

BELL SYSTEM PRACTICES
Outside Plant Construction
and Maintenance

SECTION G50.275.1
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AT&T Co Standard

LOCATING UNDERGROUND PIPES AND CABLES

LOW FREQUENCY METHOD

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1. GENERAL

1.01 This section cancels G72.275 and describes the apparatus and method for locating, tracing the path and determining the depth of underground conductors such as buried cable, buried wire, cable in conduit, submarine cable as well as buried gas and water pipes. The application of these instructions will avoid unnecessary excavation in clearing cable troubles and aid in guiding power operated trenchers. The methods of locating points of contact between telephone plant and foreign conductors where electrolysis tests show an interchange of current and of locating the end of a dead-ended duct are also described.

1.02 The use of the 93A test set is included in this section.

1.03 The method outlined in this section is known as the low frequency method since it makes use of tracing tone in the audio frequencies.

1.04 Where the subsurface structure is not available either in a manhole or at the surface and it is not practical to use ground rods, also in those cases where the presence of shield wires may interfere with the use of this equipment, use the high frequency method covered in another section of the Bell System Practices.

1.05 Buried cable, buried wire, cable in conduit, submarine cable, buried gas and water pipes will generally be referred to as "conductors" in this section.

1.06 Where conductors are traced to guide the course and extent of power operated excavation tools or hand digging, the location of the conductors should be marked on the ground.

2. APPARATUS AND MATERIALS

2.01 The following apparatus and materials are required:

Amplifier: Use a 107A, 147A or equivalent amplifier with the 93A Test Set or the Bicycle Wheel Exploring Coil. Refer to the appropriate section of the Practices for information on the amplifier used.

Coil: 93A Test Set or Bicycle Wheel Exploring Coil. These are discussed in detail below.

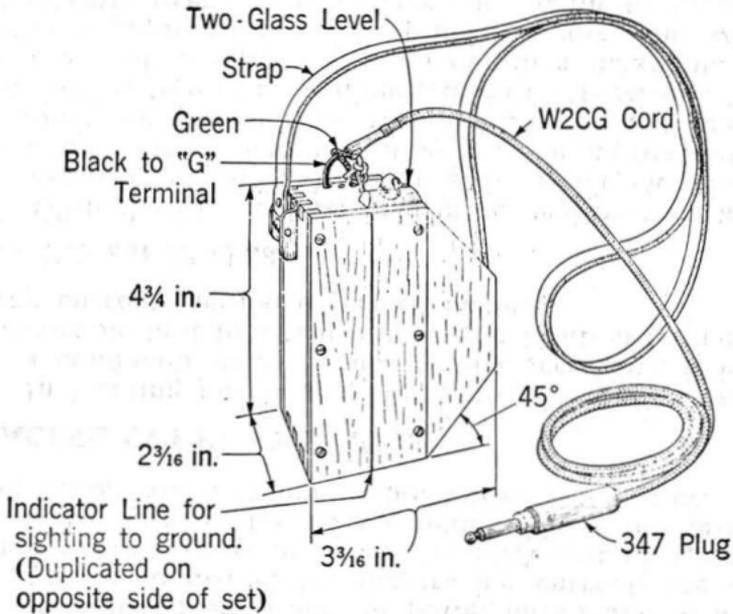
Induction Coil: The 46B Induction Coil or equivalent is used to trace vacant conduit.

Rods: Two Type S Ground Rods.

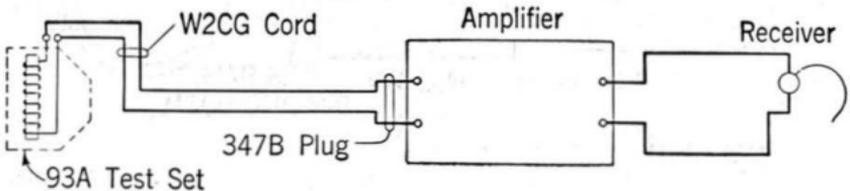
20C Test Set: The 20C Test Set supplies tracing current.

2.02 **93A Test Set:** This set is recommended for tracing and depth location work on conductors. Inside the set, the coil is mounted with its long axis parallel to the indicator line marked on the side of the wooden box, as illustrated below. The coil consists of about 10,500 turns of No. 35 A.W.G. enamelled copper wire wound on a laminated silicon steel core.

93A TEST SET



- 2.03 The 93A test set has a high impedance and for best results it must be used with an amplifier as shown below:



Bicycle Wheel Exploring Coil

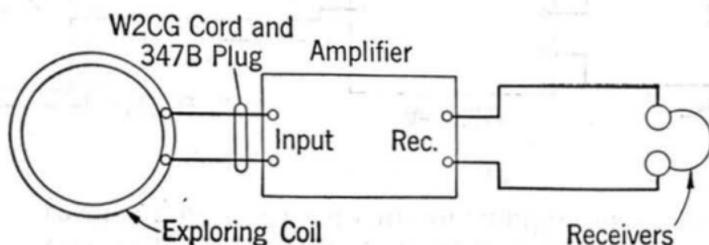
- 2.04 The bicycle wheel exploring coil is not available as a standard item.

It can be constructed locally as follows:

Using a 24-inch or 26-inch diameter wood bicycle wheel rim, drill two small holes about $\frac{1}{2}$ inch apart on the side of the rim and wind approximately 300 turns of No. 24 gauge double cotton covered copper wire in the rim groove, bringing the ends of the winding through the two holes. Wrap a layer

of rubber tape and then a layer of friction tape in the reverse direction over the rim and wire, bringing the ends of the wire out of the coil between the layers of the tapes. Terminate the ends of the windings by soldering them to binding posts mounted in a small insulating strip, such as a piece of bakelite 3/16 inch x 3/4 inch x 2-1/2 inch. Apply two coats of asphalt paint to the entire coil. Then fasten the terminal strip to the inside of the wood rim with friction tape.

2.05 Under some conditions the pickup of the exploring coil will be sufficient to give a suitable signal when connected directly to the receivers. If the signal is not strong enough, connect an amplifier in the listening circuit as illustrated below:



2.06 If induction from near-by power lines makes it impracticable to distinguish the tracing current, the results can be improved by using either the 107A amplifier equipped with the 507A filter or the 147A amplifier. These sets provide a filtering action which minimizes noise from this source.

3. TRACING CURRENT SUPPLY

3.01 In locating and tracing the path of a buried cable or a conductor which is not readily accessible, it is generally advisable first to attempt making a location by means of the stray current method described below.

Stray Current Method

3.02 With the 93A test set held in vertical position as indicated by the spirit level, or with the bicycle wheel coil held in a horizontal position, walk across the approximate path of the conductor to determine whether there is sufficient stray current flowing to give an audible tone in the receivers. If there is, the tone volume will rise gradually to a maximum as the conductor is approached, suddenly fall to a low value when the coil is directly over the conductor, rise again to its previous maximum as the conductor is passed and then decrease slowly.

3.03 If the exploring is done in the proximity of a power line, the tone heard may be the result of induction from the line.

20C Test Set Method

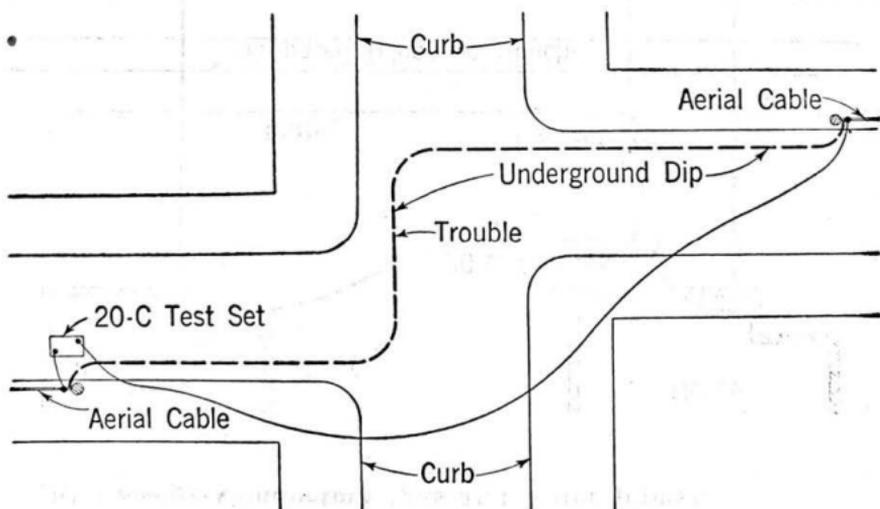
3.04 Where the conductor is readily accessible for making electrical connections or when the stray current method is not effective, use the 20C test set as a source of tracing current.

3.05 In this method, the 20C test set may be connected in one of three ways, depending on the distance to be covered and the accessibility of the conductor to be located: (1) to the conductor at two points, (2) between the conductor and a ground rod, and (3) between two ground rods. The installation of the test set under typical conditions is described and illustrated in the following paragraphs.

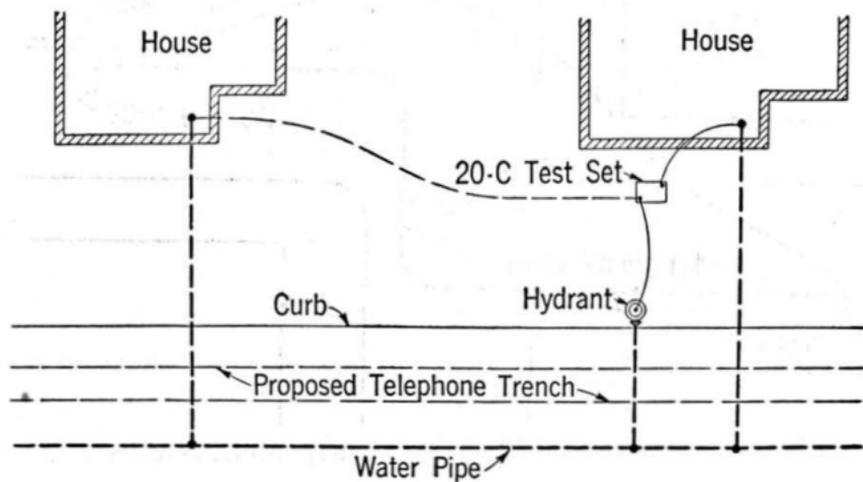
3.06 Place the 20C test set as far as practicable from the conductor at the point of tracing. Connect terminals 3 and 5 to the conductor at two points or to the ground rods by means of Block Wire or equivalent laid on the ground and so placed that it will not parallel the conductor in the area where the location is to be made. When ground rods are used, No. 3 bridging connectors can be used to facilitate attaching the leads to the rods. Intermittent tone should be used.

3.07 **Direct Connection at Two Points:** When the conductor to be traced is relatively short and accessible at two points, one on each side of the area in question, it is advisable to connect the set directly, as illustrated below:

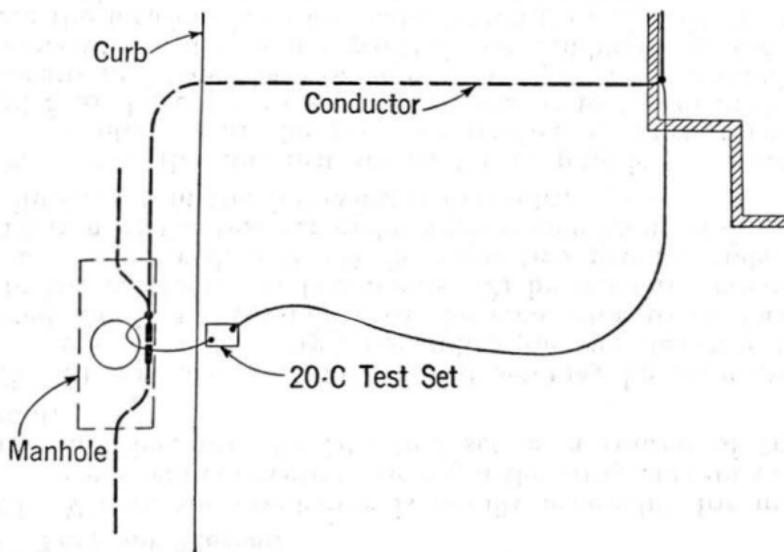
(a) Underground Dip



(b) **Foreign Conductors** (gas and water pipes).

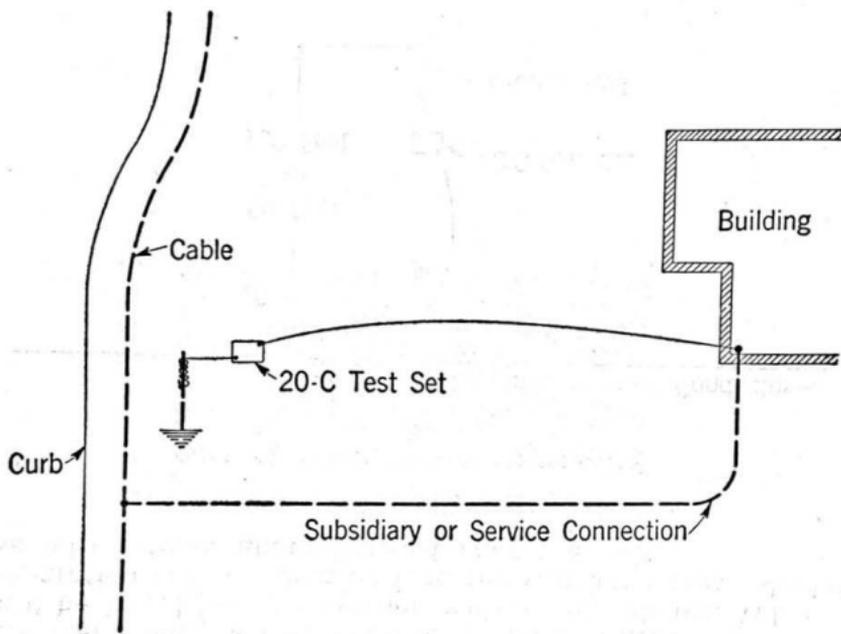


(c) **Buried Subsidiary Cable or Service Connection**



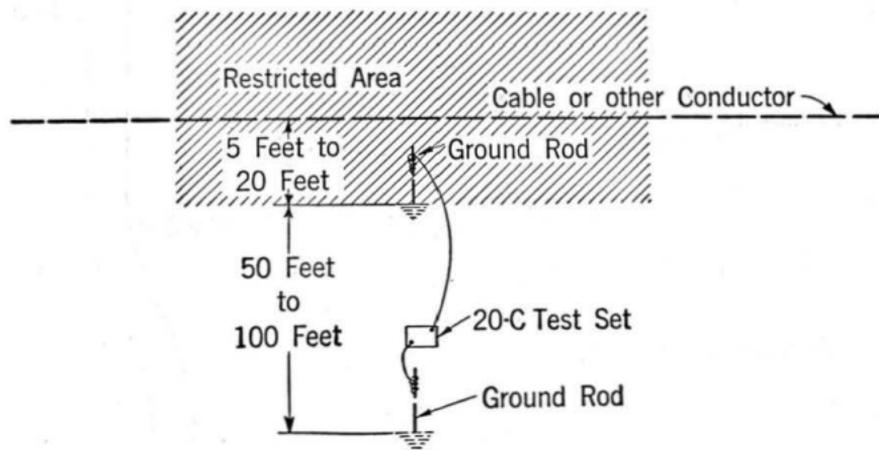
3.08 **One Direct Connection and One Ground Rod:** Where the conductor to be traced is accessible at one point and the approximate location is known at another point, the tracing current can be applied as follows:

(a) **Buried Conductors Including Buried Cable and Service Connections:** The ground rod should be installed 5 to 20 feet from the cable and driven about 2-1/2 feet into the earth, as illustrated below.



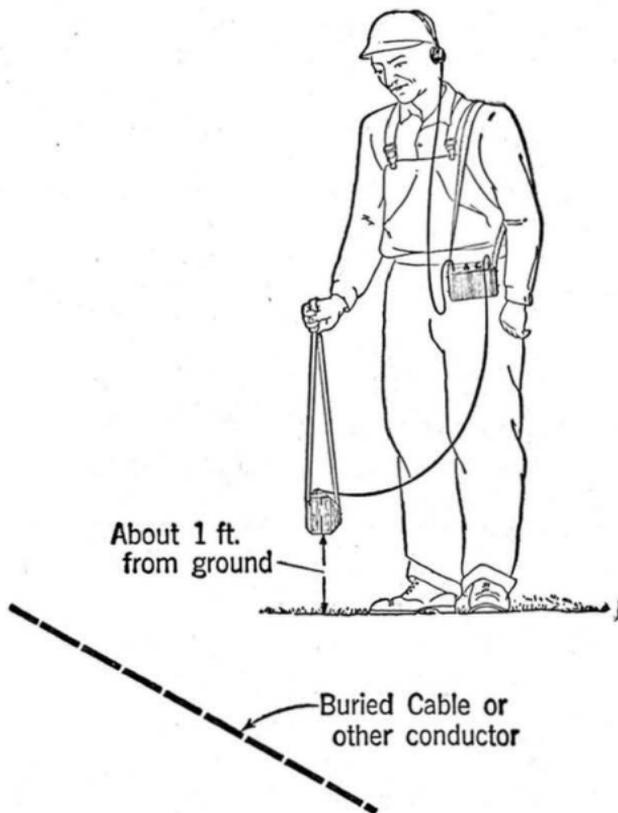
3.09 Two Ground Rods: If the conductor to be traced is not accessible and the approximate location is known, install one ground rod close to the conductor (5 to 20 feet). About 50 feet from the first rod and in a line approximately at right angles to the conductor, install a second ground rod, as illustrated below. If the approximate location of the conductor is not known, make the separation between rods about 100 feet. In case a power line is in the vicinity of the conductor, place the rods on the power line side of the conductor. Drive the rods approximately 2-1/2 feet into the earth. Where the soil is loosely packed or contains many small stones, drive the rods farther into the ground or install them at another location where soil conditions are more favorable.

3.10 Where the separation between rods is not over 50 feet, do not make location tests at a point closer than about 100 feet from the rods because within this area a strong tone will be heard but the location will not be reliable. Where the separation is more than 50 feet, the restricted area (shaded in sketch) extends about 200 feet from the rods.

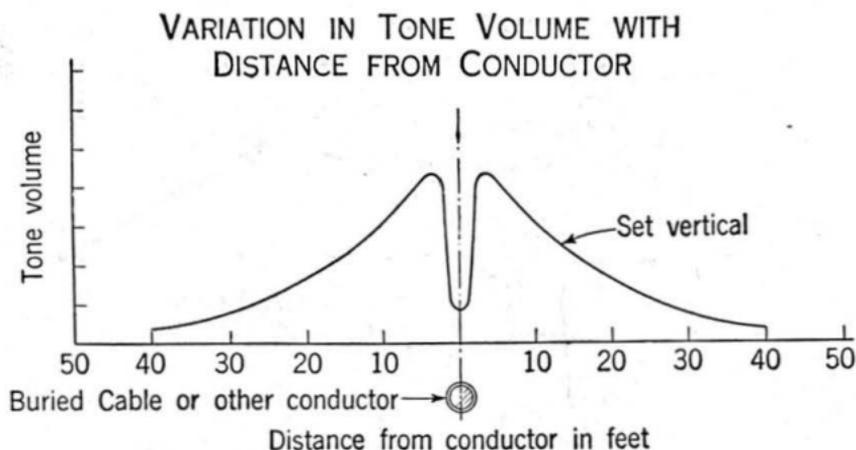


4. LOCATING AND TRACING CONDUCTORS WITH 93A TEST SET

4.01 When using the 93A test set and the approximate location and direction of the conductor is known, suspend the set about one foot from the ground by means of the strap, keeping the set vertical with the aid of the double spirit level.



4.02 As the set approaches the conductor location, the tone will increase in intensity to a maximum just at the side of the conductor, the tone will then decrease to a null or low value when it is moved directly over the cable. The variation of tone volume with distance of the set from the cable is as shown below.



4.03 When the null point is reached the set will be directly over the cable. Check that the set is in vertical position and check the null point. The change in volume will be in reverse as the set moves away from the cable.

4.04 Once the conductor location has been found, the route can be followed by walking along it and moving the 93A test set from side to side so that it crosses and recrosses the null point.

4.05 With direct connected tone, the conductor can be traced about 500 feet in each direction from the point where the tone is applied. Under favorable conditions, as usually encountered in buried cable, tracing can be done up to 1500 feet in either direction from the tone source.

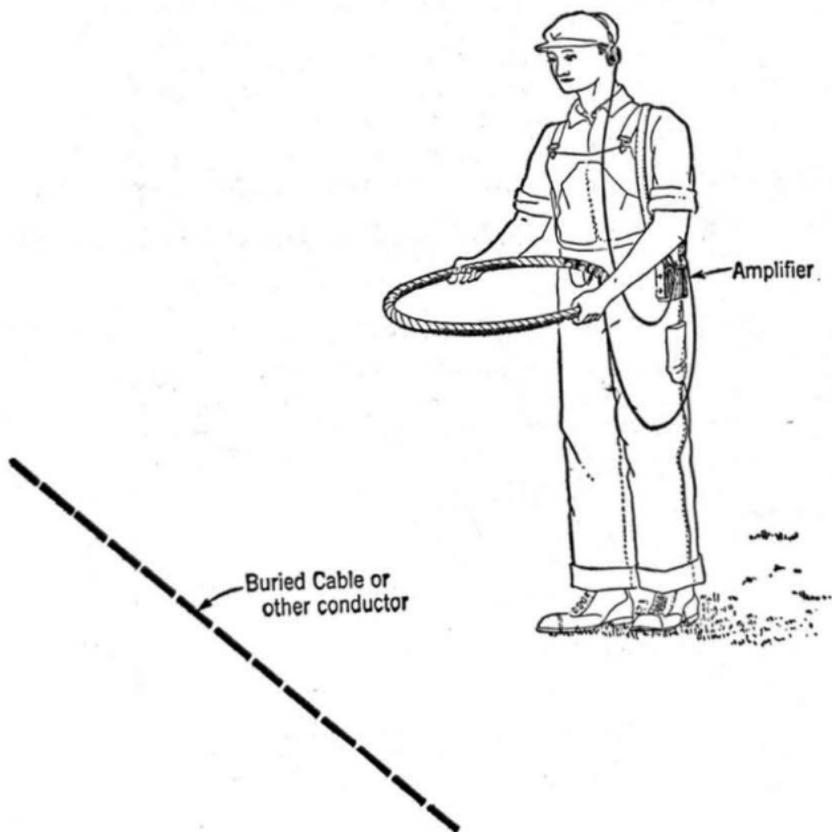
4.06 Under unfavorable conditions such as in dry sandy soil or gravel where soil resistivity is high, where power lines or other conductors interfere, tracing distances may be much less, particularly if the two ground rod method of applying tone is used.

4.07 Where the approximate location of the conductor is not known and the two ground rod method of applying tracing current is employed, check the area on both sides of the conductor, as any metallic object in the vicinity will produce tone in the coil. If several conductors are found, indicating the presence of water pipes or other subsurface metallic structures, it may be desirable to go to a point where the desired conductor is accessible so that its exact path can be determined.

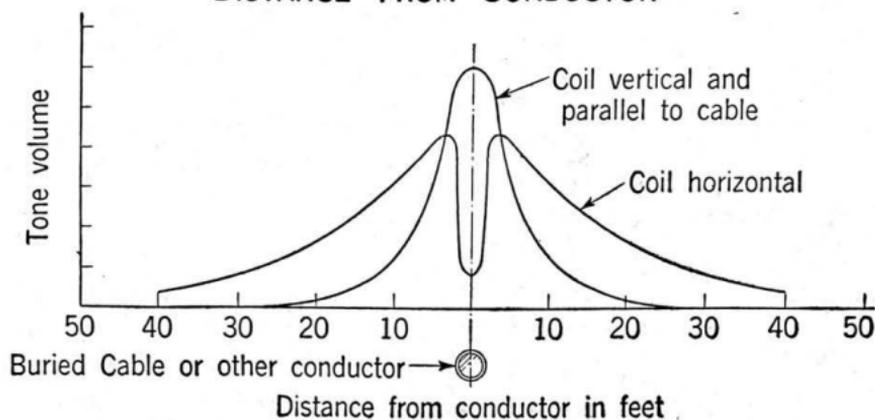
5. LOCATING AND TRACING CONDUCTORS WITH BICYCLE WHEEL EXPLORING COIL

5.01 The method of tracing the path of a conductor with the bicycle wheel exploring coil is the same as that used with the 93A test set, except that the bicycle wheel coil may be used in two ways:

- (a) Held in horizontal position which will give the same results as the 93A test set.
- (b) Held in vertical position so that it parallels the cable which will give a maximum tone over the cable.



VARIATION IN TONE VOLUME WITH DISTANCE FROM CONDUCTOR

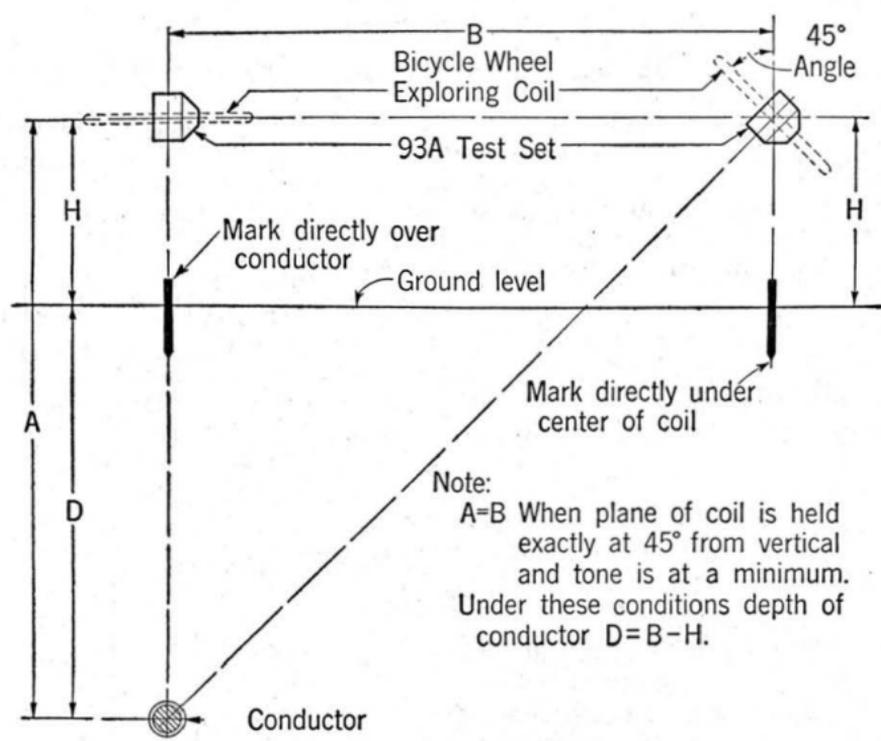


6. DETERMINING DEPTH OF CONDUCTORS

6.01 The approximate depth of a conductor can be determined as outlined below:

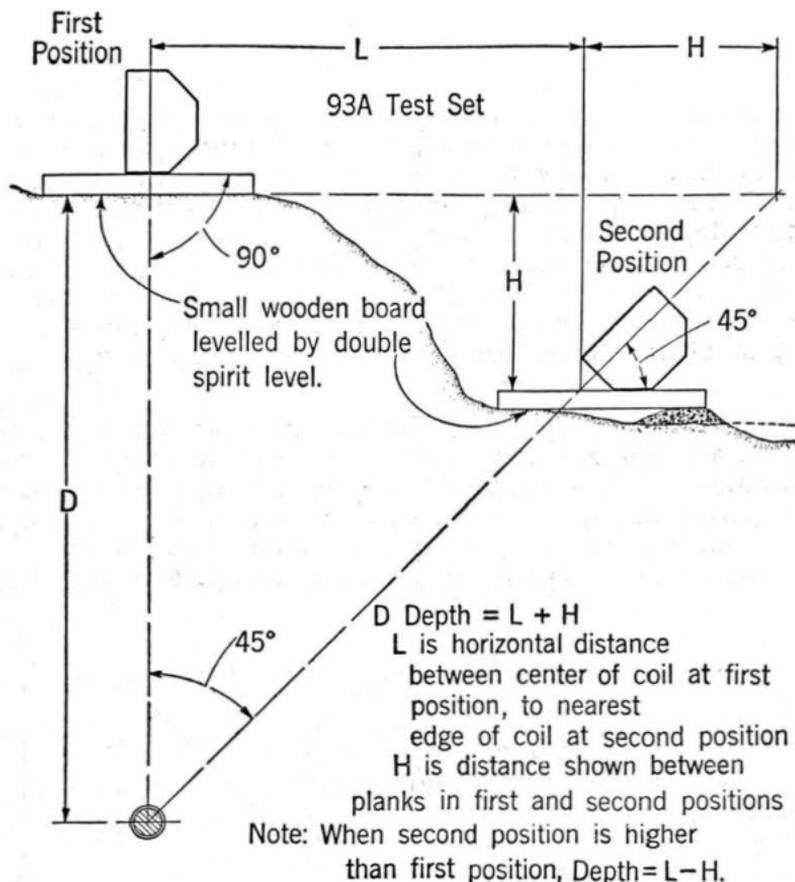
- (a) Mark on the ground by means of a stone or small stake, a spot directly over the conductor as determined by the null point. Then, with the 93A test set or the bicycle wheel coil held so that its plane is parallel to the conductor, tilt the set or coil until it is at an angle of 45 degrees with the vertical, as show in the following diagram. In the 93A test set, when the strap is unfastened on the bevelled side of the set, the set will hang at 45 degrees suspended by the other fastening of the strap.
- (b) With the 93A set or the coil held in this position, move in a direction at right angles to the conductor until the tone heard in the receivers is a minimum. Mark on the ground the point directly under this position. The depth is determined as indicated in the sketch on the following page.

DETERMINATION OF CONDUCTOR DEPTH



6.02 When maximum accuracy is desired in measuring the depth of a conductor with the 93A test set, detach the carrying strap from the set and use a small flat board as a platform, levelled by the spirit level on the set. The same procedure as above is followed except that the null points are found while the set rests on the level platform provided by the board.

6.03 Where depth measurements are made over ground that is not level, the difference in elevation must be taken into account in determining the depth. Be sure that the 45 degree angle is true, otherwise a relatively large error in calculated depth will occur. For example, if the actual depth of the conductor is 2 feet and the coil is held 1 foot above the ground, a deviation of ± 5 degrees in the angle will result in an error of about $\pm 1/2$ foot in the calculated depth. The following diagram indicates the determination of depth over ground that is not level.



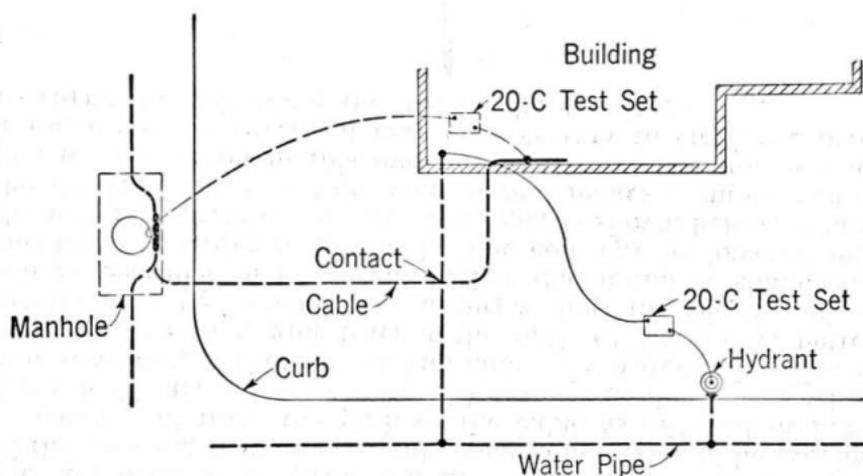
6.04 If shield wires are present with a buried cable, depth measurements made with this equipment **cannot** be relied upon for digging and trenching operations in the vicinity of the cable. In such cases, the depth should be obtained by careful excavation.

6.05 In determining the depth of one of two parallel conductors not in the same trench, first carefully determine the location of the desired conductor. Then make the 45 degree measurement on the side of the desired conductor away from the other conductor. Depth measurements made in the area between the parallel conductors may not be accurate.

7. LOCATING CONTACTS BETWEEN CONDUCTORS

7.01 The procedure for locating a contact between a foreign conductor (assumed to be a water pipe) and a telephone cable is described and illustrated below:

- (1) Connect the test set to the pipe at two convenient points, in this case to a near-by fire hydrant and the water pipe in the building. Trace and mark the path of the pipe on the ground.
- (2) Connect the test set to the cable sheath at two convenient points, as illustrated; then trace and mark its path. The intersection of the two lines determines the point of contact.
- (3) A check can be made by connecting the 20C test set between the cable at one location and the pipe at another. In this case the current is traced through the contact.



7.02 This procedure will also be applicable for locating contacts between buried water or gas mains and iron pipe conduit.

7.03 If it is found impracticable to trace the cable to the point of contact, it may be found helpful to unwipe the sleeve at the nearest splice so as to insulate the sheath of the subsidiary cable from the rest of the cable.

8. LOCATING A SUBSIDIARY OR DEAD-ENDED DUCT

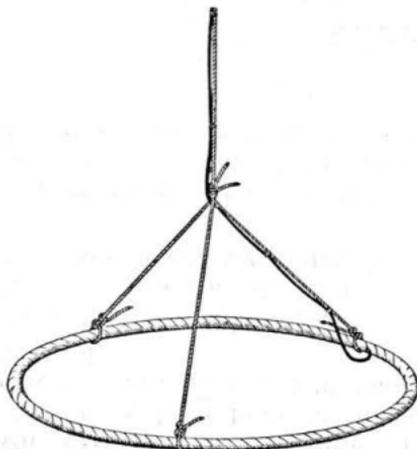
8.01 The following method is recommended as a means of tracing the path or locating the end of vacant subsidiary or dead-ended creosoted wood or vitrified clay conduit. It will also be useful for locating obstructions in ducts. (The method is not applicable to iron pipe conduit.)

8.02 Attach a No. 46B induction coil or its equivalent near the end of a duct rod or fish wire. Solder to terminals GN and C (the secondary winding of the coil) two insulated

leads of block wire slightly longer than the length of the duct. Wrap the coil and several inches of the leads at the coil with two layers of rubber tape and then two layers of friction tape. Connect the other ends of the leads to a 20C test set. Operate the test set using either steady or intermittent tone. Push the induction coil into the duct and if necessary tape the lead to the rods or fish wire at intervals of about 5 feet. Follow the course of the induction coil with the 93A test set or the exploring coil until the rods or fish wire strike the obstruction or the end of the duct. In following the induction coil along the ground, best results can generally be obtained by holding the exploring coil in a vertical plane at right angles to the approximate line of the duct.

9. LOCATING AND TRACING PATH OF SUBMARINE CABLE

9.01 Connect the 20C test set between a spare conductor in the cable and the sheath at one side of the crossing, the conductor being grounded to the sheath at the other side of the crossing. Under favorable conditions it should be possible to locate and trace the path of the cable as outlined in Parts 4 and 5 by carrying either the 93A test set or the bicycle wheel coil in a boat. If the tone pickup above the water is insufficient to permit locating and tracing the path of the cable, better results may be obtained by waterproofing the bicycle wheel coil as described in Paragraph 9.02 so that it can be submerged and brought closer to the cable. The coil may be lowered into the water by means of a sling and rope, as shown below. Where the depth of the water or river current makes it impracticable to handle the coil in this manner, or if electrical interference is objectionably severe, it may be necessary to employ a diver to carry the coil along the bed of the crossing.



9.02 To waterproof the bicycle wheel coil so that it is suitable for use under water, remove the terminal strip and connect the ends of the winding to an appropriate length of block wire. Build up a seal around each wire using DR tape, lay these on the coil and then wrap the coil with similar tape overlapped 1/2 its width. Apply a second layer of tape in the opposite direction. Finish with two layers of friction tape applied in opposite directions.

9.03 When a diver is employed, a lamp should be attached outside of the diver's helmet, just in front of the window for signalling. The leads should be brought to the boat so the observer listening to the tone can signal the diver and thus indicate the diver's position with respect to the cable.

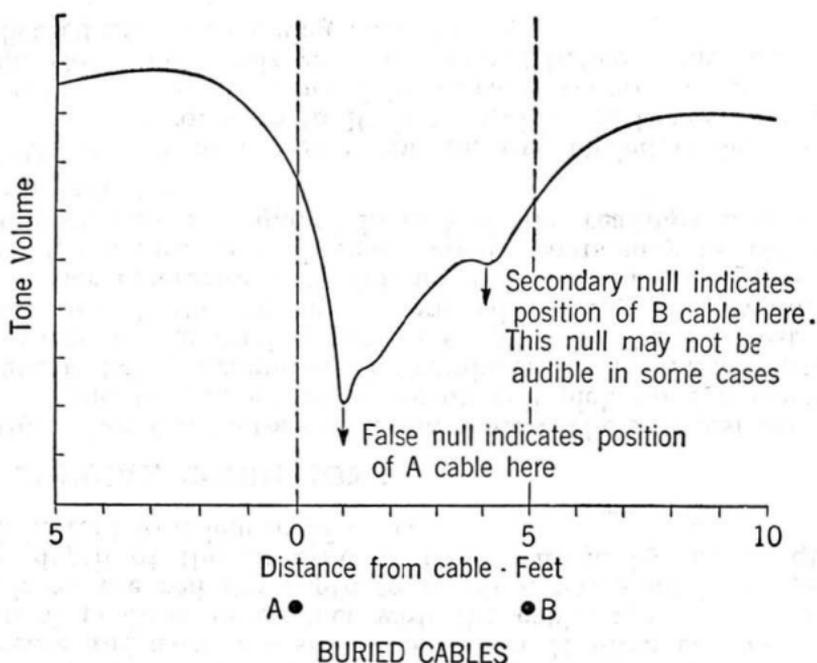
9.04 The path of the cable can be marked with lead weights equipped with floats.

9.05 To determine the exact depth of the cable, a prod having an electrical contact may be used. A prod consisting of several lengths of screw coupling duct rods and a pipe reamer terminated at one end will be found satisfactory. A wire should be connected to the reamer, through a milliammeter, a 4-1/2-volt battery and to the sheath of the cable at one end of the crossing. Standing on the bed of the river, the diver should stick the prod into the mud at the indicated locations. When the cable is struck the current will suddenly increase and assume a steady deflection. Holding the rod in a vertical position in contact with the cable, the diver should mark on the rod the depth to which it has sunk in the silt. The depth of the water can be determined by means of a weight tied to a length of rope.

10. SPECIAL CONDITIONS

10.01 **Two Conductors on Same Route:** The 93A test set and the bicycle wheel exploring coil pick up the electromagnetic field surrounding the conductor or conductors which are carrying the tracing current supplied by the 20C test set. Even though the current is supplied to only one conductor, the other conductor will pick up and carry a portion of the tracing current. In such cases, good results may be obtained but more care is required in making the readings than on a single conductor.

10.02 At the usual separation for two buried cables on the same route (5 to 10 feet), which are bonded together at valve points, the tone field surrounds both cables and in some cases false nulls may be obtained between the cables, as indicated in the following diagram.



10.03 If the location is not satisfactory use the high frequency method covered in another section of the Bell System Practices.

10.04 Where two cables have been plowed in at the same time, results will be similar to those obtained with a single cable.

10.05 **Effect of Shield Wires:** In some cases the presence of shield wires over the cable will distort the pattern of the tone field around the cable. Both line and depth measurements made with this equipment must be regarded as tentative and must be checked by actual excavation in those instances where digging or trenching is necessary in the vicinity of the cable.

For instance, errors of as much as 14 inches have been observed in measuring the path of a cable with paralleling shield wires; depth errors of as much as 30 inches have also been observed under these conditions.