BOTTLES, POTS, & PANS? –
MARKING THE SURVEYS OF THE U.S. COAST & GEODETIC SURVEY AND NOAA

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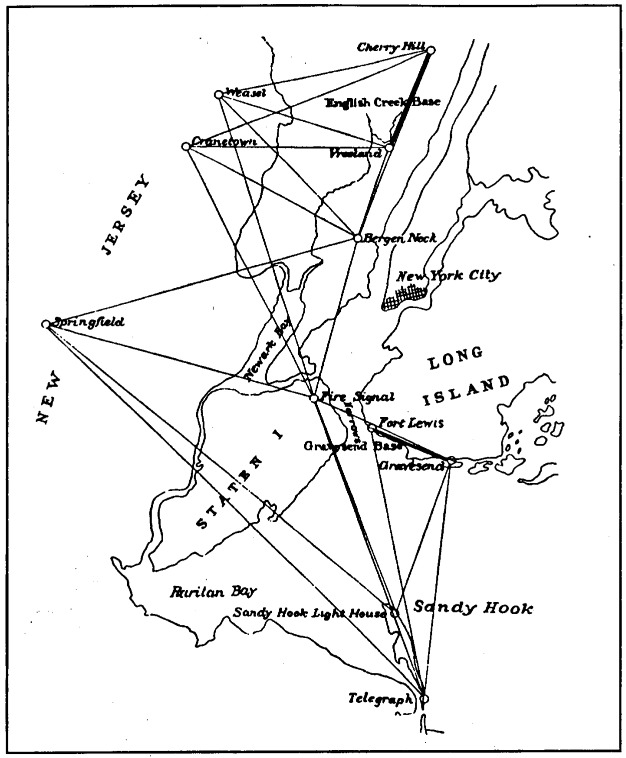
The original mandate of the Survey of the Coast in 1807 was to survey the coast of the United States in order to promote safe maritime commerce. This survey was to include the land along the coast and the water depths in coastal waters. In order to determine positions on the water, the surveyors needed to determine the positions of points on the land. Consequently, the first field work performed by the Survey of the Coast (Survey) was a land survey. The survey covered the land area around a portion of New York Harbor, see Figure 1.



Hassler's first field work, 1816-17.

Figure 1

Since this survey took a considerable amount of time and effort, it was important that the work be preserved. The Survey of the Coast did this by creating a mark on the ground at each of the points where the survey observations were made. Marking was required so that surveyors could return to the same points to complete the survey network, and so that the topographic (land) and hydrographic (water) surveyors could find and utilize the same points at a later date. It is not known how Ferdinand Hassler, the First Superintendent, marked the points of his first 1816-17 survey, but in later surveys he used buried earthenware cones and drill holes in bedrock. For a photo of this agency's oldest existing first-order survey mark see Figure 8 and for an article about the mark, see: http://celebrating200years.noaa.gov/foundations/spatial/side1_spatial.html. The surveyors realized that they needed to use marks that would not deteriorate with time. Later in the nineteenth century the Survey also used jars, bottles, chiseled "+"s, chiseled squares, simple drill holes in rock, and drill holes in rock filled with poured sulfur or a metal bolt. A chiseled triangle sometimes surrounded the mark. Chiseled lettering was sometimes added adjacent to the mark: "U S B M" (U.S. Bench Mark), "U.S.C.S." (U.S. Coast Survey), "U S C & G S" (U.S. Coast & Geodetic Survey), or "COAST SURVEY" for instance. Over the years the Survey's name changed from "Survey of the Coast" in 1807 to "U.S. Coast Survey" in 1836, to "U.S. Coast and Geodetic Survey" in 1878, to part of the National Oceanic and Atmospheric Administration (NOAA) in 1970. See Figure 2, a photo of Bench Mark "A" in Hagerstown, Maryland. The mark, a chiseled square, is between the "B" and the "M".

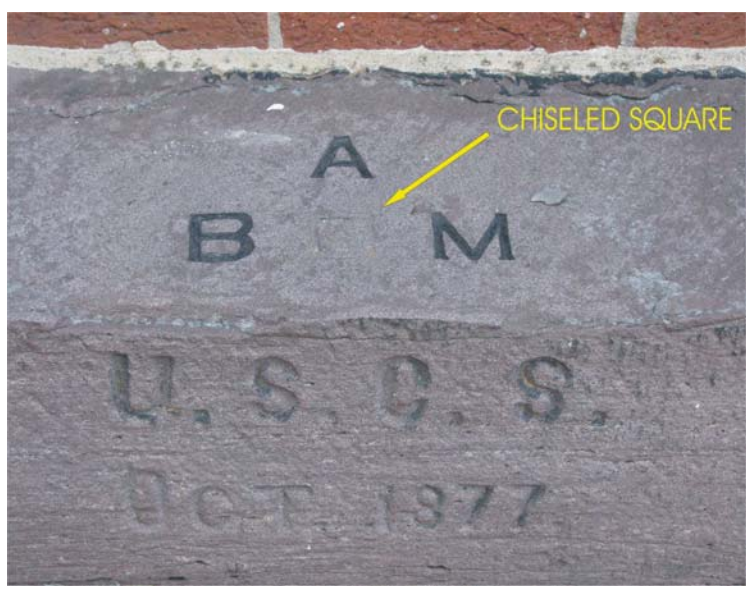


Figure 2

After concrete came into use around 1890, a nail or spike set in concrete was sometimes used as the mark. On some concrete monuments, the letters "U S C & G S" and the year were written on the top of the wet concrete, as in Figure 3 to the right (photo credit Jerry Penry). One retired surveyor recalled that while working on Alaska's North Slope, he recovered beer bottles which had been buried in the permafrost as survey marks.

Figure 3

The three most important characteristics of survey marks are stability, longevity, and the ability of future surveyors to find and use the mark. In other words, the mark shouldn't move, wash away, rust away, and/or be destroyed by cultural development, and surveyors returning to the point need to be able to find it and positively identify it. The mark needs to remain very stable or the survey values will no longer be valid. To help the mark remain stable in the early days of the survey, the marks were generally buried and/or set in bedrock. To help the marks last as long as possible, the marks were also made of non-corroding materials. Burying the mark helped it avoid natural damage such as erosion and helped it avoid cultural damage such as vandalism. However, being buried did make it harder for a later surveyor to find the mark. Non-corrosive materials used for mark construction included; pottery, rock, bronze, brass, copper, glass, concrete, etc. Other desirable characteristics of a mark include accessibility, ease of recovery, appropriate location and spacing, ability to set-up a survey instrument over the mark, and no known conflict with future development which might destroy the mark. Today the requirement for sky visibility is added to help ensure quality reception of satellite positioning signals.

To aid in finding a mark, the original surveyor wrote a brief description explaining the type of mark used and the surrounding terrain. These descriptions were later developed into comprehensive, three-paragraph narratives containing the mark's general location, an explanation of how to reach the mark (called the "To Reach"), and the reference distances and directions to nearby objects. See the following link for instructions on writing descriptions: http://www.ngs.noaa.gov/ContractingOpportunities/Grd_Survey_SOW_V7A.pdf , Attachment S.

Preserving survey marks is important. Each year many marks are destroyed by construction equipment, highway maintenance, erosion, and vandals. Once a mark is severely damaged or destroyed, it can no longer be used by surveyors, engineers and others. Please do what you can to ensure the longevity of survey marks. See the sidebar on Mark Preservation at the end of this paper.

Today, the National Geodetic Survey's (NGS) database contains data on over 1,500,000 survey points, located all over the United States and its possessions. The NGS database includes marks from other government agencies, private firms, and also includes a small number of marks in foreign countries. This data is available on-line and free of charge at the NGS homepage: http://www.ngs.noaa.gov/ under "Datasheets".

This paper covers the following four categories of survey marks used by the Survey over the last 200 years. Commemorative survey marks, set from 1993 to the 200th Anniversary in 2007, are covered in a separate article at: http://celebrating200years.noaa.gov/survey_marks/welcome.html .

I. EARLY PRE-DISK MARKS OF THE SURVEY
II. SURVEY DISKS AND RODS USED BY THE USC&GS
III. SURVEY DISKS AND RODS USED BY THE NATIONAL OCEAN SERVICE
IV. SURVEY DISKS AND RODS USED BY THE NATIONAL GEODETIC SURVEY

I. EARLY PRE-DISK MARKS OF THE SURVEY

The earliest marks used by the Survey were probably buried earthenware cones, see Figure 4 (used as a mark in 1887), and drill holes in bedrock. The center of the hole in the smaller end of the earthenware cone was the survey mark, as was the center of the drill hole in bedrock. Some drill holes were filled with sulfur or some other substance to reduce the effects of water freezing in the drill hole. Metal rods or bolts were placed in some drill holes with an etched "+" on the top marking the exact survey point, see Figure 5.

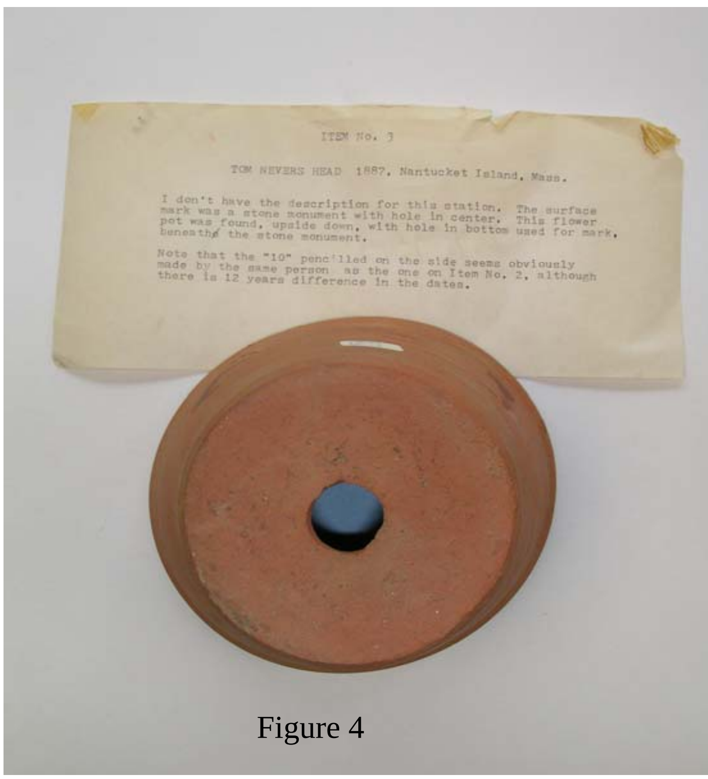


Figure 4

Figure 5

Figure 6

Figure 7

Figure 6 shows a clay pot of the type used for survey marks about 1839. Figure 7, also c1939, shows a similar clay pot, inverted, and buried in the ground with a signal pole inserted. By this method the signal pole was centered exactly over the mark. The pole was then plumbed and held in place by the stones. The tin reflector on top of the pole reflected sun-light to make the signal more visible to a distant observer, measuring angles. This idea of placing the signal pole directly into the mark may have been used for drill holes in rock also. The original drill hole at station BUTTERMILK 1833 (under pen in Figure 8) is about 3 inches in diameter, large enough for a signal pole to be inserted.

Figure 8

At many survey points, an underground mark was set in addition to the main mark set at or near the surface. The surface mark was plumbed directly over the underground mark which was set first. The surface and underground marks were set so there could be no contact between them. The intent was that the underground mark might survive if the surface mark were damaged or destroyed. An underground mark and one reference mark were specified in 1905 and by 1920 two reference marks were required. A witness mark (or post) was set nearby as an aid in finding and positively identifying the survey point. Two or more reference marks could also be used to reset the survey mark if required and one of these could be used as a substitute mark when necessary. Types of reference marks included drill holes, chiseled "+"s or chiseled arrows in rock, and buried earthenware cones. The witness post (originally a wooden post) later evolved into a metal post with a metal sign, and more recently into a fiberglass sign post. Hassler buried reference cones in a specific pattern. To also aid in recovery, Hassler buried foreign objects such as sea shells, and other rubble above the survey mark. Marks of unusual importance, such as the ends of base lines (precisely measured distances) were often marked by large cut stones, see Figure 9, photo credit North Carolina Geodetic Survey.

Figure 9

Writing in 1994, Joseph F. Dracup, NGS, observed that "From about 1850 to the turn of the century, stone posts (marble, sandstone, and limestone) 2-3 ft in length, and for sub-surface marks the same type of posts (see Figure 14, photo credit Jerry Penry) bottles (see Figure 10) earthenware jugs (see Figure 11) and crocks and similar, generally replaced cones for marking stations. However, in some instances, bolts and nails cemented in drill holes, simple drill holes, cross cuts and in fact, almost any conceivable mark, in any combination with these station markings were utilized. When necessary to bury the marks, a (circular) ditch 4-8 ft in diameter and 8-18 in. deep, surrounding the station location was usually dug and filled with coal or charcoal (as an aid in recovery).

Figure 10

Once concrete became readily available, 2-3 ft long tile and tin pipes filled with it were set over underground marks, often employed with centers marked by bolts, nails, punch holes, etc. About 1900, cast bronze disks were introduced." From "Geodetic Surveys in the United States – The Beginning and the Next One Hundred Years, 1807 – 1940" by Joseph F. Dracup, see:
http://www.history.noaa.gov/stories_tales/geodetic1.html.

The USC&GS Annual Report for 1851, page 165 states, "The stations are generally either prominent objects of permanence, such as spires, light-housed, beacons, &c., or they are the points on the prominent hills, capes, or points of land, where signals have been erected for the purpose of the survey, and which are marked on the ground. In a small number of cases in the first three Sections, but much more frequently in the southern Sections, where settlements on the coast are sparse, and few permanent objects are to be found, the stations have no other distinguishing mark than the signal erected on the spot; and after its decay, the mark left on the ground, to designate the station point. The latter generally consists of posts or stones set around the point, while the centre of the station is designated by an earthen cone or glass bottle buried under the surface of the ground and marked on top by a stone or post. Where the station is on a rock, a copper bolt, or a hole filled with lead or sulphur, will be found to designate the exact spot."

Station PENICK 1883 Underground mark

Figure 11

Another unusual USC&GS mark is near the west end of the Eads Bridge in St. Louis, MO. The mark is a rectangular plate with the lettering "U.S. COAST & GEODETIC SURVEY BENCH MARK 1882" (PID = JC0043), see Figure 12, photo credit Karl H. Kleen. Note, a similar mark is near the east end of the same bridge, PID = JC0042.

Figure 12

Figure 13 shows a very interesting mark in San Francisco, California, set in 1892 (PID = HT0688), photo credit 'Geocacher'. The mark is a metal plate 1.75 inches on a side affixed to concrete and stamped with letters and numbers. This is the earliest case found of a USC&GS mark that is stamped and is sort of the "missing link" between the earlier letters and numbers carved in stone, and the later, round, stamped survey disks which were used starting c1900.

Figure 13

Figure 14 shows station PAGE NORTHEAST BASE (PID = NN0646), in Nebraska, photo credit Jerry Penry, which was part of the 98th Meridian Arc of Triangulation.

Figure 14

So, while "kitchen pans" may not have been used to mark surveys, bottles, jugs, pots, and more were used!

II. SURVEY DISKS AND RODS USED BY THE U.S. COAST & GEODETIC SURVEY

The Survey first set survey disks in about the year 1900. That year disks were set in Kansas, Oklahoma, and Texas along the 98th Meridian Arc of Triangulation, and perhaps in other locations. For an explanation of Triangulation see http://celebrating200years.noaa.gov/foundations/spatial/side2_spatial.html. The new disks were set in poured concrete monuments that were 3-5 feet deep, or they were cemented in drill holes in bedrock or in pre-cut stone. Early concrete marks were uniform in cross-section, but later the standard concrete monument was about 4 feet deep with the bottom flared out to help resist upward vertical movement due to frost heave or man-made forces. See Figure 15, the cross-sectional drawing to right. The photo in Figure 16, below provides a rare view of the side of a concrete monument that was exposed by construction (photo credit, Daryl). As an aid to determining the directions to other survey marks, nails were sometimes set horizontally on the top of the wet concrete, pointing to other survey points. Occasionally grooves were chiseled into bedrock radiating out away from the mark for the same purpose.

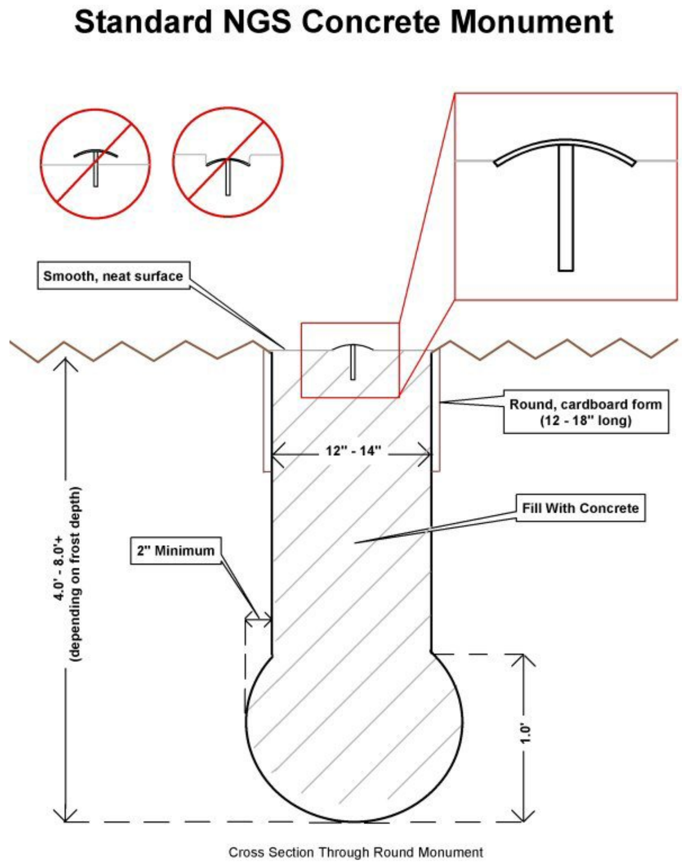


Figure 15

Figure 16

Not all disks were set in the ground. Bench Marks (marks with elevations) were sometimes set vertically in the wall of a building.

USC&GS disks were set from c1900 to c1972, (NOAA was formed in 1970). Over 700,000 disks were factory stamped with the name U.S. COAST & GEODETIC SURVEY. Many of these remain in place all over the United States, still proclaiming the former name of the surveying and mapping arm of NOAA and still providing valuable information to users.

The original, c1900, disks were manufactured with just the lettering U.S.C. & G.S. These disks were quite different from later survey disks. They were ‘cup’ shaped with a flat center and a raised, outer edge. This design may have been copied from a disk design used by Verplanck Colvin while surveying in the Adirondack Mountains in the 1870s to 1890s. The USC&GS disks were about 80 mm in diameter. On the underside was a stem that was similar to stems on later disks. The stem was 25 mm in diameter and 75 mm long, with a slit at the lower end into which a wedge was inserted so that when it was driven into a drill hole, the stem would bulge at the bottom and thereby hold the mark securely in place. The ridge around the top may have been designed to protect the machined-flat central portion of the disk containing the actual survey point. Once set, the central depressed area often became filled with dirt, water, or ice and made usage of the mark difficult. By 1912, USC&GS Special Publication (SP) #11, http://docs.lib.noaa.gov/rescue/cgs_specpubs/QB275U35no111912.pdf refers to this as the “old type of station mark”. At least one of these “old style” disks may have been set as late as 1944, see PID = HX3058. There were at least four variations of this disk, one with a large “+” inscribed in the center, one with a small “+”, one with a triangle inscribed in the center, and one with a plain center area (Figure 20 has a center-punched hole, off-center), see Figures 17-21.

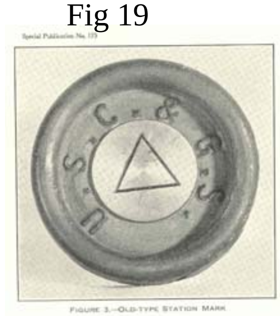
Fig 17

Large Cross
Photos: Author
e.g. SY2731

Fig 18

Small Cross
Richard Cohen
e.g. QE2273

Fig 19



Triangle
Author
e.g. QE2396

Fig 20

Plain
Richard Garland
e.g. KU3315

Fig 21

Rear View
Richard Cohen

About 1903, a flat-top bench mark disk was introduced with the lettering: “U.S. COAST & GEODETIC SURVEY, B.M.; $250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK” (Note, a semi-colon indicates the start of the next line of text on the disk.) This disk had only two rows of factory stamping, later flat and curved disks had three rows. This disk had no “lip” around the edge and was completely flat. The disk had “Bench Mark” abbreviated as “B.M.”, but most later versions had the words spelled out. Early versions of these Bench Mark disks had a slash in the center, a circle in the center, or both. See Figure 22, Z 3 (PID = RP0106) set in 1903, photo credit, Theresa Buseth. Examples from 1916 show both flat and convex topped disks, all with the center symbol being a circle with a slash. A few flat top Bench Mark disks were used as late as c1932, however these late ones are rare, see PID = HT0568. See also Bench Marks section on page 13.

Figure 22

Both the early Triangulation Station Disks and the early Bench Mark Disks came in two configurations, one with a stem on the back and the other designed as a cap to mount on a 3 inch diameter pipe set vertically in the ground. Some caps had threads and some were mounted with bolts or rivets from the side. In Figure 23, note the grooves on the stem of the disk on the top right. This type of stem was used from c1915 to c1920. The top photo is from SP#18, 1914 and bottom is from SP#11, 1912.

Note that in Figure 23, the two photos on the left show the "cap" type disks and they appear to have slightly curved tops. These were in use by 1907. The right photos show the two different types of stems, both for mounting in drill holes or in a concrete monument.

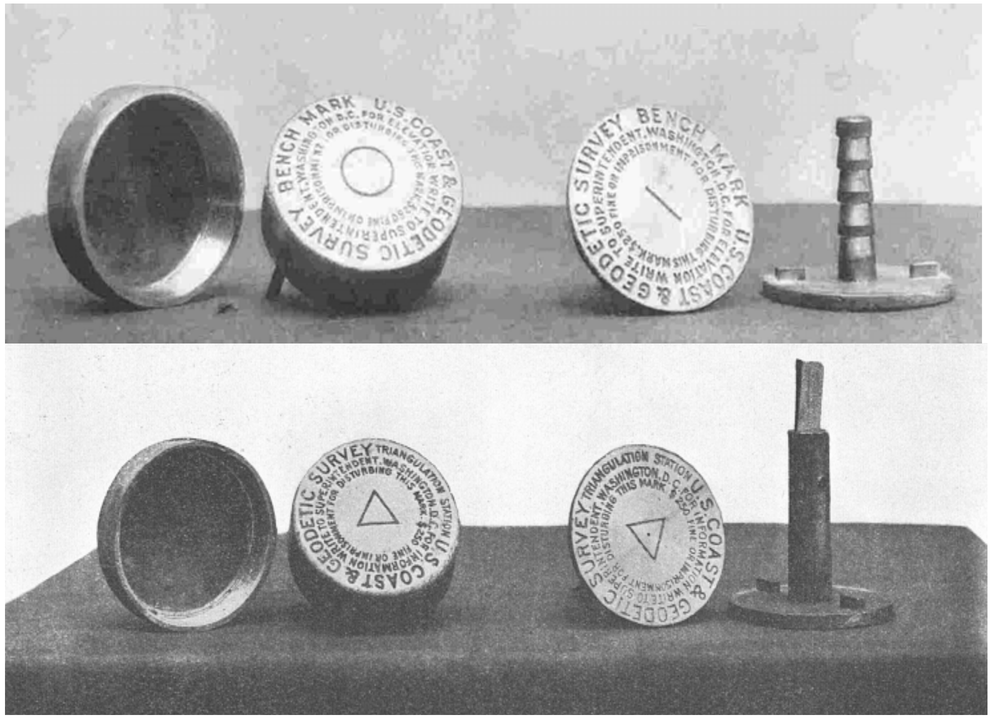


Figure 23

About 1909, a flat top Triangulation Station disk was produced and used with the lettering "U.S. COAST & GEODETIC SURVEY, TRIANGULATION STATION; FOR INFORMATION WRITE TO SUPERINTENDENT, WASHINGTON D.C.; $250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK." See Figure 24 of station DE MONTS (PID = QF0712) from 1909, photo courtesy of Paul Robertson. Flat-top Triangulation Station disks were used until c1922.

Figure 24

About 1913, a flat-top Reference Mark disk was produced and first used. It contains the lettering: “U.S. COAST & GEODETIC SURVEY, REFERENCE MARK; FOR INFORMATION WRITE TO SUPERINTENDENT, WASHINGTON D.C.; $250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.” See Figure 25 showing a flat RM disk from SP#17 in 1913. Also see Figure 26 of station QUODDY RM1 (PID = PD0690), photo courtesy of Richard Garland. These flat Reference Mark disks were used until c1922 although one was found as late as 1934. Note that the arrows on these early Reference Marks were about 4.0 cm long. They were then shortened to about 3.2 cm, and then later the USC&GS and NGS arrows were about 2.7 cm long.

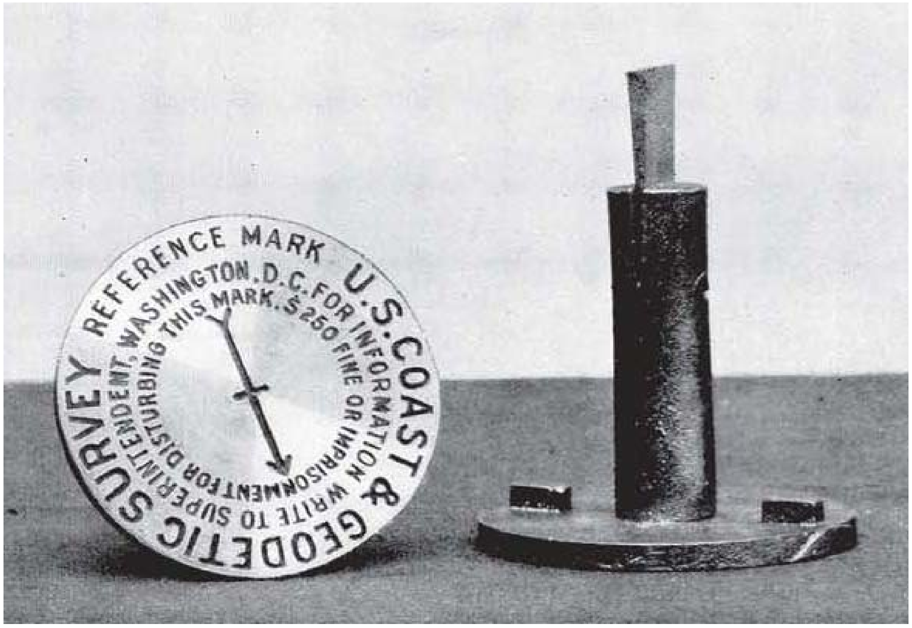


Figure 25

At the time of setting, the disks were stamped with the mark’s name and date, although this practice was not consistent in the early years. In 1916, stamping the name and date was required. The name and date were a tremendous aid in positively identifying a survey mark.

Figure 26

By 1921 there were five types of factory-produced disks and they all had curved rather than flat tops, see Figure 27. Most disks set after 1921 had convex tops rather than flat. In the early years the radius of the curved top varied, but in the later years a spherical radius of 5 inches was used. The design with the flat top did not last long, probably because the highest point for vertical referencing became the edge of the disk if the disk was not set perfectly level. This caused difficulties in trying to set a level rod on the highest point of the disk. These curved-top disks are about 90 mm in diameter. Also in 1921, "DIRECTOR" replaced the word "SUPERINTENDENT" as part of the inscribed information on the disk. The Hydrographic Station disk came with and without the dot in the center of the circle. In 1924, a sixth style of disk was added; the Traverse Station. It had a triangle in the center, but the triangle was 25 mm on a side; larger than the 20 mm Triangulation Station's triangle.

Special Publication No. 93.

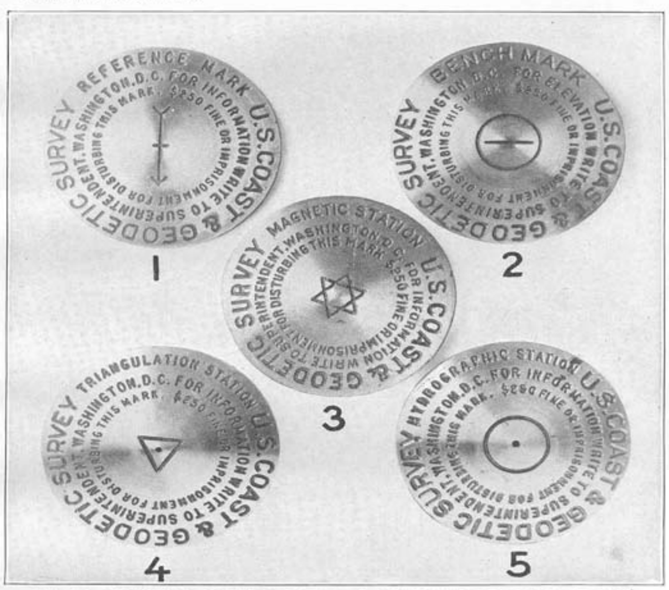


FIG. 26.—STANDARD MARKS OF THE U. S. COAST AND GEODETIC SURVEY.

1. Reference mark.
2. Bench mark.
3. Magnetic station mark.
4. Triangulation station mark.
5. Hydrographic station mark.

Figure 27

Figure 28

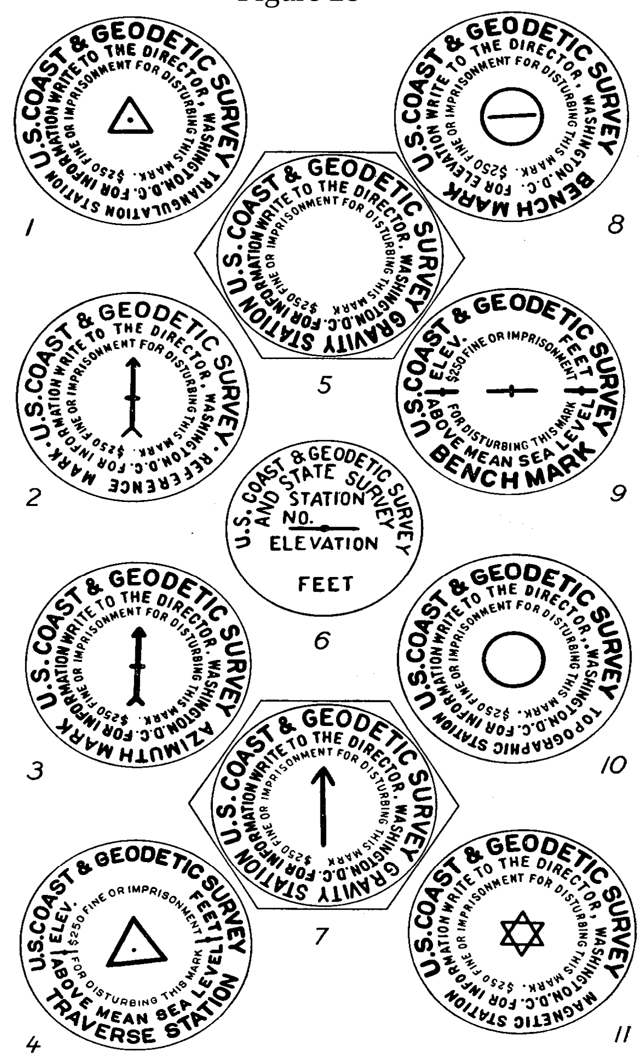
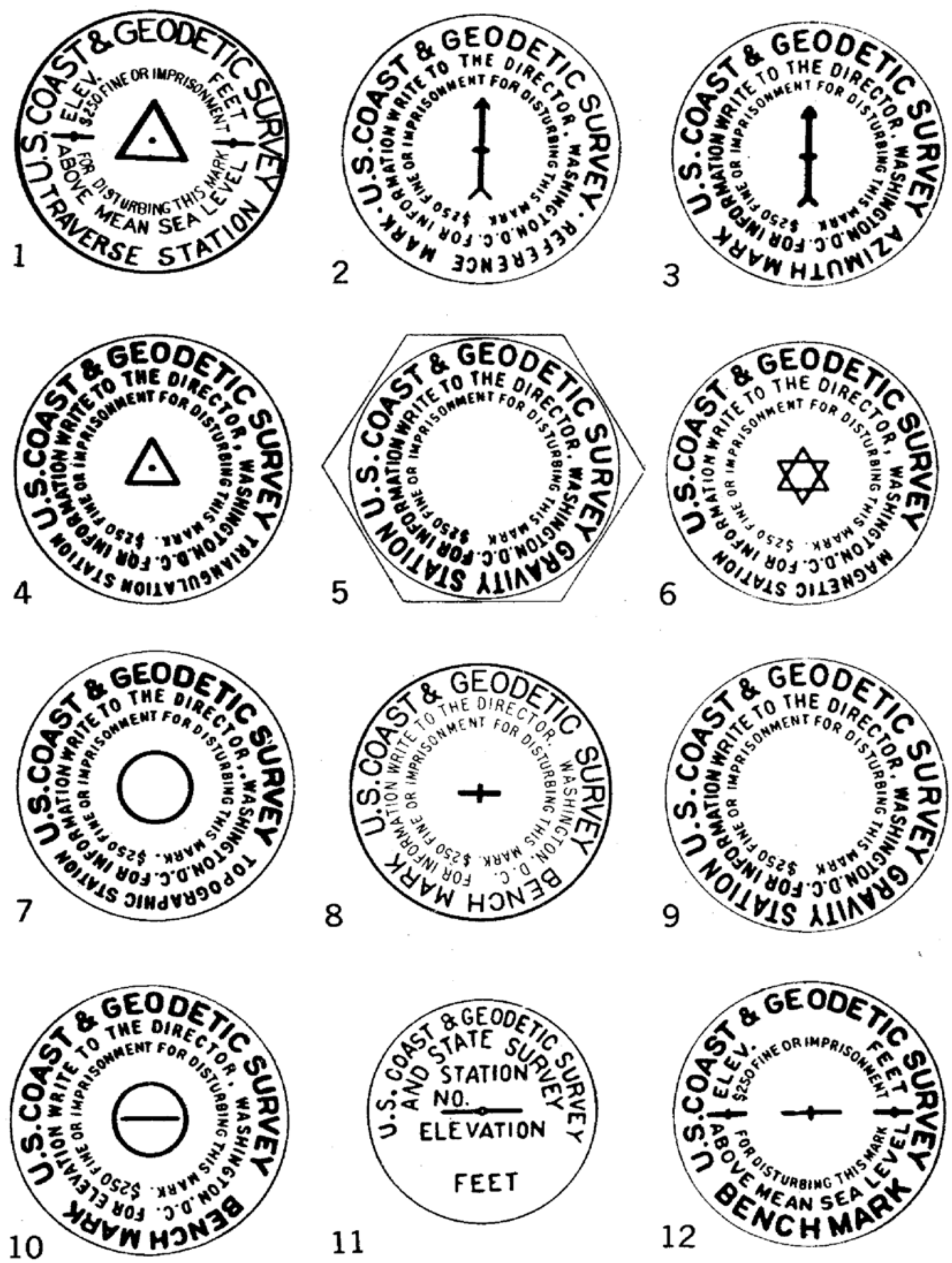


FIGURE 11.—Standard marks of the U. S. Coast and Geodetic Survey.

1. Triangulation station mark.
2. Reference mark.
3. Azimuth mark.
4. Traverse station mark.
5. Gravity station mark.
6. State Survey mark.
7. Gravity reference mark.
8. Tidal bench mark.
9. Geodetic bench mark.
10. Topographic station mark.
11. Magnetic station mark.

In 1926, disks were specified to be used for first-order, second-order, and third-order stations. The "orders" classified the level of precision of a survey, with first-order being the highest. More different styles of disks were added over the years. By 1940, USC&GS SP #158 shows 11 styles of disks, see Figure 28, and by 1961 SP #226 shows 12 styles, see Figure 29. Detailed information on the main disk types is supplied in the following pages.

Figure 29, Standard disks of the USC&GS in 1961



1. Traverse station mark.
2. Reference mark.
3. Azimuth mark.
4. Triangulation station mark.
5. Gravity station mark (old type).
6. Magnetic station mark.
7. Topographic station mark.
8. Geodetic bench mark (new type).
9. Gravity station mark (new type).
10. Tidal bench mark.
11. State Survey mark.
12. Geodetic bench mark (old type).

In later years, definitive procedures and naming conventions were specified for setting new disks and for replacing destroyed marks. For example, a triangulation station mark replacing a destroyed triangulation station mark in 1965 but set in the exact same location was stamped with the original station name, the original date, and the new date, for example "JONES 1935 1965". If the triangulation station mark was replaced in a different, but nearby location, then it was stamped "JONES 2 1965". These disks would be set in a concrete monument, set in a drill-hole, a large structure or bedrock, or crimped to the top of a long rod. These stamping criteria were specified in "Specifications for Horizontal Control Marks," USC&GS, Captain S. Baker, 1968, see: http://www.ngs.noaa.gov/web/about_ngs/history/Specifications_for_Horizontal_Control_Marks.pdf.

ROD MARKS - Starting about 1955, some copper plated steel rods were driven deeply into the ground as marks. These had brass disks crimped to the top. The electrolytic action between the different metals ended this practice, since in some soils the rods rapidly deteriorated. For more information see http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs/ , page 43. In the early 1970s, NGS made a modification to the rod mark by attaching a base plate to a 4-foot section of rod. These modifications were only used for a short time. About 1976, galvanized steel rods were also used for a short time. In 1978, after an extensive study, stainless steel rods were introduced (see National Ocean Survey and National Geodetic Survey sections below, and publication "Geodetic Bench Marks" at: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs/.) A galvanized pipe mark was used again for a short time c1996, see Figure 88.

Copper nails with copper washers stamped "U.S.C. &G.S. B.M." were used for less permanent bench marks. See Figure 30.

Figure 30

DISK STEMS - Disk stems went through a transition from a cast stem with a slit and wedge, described above (c1900 - c1915), to a cast stem with grooves cut around the shank (c1915 - c1920), to a cast stem with a wider slot (c1920 - c1950), to a brass tube crimped flat at the lower end, or a short tube for mounting on a rod (c1950 - c1970) both brazed to the back of the disk, see Figure 31. Disks were often mounted on pipes, especially in marshy areas and in Alaska in an effort to make them more permanent.

Figure 31

An unusual variation on the stem is seen in Figure 32 of a mark set in the Southwest where a standard disk was attached to a 92.6 cm (36.5 inch) long bronze stem which flares down to a 2.6 cm diameter, with a 4.8 cm flange at the bottom end.

Figure 32

USC&GS DISK TYPES – Disk types include Bench Marks, Tidal Bench Marks, Triangulation Stations, Reference Marks, Azimuth Marks, Magnetic Stations, Gravity Stations, Gravity Station Reference Marks, Topographic Stations, Hydrographic Stations, Traverse Stations, USC&GS and State Surveys. See Figure 33, of a board with eight disks types mounted.

Figure 33

BENCH MARKS - A Bench Mark is a marked point whose elevation above or below an adopted geodetic vertical datum is known with a certain amount of accuracy. For further information on datums, see: http://celebrating200years.noaa.gov/magazine/vertical_datums/welcome.html .
A Bench Mark may also have an accurate horizontal position, but most older marks do not and may only have positions scaled from a map. USC&GS Bench Mark disks were being used in 1903 or earlier. In addition to the standard agency factory stamping, a Bench Mark disk contains the factory stamping "B.M." (c1903–c1932) or "BENCH MARK" (c1913 – c1972). The center symbol on the disk changed over time. Flat BM disks (c1903 – c1932) overlapped with convex BM disks (c1921 – c1970).

Figure 34

BENCH MARK DISK CENTER SYMBOLS - Known symbols in the disk center, in approx. chronological order, include:
A. Slash (about ¾ inch long) (c1903 – c1913) One was also found from 1932,
PID = HT0568, also see Figure 22.
B. Circle (about 15/16 inch in diameter) (c1907 – c1911); a convex disk with a circle in the center was found dated 1941, PID = AG1367. (Center square mentioned in 1909 and 1914 publications, but not seen),
C. Circle with slash inside **(**c1916 – c1970), this disk is convex, first used for all bench marks, then after c1924 used for tidal bench marks only. See 1917 e.g. PID = RK0116, and 1962 e.g. HN0181.
D. Three slashes, each with a cross slash about 3/16 inch long; convex disk; most common; text "BENCH MARK" upside down compared to other disks except the TRAVERSE STATION disks. See Figure 34, photo Dan Winester, NGS ; (c1923 – c1985), PID = RL1697.
E. One slash, with a cross slash about 3/16 inch long (c1957 – c1970), see Figure 35. This disk replaced types "C" and "D" c1959.

Figure 35

Note that during the 1950s, Bench Marks had variations in the length of the slashes and in the size of the text “BENCH MARK”. Prior to c1924, the first three types were used for both geodetic Bench Marks and for Tidal Bench Marks. Beginning c1924, type C (circle with slash) was used for tidal Bench Marks and type D (3 slashes) was used for geodetic Bench Marks. Also, as mentioned above, some disks were actually caps to be mounted on 3-inch pipes. Another style of bench mark was made of cast iron during World War II due to the shortage of brass. This iron disk contained the 18 mm high lettering “USC&GS BM” with a crossed slash in the center. Examples from 1943, 1944 and 1945 have been found. The larger letters were due to the difficulty in casting smaller letters in the iron. See Figure 36.

Figure 36

The original surveyor would stamp the station name and date on the disk just prior to setting. For example, Survey Bench Marks are frequently named with letters and numbers such as “B 45 1956” (the letters I and O were not used to avoid possible confusion with the numbers “1” and “0”). The designation in the NOAA,NGS database would be “B 45” and the year it was set was 1956. The NGS database can be accessed at: http://www.ngs.noaa.gov/cgi-bin/datasheet.prl. The goal was to keep the all survey mark names unique within a given state. The Bench Mark disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. In the 1930s, pre-cast concrete posts with Bench Mark disks attached were used for several years.

TIDAL BENCH MARKS - A Tidal Bench Mark is a Bench Mark set near a tide gauge to which the tide staff and local tidal datums are referred via precise leveling, see Figure 37 of a “Basic (or Primary) Bench Mark” (photo credit, Dan Winester, NGS), and Figure 38 for photo of a Tidal Bench Mark disk. Not all are as elaborate as this stone mark. Local tidal datums are not the same as the geodetic vertical datum mentioned under “Bench Mark” above. The local tidal datum may be different at each tide gauge due to water level variations along the coast. The geodetic vertical datum is a nation-wide standard datum.

Figure 37

Figure 38

The factory stamping for these Tidal Bench Marks was “BENCH MARK” and the center symbol, after c1924, was an encircled slash. The data for Tidal Bench Marks is found in the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) database: http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Bench+Mark+Data+Sheets . The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock.

TRIANGULATION STATIONS - A Triangulation Station is a survey point established during a survey utilizing the triangulation surveying method, see Figure 39. For a brief explanation of triangulation, see: http://celebrating200years.noaa.gov/foundations/spatial/side2_spatial.html . Triangulation consists of observing the angles at the vertices of adjacent triangles, measuring the lengths of some of their sides, and computing the lengths of the remaining sides. The goal of this procedure is to determine the horizontal positions (latitude and longitude) of the vertices of each triangle. The triangulation method thus produces horizontal positions for the survey mark but only approximate elevations. A given mark may have a more accurate elevation determined by a differential leveling.

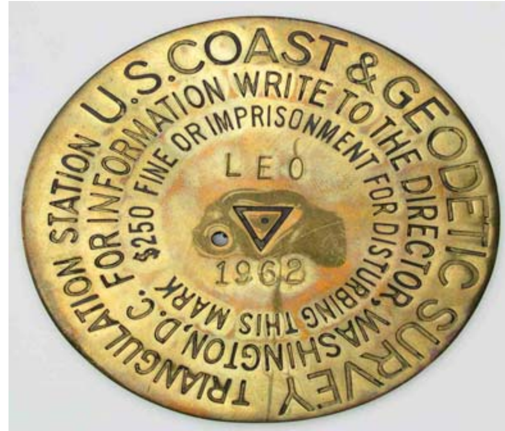


Figure 39

There may be six or more survey disks in the vicinity of each Triangulation Station. For a drawing of these marks, see: http://www.flickr.com/photos/12262796@N06/2167190392/ [NOTE, THIS LINK WILL TAKE YOU OFF THE NOAA WEB SITE.] The main station, marked with a Triangulation Station disk, contains the factory stamping "TRIANGULATION STATION" with an equilateral triangle in the center. The triangle was usually about 2 cm on each side although occasionally from c1911 to c1925 (ex PID = BM0627, PN0027, TT0805, & OF1769), flat Triangulation Station disks were used which had a triangle of about 2.5 cm on a side, similar to the later Traverse Station disks. Beginning about 1905, an underground mark was set two to four or more feet underground and centered so as to be directly under the surface mark. The underground marks were set to preserve the position if the surface mark was damaged or destroyed. Both disks contained the same factory stamping and the exact same designation (name) and date. Triangulation Stations were normally named for an area feature or the property owner. Just prior to setting, the disk would be stamped by the original surveyor, as for example, "JONES 1936." In the NGS database, the name would be "JONES" and the year set 1936. The disk was usually set so that the stamping could be read by an observer facing north. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. The concrete monument is normally about flush with the ground's surface, 12 inches in diameter, and 48 inches or more deep, see Figure 15, with the bottom larger in diameter to help resist frost heave. Standard practice at a Triangulation Station was to also set two Reference Marks and an Azimuth Mark. For a period of time, in the 1970s, underground marks were also set at Azimuth Marks, hence the possible total of six disks. Some sites had additional reference marks added and some sites had marks set by other organizations, so having more than six disks in the area was quite possible. USC&GS Triangulation Station disks were used from c1900 to c1972, and came in three styles: "old style" (cup shaped) with rim around the edge (c1900 – c1913), flat top (c1909 – c1922), and convex topped (c1919 – c1972). Note that some USC&GS disks were set for several years after NOAA was formed in 1970.

REFERENCE MARKS - Reference Marks (RM) were set to assist in locating the Triangulation Station as well as to help determine if the Triangulation Station was undisturbed and in its original position. RMs could also be used to reset a station mark if required. Reference Marks were factory stamped with "REFERENCE MARK"

Figure 40

and with an arrow pointing up, see Figure 40. The original surveyor stamped the RM with the name of the Triangulation Station plus the number of the RM and the date just prior to setting. For example, the first RM for station JONES would be stamped "JONES NO. 1 1936." When setting, the surveyor rotated the disk until it pointed directly toward the Triangulation Station disk. The surveyor then measured the direction and distance from the Triangulation Station to the Reference Marks (RMs) and recorded the information as part of the station's description. Later, if a surveyor attempting to find a Triangulation Station stumbled upon a RM first, the arrow and the published distance and direction between the RM and station would be valuable aids in the station recovery. To check the position of the Triangulation Station, the new surveyor could measure the angles and distances to the Reference Marks and compare them to the original values. Beginning in the 1920s, two Reference Marks per Triangulation Station were specified. Reference Marks were usually set within 30 meters (one tape length) of the station. They were numbered clockwise from north and set about 90 degrees apart. If a RM was destroyed, a new Reference Mark would be set using the next consecutive number. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. From c1954 to c1970, Reference Marks were set that had shorter arrows. A RM disk with a short arrow was also found from 1934. Flat RM disks were used c1913 to c1922, e.g. from 1921, PID = SY2368. Convex RM disks were used from c1922 to c1972.

AZIMUTH MARKS – Beginning in 1927, a third Reference Mark, or "long RM", was set about ¼ mile distant from the Triangulation Station for use in providing a starting azimuth (direction) for local surveys. It was also used for determining magnetic declination, which is the difference between true north and magnetic north. Standard Azimuth Mark disks replaced azimuth reference marks about 1935. Also in 1935 the accuracy of the directions to Azimuth Marks was increased by changing the number of repetitions of the angle measurements from two to four. Azimuth Marks that would be visible from the ground at the main Triangulation Station had been frequently requested by local surveyors and engineers. Azimuth Marks were factory stamped with "AZIMUTH MARK" and with an arrow pointing up, see Figure 41. The original surveyor stamped the Triangulation Station's name and date on the Azimuth Mark disk, just prior to setting. Since this was the exact same stamping as the Triangulation Station, surveyors even today have to check the factory stamping of "AZIMUTH MARK" (with arrow) versus "TRIANGULATION STATION" (with triangle) to determine which is which.

Figure 41

When setting, the surveyor rotated the Azimuth Mark disk until the arrow pointed directly toward the Triangulation Station disk. The surveyor then measured the direction to the Azimuth Mark (from the Triangulation Station) and recorded the information as part of the station's description. Azimuth Marks were usually set between ¼ mile and 2 miles from the Triangulation Station, at a point visible from tripod height at the station, and generally in or near a fence line along a road. The distance, estimated to the nearest 0.1 mile, was included in the station description. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. This type of disk was used from c1935 to c1972.

Figure 42

MAGNETIC STATIONS – The Survey began magnetic observations in 1843. The original purpose was to supply magnetic information for the nautical charts, but later observations were extended into the interior to aid local surveyors. The plan was to establish a magnetic station at every county seat and to mark the station for future use. Unfortunately, cultural development eliminated the usefulness of many of the stations that were established. In 1942, the standard for magnetic observations was to make observations at least every 10 miles along a coast and more frequently when magnetic anomalies were found. Stations were marked with natural objects or with bronze or brass Magnetic Station disks. These disks were factory stamped "MAGNETIC STATION" and with a six-pointed star in the center, see Figure 42, PID = QE0491, photo credits Chester Perkins. Note how the left photo shows the flatness of the early disks. The original surveyor infrequently stamped the station name and date on the disk just prior to setting. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. The flat-top version of this type of disk was used from c1912 to c1921 and the convex version from c1921 to c1972. For an example from 1924 see PID = DV2173.

Figure 43A & B

GRAVITY STATIONS – The Survey began gravity observations in 1871. For an article on gravity surveys, see: http://celebrating200years.noaa.gov/foundations/gravity_surveys/welcome.html#intro. Gravity observations were sometimes also made near the Gravity Station Reference Marks discussed below. This Gravity Station disk was factory stamped "GRAVITY STATION" with no symbol in the center, see Figures 43A and B. The original surveyor would stamp the station name and date on the disk just prior to setting. The station was often named after the city or the property owner. The disk was set in a concrete monument. Two different designs of Gravity Station disks were used, the older from c1936 to c1972 and the newer was used concurrently from the 1930s to c1972; an example of the newer style from 1937 was found and an example of the old style, from 1939, was found. The older design disk was very unusual in that it was hexagonal in shape, Figure 43A. The newer design was a standard circular disk factory stamped with "GRAVITY STATION" again with no symbol in the center, Figure 43B. Note that many gravity marks were set indoors. If set outdoors, the disk would be set in a concrete monument, or set in bedrock or a large structure. Note that USC&GS gravity disks may have been used as late as 1978. Photo in Figure 43A by Dan Winester, NGS.

GRAVITY STATION REFERENCE MARKS –Gravity Station RM disks were set to indicate the direction to the location of the gravity observations, rather than the direction to a Gravity Station disk. This disk was factory stamped "GRAVITY STATION" with an arrow (with no tail) in the center, see Figure 44. This disk also had the unusual hexagonal shape. The original surveyor might stamp the station name and date on the disk just prior to setting. These disks were used from c1936 to c1961. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. Photo in Figure 44 by Dan Winester, NGS.

Figure 44

TOPOGRAPHIC STATIONS - Topographic Station disks were set in preparation for, or during, topographic surveys, i.e. coastal mapping, and also on airports during airport surveys. The disks were specified to be set at one mile intervals along a coastline, except in swampy or other inhospitable areas where the spacing could be increased to two miles. Reference marks were not required. These disks were factory stamped "TOPOGRAPHIC STATION" with a circle in the center, see Figure 45. The original surveyor would stamp the station name and date on the disk just prior to setting. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. This type of disk was used from c1940 until c1972.

Figure 45

HYDROGRAPHIC STATIONS - This type of disk was set during hydrographic operations; surveys performed to measure the water's depth. Reference marks were not required. These disks were factory stamped "HYDROGRAPHIC STATION" with a circle in the center, see Figure 46. The original surveyor would stamp the station name and date on the disk just prior to setting, in this case "FRED 1919," (PID = TV0135). The disk in the photo was set in a large mass of concrete. This particular disk is interesting because it was set on St. Croix Island as part of a 1919 survey of the U.S. Virgin Islands conducted by the Survey only two years after the U.S. bought the Virgin Islands from Denmark. Unfortunately this mark was recently destroyed by construction. This type of disk was used from c1919 to c1940. Photo by Eric Linzey, NGS.

Figure 46

TRAVERSE STATIONS – This type of disk was set during traverse surveys, a type of survey that determines positions by means of a series of angles and distances between adjacent points along a route. For an explanation of traverse surveying, see: http://celebrating200years.noaa.gov/foundations/spatial/side2_spatial.html . In some cases, as in North Carolina, c1924, leveling followed along the route of the Traverse resulting in precise elevations on the Traverse Station disks. This disk was factory stamped "TRAVERSE STATION" with a large triangle in the center, about 2.5 cm on a side, see Figure 47. Note, the words "TRAVERSE STATION" are correct-side-up looking from the bottom of the disk, as opposed to other disks where the lettering is read from the center looking outward. Only this type disk and the BM disk with three slashes had this lettering orientation. This disk also had a blank spot for stamping the elevation. The original surveyor would stamp the station name and date on the disk just prior to setting. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. A 1957 USC&GS manual specified that two Reference Marks be set for each traverse mark. This type of disk was used from c1924 to c1972.

Figure 47

USC&GS AND STATE SURVEY DISKS – This type of disk was used when cooperative surveys were conducted with state agencies, and by federal government work programs during the 1930s. The factory stamping was "U.S COAST & GEODETIC SURVEY AND STATE SURVEY" with a slash and dot in the center; see Figure 48 (photo by Dan Winester, NGS). These disks came in two diameters. The more common, smaller size is 3 inches (76 mm) in diameter. These were used c1930 to c1941, and possibly in the 1950s . The larger, normal disk size is 3 5/8 in (93 mm) in diameter, and was used in the 1950s and 1960s. The factory stamping was the same on both size disks. Although from a photo of a single disk it is hard to tell the diameter, note how the location of the "A" in the word "AND" changes with respect to the outer row of lettering between the two sizes.

The center of the USC&GS and STATE SURVEY disk also included space for the survey station's number and elevation, in feet. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. These disks were mainly used in the 1930s, but could have been used to about 1970; many of these disks did not have the date stamped on them.

Figure 48

USC&GS AND SPECIFIC STATE SURVEY DISKS – For several states, a modified version of the larger disk was manufactured with the state's name factory inscribed instead of, or in addition to, the generic word "STATE". These states included: CT, KY (PID = GZ0056 from 1962), LA had at least two styles (PID = BJ5042 from 1970), MS (PID = EG1979 from 1995), ME, TN (PID = FD0659 from 1962), and PA (PID = KV1980 from 1935). Kentucky had at least three styles of these disks: "GEODETIC MARKER", "BENCH MARK", and "REFERENCE MARK". The KY disks were used as late as the 1960s during interstate highway surveys, see Figure 49. See Figure 50 for a sample from PA, and Figure 51 for a sample from LA.

Figure 49

Figure 50

Figure 51

In addition to the state disks, at least two cities used the USC&GS name on their survey disks. Two examples are Los Angeles, CA (PID = DZ0640) and Akron, OH (PID = MB1249), see Figure 52, photo credit to Robert Macomber.

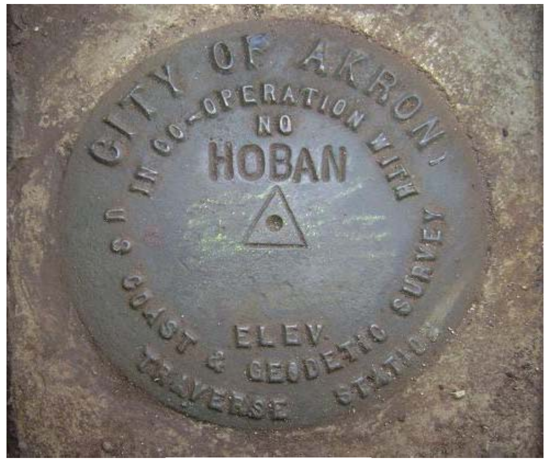


Figure 52

An interesting variation of many of the disks was the addition of an air hole. The air hole was added to allow air to escape from behind the disk, which in theory allowed for better adhesion to the concrete as the disk was pressed into the wet concrete. In Figure 39, the air hole is just to the left of the triangle. However it was soon discovered that this air hole looked too much like the survey point itself and the practice was ended. In fact, one NGS employee admitted to the author to setting up over the air hole instead of the center of the survey mark (but caught himself)! Disks with air holes were used from c1952 to c1969 (PID = SY0986).

Some disks had a blank spot for stamping the elevation. These disks include some Bench Mark disks, Traverse Station disks, and “USC&GS AND STATE” disks. This feature was soon abandoned since subsequent surveys and newer mathematical adjustments of the survey data usually changed the elevation. Also, stamping an already set disk could crack the concrete or cement holding it in place, possibly shortening the life of the mark.

SPECIAL PURPOSE USC&GS DISKS – When the appropriate disk was not available, another type of disk may have been set. For example, before Azimuth Mark disks were ever produced, Reference Mark disks were used to mark azimuth stations. Occasionally, limited production or one-of-a-kind survey disks were produced. Several examples follow.

The first example is a disk designed for usage at the South Pole; see Figure 53 (photo credit D. Doyle, NGS). The disk design was somewhat different in that it had a slightly recessed center area and another slightly recessed area containing the stamping “SOUTH POLE” in the lower portion near the outer rim.

Figure 53

The second example is an unusual disk set at a coastal artillery site in New Jersey, see Figure 54 (photo credit Mace and Patrice Shorie, PID = KV4919).

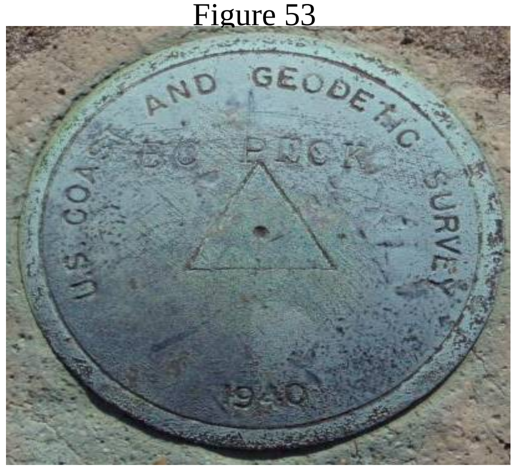


Figure 54

The third example, Figure 55 (PID = EZ1375), is a 12-inch diameter disk set in 1956 near a sundial on the campus of the University of North Carolina at Chapel Hill, NC (photo credit, Nancy Ball).

Figure 55

Figure 56

The fourth example of an unusual disk is shown in Figure 56. It shows a high water mark and the disk is mounted vertically on a wall (photo credit Bob Jensen). The center area is recessed, similar to the South Pole disk described above. Station name is 106 HIGH WATER MARK (PID = RC0860).

The fifth example is a manhole cover with the lettering "USC&GS." These were used for a 1927 survey in Atlanta, Georgia, see Figure 57 (photo credit Byron Hooks). The name of this station is TECHWOOD (PID = DG0245). This type of manhole cover was also used in other locations including Rochester, NY, see PID = OF2249 and OF2253.

Figure 57

The sixth example is a Reference Mark for the boundary between the states of Maryland and Virginia, near the southern point of the District of Columbia. The mark is located on Jones Point, in Alexandria VA, just south of the Washington Beltway bridge over the Potomac River. The arrow points to the actual, unmarked boundary point which is 42 feet away near the edge of the water. This disk is about 5 inches in diameter, much larger than the standard USC&GS disks, see Figure 58. The station name is BOUNDARY MON 58 DC MD VA (PID = HV1667).

Figure 58, Five inch disk

From 1963 to 1974, the USC&GS (and then NGS) conducted the Satellite Triangulation Program, also known as the BC-4 program. This program used ground-based cameras to photograph satellites against the star background, see:
http://celebrating200years.noaa.gov/foundations/satellite_geodesy/welcome.html#intro .
This was a world-wide program designed to determine positions around the world. For points within the U.S., standard USC&GS survey marks were used, see Figure 59 for a photo of the Azimuth Mark for station 1011 set in 1966, (PID = TU2875), photo credit Marc Moore. For points outside the U.S., special survey disks were used, see Figure 61 (a drawing from 1967) showing the three styles of disks. For a photo see Figure 60, credit Paul Spofford.

Figure 59

Figure 60

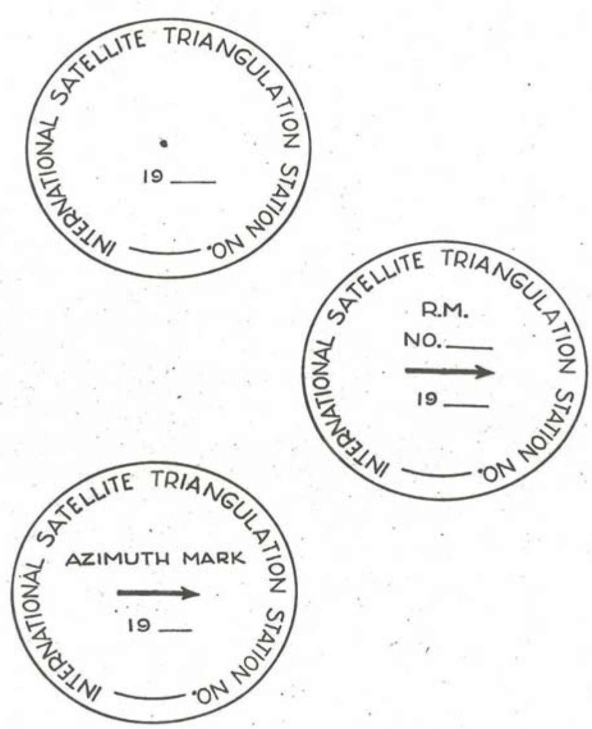


Figure 61

About 1912 in Alaska, copper bolts about ¾ inch in diameter were used for Reference Marks (with an arrow on top), and as Bench Marks (with "BM" on top). See PID = UW6569. This information is from John Oswald.

Another likely one-of-a-kind was a standard magnetic station disk with a pointed rod mounted upright upon the center of the disk. A photograph of this disk was seen on-line.

FAMOUS FINE - "The authority for the warning concerning punishment for disturbing the mark is contained in an act of Congress, approved March 4, 1909, entitled 'An act to codify, revise, and amend the penal laws of the United States,' and reads as follows: 'Whoever…shall willfully deface, change, or remove any monument of bench mark of any Government survey shall be fined not more than $250, or imprisoned not more than six months, or both,' 35 Statute 1088, section 57." Above quote is from USC&GS Special Publication No. 26, 1921. http://docs.lib.noaa.gov/rescue/cgs_specpubs/QB275U35no262nded1921.pdf Adjusting for inflation, the value in the year 2007 for the 1909 amount of $250 is over $5700.00! For additional information, see: http://www.amerisurv.com/content/view/4318/136/ . [NOTE, THIS LINK WILL TAKE YOU OFF THE NOAA WEB SITE.]

ACCESS TO PRIVATE LAND (or GO DIRECTLY TO JAIL) - In order to help ensure access to survey marks on private land, many states passed laws requiring land owners to allow passage. Some of these laws also made it a crime to damage USC&GS marks or equipment. In 1847, Georgia passed such a law with the following penalty, "shall be punished by a fine not to exceed one thousand dollars, imprisonment not to exceed six months, to work in the **chain-gang** on the public works, or on such other works as the county authorities may employ the chain-gang, not to exceed twelve months...."

So, how many different styles, inscriptions, versions, and materials of USC&GS disks are there? The author can only say, over 52 and counting. This total does not include: minor changes in font size, changes in the length of the arrows on Reference Marks and Azimuth Marks, or the type of setting (rod, concrete, drill hole, etc.)

III. SURVEY DISKS & RODS USED BY THE NATIONAL OCEAN SERVICE

After the formation of NOAA in 1970, NOAA surveyors continued to use the stock of USC&GS disks until new disks were produced. About 1971, the first new National Ocean Survey (NOS) disks were manufactured. The three main users of the NOS survey disks were the NOAA hydrographic survey units (field parties and ships), the NOAA airport survey crews, and the tides and water level division of NOAA, which is called the Center for Operational Oceanographic Products and Services (CO-OPS).   NOS disks were used by the hydrographic survey units and airport survey crews for marking third-order surveys (lower accuracy than first-order or second-order), while CO-OPS used a Tidal Bench Mark version of the disk for second- and third-order leveling surveys. NOAA airport survey crews set NOS disks from about 1971 to about 1997 when NGS disks began to be used. The NOS disks are still set by hydrographic and CO-OPS survey units. In addition to the casting on the disk, different units stamp their disks with identifying information (station names, dates, etc.) according to their respective organizational identification protocols.

NATIONAL OCEAN SURVEY DISKS – When NOAA was formed, the NOS official name was National Ocean Survey, reflecting the previous name of U.S. Coast & Geodetic Survey. Hence the original NOS disks were factory stamped NATIONAL OCEAN SURVEY. See Figure 62, which shows five styles of National Ocean Survey disks. Figure 63 shows an actual example, and Figure 64 shows a special NOS disk. The three styles in the left column of the drawing are known to exist. For an example of the upper, left disk see PID = SY3062 from 1980. The disks have a convex top, that is, the center is higher than the outer edge. Some styles were made with both short tubular stems for mounting onto a rod, and crimped stems, with one or two sections of the stem crimped flat to help resist rotation and extraction from concrete or the cement in a drill hole. A search of the NGS data base shows that a disk with the NOS logo was set in Oregon as early as 1971. The disk would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. An aluminum National Ocean Survey disk with a cross and very small circle in the center was also used. Examples from 1979 to 1984 have been found. National Ocean Survey disks were used from c1971 to c1985, although at least one old stock disk was used as late as 1992. Rod marks made of copper-clad steel and then galvanized steel (c1976) were both used for short periods. About 1978, stainless steel rod marks began to be used at some tide gauge sites as the primary bench mark. See the NGS section below for additional information on stainless steel rod marks.

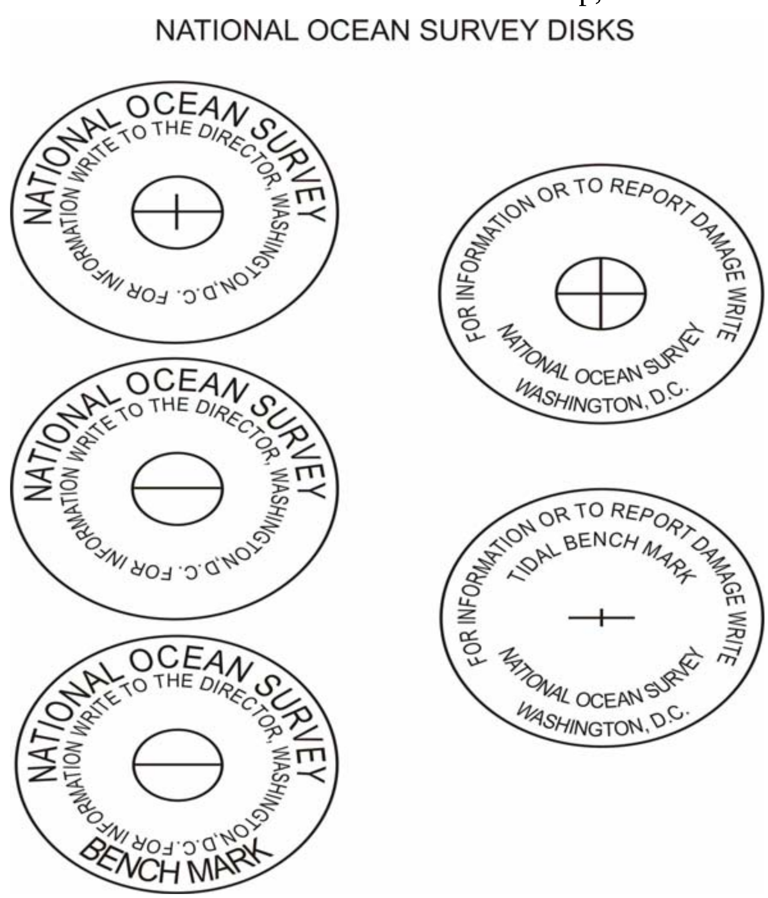


Figure 62

Figure 63 – Standard NOS Disk

Figure 64 – Special NOS Disk

NATIONAL OCEAN SERVICE DISKS - In 1985, the name of the organization was changed from National Ocean Survey to National Ocean Service. In September of that year, a new disk was ordered with the lettering "NATIONAL OCEAN SERVICE." Figures 65 through 68 show National Ocean Service disks. Note that the disk in Figure 56 is slightly different from any of the disks in Figure 57, it does not have the short, cross slash in the center. In the documentation with the purchase order for the new disks, the disk at the upper left was called the "NOS Universal" and the disk at the lower left was called the "Tidal Bench Mark." The factory stamping for the "universal" disk includes "NATIONAL OCEAN SERVICE" with an encircled large cross in the center. For an example see PID = AH7029 from 1997. The factory stamping for the other includes "TIDAL BENCH MARK NATIONAL OCEAN SERVICE" with a crossed slash in the center. Both were

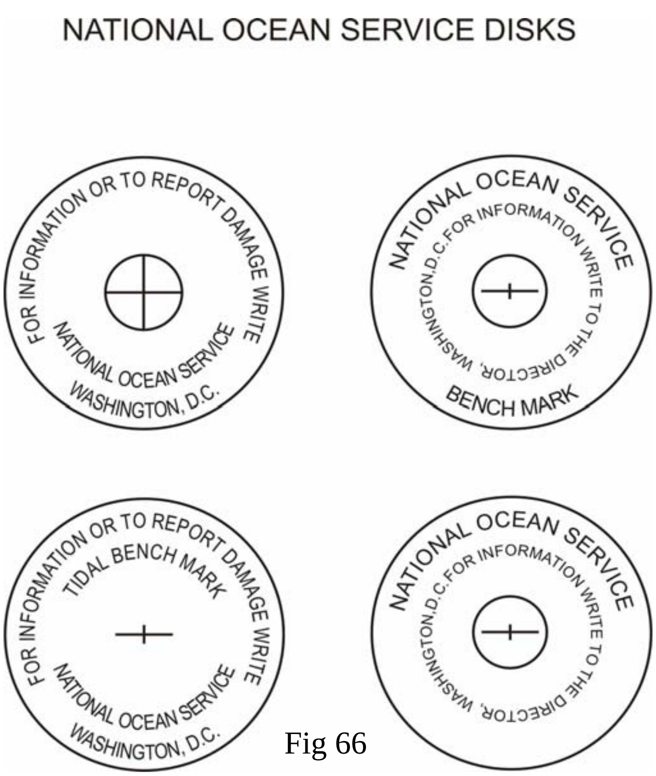


Fig 66

Figure 65

intended to have tubular and crimped stem types. The "NOS Universal" with the crimped shank is known to exist. Interestingly, an error was made and some disks were manufactured, and perhaps set, with the lettering NATIONAL OCEAN SERVICES (extra "S"), see Figure 67.

An aluminum NOS disk with a plain center was also produced and used (examples from 1987 were found and an aluminum disk with a "+" in the center dated 1992 was found, see PID = GV6180).

Figure 67

More recently a solid, cast NOS disk has been produced which is thicker than the previous types and is flat on the under surface rather than concave, see Figure 68.

These NOS disks would be set in a concrete monument, or set in a drill-hole in a large structure or bedrock. These NOS disks have been used from c1985 to the present.

Figure 68

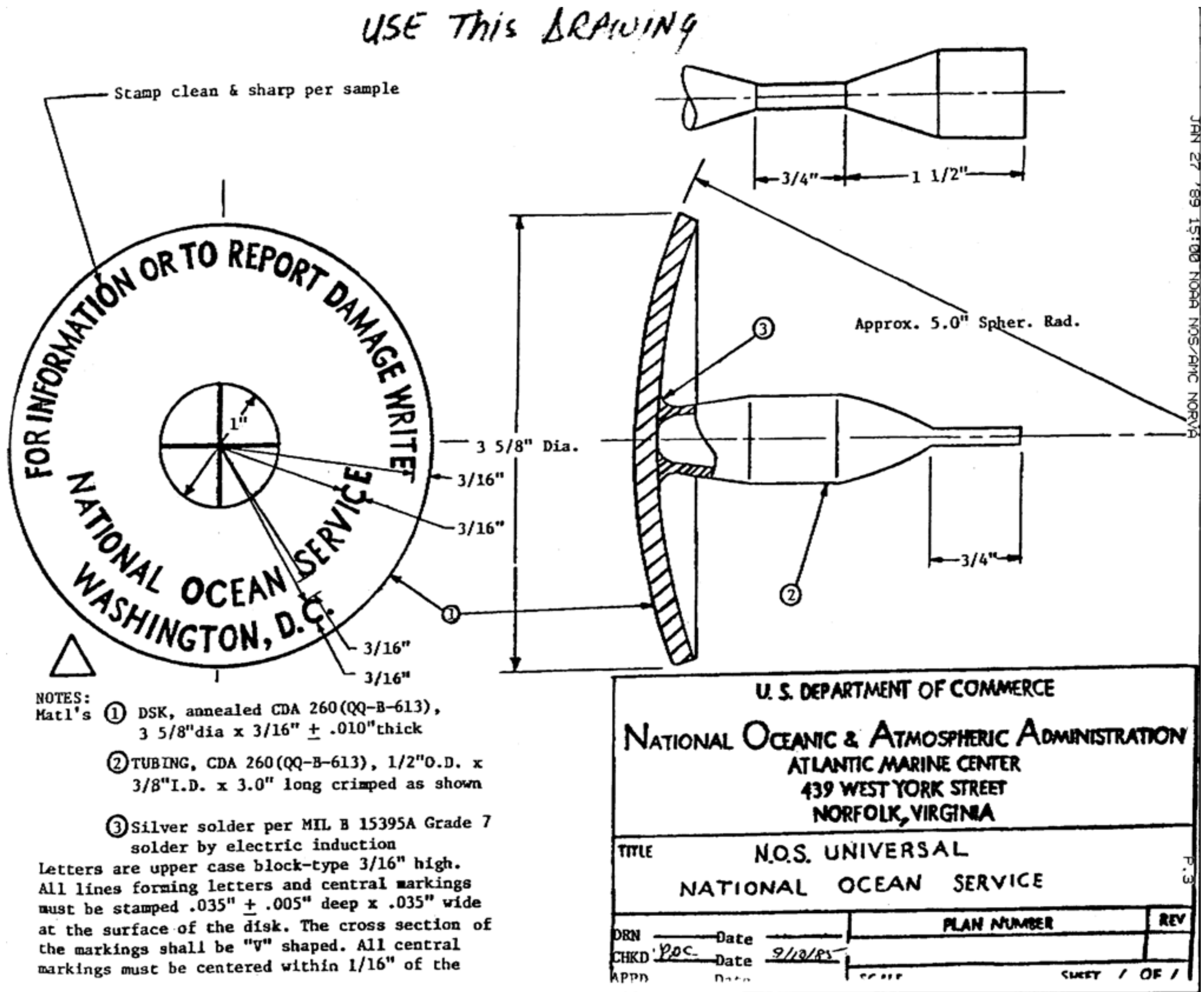


Figure 69

Figure 69 shows a disk drawing made for a disk order in 1985.

See Figure 70 of an aluminum "logo cap" factory stamped "TIDAL BENCH MARK" with a space to the right for the Tidal Bench Mark's name and date set. See the NGS section below for more information on aluminum logo caps and the stainless steel rod marks that they protect.

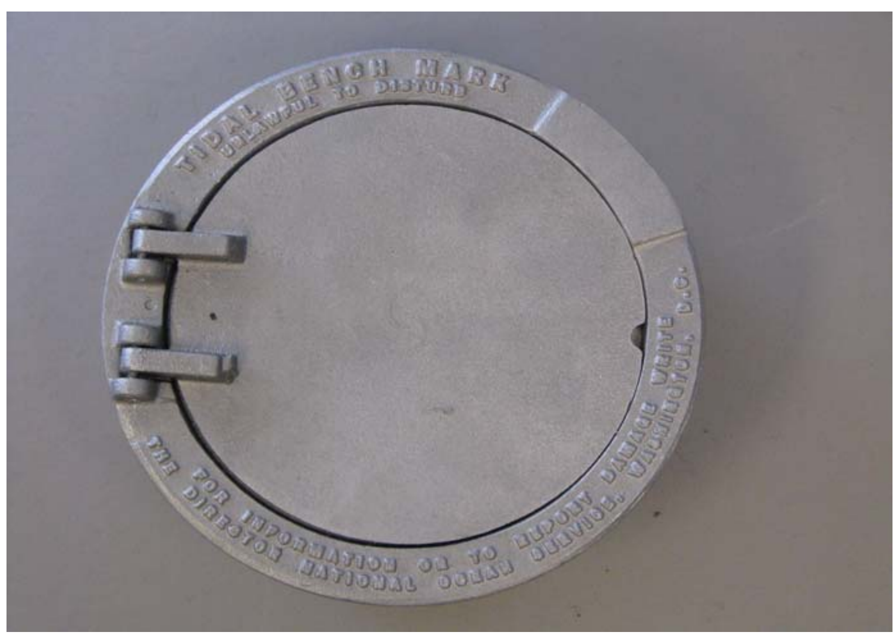


Figure 70

IV. SURVEY DISKS & RODS USED BY THE NATIONAL GEODETIC SURVEY

Disks stamped "NATIONAL GEODETIC SURVEY" were used starting in 1971 after the formation of NOAA in late 1970. They were used for first-order, second-order, and higher accuracy surveys. The standard factory stamping was "FOR INFORMATION OR TO REPORT DAMAGE WRITE: THE DIRECTOR; NATIONAL GEODETIC SURVEY; WASHINGTON, D.C." (With ";" indicating the start of another line). The unique factory stampings for the different styles of disks are explained in the following paragraphs. In addition to the factory stamping on the disk, at the time of setting NGS stamped disks with the identifying information of the mark name and the date set.

Disks were set in a concrete monument, or set in a drill-hole in a large structure or bedrock. The concrete monument was normally about flush with the ground's surface, 12 inches in diameter, and 48 inches or more deep with the bottom larger in diameter to help resist frost heave.

It should be noted that since a mark stability study was done in the late 1970s, many NGS survey points were set as stainless steel rods driven into the ground rather than as survey disks. For rod marks, no underground mark was set. Soon after NGS began using the GPS in 1983, Reference Marks and Azimuth Marks were also no longer set. The data sheet from the NGS database will state which type of mark was set (disk, rod, or other), contain a description and the data associated with the mark (latitude, longitude, elevation, etc.) and tell how to reach the mark. Also, for a period of time from 1979 to 1980, disks were crimped onto the top of stainless steel rods and encased in a 4-inch PVC pipe with a screw lid.

HORIZONTAL CONTROL MARK DISKS (with triangle in center) – This style disk was a replacement for the USC&GS Triangulation Station disk and the Traverse Station disk, and was used for second-order and higher horizontal surveys. The unique factory stamping for this disk is "HORIZONTAL CONTROL MARK" with an equilateral triangle in the center, see Figure 71. Just prior to setting the disk, the surveyor would stamp the name and date on the disk. The disk was usually set so that the stamping could be read by an observer facing north. The primary data for this type disk would be latitude and longitude (horizontal) positions determined by any of several methods. A brief discussion of the classic horizontal surveying methods can be found at: http://celebrating200years.noaa.gov/foundations/spatial/side2_spatial.html . In addition, after c1983 GPS surveying methods were used to position these disks. Most of these marks have at least an approximate elevation and some have more accurate elevations. This style of disk was used from c1971 to c2007.

Figure 71

VERTICAL CONTROL MARK DISKS (with crossed slash in center) - This style disk was a replacement for the USC&GS geodetic Bench Mark disk and was used for vertical surveys. The unique factory stamping for this disk was “VERTICAL CONTROL MARK” with a crossed slash in the center, see Figure 72. Just prior to setting the disk, the surveyor would stamp the name and date on the disk. The primary data for this type disk would be its elevation determined by differential leveling. A brief discussion of this method of determining elevations can be found at: http://celebrating200years.noaa.gov/foundations/leveling/welcome.html . Most of these marks have at least an approximate (scaled) horizontal position and some have more accurate positions. Beginning in the late 1970s, stainless steel rod marks were usually set for Bench Marks. Most of these NGS VERTICAL CONTROL disks were made of a brass alloy. A few were manufactured of aluminum with a raised center. Examples of aluminum disks set in 1975 and 1981 have been found, see Figures 82 and 83. In c1978, the brass disk was available both with a stem on the back and with a tube on the back for crimping onto a driven rod. This style of disk was used from c1971 to c2008.

Figure 72

REFERENCE MARK DISKS (with crossed arrow in center, pointing to the right side) - Reference Marks (RM) were set to assist in locating the Horizontal Control (HC) station (mark) but also to help determine if the station was undisturbed and in its original position. They could also be used to reset a station mark if required. Reference Marks were factory stamped with “REFERENCE MARK” and with an arrow pointing to the right, see Figure 73. The original surveyor stamped the RM with the name of the station, the number of the RM, and the date just prior to setting. For example, the first RM for station JONES would be stamped “JONES NO. 1 1975.” When setting, the surveyor rotated the disk until the arrow pointed directly toward the HC station disk. The surveyor then measured the direction and distance from the station to the RMs and recorded the information as part of the station’s description. Later, if a surveyor attempting to find a HC station stumbled upon a RM first, the arrow and the published distance and direction between the RM and station would be valuable aids in the station recovery. To check the position of the HC station, the new surveyor could measure the angles and distances to the RMs and compare them to the original published values. Two RMs were specified. Reference Marks were usually set within 30 meters (one tape length) of the station. Reference marks were numbered clockwise from north and set about 90 degrees apart so that there would be a strong intersection between distances measured from them to the Triangulation Station. If a RM was destroyed, a new Reference Mark would be set using the next consecutive number. Most of these NGS RM disks were made of a brass alloy. A few were manufactured of aluminum with a raised center, see Figure 82. NGS Reference Mark disks were used from c1971 to the mid-1980s.)

Figure 73

AZIMUTH MARK DISKS (with crossed arrow in center, pointing up or left) – Before the advent of GPS surveys, an Azimuth Mark was set near each Horizontal Control (HC) Station. Its purpose was to provide an initial azimuth for local surveyors beginning surveys at a HC Station. Azimuth Marks were factory stamped with “AZIMUTH MARK” and with an arrow pointing to the left or up, see Figure 74. The original surveyor stamped the HC Station’s name and date on the Azimuth Mark disk, just prior to setting. Since this is the exact same stamping as the HC Station, surveyors even today must check the factory stamping of “AZIMUTH MARK” (with arrow) versus “HORIZONTAL CONTROL STATION” (with triangle) to determine which is which. When setting, the surveyor rotated the Azimuth Mark disk until the arrow pointed directly toward the HC Station disk. The surveyor then measured the direction (and in some cases the distance) to the Azimuth Mark (from the HC Station) and recorded the information as part of the station’s description. Azimuth Marks were usually set between ¼ mile and 2 miles from the HC Station at a point visible from tripod height at the station, and generally in or near a fence line along a road. For a time, in the mid to late 1970s, Azimuth Marks were positioned and underground marks were set beneath. NGS Azimuth Mark disks were used from c1971 to about the early 1990s.

Figure 74

GRAVITY CONTROL MARK DISKS (with crossed slash in center) - This type of disk was set during gravity surveys. This disk was factory stamped “GRAVITY CONTROL MARK” with a crossed slash in the center, see Figure 75. The original surveyor would stamp the station name and date on the disk just prior to setting. The station is often named for the city, often with a suffix, and is usually set so it can be read by the user facing north. Note that many gravity marks were set indoors. If set outdoors, the disk would be set in a concrete monument, or set in bedrock or a large structure. For indoor marks, an “Absolute Gravity Plug” may have been used. The Plug is a 2 cm diameter brass dowel, 0.5 to 3 cm long. It is usually epoxied into a drill hole in the floor and set flush. NGS gravity disks were used from c1979 to the present.

Figure 75

CALIBRATION BASELINE DISKS (with “+” in center, or a small punch mark in the center) - see Figures 76 and 76. “During the early 1970s, the number of types of Electronic Distance Measuring Instruments (EDMI) dramatically increased. Their use was expanded to cover almost every conceivable surveying problem. Quality assurance became a pressing concern and NGS began establishing a series of Calibration Base Lines (CBL) for this purpose.” [Quote from “Use of Calibration Base Lines” NGS, 1977] Today, CBL have been established in every state in the country totaling over 300. Information and data on CBL are available on-line at: http://www.ngs.noaa.gov/CBLINES/calibration.html . The unique factory stamping for this disk is “CALIBRATION BASELINE.” Two styles of CBL disks were produced, one with a “+” in the center and the other blank or with a small punch whole in the center. The “+” disks are used to mark the following distances: 0, 150, 430, and 1400 meters. The blank disk is used to precisely mark 100 feet from the “0” disk, for checking 100-foot measuring tapes. The disks are stamped in the field with “CBL”, the distance to the nearest meter, and the year. Neither accurate horizontal nor vertical positions are normally available for CBL marks. The distance between each of the CBL marks and the difference in elevation of the four marks are published on-line. These disks were first used in c1974 and are still used today.

Figure 76

Figure 77

GEODETIC CONTROL MARKS (with triangle in center) – A limited quantity of these disks was manufactured for a survey project in Alaska in 2001. They were of special design to be mounted on a pipe for placement in a drill hole in the tundra and were 3 3/16 inches in diameter. The unique factory stamping for this disk is “GEODETIC CONTROL MARK,” see Figures 78 and 79. Just prior to setting the disk, the surveyor would stamp the name and date on the disk. The disk was mounted on a 3- to 10-foot long pipe using rivets, for setting in the tundra. The primary data for this type disk is its horizontal position determined by GPS surveys. This NGS Geodetic Control Mark was used in Alaska in the year 2001.

Figure 78

Figure 79

GEODETIC CONTROL MARKS (with NOAA Seagull and triangle in center), see Figure 80. - This new style disk was designed in 2005-2006 and only 50 prototypes have been produced to date. Some of these have been set in the field.

Figure 80

GEODETIC CONTROL MARKS 2006 – This general purpose disk design was approved in late 2006 for use in all types of NGS surveys. This style was first used widely in a leveling project in Puerto Rico in 2009. See Figure 81.

Figure 81

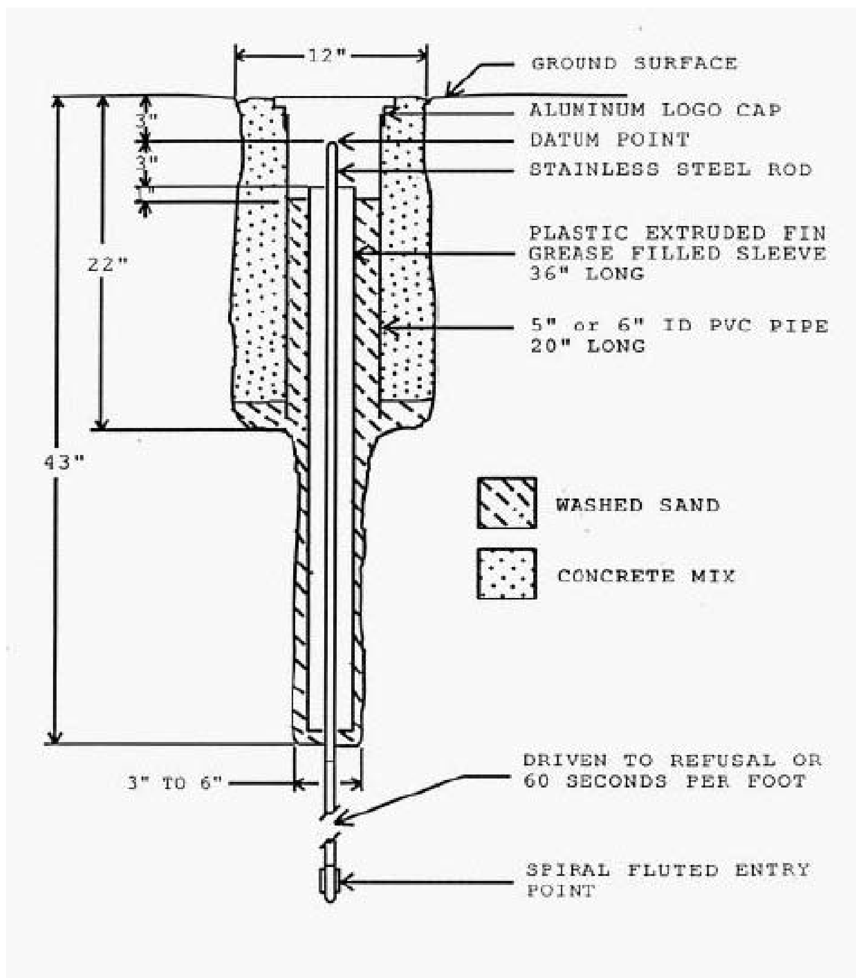
In addition, in the middle to late 1970s, NGS had at least two different aluminum disks produced, a Reference Mark disk and a Vertical Control disk, both with an unusual raised center area, see Figures 82 and 83 (photo credit, Richard Cohen). The RM is a variation for mounting on a pipe. For a vertical control example from 1981 see PID = FL2094.

Figure 82

Figure 83

STAINLESS STEEL RODS WITH ALUMINUM LOGO CAPS – Beginning about 1978, NGS began setting stainless steel rods as vertical control marks, then later as horizontal control marks. The rod is driven to refusal (or near refusal), and cut off. For a year or two disks were crimped to the top of the rod. Then for another couple of years a stainless steel domed cap with stamping was crimped onto the rod. Eventually the present method was begun of rounding off the top and, for horizontal control points, center punching a "dimple" onto the top of the rod to create the survey point. Two versions of rod marks are set; one with a sleeve and one without. The grease-filled sleeve was designed to help isolate the rod mark from movement of the ground near the surface. The top of the rod is protected and identified by an aluminum "logo cap" and PVC tube; see Figures 84 and 86, below. The stamping is made on the blank area on the rim of the logo cap since the top of the rod is very small. These stainless steel marks are extremely stable, especially in the vertical direction. Details may be found in the publication "Geodetic Bench Marks" at: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs/ . See Figure 85, drawing below for a cross-section view of this type of mark.

Figure 84



Schematic of the Revised NGS 3-D Rod Mark, Side View

Figure 85

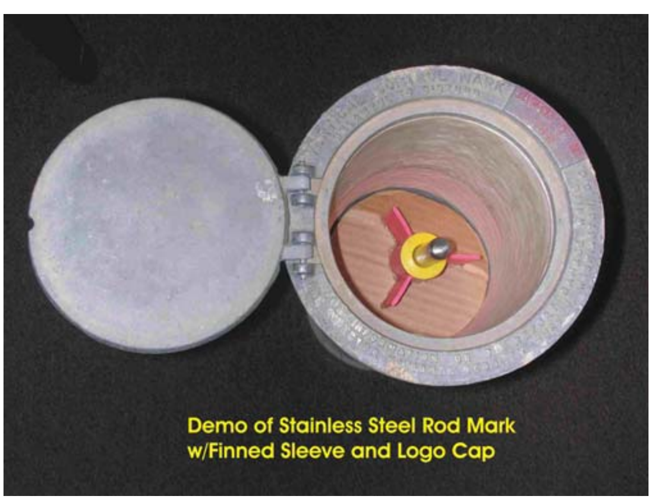


Figure 86

VERTICAL ALUMINUM LOGO CAPS – This cap was factory stamped with “VERTICAL CONTROL MARK; UNLAWFUL TO DISTURB; ACCESS COVER; FOR INFORMATION OR TO REPORT DAMAGE WRITE; THE DIRECTOR NATIONAL GEODETIC SURVEY, WASHINGTON, D.C.,” see Figure 87. The cap had an opening lid allowing access to the disk or rod beneath. The rim of the cap also contained a blank area allowing the surveyor setting the mark to stamp the name and date for positive identification (since the top of a rod does not have space for stamping). The logo cap was mounted on a PVC tube as part of the protection of the mark. This cap was in use from c1978 to c1992.

Figure 87

GEODETIC ALUMINUM LOGO CAPS - This cap was stamped as above except that the word “GEODETIC” replaced the word “VERTICAL”, see Figure 88. The original intent of the rod mark was to create an extremely stable Bench Mark. It was later decided to use this type mark for horizontal marks as well, hence the name change. This logo cap began use in the early 1990s and is still in use today. The mounting collar of this cap is manufactured so that it will mount outside of a 5-inch diameter PVC pipe or inside a 6-inch diameter PVC pipe. As with the other types of logo caps, the mark’s designation and date are stamped in the blank area on the outer rim (upper right in photograph).

Figure 88

SMALL DISKS USED WITH GALVANIZED PIPE-TYPE MARKS – This type of mark and disk was used for airport surveys in Maine in 1996. The small bronze disk was 2 inches in diameter and its stem was force-fitted into the hollow top of the pipe mark after the 1 or 1.5 meter long, galvanized pipe was driven into the ground and its anchors extended. This disk was factory stamped with “NATIONAL GEODETIC SURVEY 1996," with a triangle and dot in center, see Figure 89. This type of mark was intended to be quick and inexpensive but complications with a concrete collar NGS added ended its use after this first project.

Figure 89

SURVEY NAIL WITH WASHER – This type of mark has been used as a temporary point on airports and other locations. “NGS” is factory stamped on the washer to aid in identification, see Figure 90 and 91. The nail and washer (approximately 1.5 inches in diameter) are made of aluminum or similar alloy.

Figure 90

Figure 91

For detailed information on how to set marks to NGS specifications, see: http://www.ngs.noaa.gov/ContractingOpportunities/Grd_Survey_SOW_V7A.pdf , especially Attachments T, U, and V.

V. OTHER DOC AND NOAA SURVEY MARKS

The U.S. Department of Commerce’s Bureau of Public Roads also had at least one style of survey disk.

The National Weather Service (formerly U.S. Weather Bureau) also set disks, see Figure 92 of “1908.2 USWB”, PID = GJ0237, in Woodward County, Oklahoma. (Photo credit – Laura Huskins)

Figure 92

In addition, the U.S. Lake Survey (USLS) was included in the new organization when NOAA was formed in 1970. Prior to 1970, the USLS was part of the U.S. Army Corps of Engineers, and had at least two styles of disk: station (“+” in center) and reference mark (arrow in center). These disks are about 2 5/16 inches in diameter. After NOAA was formed, a disk with stamping including “NOAA NOS LAKE SURVEY” was used as late as 1975. An early example of a USLS disk from 1934 was found, see PID = RJ0016. The disk in Figure 93 is stamped 1874, but the original station was probably reset with this disk at a later date. For examples of the three types, see Figures 93 through 95, and a back view of the Figure 93 disk is shown in Figure 96.

Figure 93

U.S. LAKE SURVEY STATION
Photo credit – author

Figure 94

U.S. LAKE SURVEY RM
Photo credit – Ray Petti

Figure 95

NOAA NOS LAKE SURVEY
Photo credit – Mark O.

Figure 96

USLS Disk, Back View
Photo credit - author

SIDEBAR ON MARK PRESERVATION

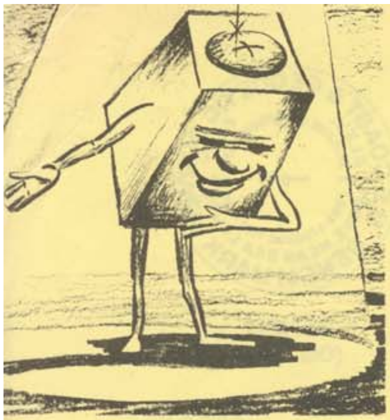
Survey marks established by the National Geodetic Survey (the former U.S. Coast & Geodetic Survey), are part of the nationwide survey network managed by the National Geodetic Survey (NGS), NOAA. This network, the National Spatial Reference System, includes more than 1,500,000 survey points spread across the United States. Each of these survey marks provides one or more types of very accurate survey data. This data may include: latitude, longitude, elevation, magnetic, and gravity values. Data on all 1,500,000 survey points are contained in the NGS database and are available on-line at: http://www.ngs.noaa.gov/ under "datasheets". Surveyors, engineers, planners, mappers, and scientists use these survey marks to give their work accurate geographical reference and connection to the national survey network, called the National Spatial Reference System (NSRS). Because the NSRS provides the fundamental positional framework for the nation's buildings, roads, utilities, and boundaries, we all ultimately benefit from their proper use. When a survey mark is removed from its setting, it can no longer serve its intended purpose and its loss contributes to our general detriment.

Figure 97

All persons are respectfully requested to protect and preserve these marks. Marks are frequently destroyed by construction equipment or by vandalism, see Figure 97. During construction, preserve the marks if at all possible by flagging them so that equipment operators will avoid the marks. If a mark is on your property, attempt to keep it safe from damage and destruction. If the destruction of a USC&GS or NGS mark can not be avoided, contact NGS for guidance.

About 1960, the USC&GS created a cartoon character to help preserve survey marks. His name was "Marvin Marker". See Figures 98 and 99 for his story.

Figure 98



U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON 25, D.C.

INTRODUCING MARVIN MARKER

My name is Marvin Marker. I belong to an extremely large family of bronze station markers which are property of the U. S. Coast and Geodetic Survey. Because of my 150-year's longevity, I was chosen to solicit your help in a serious family problem.

Our problem is the same as that faced by people throughout the world today -- SURVIVAL. Yet our concern, apart from man's, is not because of the present world situation. Our chances of survival are slim regardless of the world's condition! And they are getting slimmer all the time! That's why I am appealing to you.

Lately our lineage has suffered terrifically because of premature deaths. Last year, thousands of Markers met with ill-fated deaths. Hundreds were mistreated, abused, uprooted and thrown away. Some were even brutally murdered. Few, I am sorry to say, ever die comfortably of old age.

Although I am emotionally involved as a member of the family, I can't help but think that people, too, would become a bit emotional if they knew the terrific expense involved in replacing us. Someone told me that the Government spends thousands of dollars each year just replacing unfortunate Markers. (Boy! That sounds like an awful lot of the people's money, since they're always complaining about not having enough!!) And yet I'm sure that if people were made aware of a few things about us, 95% of these losses could be prevented.

From time to time we suffer through maliciousness. Halloween, without fail, finds pranksters attempting in various ways to pry us up. Souvenir hunters, too, frequently steal us for use as paperweights, bookends, or just for the thrill of an unusual memento. The laugh will be on them if they are ever caught, though! Imprisonment or a $250 fine hardly seems worth the thrill they receive from such frolicking.

Our biggest enemy, however, is the man behind the bulldozer or grader. Brother! On more than one occasion in my lifetime I have had to do some fast praying for fear that I would follow some of my relatives to the grave — an unfortunate victim of a crushed disk! I thank my lucky stars that the present owner of the property on which I live knows all about me, and my value to surveyors and engineers. He takes special precautions to see that I stay healthy, and that no man or machine damages me.

It's because of these well informed, thoughtful people who are careful to watch for us and for our distress signs, that many Markers live long, useful lives. Actually, we are supposed to be immortal. But, some of the family have died of old age, erosion or sedimentation because the services of a professional engineer were not engaged soon enough to save them.

Please, won't you perform a valuable service to your country and community by helping Markers live a normal life span? Engineers, businessmen, housewives, students, — Just about every citizen can help!

Remember these facts!

(1) Never remove a survey marker. Once this is done, the value of it is lost entirely, and replacement is costly.

(2) If there is construction going on in your area and you notice a survey mark which appears to be in the way, call it to the attention of the surveyor in charge to insure that he is aware of it.

(3) If you see a survey mark which appears to be susceptible to damage of any kind, or which seems to be undergoing erosion or other "old-age ailments," flag it by driving stakes nearby and marking them with red ribbon, cloth, or plastic.

(4) In all cases, submit a report of your findings to The Director, Coast and Geodetic Survey, U.S. Department of Commerce, Washington 25, D.C.

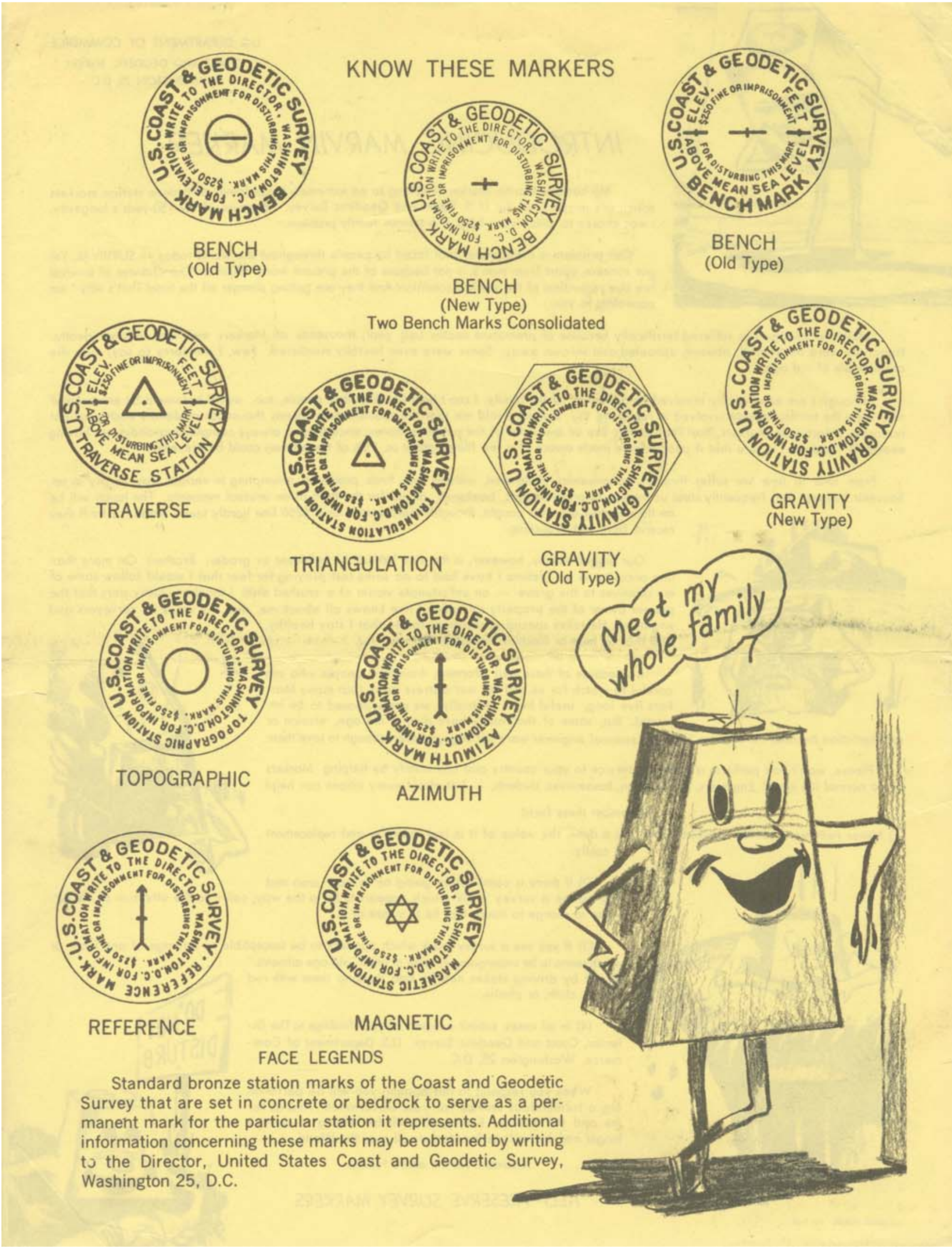
When you respond to this appeal, you will be performing a tremendous service for your Government. And as for me and the Marker Family, you will be helping to achieve longer and better lives for Markers all over the World.

Thanks from the entire family!

HELP PRESERVE SURVEY MARKERS

US COMM-CGS-DC PIO 2-62

Figure 99


KNOW THESE MARKERS
BENCH
(Old Type)
BENCH
(New Type)
Two Bench Marks Consolidated
BENCH
(Old Type)
TRAVERSE
TRIANGULATION
GRAVITY
(Old Type)
GRAVITY
(New Type)
Meet my whole family
TOPOGRAPHIC
AZIMUTH
REFERENCE
MAGNETIC
FACE LEGENDS
Standard bronze station marks of the Coast and Geodetic Survey that are set in concrete or bedrock to serve as a permanent mark for the particular station it represents. Additional information concerning these marks may be obtained by writing to the Director, United States Coast and Geodetic Survey, Washington 25, D.C.

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THANKS

The author would like to thank Richard Cohen, NGS Retired, and Dan Winester, NGS, who both made numerous technical contributions including many photographs; and to the many people who submitted photographs and permitted them to be included. Credits for photographs and information are listed below. The author would also like to thank Aria Remondi, NGS who did a considerable amount of editing and made numerous improvements.

Daryl
Bobby Alexander
Nancy Ball
Kevin Bashant
Teresa Buseth
Richard Cohen, NGS Retired
Dave Doyle, NGS
Kendall Fancher, NGS
Richard Garland
Geocacher
Byron Hooks
Laura Huskins
Bob Jensen
Eric Linzey, NGS
Robert Macomber
Marc Moore
NC Geodetic Survey
Mark O.
John Oswald, former NGS
Jerry Penry
Chester Perkins
Ray Petti
Paul Robertson
Paul Spofford, NGS Retired
Mace & Patrice Shorie
Dan Winester, NGS
Author, NGS