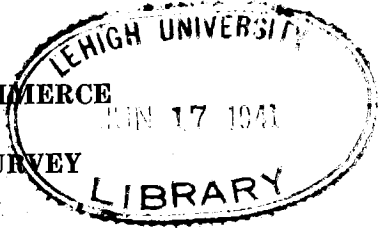


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U. S. DEPARTMENT OF COMMERCE
 JESSE H. JONES, Secretary
 ✓ COAST AND GEODETIC SURVEY
 LEO OTIS COLBERT, Director



THE PRESERVATION OF TRIANGULATION STATION MARKS

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GENERAL STATEMENT

The network of triangulation surveys of the U. S. Coast and Geodetic Survey includes thousands of monumented stations distributed throughout the United States. These stations are coordinated into a standard rigid system in which the distances and directions between adjacent monuments are held fixed and each station is in its correct relationship to all others established throughout the country. These stations are used by governmental mapping organizations and by local engineers and surveyors as control points for local projects. Individual projects based on survey monuments of the Federal system are determined in their correct relationship to all other surveying and mapping projects similarly connected. These monumented stations are therefore of great value in furnishing a means of connecting local surveying and mapping projects to the national system and thus insuring permanency of location. They are particularly valuable for property and boundary surveys, since a

survey corner properly connected to the Federal system may at any time be relocated by a competent engineer with certainty that the original location has been reestablished.

All persons are respectfully requested to protect and preserve these marks and to inform the Director, U. S. Coast and Geodetic Survey, Washington, D. C., whenever there is danger of disturbance or destruction of any mark or whenever any action is necessary to preserve a mark.

The marks established at a triangulation station by the Coast and Geodetic Survey consist of a station mark, two reference marks and an azimuth mark. The monument marking the station designates the exact location of the triangulation point determined. Usually a subsurface monument is placed below the surface monument and this can be used in case the upper mark is destroyed. The two reference marks are established close by to aid in finding the triangulation station. The distance and direction from the station monument to each of the reference marks is measured and from these data the triangulation station can be reestablished should the monument itself be destroyed. During the past decade an azimuth mark also has been set for practically every triangulation station established by this Bureau. Usually this mark is from 1/4 mile to 2 miles distant from the triangulation station. Its purpose is to make available to any local surveyor using the triangulation station an accurately determined azimuth (bearing) as an initial direction for his survey.

Quite often because of road improvements, or other engineering projects, it becomes necessary to move one or more of the marks at a triangulation station. Whenever this is necessary, it is urged that the engineer doing the work exercise the greatest care in preserving the accuracy of the location in order that the station may still serve properly the purpose for which it was intended.

The data for its triangulation stations are published by the Coast and Geodetic Survey and are available for use by engineers, surveyors, and the general public. These data include the description of the station and its latitude, longitude and azimuth, and also the plane coordinates and grid bearings. Accurate and reliable data of this nature are indispensable for cadastral and boundary surveys and for surveys in connection with large-scale engineering projects. It is therefore essential that definite records be kept of all changes affecting the data for the triangulation stations.

With the hope of encouraging cooperation in the preservation of station marks, there are printed in the following pages instructions for moving all classes of triangulation marks. In every case it is desirable that the marks should not be disturbed until new bronze disks are obtained from the office of the Coast and Geodetic Survey by the person who is to make the change. After the new marks have been set, the old tablets should always be removed from the old concrete monuments and forwarded to the Director, U. S. Coast and Geodetic Survey, Washington, D. C. Mailing bags, which may be used to send these marks without payment of postage, will be furnished by this Bureau.

It is requested that whenever marks are moved or reestablished a complete report be sent to the Director, U. S. Coast and Geodetic Survey, Washington, D. C., giving the new directions and distances, and including the record itself (not a copy) of the angles and dis-

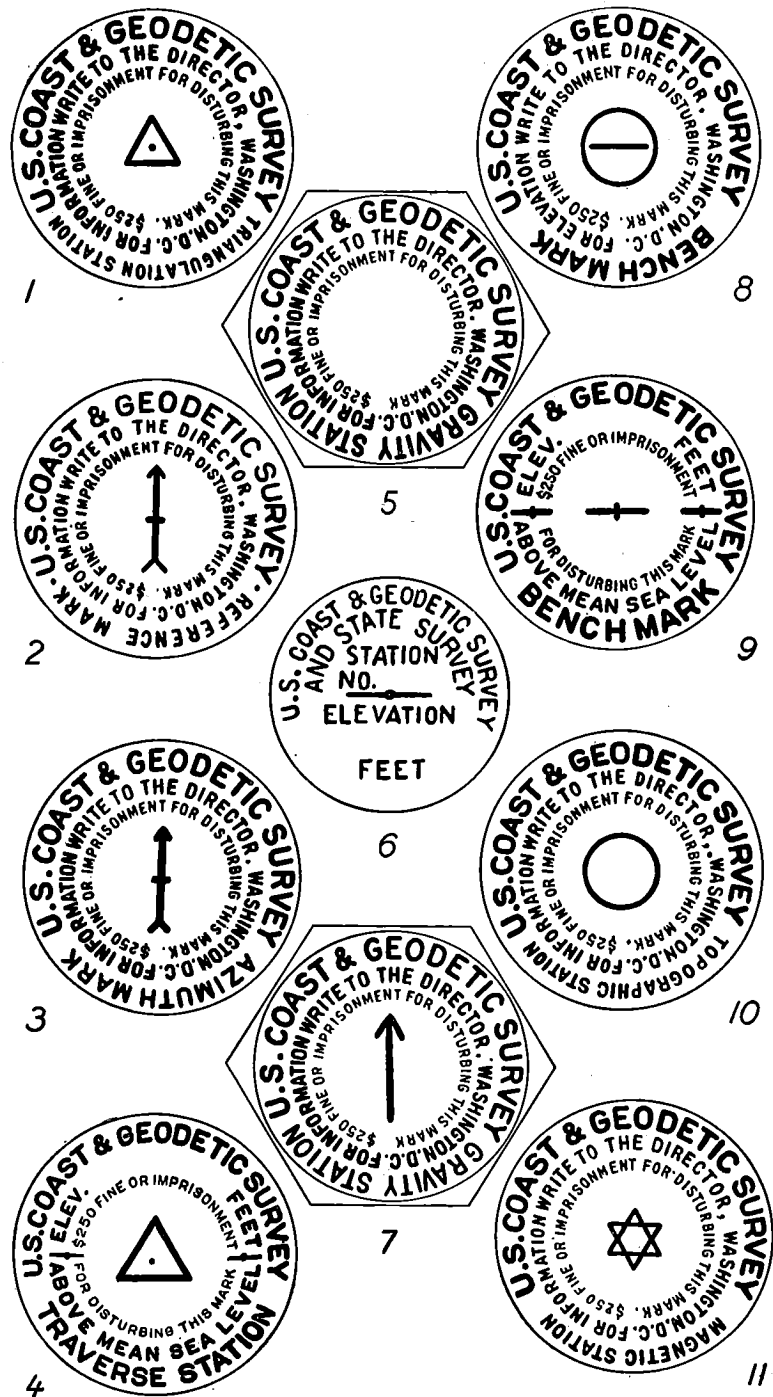


FIGURE 1.—Standard marks of the United States Coast and Geodetic Survey.

- | | | |
|--------------------------------|------------------------------------|-------------------------------|
| 1. Triangulation station mark. | 5. Gravity station mark. | 8. Tidal bench mark. |
| 2. Reference mark. | 6. Local control survey mark. | 9. Geodetic bench mark. |
| 3. Azimuth mark. | 7. Gravity station reference mark. | 10. Topographic station mark. |
| 4. Traverse station mark. | | 11. Magnetic station mark. |

tances measured, and a sketch showing the relative locations of the old and new marks.

In order to avoid confusion, it is requested that imprints of all marks be attached to the record. These imprints may be made by placing a sheet of paper over the disk and rubbing it with a fairly hard pencil held almost horizontally, until the legend is transferred to the paper. If this safeguard is followed, there will be no confusion regarding the identity of the marks involved and the necessary corrections can be made in the recorded data.

GENERAL DESCRIPTION OF MARKS

As stated on page 2, the present system of marks for triangulation stations established by the U. S. Coast and Geodetic Survey consists of a station mark, an azimuth mark and two reference marks. (See figure 1.)

The station mark is a bronze tablet, or disk, $3\frac{1}{2}$ inches in diameter, with a small drill hole in the center surrounded by a triangle. The upper surface has a cast inscription indicating that it is a "Triangulation Station" mark and giving the name of the Bureau. The smooth surface surrounding the triangle is stamped with the name of the station, and the year established.

The reference mark is a bronze disk, $3\frac{1}{2}$ inches in diameter, with an arrow inscribed on the upper surface pointing toward the station mark. The inscription indicates that it is a "Reference Mark," and the smooth surface about the arrow is stamped with the station name and an identifying number. It is customary to set two reference marks at each station. They are seldom over 100 yards from the station, and usually are within 50 yards. At a few stations, determined many years ago, the marks are not stamped with names and numbers.

The azimuth mark is a bronze disk, $3\frac{1}{2}$ inches in diameter with an arrow inscribed on the upper surface pointing toward the station mark. The inscription indicates that it is an "Azimuth Mark" and it is stamped with the station name and date. It is customarily set from $\frac{1}{4}$ to 2 miles from the station. Prior to 1935, a reference mark tablet was used as the azimuth mark. Usually this was stamped with the station name and the letters "AZIMUTH" or "AZI," and sometimes it was given a number the same as the reference marks.

Except in areas where there is solid rock or large boulders, these different tablets are, with few exceptions, set in concrete blocks 12 inches square on top (or 12 inches in diameter, if round) 14 inches square at the bottom (or 14 inches in diameter, if round), and 3 to 4 feet deep. In addition, at the station itself, there is a subsurface mark consisting of a triangulation tablet set in a smaller block of concrete, plumbed directly under the surface disk, and separated from the upper block by a few inches of earth. (See figure 2.) In a few instances, marks have been set in drain tiles or iron pipes.

RELOCATION OF MARKS

Marks established by this Bureau may have to be moved for the following reasons:

- (1) To permit clearing and free cultivation of soil.
- (2) To remove them from sites of new buildings or new developments, such as for highway construction, excavations, grading, paving, etc.

(3) Because of eroding shore lines and stream banks, and shifting of surface materials.

In general, a mark may be moved by lowering it in a vertical line to an elevation where it will no longer be in the way or in danger, or by shifting it horizontally to a new location.

Lowering the mark is the simplest and probably the most accurate method that can be used. It has the advantage that no horizontal

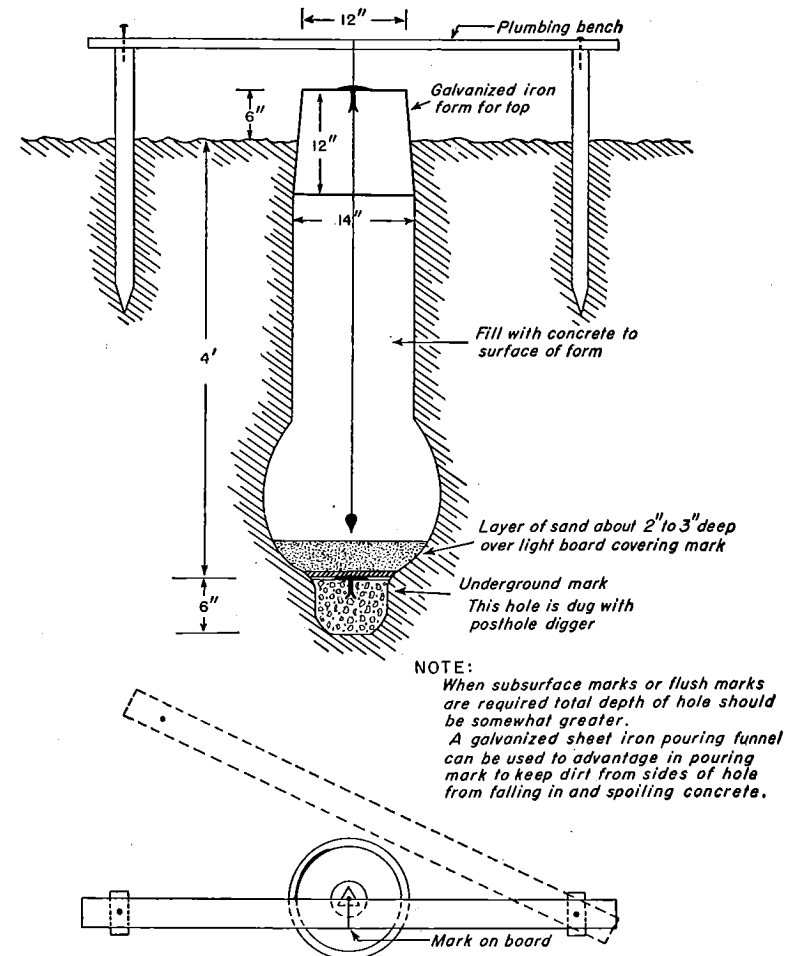


FIGURE 2.—Dimensions of surface and underground marks at triangulation stations. No underground marks are required for reference and azimuth marks.

lengths or azimuths are changed, and no corrections to published data are required. It should if possible be the method chosen. It will generally suffice where convenience of cultivation is involved, and in many instances where cutting or grading is to be done to a depth of 6 feet or less, and the excavation is not to be occupied by buildings or paving. One of the most frequent needs for moving stations is caused by the widening of highways along which marks were placed

in the original right-of-way lines. When the set-back is such that the mark will remain between the ditch and fence, it is usually best to lower it to make it conform to the new grade.

DIRECTIONS FOR LOWERING A MARK

Drive two stakes, preferably of 2 by 4 or 4 by 4 inch lumber, firmly into the ground on opposite sides of the mark, at distances of about 3 feet from it, and in such positions that the edge of a board laid from top to top of the stakes will pass approximately over the center mark. (See figure 2.) These stakes should be driven 16 or 18 inches into the ground, and project 4 to 6 inches above the elevation of the mark. They should be flat on top. If loose soil is encountered, the stakes may be placed farther from the mark and driven deeper.

Lay a smooth-surfaced board, 1 by 6 or 2 by 4 inches in size, across the tops of the stakes, and drive a nail through one end into one of the stakes. Suspend a plummet over the station mark, and adjust the board by swinging its free end until the edge of the board is directly over the center hole in the mark. Then tack the free end to the other stake or mark the top of the stake along the edge of the board with a sharp pencil or a knife cut.

Adjust the plummet exactly over the station, and mark the position of the plumbline on the edge of the board with a fine pencil or a knife cut.

Remove the tacked end of the board from the stake, and swing the board out of the way, leaving it attached by the single nail to the other stake, but with the free end supported to prevent strain on the stake.

Remove the concrete mark, and deepen the hole without disturbing the stakes. When the hole is deep enough, replace the mark, using care to see that its top surface remains horizontal.

Replace the board across the stakes in its original position by fitting the nail back into the hole or by using the marks on the stake at the loose end, and accurately center the station mark under the mark on its edge.

Tamp the earth firmly in filling the hole around the concrete, and again check with the plummet. If the position is correct, the job is completed.

When the mark is a station mark, as indicated by the triangle on the disk, a smaller subsurface mark will ordinarily be found under it. This must be lowered in the same manner, centered so as to be vertically under the surface mark, and separated from it by about 4 inches of earth.

As the concrete surface monuments weigh about 800 pounds each, adequate means for handling them should be at hand.

DIRECTIONS FOR MOVING A MARK HORIZONTALLY

A.—WHEN THE STATION MARK IS TO BE MOVED

Determine the best new site for the mark. If possible, the mark should be moved exactly in line toward or away from the azimuth mark. This will simplify the redetermination of the azimuth and result in a minimum loss of accuracy. If it is impractical to place the new monument on line with the azimuth mark because of topo-

graphic conditions or because the distance involved would be too great, it should be placed at a site nearest the old position from which the old mark and the azimuth mark are both visible, and where it will be free from disturbance.

New bronze disks will be furnished by this Office. Place one of these in a new concrete block, similar to the original mark, at the new site. In all cases where the station marks are placed in soil, a subsurface mark, consisting of a similar bronze disk set in a concrete block of about one cubic foot content, should be placed vertically below the surface mark, and separated from it by about 4 inches of earth. (See figure 2.) In removing the old station mark, its subsurface mark should, if possible, be left undisturbed.

It is next necessary to determine the position of the new station mark and to obtain the directions from it to the azimuth and reference marks. This should be done as follows:

(1) Measurements to be made when the new mark is on line with the old mark and the azimuth mark. (See figure 3.)

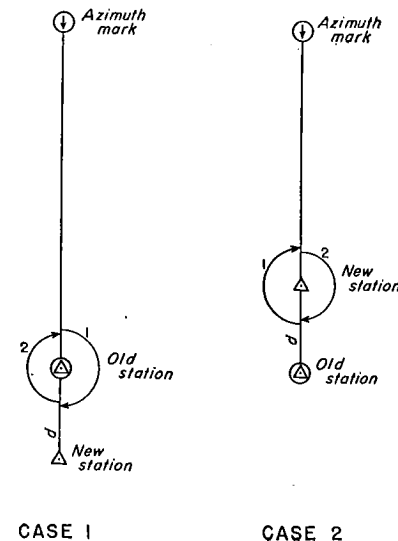


FIGURE 3.—Establishment of new station on line from old station to azimuth mark. Measure angle, 1, and explement, 2, and distance, d .

Carefully center the best available transit over either the old or the new mark depending on which one is nearer to the azimuth mark. In other words, if the new mark is in a direction *away* from the azimuth mark, occupy the old station mark; but if the new mark is *toward* the azimuth mark, occupy the new station mark. Measure the angle between the extreme marks by the method of repetitions. Two or more sets should be measured, in order to preserve the original accuracy. It will be noted that the outside or explement angle should also be measured in order to close the horizon. Both angles should be approximately 180 degrees. Measure to 0.001 foot, the distance from the new to the old station mark and to each of the reference marks (see footnote on p. 8). These measurements are

needed in order that this Bureau may have a definite written record of the change in position of the station. The old mark can then be destroyed. The bronze tablet should be broken out and forwarded to Washington.

(2) *Measurements to be made when the new mark is not on line with the azimuth mark.* (See figure 4.)

Carefully center the transit over the azimuth mark, and measure the angle between the old and new marks by the method of repetitions. (See sample record, figure 5a.)

Center the instrument over the old station mark and measure accurately the angle between the azimuth mark and the new station mark. (See figure 5b.)

Center the instrument over the new station mark and measure accurately the angles between the azimuth mark and each of the reference marks and the old station mark. (See figure 5c.)

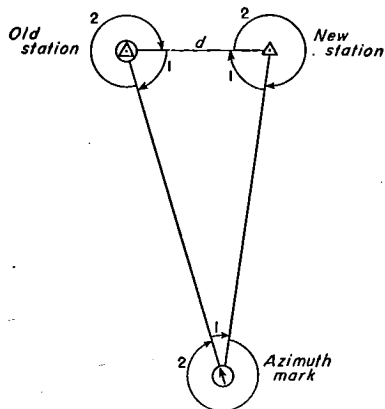


FIGURE 4.—Establishment of new station in any direction from old station. Measure angles, 1, and explements, 2, and distance, d.

Measure to 0.001 foot the horizontal distances from the old to the new station marks, and from the new station mark to the reference marks,¹ and record. The old mark can then be destroyed. If it is not necessary to excavate to the depth of the submark, leave the latter undisturbed.

B.—WHEN THE AZIMUTH MARK IS TO BE MOVED

In case the new azimuth mark can be set exactly on line toward or away from the station mark, proceed as in A and (1), page 7.

If it is impossible to place the new mark on line, place it at a site nearest the old position from which the station mark is visible and where it will be free from disturbance. (See figure 6.)

Center the transit accurately over the station mark and measure

¹The arrows on the reference marks will point toward the old station instead of the new station. (See figure 7.) It is not advisable, however, to attempt to correct this condition by loosening the disks and pointing the arrows toward the new station. Of course, if it becomes necessary to move the reference marks to new locations, the arrows may then be properly oriented with relation to the new station. The record should state whether or not this was done.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

HORIZONTAL

STATION: *Azimuth Mark* STATE: *Ill.*
OBSERVER: *P. T. H.*

ISLAND OR COUNTY: *Cook* DATE: *1/31/1941*
INSTRUMENT: *Berger Transit*

OBJECTS OBSERVED	TIME T.E.D. OR I.R.	H. M.	REF'S	ANGLE		REMARKS
				11-TH	11-TH	
<i>Old Station</i>	<i>D</i>	<i>0</i>	<i>00-00</i>	<i>0</i>	<i>0</i>	
<i>New Station</i>	<i>D</i>	<i>1</i>	<i>00-25</i>	<i>0</i>	<i>1</i>	
<i>New Station</i>	<i>D</i>	<i>6</i>	<i>02-32</i>	<i>0</i>	<i>0</i>	
<i>New Station</i>	<i>R</i>	<i>6</i>	<i>00-00</i>	<i>0</i>	<i>0</i>	<i>20.0 20.0 -03.8 = 16.2</i>
<i>New Station</i>	<i>R</i>	<i>0</i>	<i>00-00</i>	<i>0</i>	<i>0</i>	
<i>New Station</i>	<i>R</i>	<i>1</i>	<i>359-35</i>	<i>0</i>	<i>1</i>	
<i>Old Station</i>	<i>R</i>	<i>6</i>	<i>357-29</i>	<i>0</i>	<i>0</i>	<i>359-34-50</i>
<i>Old Station</i>	<i>D</i>	<i>6</i>	<i>00-00</i>	<i>30</i>	<i>30 30</i>	<i>45 47.5 - 03.7 = 43.8</i> <i>07.5</i>

FIGURE 5a.—Sample record of angle observations at azimuth mark.

HORIZONTAL

STATION: *Old Station* STATE: *Ill.*
OBSERVER: *P. T. H.*

ANGLES

ISLAND OR COUNTY: *Cook* DATE: *1/31/1941*
INSTRUMENT: *Berger Transit*

OBJECTS OBSERVED	TIME D. M.	TEL. D OR R	REF'S	ANGLE		REMARKS
				11-77	11-77	
<i>New Station</i>	<i>D 0</i>	<i>00-00</i>				
<i>Azimuth Mark</i>	<i>D 1</i>	<i>98-17</i>				
<i>Azimuth Mark</i>	<i>D 0</i>	<i>00-00</i>				
<i>New Station</i>	<i>D 1</i>	<i>261-43</i>				

*Distance old
station to new
station = 23.463 ft.*

FIGURE 5b.—Sample record of angle observations at old station.

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HORIZONTAL

STATION: *New Station* STATE: *Ill.*
OBSERVER: *P. T. H.*

ANGLES

ISLAND OR COUNTY: *Cook* DATE: *1/31/1941*
INSTRUMENT: *Berger Transit*

OBJECTS OBSERVED	TIME D. M.	TEL. D OR R	REF'S	ANGLE		REMARKS
				11-77	11-77	
<i>Azimuth Mark</i>	<i>D 0</i>	<i>00-00</i>				
<i>Old Station</i>	<i>D 1</i>	<i>81-18</i>				
<i>Ref. Mark No. 1</i>	<i>D 1</i>	<i>85-32</i>				
<i>Ref. Mark No. 2</i>	<i>D 1</i>	<i>176-47</i>				

*Distance 92.12 ft.
Distance 118.65 ft.*

FIGURE 5c.—Sample record of angle observations at new station.

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the angle between the old and new azimuth marks by the method of repetitions, as in (2), page 8.

Measure and record the distance between the old and new azimuth marks. If the new mark is established at a considerable distance from the old, the estimated distance from the station mark to the new azimuth mark will be sufficient.

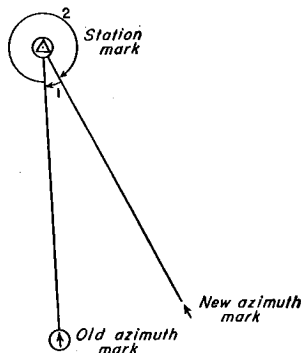


FIGURE 6.—Establishment of new azimuth mark.
Measure angle, 1, and exponent, 2.

C.—WHEN BOTH STATION AND AZIMUTH MARKS ARE TO BE MOVED

Proceed as in A, page 6, to establish the new station mark.

With the new station mark in place, proceed as in B, page 8, to reestablish the azimuth mark. It is preferable where possible to place the new marks on a line through the original sites.

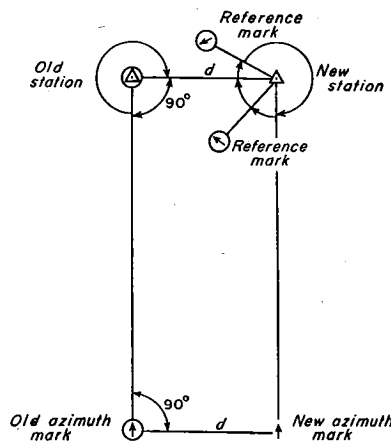


FIGURE 7.—Establishment of new station and azimuth marks at right angles and equidistant from line joining old marks.

The two distances, d , are equal as are also the two right angles, of course. Measure all angles indicated by circular arcs.

D.—SPECIAL CASE OF C

Occasionally it may be desirable to move both the station mark and the azimuth mark at right angles to the line connecting them, and in the same direction. If the distances can then be made exactly the

same, the line connecting the new marks will be parallel to, and have the same azimuth as that between the original marks. (See figure 7.)

Center the instrument over the original station mark and sight on the original azimuth mark. Lay off an angle of 90 degrees and establish the new station mark at a suitable distance from the old mark. After the new station mark has been set, measure the angle at the old station mark between the new station mark and the old azimuth mark, using the method of repetitions explained in (2), page 8.

Measure the horizontal distance to 0.001 foot between the old and new station marks and record.

Center the transit over the original azimuth mark and sight on the original station mark. Lay off an angle of 90 degrees, and establish the new azimuth mark at exactly the same horizontal distance from the original azimuth mark as that between the old and new station marks.

Center the transit over the new station mark and measure, with an accuracy of one minute, the angles between the new azimuth mark and the reference marks. (See footnote on p. 8.)

Measure and record the horizontal distances to 0.001 foot from the new station mark to the reference marks.

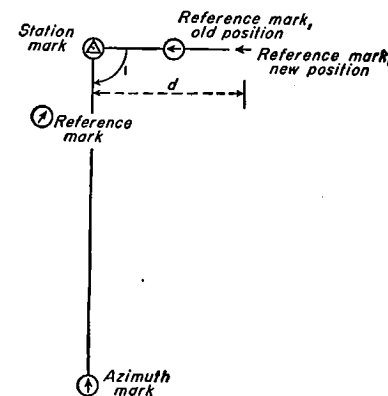


FIGURE 8.—Moving reference mark to new position on extension of line from station to old position.

Measure angle, 1, and distance, d .

E.—WHEN ONE OR MORE REFERENCE MARKS ARE TO BE MOVED

(See figure 8)

Select the best new site for the reference mark to be moved, preferably on a line through the station mark and the original position of the reference mark.

Remove the concrete block containing the reference mark and replace it in a similar position in its new location, with the arrow on the disk pointing toward the station mark.

Center the transit accurately over the station mark and measure the angle between the azimuth mark and the relocated reference mark with an accuracy of one minute. (This accuracy is sufficient because of the short lines involved.) Check the angle, preferably by measuring the exponent, to avoid a possibility of error.

Measure and record the horizontal distance to 0.001 foot from the station mark to the relocated reference mark.