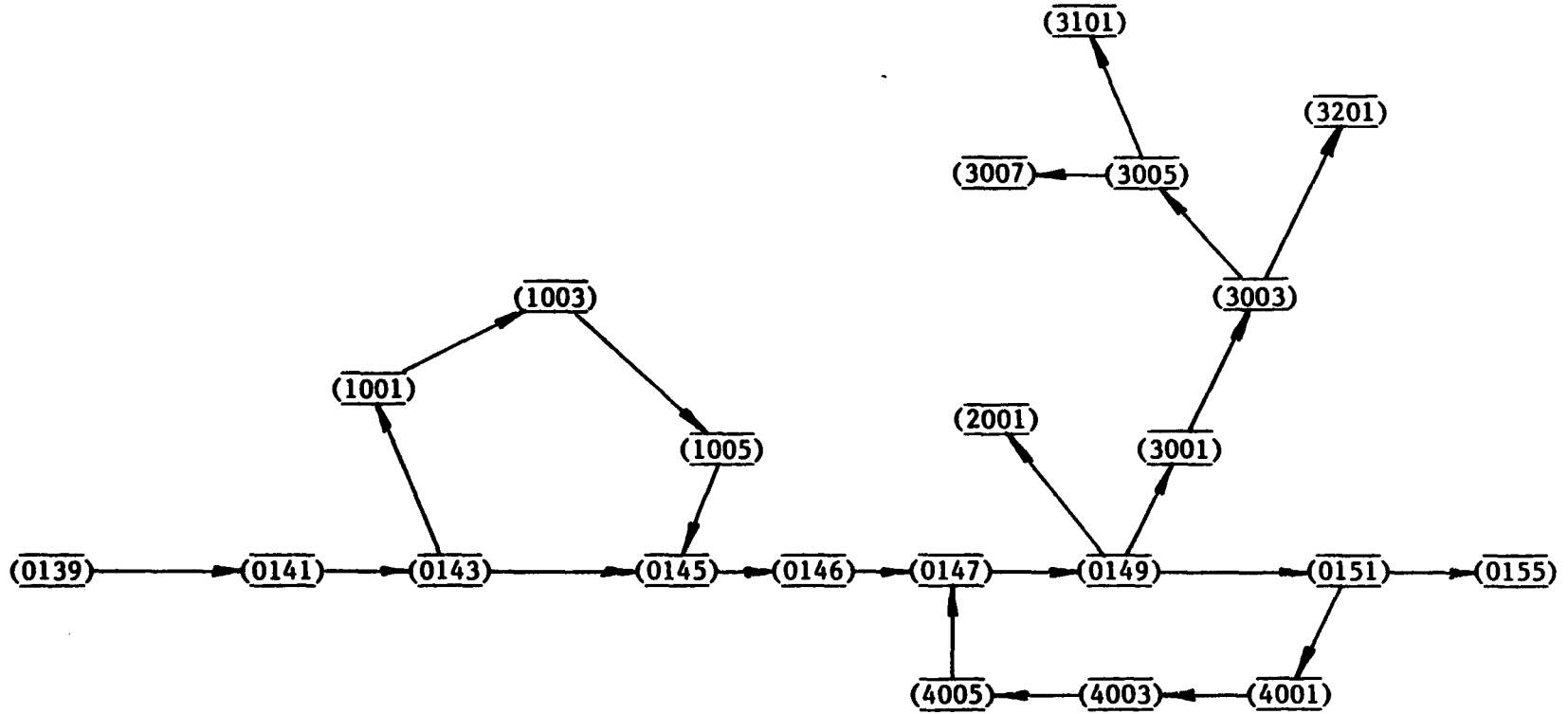
Sequence of the *30* Records:

1. 0139	5. 1003	9. 0146	13. 3003	17. 3201	21. 4003
2. 0141	6. 1005	10. 0147	14. 3005	18. 2001	22. 4005
3. 0143	7. 0145	11. 0149	15. 3101	19. 0151	23. 0147
4. 1001	8. 0145	12. 3001	16. 3007	20. 4001	24. 0155

FIGURE 6-1 - Example of Field Abstract Record sequence.

National Geodetic Survey, National Ocean Survey, or Coast and Geodetic Survey (see Origin). For marks not having a precast agency name, append the acronym or abbreviation of the agency which set the mark (see Setting-by-Agency). If the agency cannot be determined, do not append an agency acronym or abbreviation. Less frequently, a bench mark is assigned a concise, intelligible name (e.g., when a horizontal control point also becomes a bench mark); the appropriate acronym or abbreviation should be appended to these also. A maximum of 25 characters (including all imbedded blanks) is allowed.

In every case, the bench mark designation entered on the *30* record must be identical to the (primary) designation used to identify the same vertical control point in the companion VERT DESC data set of the vertical control job - refer to Chapter 7. Use the same general guidelines for the designations of any survey points which lack descriptive data (e.g., undescribed temporary bench marks which may have to be carried in the VERT OBS data set but which do not appear in the companion VERT DESC data set).

Accumulated Distance: The distance covered by the differential leveling operation from the nominal starting point of the leveling line to the survey point in question. It is obtained by successively adding the lengths of the intervening sections (following the line-order conventions used for the ordering of the *30* records in the case of a survey point located on a spur or leveled to via a spur loop - see Order of the *30* Records). Recall that "section" is a segment of the leveling line consisting of two neighboring survey points connected by a chain of differential leveling observations (i.e., connected by a "running").

The individual section lengths are obtained by accumulating the lengths of the backsight and foresight of each setup of the respective running, which in turn are usually obtained as a function of the corresponding stadia intercepts (see Stadia under OBSERVATION DATA RECORDS) and the stadia factor of the leveling instrument used. For this purpose, use the minimum section length if more than one running has been made over a section, as is the normal case.

The accumulated distance (as well as the field elevation - see below) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of survey point serial numbers, etc. For this reason, the accumulated distance entered in this field must be the value which is normally computed and "abstracted" in the course of the differential leveling operation. In particular, the accumulated distance must not be generated (e.g., by software) from the respective *41* and *42* records (see OBSERVATION DATA RECORDS), as this would defeat the purpose for which it is intended.

Field Elevation: The approximate elevation of the survey point in question is obtained as the (algebraic) sum of the elevation of the starting point of the leveling line and the raw (i.e., uncorrected) elevation differences determined for the intervening sections (following the line-order conventions used for the ordering of the *30* records in the case of a survey point located on a spur or leveled to via a spur loop - see Order of the *30* Records). (Recall that a "section" is a segment of the leveling line consisting of two neighboring survey points connected by a chain of differential leveling observations referred to as a "running.")

The end product of every running over a section of the leveling line is the respective observed, uncorrected elevation difference (see Elevation Difference under OBSERVATION DATA RECORDS). When more than one running has been made over a section, as is the normal case, a "section mean" must be computed using all forward and backward runnings made over that section which have passed appropriate field rejection criteria.

Noting that a backward running produces an elevation difference of opposite sign, the respective section mean is defined as the algebraic difference between the sum of elevation differences determined by forward runnings and the sum of elevation differences determined by backward runnings divided by the number of runnings. In other words, if ΣF is the sum of all acceptable forward-running elevation differences, and ΣB is the sum of all acceptable backward-running elevation differences, the desired section mean is $(\Sigma F - \Sigma B)/n$, where n is the number of runnings.

The field elevation (as well as the accumulated distance - see above) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of survey point serial numbers, etc. For this reason, the field elevation entered in this field must be the value which is normally computed and "abstracted" in the course of the differential leveling operation. In particular, the field elevation must not be generated (e.g., by software) from the respective *41* and *42* records (see OBSERVATION DATA RECORDS), as this would defeat the purpose for which it is intended.

OBSERVATION DATA RECORDS

> *40* Survey Equipment Record
> *41* Running Record
> *42* River/Valley Crossing Record
> *43* Correction/Rejection Record

The observation data records, identified by *40*-series data codes, are listed above; the block diagrams illustrating the respective formats are given in the FORMAT DIAGRAMS. The purpose of the *40*-series

records is to provide the means to record the differential leveling observations carried out along a leveling line. Recall that a leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks) connected by differential leveling observations, and that "section" is a segment of the leveling line consisting of two neighboring survey points which are connected by one or more differential leveling observations.

The differential leveling observations carried out over a section of leveling line are of two basic types - runnings and crossings - see below.

Normally, the (observed) elevation difference between the endpoints of a section is determined as the accumulation of a continuous series of small elevation difference measurements, each obtained as the difference between the respective backsight and foresight readings on a pair of leveling rods positioned vertically over "turning points" at a relatively short sight distance from the leveling instrument. This type of differential leveling observation which consists of a chain of small elevation difference measurements (i.e., leveling instrument "setups") is called a "running."

When carried out in the nominal direction of progress of the leveling line, it is called a "forward" running; when carried out in the opposite direction, it is called a "backward" running. A section which is "double-run" (as is the normal case) will have at least one forward and one backward running (among possibly several runnings in either direction) which meet field acceptance criteria (i.e., the disagreement between the respective observed elevation differences does not exceed the tolerance which is in effect for the order and class of the vertical survey in question).

Submit a *41* record for every running carried out along the leveling line, regardless of its field acceptance or rejection status (rejected runnings may be brought within the respective tolerance after various corrections are applied in the course of subsequent data processing). The *41* records must be submitted in sets consisting of a *40* record followed by one or more *41* records - one for each running made on the same date, using the same leveling instrument and the same leveling rods, and subject to the same level collimation error (see below) as specified in the respective leading *40* record - see STRUCTURE OF THE VERT OBS DATA SET.

The other type of differential leveling observation is the "river/valley crossing" (or "crossing") which is used when a gap larger than the maximum allowable sight length of a setup must be spanned, as when a river (or dry canyon) must be crossed without using a suitable bridge. This type of differential leveling observation is the result of a series of reciprocal measurements carried out simultaneously from both sides of

such a gap using special "valley-crossing" equipment. Note that each individual river/valley crossing must be treated as a separate section of the leveling line.

Submit a *42* record for every river/valley crossing along the leveling line. The *42* records, if any, must appear as the last group of records of the respective leveling line block in the VERT OBS data set (see STRUCTURE OF THE VERT OBS DATA SET).

Submit a *43* record for each running or river/valley crossing for which a refraction correction was determined from temperature profile measurements made by field personnel, or for which a rod correction was determined using detailed rod calibrations furnished by the National Bureau of Standards. Also, if a running or river/valley crossing was rejected, include a *43* record indicating the source of the rejection (field or office). Each required *43* record should immediately follow its corresponding *41* or *42* record. If temperatures were observed only at the upper- and lower-   *
temperature probes, leave the columns labeled "Mean temperature for middle   *
probe" and "Height of middle probe" blank. The columns labeled "Rod   *
Correction in mm" refer to values determined using "detailed" rod calibra-   *
tions (the calibration of all rod graduations) furnished by the National   *
Bureau of Standards.

   Level Collimation Error: The (small) angle by which the line of sight defined by the center of the crosslines in the reticle and the optical center of the objective lens of a leveling instrument departs from the horizontal when the instrument is "level": positive when the line of sight deviates upward, and negative when the line of sight deviates downward from horizontal. The collimation error is due to a small misalignment between the respective bubble vial (in the case of spirit-level instruments) or compensator mechanism (in the case of self-aligning instruments) and the line of sight (line of collimation).

The level collimation error can be resolved into two components--a residual constant component (which can be minimized by careful adjustment of the instrument) and a variable component which is caused by transient deforma-tion of the structural parts of the instrument brought about by stresses and strains due to uneven temperature distribution (differential heating) and other intermittent physical forces which are active in the course of the daily handling of the leveling instrument.

Because of the unpredictable nature of the intermittent component, the level of collimation error must be determined at sufficiently frequent intervals to permit the application of meaningful corrections to the respective level-ing rod readings. Note that the effect of the collimation error cancels for a setup with backsight and foresight of equal length; it is the total accu-mulated length imbalance between all the backsights and foresights of a funning to which the correction for collimation error is applicable.

   Tangent of Collimation Error: The observing procedure by means of which the collimation error is determined (commonly known as the "C-Test") produces the ratio of the corresponding rod reading error to the length of line of sight, i.e., the trigonometric function tangent of the collimation error.

Note that the tangent of an angle is a unitless number; however, since it is a very small (positive or negative) decimal fraction, it is convenient to use the tangent of collimation error multiplied by 1000 (i.e., as millimeters per meter, if the metric units are being used). Accordingly, enter the tangent of collimation error with the decimal point moved three places to the right.

Wind Code: A one-character numeric code, the purpose of which is to denote the approximate wind conditions prevailing during the course of the running. The three wind codes are:

> 0 - wind speed less than 10 kilometers per hour
> 1 - wind speed from 10 to 25 kilometers per hour
> 2 - wind speed greater than 25 kilometers per hour

Sun Code: A one-character numeric code, the purpose of which is to denote the approximate conditions of insolation prevailing during the course of the running. The three sun codes are:

> 0 - less than 25% of setups under sunny conditions
> 1 - 25% to 75% of setups under sunny conditions
> 2 - more than 75% of setups under sunny conditions

Stadia, Stadia Intercept, and Stadia Intercept Code: Stadia is a method of obtaining the approximate distance (typically to the nearest 0.1 meter) between the leveling instrument and a vertically positioned leveling rod as the product of the instrument's stadia factor (as specified in the corresponding *20* record) and the respective stadia intercept - the difference between the high and low stadia line readings on the respective rod. Recall that stadia lines are two horizontal lines spaced equally above and below the horizontal crossline in the reticle of the leveling instrument. Note that the distance obtained in this manner is in the same units as the stadia intercept, i.e., in rod units of the respective leveling rod (as specified in the corresponding *21* record).

For differential leveling observations, stadia information is desired (1) to compute the total length of the running, and (2) to compute the total accumulated length imbalance between the backsights and foresights of the running (to eliminate the residual effect of collimation error - see Level Collimation Error above). Because of the latter requirement, two fields are provided for the entry of stadia information, one for the Sum of Backsight Stadia Intercepts and the other for the Sum of Foresight Stadia Intercepts.

As was mentioned previously, the two stadia lines are equidistant from the horizontal crossline (level line) of the leveling instrument. The use of full stadia intercepts requires the observation and recording of two rod readings (the stadia high and the stadia low readings) in

addition to the level line reading. It is possible to observe only one
stadia line reading (either the stadia high or the stadia low) in
addition to the level line reading, in which case half stadia intercepts
are obtained. Note that either full stadia intercepts or half
intercepts must be observed consistently throughout a running. To
specify which one of the two possible procedures has been followed,
provision is made on the *41* record for a one-letter Stadia Intercept
Code:

                    F - full stadia intercepts observed
                    H - half stadia intercepts observed

    Units: A set of two-letter codes for the various units of length
in which the length of running (*41* record), length of crossing (*42*
record), and elevation difference (*41* and *42* records) may be given.
It is the same set of unit codes which is used on the *30* record to
denote the units of accumulated distance and field elevation - see
FIELD ABSTRACT DATA RECORDS. The specific unit codes are:

                    MT - meters   KM - kilometers
                    FT - feet   KF - kilofeet
                    YD - yards   SM - statute miles

    Running Length: The overall length of the running (i.e., the
distance covered by the differential leveling observations), preceded by
the respective units code, only if the stadia information (see above) is
not available; otherwise leave blank.

    Crossing Length: Enter the overall length of the crossing (i.e.,
the distance spanned by the river/valley crossing observations),
preceded by the respective units code.

    Elevation Difference: Enter the observed difference of elevation
as determined by the running or crossing in question, preceded by the
respective units code. Note that this must be the raw observed
elevation difference, i.e., the result of the running or crossing
observations to which no corrections have been applied.

FORMAT DIAGRAMS

For each record which appears in a VERT OBS data set (see Table 6-1), a
block diagram has been prepared to illustrate the respective format.
These "format diagrams" have been designed to fulfill the following
objectives:

    1. Each record is 80 characters long (standard punched card image).

    2. Each record has a fixed format, i.e., every data field has a
        specific length and specific position within the record.

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3. Each format diagram is a graphic image of the respective record.

4. Within the limits of available space, information and instructions concerning the data item to be entered in each data field are provided on the format diagrams to render them self-explanatory.

5. When appropriate, sample entries are shown in the data entry line of each format diagram.

6. Each data field is characterized as to its type by a string of lower-case characters which appear immediately below the data entry line.

Data Field Types:

1. Alpha Field (aa...a) - intended for a data item which is coded as a string of alphabetic, numeric, and/or special characters, with or without imbedded blanks, to be entered into the respective data field left-justified and blank-filled on the right. See Chapter 5 for a list of special characters which are allowed.

2. Blank Field (bb...b) - to be blank-filled. Data fields which are designated as blank fields must be left blank, i.e., no data items may be entered in these fields.

3. Constant (Numeric) Field (cc...c) - intended for a data item which is a number (i.e., an integer, a proper or improper fraction, or a decimal fraction) coded as a string of numeric characters (prefixed with a minus sign if the number is negative) which may contain one leading or imbedded (but not trailing) decimal point if it is a decimal fraction, or an imbedded hyphen and/or slash if it is a proper or improper (mixed) fraction such as 3/4, 5-1/2, etc., to be entered into the respective data field left-justified and blank-filled on the right.

4. Floating-Point Field (ff...fdd...d) - intended for a data item which is coded as a decimal number, i.e., as a string of numeric characters (prefixed with a minus sign if the number is negative) which may not contain any imbedded blanks. If the decimal point is present, the character string representing the integer digits, the decimal point, and the decimal fraction digits may be positioned anywhere within the respective field (generally left-justified), and the unused columns of the data field are blank-filled.

When the decimal point is not coded, the "f" portion of the floating-point field is to contain the integer part of the decimal number, and the "d" portion the corresponding decimal fraction part,

the decimal point being _implied_ between the rightmost "f" column and the leftmost "d" column of the field.

Accordingly, a string of numeric characters representing m integer digits followed by n decimal fraction digits with the decimal point absent must be positioned in the floating-point field in such a manner that its integer part falls into the m rightmost "f" columns, and its decimal fraction part into the n leftmost "d" columns, with any unused columns of the data field being blank-filled. When a negative number is entered, code the minus sign immediately preceding the leading digit.

     5.   _Integer Field_ (ii...i) - intended for a data item which is coded as a string of numeric characters representing a positive or negative integer number, to be entered into the respective data field right-justified. In the case of a positive integer number, zero-fill any unused columns on the left. In the case of a negative integer number, code the minus sign immediately preceding the leftmost non-zero digit, and blank-fill any unused columns to the left of the minus sign.

     6.   _Specific Character Field_ (ss...s) - intended to contain a specific alphabetic, numeric, special character, or a specific group of characters. Every "s" column of a specific character field must contain the character shown in that position in the data line of the respective format diagram.

  Required Data: In general, only those records which are applicable to the data at hand should be included in a VERT OBS data set (e.g., no *42* records need be submitted if there are no river/valley crossings along the respective leveling line). The character fields intended for data items which are essential have been shaded on the format diagrams; if applicable to the data being coded, these character fields must be in accordance with the instructions given on the respective format diagrams or in the text of this chapter. Records which are optional or those which may be omitted under certain circumstances are clearly designated in the headings, footnotes, or bodies of the corresponding format diagrams.

Data Set Identification Record. This must be the first record of every data set submitted.
A data set may be submitted either as a deck of cards or as a magnetic tape file containing
formatted records. Magnetic tape is preferred; use punched cards for small, isolated jobs only.

```
000000000111111111122222222223333333333444444444455555555556666666666777777777778
123456789012345678901234567890123456789012345678901234567890123456789012345678 90
```

Name of Submitting Agency or Firm

Column descriptions (left to right):

- **Sequence Number** – must be 000010 on this record. Increment by 10 on successive records to allow for insertions.
- **Data Set Identification**
  - **Job Code** – preceded and followed by asterisk.
  - **Data Class** – VERT for vertical control data.
  - **Data Type** – OBS for field observation data.
  - **Abbreviation** – must be unique. Enter the symbol listed in ANNEX C. See footnote for other agencies or firms.
  - **Full Name**
- **Date Data Set Created** (e.g. date this record keyed) Century, year, month, day (CCYYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.

Filled example row:

```
000010*CX*VERTOBS USGS  US GEOLOGICAL SURVEY                                                  19780510
iiiiiisaasssssssssaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaabbbbbbiiiiiiii
000000000111111111122222222223333333333444444444455555555556666666666777777777778
123456789012345678901234567890123456789012345678901234567890123456789012345678 90
```

Important: To insure uniqueness, agencies or firms not listed in ANNEX C must have their
proposed abbreviation symbol accepted by NGS prior to first submittal of data – see ANNEX K.

1 = single or double - simultaneous run
2 = double run

ORDER AND CLASS OF SURVEY							
ORDER	1st		2nd			3rd	LOWER
CLASS	*	I	II	*	I	II	**	**
CODE	10	11	12	20	21	22	30	40

*Class unspecified   **No class subdivision

Agency which made the observations. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.

Initials of Chief of Party - i.e., person responsible for the survey; leave blank if unknown.

State or Country Code - see ANNEX A. Enter the code(s) for the state (or country) in which the leveling line begins (and into which it extends).

Order and Class of Survey - see table above.

Tolerance Factor used to compute maximum disagreement allowed for each double-run section of the line - see footnote. | Factor / Units

Date Field Observations Terminated
Century, year, month, day (CCYYMMDD).
If day is unknown, leave last two columns blank.
If month is unknown, leave last four columns blank.

Date Field Operations Commenced
Century, year, month, day (CCYYMMDD).
If day is unknown, leave last two columns blank.
If month is unknown, leave last four columns blank.

Releveling Code - see footnote.

Agency-specific pointer to its own archives - usually given as an "accession number" (or other cataloguing symbol) which identifies the block of data, possibly supplemented by a further "line" or "part" designation. | Line/Part / Accession Number

Data Code - preceded and followed by asterisk.
(*10* - Line Information Record)

Sequence Number
Increment by 10 on successive records to allow for insertions.

Releveling Code: Enter R if releveling over previously established line; leave blank otherwise. Units (of Tolerance Factor): MM - mm/square-root of km, FT - feet/square-root of statute miles.

Line Title – use *12*,*13*,*14* Line Title
Continuation Record(s) as required if the
title exceeds 70 characters or if subtitles
are necessary (e.g. the title of an area
network followed by title of the line).

The title of a leveling line should be
descriptive of the route followed, i.e.,
it should indicate the starting and ending
locations and prominent "via" points, if
any (Example: ALBANY GA VIA MORVEN TO
CALLAHAN FL).

Do not divide words (or other character groups)
between the *11*,*12*,*13*,*14* Line Title and
Line Title Continuation Records. Omit punctua-
tion marks (periods, commas, etc.) and paren-
theses whenever possible. Use ANNEX A state
and country codes whenever reference to a state
or country is necessary.

Abbreviate and/or edit a line title in the
interest of fitting the entire title on the
11 Line Title Record, if possible.

Data Code
(*11*,*12*,*13*,*14* Line Title Records)

Sequence Number
Increment by 10 on successive records to allow
for insertions.

15 Comment Record (Optional). Use this record for any comments pertinent to the leveling line. If the comment(s) exceed 70 characters, use another *15* record for continuation; any number of *15* records is allowed. Do not divide words between consecutive *15* records.

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Sequence Number — Increment by 10 on successive records to allow for insertions.	Data Code (*15* - Comment Record)	Comment

```
nnnnnn*15*GRAVITY SURVEY OBSERVED OVER THIS LINE.
iiiiiisiisaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Stadia Factor - instrument-specific number which multiplied by Stadia Intercept gives dist to rod.

Date Determined - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.

Agency which owns or has the custody of the instrument.

For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.

Model or Type - examples:

    FISHER
    N-3
    NK3-M
    NI1
    NI-002

Manufacturer - examples:

    USC+GS
    WILD
    KERN
    ZEISS/OBERKOCHEN
    ZEISS/JENA
    K+E
    HILGER-WATTS

Instrument Serial Number - alphanumeric, left-justified.

NGS Survey Equipment Code - see ANNEX F.

Data Code
(*20* - Instrument Information Record)

Sequence Number
Increment by 10 on successive records to allow for insertions.

Example data: NGS; ZEISS/OBERKOCHEN NI1; 23190760; *20*; 7502710 05

Note: Omit for those instruments for which *20* record(s) containing identical information have been given in another line of this data set - or in a previously submitted VERT OBS data set.

21 Rod Information Record. Submit this record for every rod (identified by the respective Survey Equipment Code and Rod Serial Number) once initially with or without one or more *22* (Rod Standardization) and/or *23* (Rod Calibration) Records for that rod - see footnote.

```
0000000001111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

Sequence Number
Increment by 10 on successive records to allow for insertions.

Data Code
(*21* - Rod Information Record)

NGS Survey Equipment Code - see ANNEX F.

Rod Serial Number - alphanumeric, left-justified.

Manufacturer - examples:
USC+GS
WILD
KERN
ZEISS/OBERKOCHEN
ZEISS/JENA
K+E
HILGER-WATTS

Model or Type - examples:
INVAR
NILEX
LOVAR
WOOD

Agency which owns or has the custody of the rod.
For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.

Rod Units = CF, CM, CY, or HC - see below.
Rod Units:
CF-centifoot (0.01ft)
CM-centimeter (0.01m)
CY-centiyard (0.01yd)
HC-half centimeter (0.005m)

Graduation Code - see above.
1-line graduation (single scale)
2-line graduation (double scale)
3-block graduation (including checkerboard)
4-other

Example record:

Sequence Number	Data Code	NGS Survey Equipment Code	Rod Serial Number	Manufacturer	Model or Type	Agency	Rod Units / Graduation Code
nnnnnn	*21*	316	20900	KERN	INVAR	NGS	HC2
iiiiii	s	iis	ii	aaaaaaaaa	aaaaaaaaaaaaaaaaa	aaaaaaaaaaaa	aaaaaaaaaaaaaaaaaaaaaaa aa bbbbbbbbb

```
0000000001111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

Note: Aside from being required at least once initially for every rod, this record must precede every *22* and/or *23*,...,*22* and/or *23* record group subsequently submitted for any given rod.

22 Rod Standardization Record. Submit this record for every rod (with or without accompanying *23* record(s)) once for each past standardization or calibration (to form historical file) and whenever restandardized or recalibrated (NOT REQUIRED FOR 3RD AND LOWER ORDER) - see footnote.

```
000000 0001 111 1111112 222222 223333 3333334444444444555555555 5666666666667777777777 8
123456 7890 123 4567890 123456 789012 345678901234567890123456 789012345678901234567890
```

Column field descriptions:

- **Sequence Number** — Increment by 10 on successive records to allow for insertions.
- **Data Code** (*22* - Rod Standardization Record)
- **NGS Survey Equipment Code** — see ANNEX F.
- **Rod Serial Number** — alphanumeric, left-justified.
- **Laboratory or other source of standardization** — see ANNEX C. Enter MAKER if furnished by the manufacturer.
- **Date of Standardization** — year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
- **Scale** — C-Celsius, F-Fahrenheit. **Standardization Temperature**
- **Coefficient of Expansion x10000** (i.e., enter with decimal point moved four places to the right) - see text.
- **A-Flag** — A-assumed, blank otherwise.
- **Rod Excess x1000** (i.e., enter with decimal point moved three places to the right) - see text.
- **Index Error in rod units** — see text.

NOTE - The *22* record is optional if <u>all</u> data elements hereunder are inferable from accompanying *23* records.

Optional if inferable from accompanying *23* record(s).

UNITS OF COEFFICIENT OF EXPANSION		
ROD	TEMPERATURE SCALE	
UNITS	C	F
CF	feet/degree C	feet/degree F
CM	meters/degree C	meters/degree F
CY	feet/degree C	feet/degree F
HC	meters/degree C	meters/degree F

```
nnnnnn *22* 016 120900 NBS    750211 C25.0 .0080 A -.0650 .01534
iiiiii s ii  ii  aaaaaaaaa aaaaaa iiiiii a ccccc ccccc a cccccc c ccccc bbbbbbbbbbbbbbbbbbbbbb
000000 0001 111 1111112 222222 223333 3 3333 3 44444 4 444455 5 555555 6666666666677777777778
123456 7890 123 4567890 123456 789012 3 4567 8 90123 4 567890 1 234567 8901234567890123456789 0
```

<u>Note:</u> Omit for those rods for which *22* and/or *23* record(s) containing identical data have been given in another line of this data set - or in a previously submitted VERT OBS data set.

23 Rod Calibration Record. In addition to the respective *22* record, submit one or more *23* records for every past single- and multiple-temperature calibration of the rod for which the data are available and when recalibrated (NOT REQUIRED FOR 3RD AND LOWER ORDER) – see footnote.

Field description	Example
Sequence Number — Increment by 10 on successive records to allow for insertions.	nnnnn
Data Code (*23* – Rod Calibration Record)	*23*
NGS Survey Equipment Code — see ANNEX F.	316120909
Rod Serial Number — alphanumeric, left-justified.	ssslll
Laboratory or other source of calibration — see ANNEX C. Enter MAKER if furnished by the manufacturer.	NBS
Date of Calibration — year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	750211
Scale — C-Celsius, F-Fahrenheit.	C
Calibration Temperature	25.0
Units of Measured Length (FT, MT, or YD).	MT

For each interval, specify the point on the rod (XXX in rod units) at which the calibration measurement starts, the point at which it ends, and the measured length of the respective interval (Xxxxxxx in feet, meters, or yards – as per Units of Measured Length).

Interval	Field	Example
INTERVAL 1	Starting Point in rod units.	aaa
	Ending Point in rod units.	aaa
	Measured Length — in feet, meters, or yards (see Units of Measured Length); decimal point implied after column 47.	lllll
INTERVAL 2	Starting Point in rod units.	ccc
	Ending Point in rod units.	ccc
	Measured Length — in feet, meters, or yards (see Units of Measured Length); decimal point implied after column 60.	ddd
INTERVAL 3	Starting Point in rod units.	iii
	Ending Point in rod units.	iii
	Measured Length — in feet, meters, or yards (see Units of Measured Length); decimal point implied after column 73.	fddd

Note: Omit for those rods for which *22* and/or *23* record(s) containing identical data have been given in another line of this data set – or in a previously submitted VERT OBS data set.

30 Field Abstract Record. Submit this record for the first (starting) survey point (bench mark or temporary bench mark) and thereafter for each elevation carried forward (possibly more than once for any given survey point) in the order of occurrence along the leveling line - see text.

```
00000000001111111111222222222233333333334444444444555555555566666666667777777777 8
123456789012345678901234567890123456789012345678901234567890123456789012345678 90
```

Sequence Number — Increment by 10 on successive records to allow for insertions.

Data Code (*30* - Field Abstract Record)

Survey Point Serial Number (SPSN) - see Chapter 5. Must be same as SPSN used in VERT DESC data set.

The designation entered in this field must be identical (character for character) with the designation given for the same point in the corresponding VERT DESC data set.

This is the primary designation which will be associated with the vertical control point for publication purposes. In every case, the designation must be edited in conformity with Guidelines for Survey Point Names and Designations (ANNEX D).

Designation - must not exceed 25 characters.

Units - see footnote.

Important: Data items hereunder must be keyed from the Field Abstract and not generated from the respective *41*/*42* records - see text.

Accumulated Distance

Accumulated Distance - see text. Enter left-justified and key the decimal point.

Units - MT, FT, or YD.

Field Elevation

Field Elevation - see text. Enter left-justified and key the decimal point. Prefix minus sign if applicable.

```
nnnnnn*30*0187D 1956                              KM23.49    MT57.11702
iiiiiiisiisiiiiaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaccccccccaaccccccccccbbbbbbbbbbbbbbbbbbbb
00000000001111111111222222222233333333334444444444555555555566666666667777777777 8
123456789012345678901234567890123456789012345678901234567890123456789012345678 90
```

Units:	MT - meters	FT - feet	YD - yards
	KM - kilometers	KF - kilofeet	SM - statute miles

40 Survey Equipment Record. Submit this record at the start of every day's work and whenever an item of survey equipment changes, height of instrument changes by 5 cm or more, the heights of the temperature probes change, or the collimation error is redetermined, to be followed by one or more *41* records for the runnings to which data on the *40* record are applicable.

NOTE - Collimation error data are not required for 3rd- and lower-order differential leveling.

| Time of Collimation Error Determination | Local Time - hours and minutes (HHMM). Time Zone - see ANNEX H. |

Tangent of Collimation Error x1000 (i.e., enter with decimal point moved three places to the right) - see text. Leave blank if none determined.

Height of middle temperature probe in centimeters.

Height of lower temperature probe in centimeters.

Height of upper temperature probe in centimeters.

Average height of instrument in centimeters.

| ROD 2 | Rod Serial Number - alphanumeric, left-justified. Must be identical to the serial number given on the corresponding *21* record |
| | NGS Survey Equipment Code - see ANNEX F. |

| ROD 1 | Rod Serial Number - alphanumeric, left-justified. Must be identical to the serial number given on the corresponding *21* record |
| | NGS Survey Equipment Code - see ANNEX F. |

INSTRUMENT	M-Flag - M if micrometer used, blank otherwise
	Instrument Serial Number - alphanumeric, left justified. Must be identical to the serial number given on the corresponding *20* record
	NGS Survey Equipment Code - see ANNEX F.

Date of Running(s) - year, month, day (YYMMDD).
If day is unknown, leave last two columns blank.
If month is unknown, leave last four columns blank.

Data Code
(*40* - Survey Equipment Record)

Sequence Number
Increment by 10 on successive records to allow for insertions.

Important: This must be the leading record of every *40*, *41*, *41*, ..., *41* set containing run-nings made on the same date using the same equipment and affected by the same collimation error.

****

41 Running Record. Submit this record for every running other than river/valley crossing. The *41* records for all runnings made on the same date, using the same equipment, to which the same collimation error applies must follow, as a group, immediately behind the respective *40* record.

Field Description	Sub-field	Example
Initials of the Observer - left-justified.		NLM
Elevation Difference - observed, uncorrected elevation difference determined by the running.	Elevation Difference - in the units indicated, left-justified.	MT-5.48392
	Units - MT, FT, or YD.	
Length of Running - if stadia data unavailable; leave blank otherwise.	Length of Running - in the units indicated, left-justified.	
	Units - see *30* record	
Stadia - enter to the nearest 0.1 of the respective rod unit. Note implied decimal point.	Sum of Foresight Stadia Intercepts	1563
	Sum of Backsight Stadia Intercepts	1572
Stadia Intercept Code - F-full, H-half.		H
Number of Setups in the running.		12
Wind and Sun Codes - see footnotes.	sun / wind	02
Temperature of Air	Temperature at ending time and place - left-justified.	18.920
	Temperature at starting time and place - left-justified.	
	Scale - C-Celsius, F-Fahrenheit.	C
Local Time in hours and minutes (HHMM).	Ending Time of running.	1713
	Starting Time of running.	
	Time Zone - see ANNEX H.	
Ending Survey Point Serial Number (SPSN) - must be same as SPSN on the corresponding *30* record.		009
Starting Survey Point Serial Number (SPSN) - must be same as SPSN on the corresponding *30* record.		0187
Date of Running - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.		750326
Data Code (*41* - Running Record)		*41*
Sequence Number — Increment by 10 on successive records to allow for insertions.		

Wind Code: 0 - less than 10 km/hour, 1 - 10-25 km/hour, 2 - more than 25 km/hour wind speed.

Sun Code: 0 - less than 25%, 1 - 25-75%, 2 - more than 75% of setups under sunny conditions.

Field Description	Sub-field
Elevation Difference – observed, uncorrected elevation difference determined by the crossing.	Elevation Difference – in the units indicated, left-justified.
	Units – MT, FT, or YD.
Total Length of the river/valley crossing.	Length of Crossing – in the units indicated, left-justified.
	Units – see *30* record
Local Time in hours and minutes (HHMM).	Ending Time of crossing.
	Starting Time of crossing.
	Time Zone – see ANNEX H.
Ending Survey Point Serial Number (SPSN) – must be same as SPSN on the corresponding *30* record.	
Starting Survey Point Serial Number (SPSN) – must be same as SPSN on the corresponding *30* record.	
Date of Crossing – year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	
Data Code (*42* – River/Valley Crossing Record)	
Sequence Number. Increment by 10 on successive records to allow for insertions.	

Example data (column positions):
MT0.61874   KM0.75   R1025110   014R1025110   2*75101801130   **2*75101801130**

43 Correction/Rejection Record. Submit this record for each running or river/valley crossing when 1) temperature profiles were measured in the field, 2) a rod correction can be determined using detailed rod calibrations furnished by the National Bureau of Standards, or 3) the running or river/valley crossing is to be rejected.

```
0000000000111111111122222222223333333333444444444455555555556666666666777777777 8
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

Field descriptions (by column position):

- **Sequence Number** — Increment by 10 on successive records to allow for insertions.
- **Data Code** — preceded and followed by asterisk (*43* - Correction/Rejection Record)
- **Date of Running or River/Valley Crossing** — year, month, day (YYMMDD)
- **Starting Survey Point Serial Number (SPSN)**
- **Ending Survey Point Serial Number (SPSN)**
- **Starting Time of Running or River/Valley Crossing**
- **Refraction Correction in mm.** Enter left-justified and key the decimal point.
- **Field/Office Rejection** — see note above.
- **Rod Correction in mm.** Enter left-justified and key the decimal point.
- **Temperature Scale** C - Celsius F - Fahrenheit
- **Mean temperature for upper probe.** Enter left-justified and key the decimal point.
- **Mean temperature for lower probe.** Enter left-justified and key the decimal point.
- **Mean temperature for middle probe.** Enter left-justified and key the decimal point.
- **Temperature Code.** O=Observed, P=Predicted.

Note - Field/Office Rejection Codes:

F = Field rejection
O = Office rejection
≠ = not rejected

Example row:

```
nnnnnn *43* 790914 01220 01231 452 -1.21  -9.81  C 19.1 20.1 19.4 P
iiiiii siis  iiiiii iiiii iiiii iii cccccccc ccccccccc a ccccc ccccc ccccc a bbbbbbbbbbbbbbbbbbbbb
0000000000111111111122222222223333333333444444444455555555556666666666777777777 8
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

****

Data Set Termination Record. This must be the last record of every data set submitted.

Data Set Structure: A VERT OBS Data Set consists of one or more leveling lines.

Data Set Identification Record	
10-series records *20*-series records (if any) *30* records *40*-series records	FIRST LINE
10-series records *20*-series records (if any) *30* records *40*-series records	SECOND LINE
: : : : : : : :	: : : : : : : :
10-series records *20*-series records (if any) *30* records *40*-series records	LAST LINE
Data Set Termination Record	

Job Code - preceded and followed by asterisk.

Sequence Number
Increment by 10 on successive records to allow for insertions.

6-40