

CHAPTER 4

DIRECTION

DIRECTION

Direction in cadastral cartography is the angular relationship of one line to another line; or one line to a meridian, without reference to the distance between them. One angular measurement of direction is done on a horizontal plane¹ and is called *horizontal direction*.

HORIZONTAL DIRECTION

Horizontal directions are measured in both a clockwise and counterclockwise direction from the zero base. Horizontal direction is also expressed as a bearing within a quadrant.

Horizontal direction should always be accepted as being a clockwise measurement, unless designated in some manner as being a counterclockwise measurement.

Horizontal direction may be based on four different meridians (1) geodetic (true) north, (2) magnetic north, (3) grid north, and (4) assumed north (direction measured from a line assumed to be, but is not geodetic north).

ANGULAR MEASURE

Angular measure is used for designating the value of horizontal angles. To determine how far an angle has been generated, a unit of measurement is required. At the same time an angle is generated, a corresponding arc is generated. When the line being turned makes one revolution, a circle is generated. Therefore, the circle is divided into divisions known as *units of arc*, that are used to measure angles. In other words, the unit of angular measure is the angle at the center of the circle subtended by one of the small subdivisions of the circumference.

There are several systems of angular measure; each designed for a specific purpose. They are:

1. The *sexagesimal* system. The most commonly used system in cartography, surveying, navigation and mathematics.
2. The *centesimal* system. This is the metric system of angular measure. Unlike other metric units of measure, the centesimal system has not been widely accepted. Even in some countries under the metric system, the sexagesimal system is used more than the centesimal system.
3. The *mil* system. This system is principally used by the military for artillery purposes. However, there are rare cases where the map system has been used on surveys and deeds.

4. The *radian* system. This is a fundamental method of measuring angles. It is used in advanced mathematics and is commonly used in highway spiral formulas.
5. The *point* system. This outdated system was used for navigation in the days of the big sailing ships.
6. The *cardinal and intercardinal* system. The cardinal points are often used in surveying and deeds. Intercardinal points are seldom used in surveys but are often used in deeds.

The Sexagesimal System

In this system the circle is divided into 360 *degrees* of arc. Each degree of arc is divided into 60 equal parts known as *minutes* of arc; and each minute of arc is divided into 60 equal parts known as *seconds* of arc.

Angles in this system are written, for example, as 47°20'33", which is read as "forty-seven degrees, twenty minutes and thirty-three seconds."

In the sexagesimal system north is zero degrees, expressed as 0°. East is ninety degrees (90°); south is one hundred and eighty degrees (180°); west is two hundred and seventy degrees (270°), and a full revolution to north is three hundred and sixty degrees (360°).

The Centesimal System

Also referred to as the metric system of angular measure. In this system each quadrant of a circle is divided into one hundred equal parts called *grads* or *grades*. Each grad is further divided into decimal parts.

Angles in this system are written, for example, as 275°72'89", which reads as "two hundred seventy-five point seven two eight nine grads;" or it may be written as 275°72'89", which reads as "two hundred seventy-five grads, seventy two centesimal minutes, and eighty-nine centesimal seconds."

The Mil System

In the mil system the circle is divided into 6400 equal parts known as *mils*. The mil (symbolized as m) is divided into decimal parts.

Angles in this system are written, for example, as 1625.39 m , which reads "one thousand six hundred twenty five point three nine mils."

The Radian System

This type of system has some advantages over the sexagesimal system for it relates the length of arc generated to the size of the angle. Radian measurement

also simplifies work with trigonometric functions in calculus.

Assume that an angle is generated, as shown in figure 4-1. If we impose the condition that the length of the arc (s), described by the extremity of the line segment generating the angle, must equal the length of the line (r), then we would describe an angle exactly one radian in size; that is, for one radian, $s = r$. The fact that the length of the circumference of a circle is 2π times the radius, tells us that there are 2π radians in a circle; and, there are π radians in 180° . Therefore, 1 radian is equal to 180° divided by pi, or $57^\circ 17' 45''$ (approximately 57.3°). Also, $1^\circ = \pi/180$ radians, or 0.017453 radians.

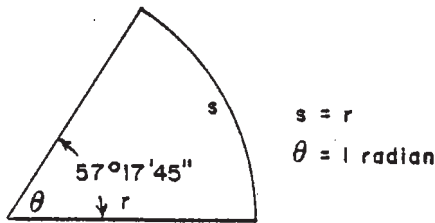


Figure 4-1

The simple relation $s = r\theta$, where s = the length of arc, r = the radius and θ is the size of the angle in radians, is convenient for solving spiral curve problems. Radian conversion tables are included in the appendix.

The Point System

This system is of historical interest only. It is occasionally used in navigation and may still be found on charts and marine compasses.

In the point system, the circle is divided into 32 points; each point equal to 11.75 degrees.

$$32 \text{ pts.} \times 11.75^\circ = 360^\circ$$

It was further divided into fractions of points.

The Cardinal and Intercardinal System

The cardinal and intercardinal system is directly tied to the sexagesimal, and point system.

The cardinal points are known as east, west, north and south, the four main points of the compass.

Intercardinal points are northeast, southeast, southwest, northwest, and are broken down to subintercardinal points such as north-northeast, east-northeast, south-southwest, etc.

The cardinal points have definite meanings. North is exactly 0° north; east is 90° , south is 180° and west is 270° .

Surprisingly enough, the intercardinal points have exact equivalents in degrees (see Table 12), although

few who use the terms realize they are referring to exact points in a circle.

When cardinal and intercardinal points are used in the description in a deed, the exact bearing equivalent should be used unless a specific point of call has been designated in the deed description; or unless a survey shows otherwise. Tables 12 and 13 show compass cardinal and intercardinal equivalents of sexagesimal angular measure and bearing measure.

MERIDIANS

Meridians are north-south lines from which direction is based. As stated earlier in this chapter, meridians can be geodetic (or true), grid, magnetic or assumed.²

Geodetic Meridian

This is the "true" north meridian on a great circle to the north and south geodetic (geographic) poles. Surveys should be considered as being based on a geodetic meridian unless specified in some manner as being grid or magnetic.

Grid Meridian

This is the meridian of a local or state plane coordinate system. In the Oregon Coordinate System the central meridian is the only grid meridian that is also a geodetic meridian (it is longitude $120^\circ 30'$).

Magnetic Meridian

Magnetic meridians are magnetic north. Contrary to popular belief, magnetic meridians are not on a great circle running to what is commonly known as the magnetic north pole. This is because the magnetic meridians are compass meridians, and the earth's magnetic influence on magnetic compasses at any point is always changing. At one point on the earth's surface, the needle of a magnetic compass may point to one certain position as being magnetic north, yet at a point only a few miles away the needle of the magnetic compass may put magnetic north in an entirely different position.

The horizontal angle between the magnetic meridian and the true meridian, at a point, is called magnetic declination.

Magnetic Declination

The meridian indicated by the needle of a magnetic compass seldom coincides with geodetic north. As explained above, this difference between magnetic

and geodetic meridians is known as magnetic declination. These declinations change during the day (diurnal), and they change by the day and annually. The changes in declination are known as *diurnal variations*, *daily variations* and *annual variations*. Unpredictable variations are called *irregular variations*. Unpredictable, but important changes in variations, are called *secular variations*.

When the compass needle points westward of true north, the magnetic declination is *west*. When the compass needle points eastward of true north, the magnetic declination is *east*. (Note: All magnetic declinations in Oregon are between 18° east and 23° east.) Figure 4-2 illustrates the relationship of magnetic and true meridians with easterly and westerly variations.

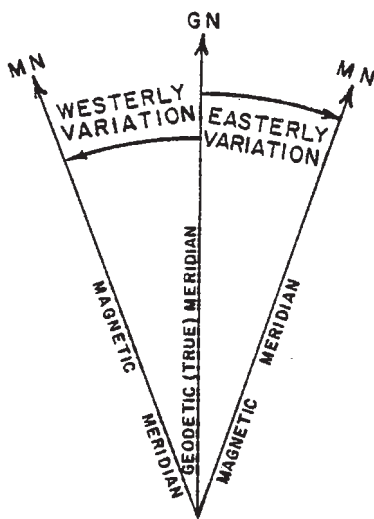


Fig. 4-2

Remember, the magnetic declination at any point is not a constant value, but is always changing.

Angular values added to the magnetic azimuth of a line gives the true azimuth of the line. Because of the constant variations in magnetic declination, true azimuths determined this way cannot be relied on closer than to about 15 minutes of arc (.25 degrees).

Information on past and present declination of the earth's magnetic field is available from the "Environmental Data Service, National Oceanic and Atmospheric Administration" of the U.S. Department of Commerce (abbreviated N.O.A.A., formerly the U.S. Coast and Geodetic Survey). The present value of magnetic declinations of cities, townships, or other points of interest, can be derived from *isograms* or *isogones*³ on *isogonic charts* from the N.O.A.A.

Information on the magnetic fields in past years, often needed for plotting or rerunning old surveys, is available from the N.O.A.A. Tables are available giving values for specified locations of magnetic declina-

tion on a 1° geographic grid from the earliest date of valid observations to the present; at ten-year intervals up to the year 1900, and at five-year intervals thereafter. To derive values from the tables, the cartographer must interpolate for geographic position and for year. As an alternative to the hand computation from tables, a computer derived table can be furnished by the N.O.A.A. giving values for specified location in specified years.

On some maps and charts there are two 360° divisions of the circle; one circle inside the other. The outside circle is usually based on geodetic north and the inside circle is based on magnetic north. This graphic configuration is known as a *chart rose*. The magnetic variation is noted in the center of the chart rose for the year stated. Included in the chart rose is a notation as to the annual increase, or decrease, in variation (to the nearest minute of variation). At some geographic locations there may be no annual change in variation. This will also be noted in the chart rose.

On many of the old Government Land Office plats, the variations are noted at each section corner, and at the right-hand side of the plat. These were the variations at the time the townships were surveyed; however, they will not be the present variations. In the original survey of Township 31 South, Range 13 West, W.M., the variations were from 18°30' east to 19°15' east. Figure 4-3 illustrates how this is noted on the G.L.O. plat.

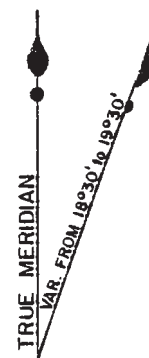


Fig. 4-3

LOCAL ATTRACTION

Local attraction is a term to denote any local influence that causes *deviations* of the magnetic needle in a compass. A deviation is when the local attraction causes the needle to be deflected from the magnetic meridian; being the angle between the compass magnet and the true magnetic meridian.

Some sources of local attraction are (1) magnetite (loadstone), (2) metal structures, (3) electric power lines, (4) steel railroad rails, (5) surface and underground pipes, (6) automobile and trucks, (7) wire fences, and (8) other permanently fixed objects of iron and steel. Ordinary iron ores do not attract a magnetic compass needle unless those ores contain magnetite or pyrrhotite.

AZIMUTH

Azimuth is direction, expressed as a horizontal angle, measured clockwise from a zero line (north or south). Every line has two azimuths depending on the observer's position. For example, in figure 4-4 a survey progressing from point A to point C generates the forward azimuths a or a^1 . When observing from point C to point B, the back azimuths b or b^1 are generated.

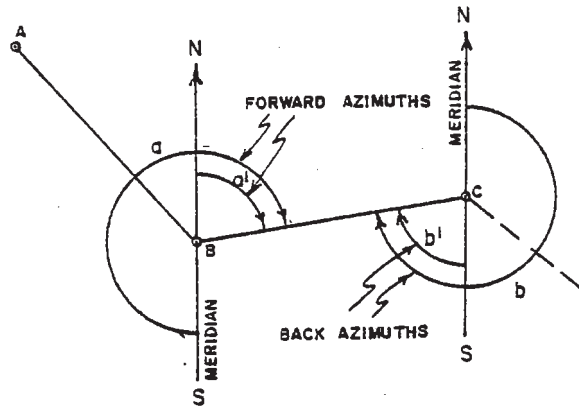


Figure 4-4

The forward and back azimuths are written as angles in the sexagesimal units. Forward and back angles of a line should differ by 180° for the purpose of plane surveying. Azimuths may be categorized as *true azimuths*, *grid azimuths* or *magnetic azimuths*.

True Azimuth

True azimuths are based on a true north (geodetic) meridian. Unless noted as grid or magnetic azimuths, in some manner, azimuths should be considered as being based on a true north meridian.

Grid Azimuth

Many surveys are based on the Oregon Coordinate System or on a local coordinate system. Coordinate systems are based on the assumption that a small portion of a geometric figure will nearly coincide with a narrow strip of the earth's surface, and that the surface of this geometric figure can be developed into a plane. A system of squares, called a rectangu-

lar grid, is superimposed over the developed plane surface. One line of this grid, the principal meridian, coincides with the geodetic meridian. All other grid meridians differ from geodetic north by the value of θ , the mapping angle.

Grid azimuths must always be determined with the north grid meridian designated as zero.

Magnetic Azimuths

Magnetic azimuths are measured with magnetic north as the line of zero azimuths.

Magnetic compasses are usually only used in surveying to detect large errors in horizontal angles, measured by more accurate methods, or to obtain approximate values for angles. Although forward and back azimuths of a line should differ by 180° , compass measured distances may vary several degrees from 180° because of local magnetic attraction. This factor, however, is usually corrected when the final survey drawing is prepared.

QUADRANTS

A quadrant⁴ of a circle is an arc of 90° ; or one quarter of a circle. The NE quadrant of a circle lies between 0° north and 90° east. The SE quadrant of a circle lies between 90° east and 180° south; the SW quadrant between 180° south and 270° west; and the NW quadrant between 270° west and 360° or 0° north.

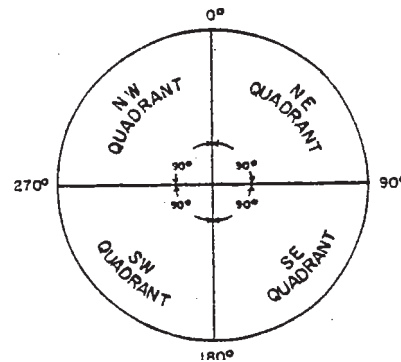


Figure 4-5

Quadrants are an important part of the bearing system of direction. In that system, the quadrants are as labeled in figure 4-5, but the cardinal points have slightly different sexagesimal values; north is 0° and south is 0° , east is 90° and west is 90° .

Quadrants of rectangular coordinates are any part of the four parts into which a plane is divided by the coordinate axes lying in that plane. For example: The quadrants of a section are the NE $\frac{1}{4}$, SE $\frac{1}{4}$, NW $\frac{1}{4}$ and SW $\frac{1}{4}$ of the section; the quadrants of a $\frac{1}{4}$ section are the NE $\frac{1}{4}$, SE $\frac{1}{4}$, NW $\frac{1}{4}$ and SW $\frac{1}{4}$ of the $\frac{1}{4}$ section.

BEARINGS

The bearing of a line is its direction within a quadrant of a circle with reference to a meridian.

Bearings are measured clockwise and counterclockwise; clockwise in the NE and SW quadrants, counterclockwise in the NW and SE quadrants.

A bearing is identified by naming the end of the meridian from which it is reckoned (north or south), and the direction from that meridian (east or west). Thus an angle generated from the north end of the meridian and turning clockwise in an easterly direction would be a NE bearing. If, for example, the angle generated was 45° , the bearing would be $N\ 45^\circ\ E$.

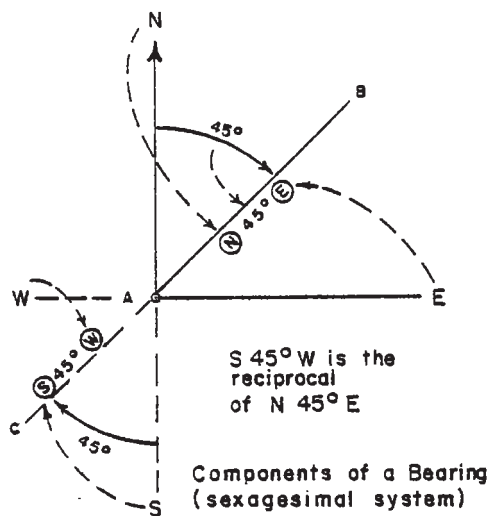


Figure 4-6

Every bearing has a reciprocal of that bearing; for example, the reciprocal of line AB in figure 4-6 is line AC. Line AC has an identical angular value to that of AB; however, line AC would be generated from the south end of the meridian in a westerly direction. Therefore, it would be identified by the letters S and W, or $S\ 45^\circ\ W$. Likewise, the reciprocal of a NW bearing would be a SE bearing of equivalent value.

Another method of clarifying the direction of a bearing is to use the first and last letters in the bearing (the only letters in a bearing) to determine what quadrant the bearing is running from. For example, the bearing $N42^\circ30'W$ would be running from the angle point (A

in figure 4-6) through the NW quadrant. Imagine that each point in a traverse is the center of a compass. In figure 4-7, line AB is running from point A from the SE quadrant to point B. Therefore, line AB would be a south and east bearing, or $S40^\circ E$. Likewise, line BC is running from the SW quadrant so the bearing is a south and west bearing, or $S44^\circ W$, and line CD would be a north and east bearing, or $N72^\circ E$.

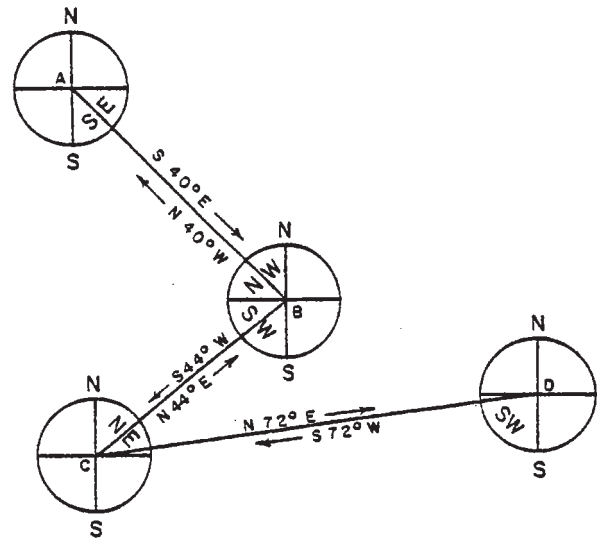


Figure 4-7

The traverse DC, CB and BA would be the reciprocal, of traverse AB, BC and CD. Line DC would be running from the SW quadrant and would therefore be a south and west bearing, or $S72^\circ W$ (the reciprocal of $N72^\circ E$). The bearings $N44^\circ E$ and $N40^\circ W$ would be the reciprocals of $S44^\circ W$ and $S40^\circ E$.

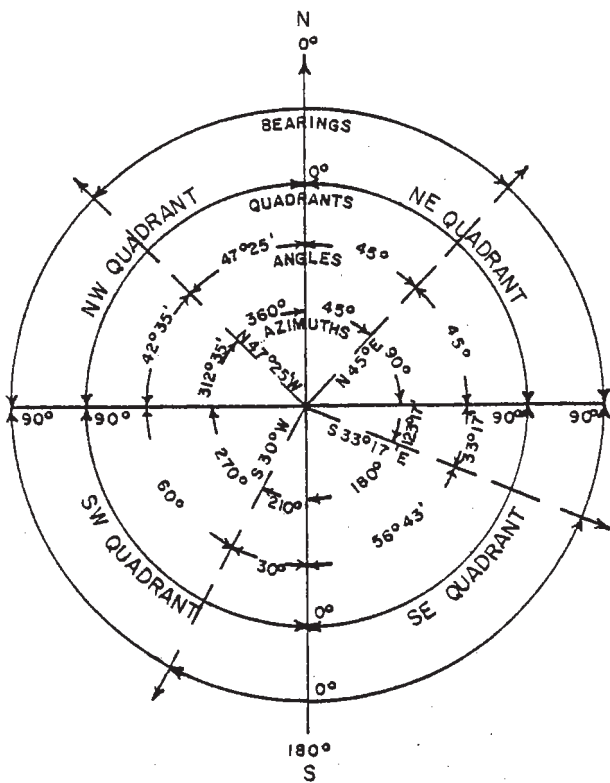
At present, bearings used in cadastral cartography are in sexagesimal units. They can be in degrees, minutes and seconds.

Bearings, like azimuths, can be true, grid or magnetic.

Figure 4-8 illustrates the relationship between azimuth, bearings, quadrants and angles.

DEFLECTION ANGLES

A deflection angle is the clockwise or counterclockwise angle from the prolongation of a line. Deflection angles are always less than 180° . Figure 4-9 illustrates clockwise and counterclockwise deflection angles.



RELATIONSHIP BETWEEN AZIMUTH, BEARINGS, ANGLES and QUADRANTS.

Figure 4-8

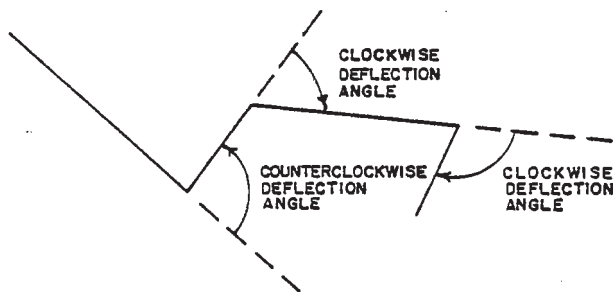


Figure 4-9

PLOTTING ANGLES & BEARINGS

The most accurate method of plotting a traverse is by *plotting by coordinates*. If a traverse is to be plotted by angles or bearings, an *engineer's drafting machine* must be used.

Angles can be plotted with hand protractors; however, this is a very poor tool for accurately plotting a traverse. It is a common source of plotting errors. In addition to being inaccurate, protractors are more

time consuming than a good drafting machine. The protractor is, however, an excellent tool for checking for large angular errors.

The Drafting Machine

Cadastral cartography demands the utmost skill and accuracy in laying out angles and bearings. A drafting machine is a precision instrument that is used to lay out angles and bearings. When compared to a hand protractor, the drafting machine can save up to 50 percent of the time required to plot by protractor. Because the machine has the ability to retain a constant meridian, accuracy can be increased as much as 75 percent when compared to hand protractors.

A drafting machine combines the features of a T-square, triangle, straightedge and protractor. There are drafting machines for architectural drafting, mechanical drafting, structural drafting, and civil engineering drafting. The only significant difference between the different types of drafting machines is in the type of *drafting machine head*. For cartography, the *civil engineering head* is desirable.

Drafting machines are available for any size table, and there are special machines designed for tilt-top drafting tables.

The civil engineering drafting machine head is, in effect, a precise *engine divided protractor* designed for extreme accuracy in plotting. Some civil engineering heads have double verniers that read up to one minute of arc. Most civil-engineering drafting machines, such as Bruning Machines, have automatic stops at 15-minute intervals.

The machines are equipped with *base-line settings* which will allow the cartographer to adjust the drafting machine to any meridian. Figure 4-10 illustrates the working components of a typical drafting machine (in this case, a Bruning 48-110 civil engineering machine).

The features of each make machine will vary, but in effect, most machines have nearly the same components. The quality of engineering head and ease of operation are the two main features to examine when choosing a machine.

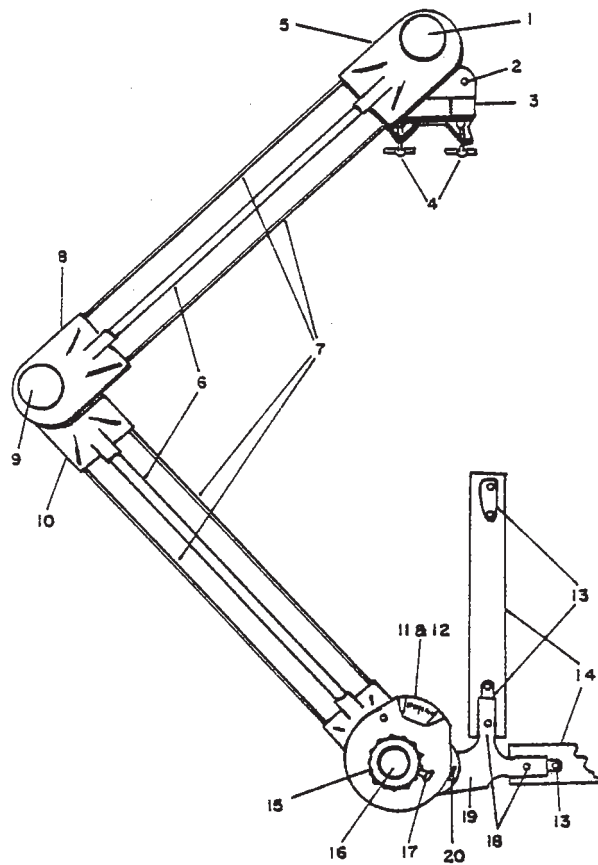
Drafting machines can be purchased that operate on a sliding track rather than rotating swivel arms. These are best suited to large drafting tables. They are ideal for laying out large base control maps.

When the drafting machine is mounted to the drafting table, a meridian will remain constant anywhere on the table (as long as the head remains locked in place). Figure 4-11 illustrates how a meridian remains constant even though the drafting machine arm is ro-

tated. In figure 4-11, only the lower arm was rotated; however, either arm can be rotated without losing the meridian. This ability to maintain meridian is one of the key features that makes a drafting machine superior to a hand protractor.

By releasing the base-line brake, the machine can be oriented to any other meridian; for example, from a true meridian to a grid meridian.

With the base-line brake locked, the protractor can be adjusted to any angle or bearing.



- | | |
|-------------------------|--------------------------|
| 1. Mast control knob | 11. Protractor circle |
| 2. Leveling screws | 12. Protractor vernier |
| 3. Clamp casting | 13. Chuck plates |
| 4. Clamp screws | 14. Straightedges |
| 5. Clamp bracket | 15. Base-line lever |
| 6. Arm | 16. Head control knob |
| 7. Bands & covers | 17. Touch control button |
| 8. Upper elbow bracket | 18. Scallock® |
| 9. Elbow control knob | 19. Scale square |
| 10. Lower elbow bracket | 20. Wing nut |

Figure 4-10

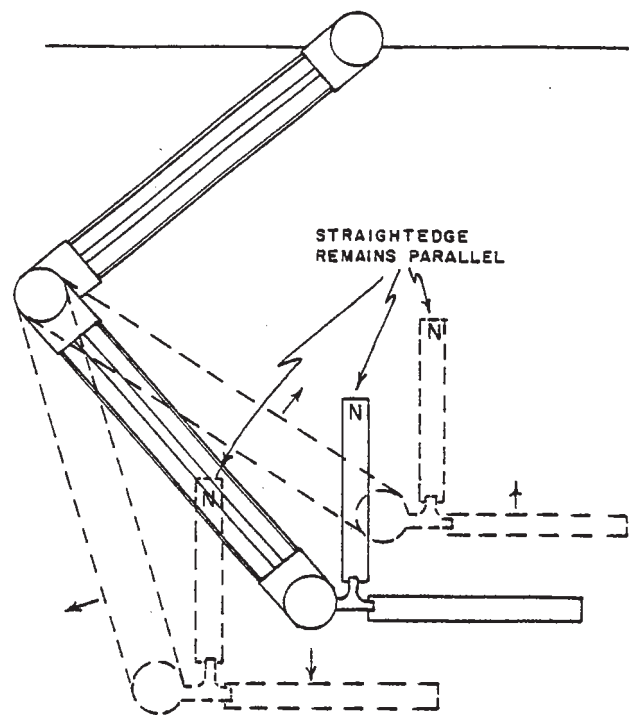


Figure 4-11

The Drafting Machine Protractor

The part of the machine that shows the units, or divisions of arc, is the protractor. It consists of the *circle*, on which the divisions of *degree* are shown; and the *vernier*, in which the divisions of *minutes* are shown. Figure 4-12 illustrates a typical protractor circle and vernier.

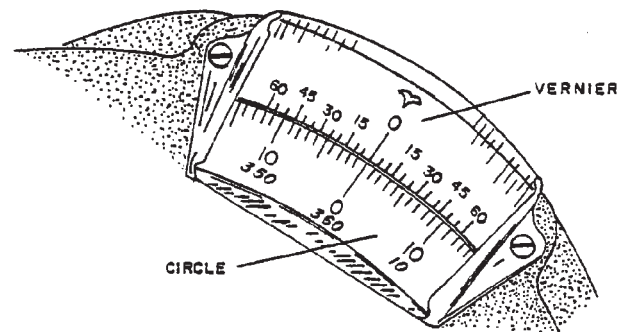


Figure 4-12

Most protractor circles are marked from zero degrees to three hundred and sixty degrees; and in ninety-degree quadrants — each from zero degrees to ninety degrees (for reading bearings).

The smallest accurate reading of a protractor is referred to as the *least count* of the vernier. In figure 4-12, the least count of the vernier is five minutes. This is acceptable for cadastral purposes; but a vernier with a least count of one minute, such as that

illustrated in figures 4-13 and 4-14, is desirable for cadastral cartography.

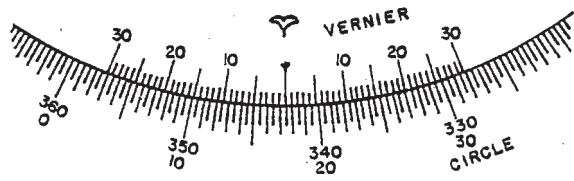


Figure 4-13

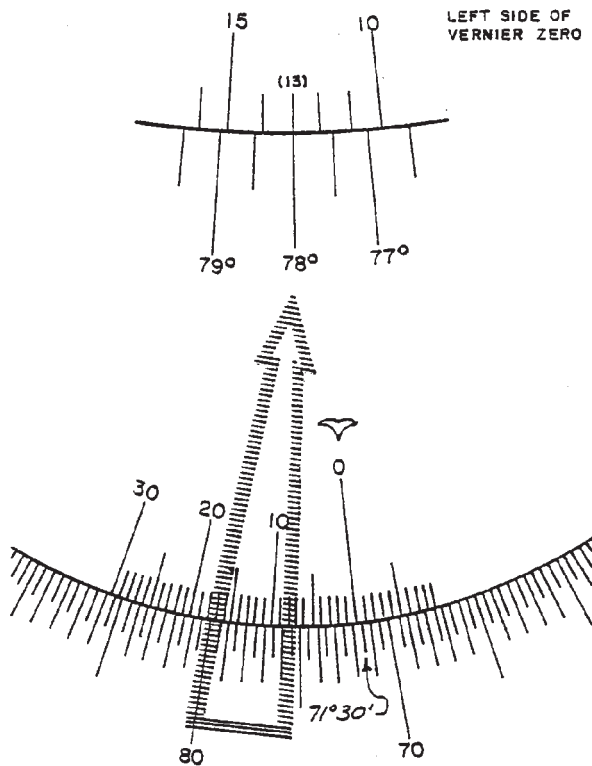


Figure 4-14

The protractor on a drafting machine is very similar to that of a surveyor's transit; and for all practical purposes, the drafting machine is *the cartographer's transit*.

Verniers

The vernier in figure 4-12 is an *outside vernier*, that is, it is located on the outside edge of the circle. Some verniers, such as the verniers in figures 4-131 and 4-14, are *inside verniers* located on the inside edge of the circle. The location of the vernier does not affect the manner in which it is to be read.

Reading a vernier is a stumbling block for most beginning cartographers; however, with a little practice it is no more difficult than reading an engineer's scale. Some of the important rules for using the protractor circle and vernier are:

1. If the protractor does not have an attached magnifying glass, use a hand magnifying glass to get an accurate reading.
2. Always view the protractor from directly above the circle and vernier. This will prevent erroneous readings resulting from *parallax*.
3. Always read the side of the vernier in which the angle is being generated.
4. Always make sure that you are reading angles in the right quadrant.
5. Never put a pen or pencil mark on the circle or vernier. The circle and vernier should be kept as clean as possible.
6. Always make certain that you are oriented to the proper meridian and have the base line brake tightened.
7. Straight edges should always be tightened so that there is no play in either straightedge.
8. Never lay an angle with a triangle. Always use the drafting machine straightedge.
9. Always make certain that the vertical and horizontal straightedges are at 90° from each other. Most cartographers use the horizontal straightedge for all bearings because it is difficult to maintain 90° between the two straightedges.
10. Always tighten the *wing nut* (No. 20 in figure 4-10) after the protractor is set on the desired bearing.

In addition to the above rules regarding the use of the machine:

1. When plotting a bearing, the pencil lead should be sharp and the point of the lead should be snug against the straightedge.
2. The drafting media must be securely fastened to the drafting table surface.
3. After leaving your work for a considerable amount of time, such as overnight, check the machine with the meridian you are using. A good rule is to check the machine setting as often as possible.

Failure to abide by the above rules will result in costly errors.

Figure 4-13 shows a typical *inside vernier* protractor.

The following step-by-step instructions are for setting a bearing on the enlarged view of an inside vernier protractor shown in figure 4-14. The given bearing is N 71°43' E.

1. Depress the touch control button (or equivalent device) and line up the zero on the circle with the zero on the vernier. Release the touch control button. (The protractor will probably

have an *automatic stop* which will secure the zero setting.)

- When set at zero, the horizontal straightedge should be in a vertical position. If not, loosen the *wing nut* and align the straightedge as close as possible to the chosen meridian. Tighten the wing nut.

Often it is simpler to establish an east-west parallel (or base line). By doing this it is not necessary to rotate the horizontal straightedge to a vertical position.

- Loosen the *base-line lever* and align the straightedge to the meridian (or east-west base line). Tighten the base-line lever.

On some drafting machines step 3 can be eliminated by carefully aligning the machine at step 2.

You are now ready to set the bearing (N 71°43'E) on the protractor.

- Depress the touch control button and set the protractor in the proper quadrant (in this case, the NE quadrant, or between zero degrees north and ninety degrees east).
- With the touch control button still depressed, set the 71° reading on the circle, with the zero reading on the vernier.

We know that 43' lies between 30' and 1°, so:

- Move the straightedge in a *counterclockwise* direction until the 71°30' graduation on the circle lines up with the zero graduation on the vernier.

To set the machine at 71°43', we still need an additional 13' of arc.

$$71^{\circ}30' + 13' = 71^{\circ}43'$$

However, the circle is not graduated to 43' so we must use the vernier.

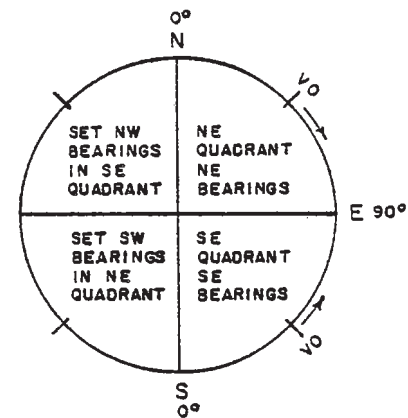
- With the touch control button still depressed, slightly move the straightedge in a counterclockwise direction until 13' on the vernier is in line with the nearest degree graduation on the circle (in this example, at 78°). Release the touch control button. The bearing is set.
- Check your setting before plotting the line.

Remember, the knowledge of *direction, angles, azimuths and bearings* will be worthless if you do not exercise care when setting the protractor.

The best method of practicing machine—protractor settings is to practice setting the machine on lines of known bearings on an existing map.

Figure 4-15 illustrates one very important rule: NW bearings are always set, on the machine, as if they were SE bearings (the reciprocal of NW); and SW

bearings are always set, on the machine, as though they were NE bearings (the reciprocal of SW).



VO represents vernier zero. The direction of the arrow represents the proper side of vernier readings, when turning bearings in that quadrant.

Figure 4-15

By doing this, the straight-edges will not have to be set to the left of the drafting machine head, which is nearly impossible on many machines, and impossible on others.

Note: Each manufacturer of drafting machines will have special names for machine components. For example, the Bruning *base-line control lever* is called a *base-line selector* on "Universal Drafting-Machine Corp." machines. The Bruning *touch control* knob is called an *index control* by universal; and the Bruning *wing nut* is called a *vernier clamp* by Universal. Regardless of the part name, they are located in the same general location on each machine, and their operation is the same.

PROBLEMS & ERRORS

Many direction problems and errors are not due to poor surveys. If angles and bearings do not fall in place with common lines on a map, the first step to solving the problem is to carefully retrace your steps in plotting. In many instances it is the cartographer who has made the error, not the surveyor. Problems and errors could be the result of any of the following:

- Transposition of bearings or dimensions from a survey to a map.
- Careless setting of the drafting machine protractor, or parallax.

3. Erroneous linear measurements. Many times it is the mismeasurement of distances that create bearing and angle problems.
4. Failure to check drafting machine settings.
5. Loose straightedge.
6. Paper not firmly attached to drafting table surface.
7. Accumulative plotting errors. (A very common problem when plotting by bearings and angles. The accumulative errors can be virtually eliminated by plotting by coordinates.)
8. Failure to recognize surveys where assumed meridians have been used by the surveyor. Often,

certain lines are assumed to be based on geodetic north, when actually they are not. The assumed meridian is usually a product of the laymen, rather than the professional surveyor.

9. Failure to orient lines to known lines of accuracy. And, of course, some lines plotted from surveys appear to be incorrect when, in fact, they are correct. For example, many overlaps appear to be the result of incorrect bearings when actually the overlap exists on the ground. This problem will be discussed elsewhere in the manual.

Endnotes

1. A plane, perpendicular to the direction of gravity.
2. Assumed meridian is discussed in the section on "Direction Problems."
3. An isogram, or isoline, is a line which connects points of equal value.
4. The root of the word quadrant is quadran which means the fourth part, or the quarter of any number, measure, or quantity.