

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

IN REPLY ADDRESS THE DIRECTOR  
U. S. COAST AND GEODETIC SURVEY  
AND NOT THE SIGNER OF THIS LETTER  
AND REFER TO NO. 62-RM

19 April 1948

To: Mr. C. T. Husemeyer  
Associate Geodetic Engineer  
U. S. Coast and Geodetic Survey  
General Delivery  
Petaluma, California

Subject: INSTRUCTIONS

Reference: Project G-910, Special Surveys, Utah

1. As soon as the necessary arrangements can be made, you will transfer the triangulation party of which you now have charge to Lieut.(j.g.) Gerald L. Short. Transfer of property and instruments will be made in accordance with paragraph 1024 of the Regulations. You will inform Lieut. Short of the status of your outstanding accounts and the leave earned by your personnel.
2. You then will proceed to Salt Lake City, Utah, by truck, where you will contact Mr. H. O. Plath, Field Engineer, in charge of the Salt Lake Field Office of the Corps of Engineers, at 222 S. W. Temple Street, relative to the Underground Explosion Tests project. Most of these tests will be conducted in the Dugway Proving Ground area, about 90 miles southwest of Salt Lake City. You will make arrangements with Mr. Plath in regard to the cooperative project, our part of which will be the determination of permanent displacements of the target structures resulting from the underground explosions.
3. From the last information available at this Office, there will be four sites at which target structures will be constructed for these tests. The full scale targets are to be concrete walls about 18 inches thick, forming a square 25 feet wide. The entire structure will be underground, the top being about 7 feet below the surface but entirely exposed. There are to be at least four points set on each target, one at each corner and probably four others near the center of each side. The purpose of the surveys is to determine, within 0.1 inch if possible, the permanent displacements of these points after the explosions. There will be three targets in each group

and from two to four groups at each site. These targets will be constructed at four different scales; namely, 0.1, 0.2, 0.5 and full. The scale ratio is carried through completely in regard to the size of the target, its distance from the center of the explosion and the power of the explosion itself. Following is a tentative setup by sites.

1. Dry sand, all four scales
2. Wet sand, scales 0.1 and 0.2
3. Dry clay, all four scales
4. Wet Clay, scales 0.1, 0.2 and 0.5

These four sites are in the Dugway area. A fifth site in the region of Grand Junction, Colorado, will have as targets four tunnels, one at each scale, driven in granite. The procedure required at this site must be determined by you after consultation with the Corps of Engineers.

4. For a full understanding of the following instructions, it must be realized that what is required is the determination of small displacements at each group of targets and not the relative positions of the theodolite stations with these targets. The precision of 0.1 inch applies to all groups of targets regardless of scale. It follows that the accuracy can be more easily attained for the targets at the smaller scales.

5. Reference is made to the attached sketch as an aid in the explanation of the procedure at one group of targets. The three squares represent target structures which, at full scale, will be spaced at intervals on the order of 150 feet. Theodolite stations A and B shall be selected at least one-quarter of a mile from the target structures and in a position to form an approximate right angle at point C somewhere near the central target. Points M and N shall be selected at least one-quarter of a mile and preferably near one-half mile from the target group on range with AC and BC. The theodolite stations A and B should be of extremely rigid construction, preferably a concrete shaft sunk well into the ground and projecting at a convenient instrument height above the ground. Tribrachs should be cemented on the tops of these monuments. It is suggested that plaster of Paris be employed for this purpose in order that these tribrachs may be easily removed for use at other sites. Points M and N shall be marked with a similarly rigid structure for supporting a signal. It is necessary that these signals be of such design as to permit very accurate pointings. A small signal lamp provided with a vertical slit aperture is suggested and it should be cemented to the structure as in the case of the tribrachs. Point P, which is near the intersection of the lines AM and BN, designated as C, may be either

temporarily or permanently marked if it is felt that the explosion will not destroy this mark. It is suggested that it be of construction similar to A and B.

6. The basic point of reference for the surveys is point C, the exact intersection of the two lines AM and BN. The basic orientation is the direction of the line AC. In the sketch, point P represents the instrument station near C. The coordinates of P as related to C shall be determined by the measurements of the small angles at A and B. No attempt should be made to place P exactly at C, but the small angles shall be kept within three or four minutes of arc.

7. Angles PAM and PBN shall then be measured by the following method. The measurements of these small angles shall be made entirely with the micrometers, the circle graduations not entering into the measurement except as reference lines for the micrometer hairs. Any pair of graduations five minutes apart shall be selected for each angle measurement and this pair used throughout the measurement. Ten direct and ten reverse observations shall be made, advancing the circle setting approximately 12 seconds between a set of direct and reverse observations. This procedure will distribute the observations over one entire turn of the micrometer screw. The rejection limit shall be determined by experience. It is believed that any residuals greater than 2 seconds should indicate a rejection and experience might prove that even this limit should be reduced. Refractive errors should be at a minimum, as both lines of sight are so close together. The circle errors will not enter into the problem at all. The signal at point P might be a slit-light, in which case it would have to be faced alternately towards A and B. A frosted flashlight bulb might prove to be a satisfactory signal, provided extreme care is taken in plumbing its center directly over the mark at P.

8. When the small angles at A and B become known, the coordinates of P, in relation to C, may readily be computed. The problem now is to determine the coordinates of the points on the target structures by the measurement of directions, using PA or PB as an initial and measuring the distances by a single catenary of the tape from the point P. A 7" Berger theodolite employed as a direction instrument will be satisfactory for the measurements of the directions, provided caution is exercised to avoid reading errors. One set of direct and reverse should suffice. As some of the distances to be measured will be greater than 100 feet, a 300-foot steel tape will be required. Again, it must be realized that it is the determination of small relative movements that is required, and the absolute length of the tape is not of great

importance. The same divisions on the tape should be used for each individual measurement to some certain target point, before and after the explosion. In this way the errors of the tape will not enter into the differential measurements. In the case of the smaller-scaled targets, a standardized 30-meter tape may be employed, but only when all points on one target structure can be reached by this tape.

9. It is suggested that plumb lines be set over the corner points on the target structures to which the measurements from point P can be made. It is in this operation that a loss of accuracy could easily be sustained. The plumb lines, which will be from 8 to 10 feet long at the full scale groups, should be completely shielded from the wind by some such device as a length of stovepipe or, perhaps, an elongated box-like structure made of 1" x 4" lumber. The contact during the taping should be made directly with the plumb line at its highest point. A single catenary is to be preferred as this system can be duplicated with exactness. These measurements must be made when there is little or no wind.

10. A fairly accurate calibration of the length of the 300-foot tape (single catenary, if practicable) should be made by comparison with two lengths of the 50-meter invar tapes. In this comparison it will be necessary to set back about 28 feet from the 100-meter interval with a standardized 30-meter steel tape. The weight per foot of the 300-foot tape should be determined, at least roughly, in order that the corrections for catenary may be calculated. It might be well to calibrate the 300-foot tape at as wide a range of temperature as possible to obtain a check on the coefficient of expansion.

11. The distances in the triangle APB need not be known to geodetic accuracy. However, two of these distances should be determined with the 300-foot tape to within a few tenths of a foot. In making these measurements, as well as those between point P and the target points, the differences of elevation shall be determined for correction to the horizontal.

12. In setting the theodolite on the tribrachs at A and B, a note should be made as to which foot screw is set in each groove in order that the instrument may be replaced in this exact manner for surveys after the explosions. This will eliminate any difficulty or doubt in centering the theodolite. It is possible that, after a study of the plan at each site, one set of A and B theodolite stations may be made to serve more than one group of target structures. The angle at C should approach  $90^\circ$  between A and B for the full scale targets but may be considerably less for the smaller scales,

particularly the 0.1 scale. The final criterion of 0.1 inch will govern your decision in the size of the angle at point C.

13. The estimate of the one-quarter mile distance for points A and B from the targets is a minimum. It is quite possible the explosion might affect these points at that distance, in which case a greater distance must be used. Further consultation with the Corps of Engineers is desirable in this respect. Angles A and B of triangle APB should be measured with first-order accuracy before and after the explosion to determine any relative movements. This precaution shall be taken in all cases when any doubt exists as to whether or not there is a permanent displacement of the theodolite stations due to the explosions. If any movement is detected or suspected, points A and B must be moved further out. The angle at P (or P' after the explosion) shall also be determined during the round of observations at this point in order to obtain a check on the angle work. This angle needs to be measured only within about 10 seconds.

14. The computation shall include reductions in lengths for temperature, inclination and sag of the tape and the coordinates of all target structure points referred to point C. The coordinates of point P must be re-determined from the small angle measurements after the explosion. It is suggested that point C be assigned the arbitrary coordinates of 500 feet for both x and y, and that the azimuth of the line CA be considered zero. The azimuth of the line PA will change to that of P'A after the explosion if P' is considered to be the newly determined instrument position.

15. An alternate method, one calculated to yield the greatest precision, would be to straddle the line AM near C with a brace of two signals attached rigidly together and about one foot apart. The two small angles at A are then measured with the common line AM between the signals. Five measurements, direct and reverse, should be made, using the direction method. The position of the line AM can then be determined by a simple proportion, dividing the space between the signals in proportion to the small angles. This should be repeated with the brace of signals moved slightly. The position of the line BN is then determined similarly and thus the point C is fixed at the intersection. This method has the highest inherent accuracy, permits the use of point C directly in the tape measurements both before and after the explosions and is totally independent of the distance of the theodolite stations A and B. Observations may be made at any time of the day or night as long as atmospheric conditions permit accurate pointings.

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16. It is also required that vertical displacements be determined as a result of the explosions. You shall, therefore, connect the monuments A and B with the points on the target structures by a system of first-order levels, incorporating all checks you consider necessary to guard against blunders. If the sights are kept short, little trouble should be encountered in attaining a precision of about two millimeters in relative elevations in your scheme. This leveling, as in the case of the horizontal work, shall be performed both before and after the explosions.

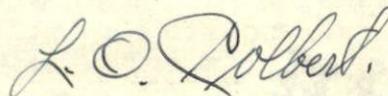
17. You should make all field computations necessary to satisfy the requirements of the Corps of Engineers. Your records and computations should be so clearly made as to leave no doubt concerning what was done. These records and computations shall be forwarded to the Washington Office when you have no further use of them. The program of the tests is not known at this Office, but is expected to last several months.

18. These Instructions have been written in detail for two reasons; first, as an outline of the general procedure desired and second, to bring out the desirable features in procedure for the determination of differential quantities brought about by small permanent displacements. You are authorized to make revisions when to do so will expedite the work with no loss in precision. You are also authorized to execute any additional work required which, in your opinion, is necessary to the success of the project. You should feel free to consult with this Office on any matters which have not been made clear to you.

19. Two employees will be assigned to you from the party of Lieut. Dorland H. Konichek to assist you on this project. It is expected that these will be a recorder SP-5 and a light keeper builder SP-4. After starting work on the project, if you find that additional personnel are required, this Office should be so informed. The necessary instrumental equipment is being shipped to you in care of Salt Lake Field Office, Corps of Engineers, 222 S. W. Temple Street, Salt Lake City, Utah.

20. Expenses will be charged to an allotment to be made to you from 1385908.007, Working Fund, Department of Commerce, Coast and Geodetic Survey. You should submit estimates on form 1.

21. You will please acknowledge receipt of these Instructions.



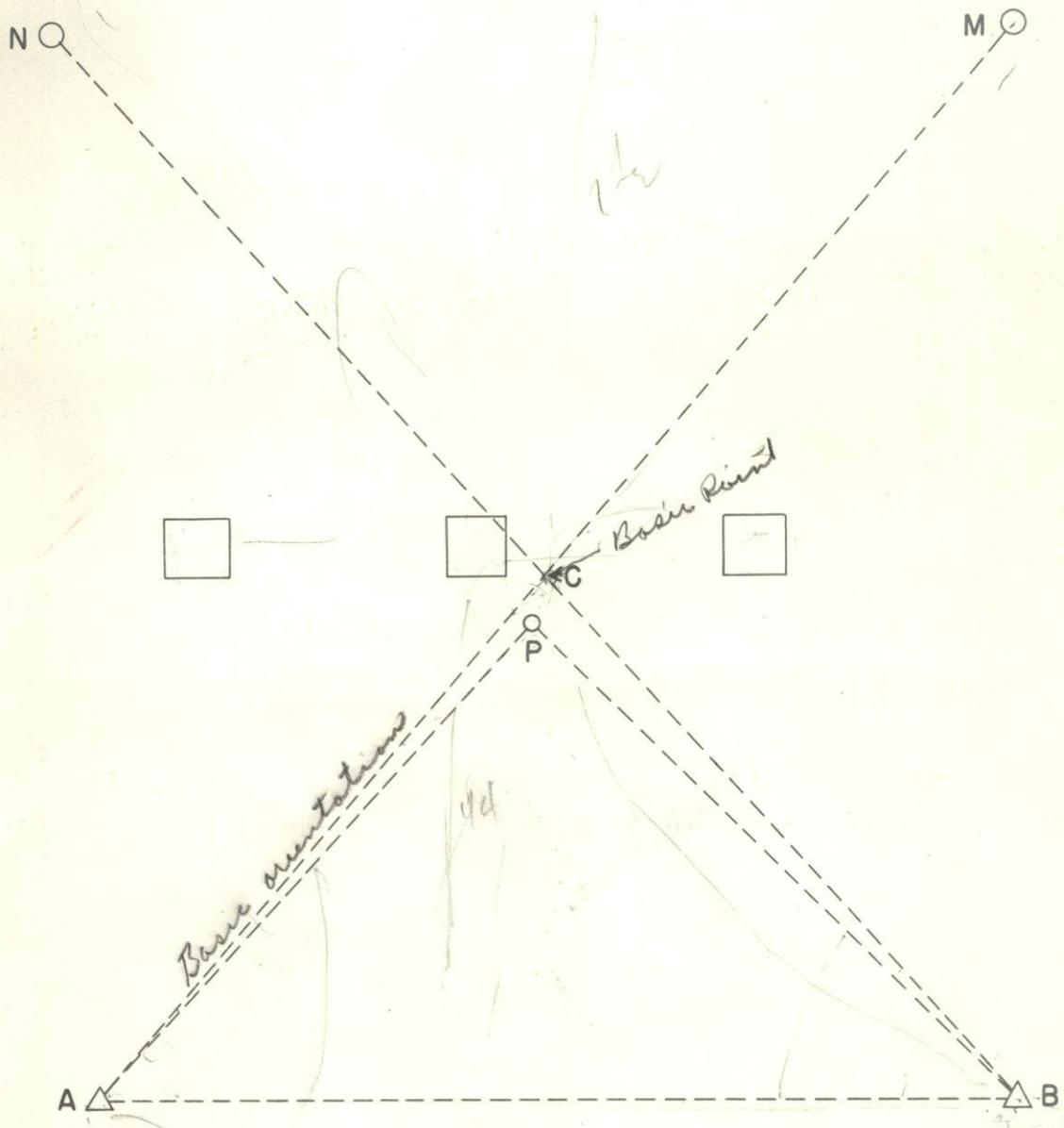
Director

Mr. H. E. MacLean  
In charge of Program for Eng.  
Fri May 7

Mr. Monte H. Construction  
May 6 + 7th.

H. O. Plath  
May 5 + 7th.

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 UNDERGROUND EXPLOSION TESTS