# LOCATING UNDERGROUND PIPES AND CABLES

# LOW FREQUENCY METHOD

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## 1. GENERAL

**1.01** This section 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** This section is reissued to update text and illustrations and to delete old references.

**1.03** The use of the 93B test set is included in this section.

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

**1.05** 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 ➧Bell System Practice 634-220-501.➧

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

**1.07** 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 clearly marked with paint or nonwashable marker on paved surfaces and staked on earth surfaces.

## 2. APPARATUS AND MATERIALS

**2.01** The following apparatus and materials are required:

| | |
|---|---|
| Amplifier: | 147B Amplifier |
| Coil: | 93B Test Set |
| Rods: | Two Type S Ground Rods. |
| 20C Test Set: | The 20C Test Set supplies tracing current. |

**2.02** ➧93B Test Set (Fig. 1)➧ : 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 case. The coil consists of about 3500 turns of No. 35 AWG enameled copper wire wound on a laminated silicon steel core.

**2.03** The 93B test set has a high impedance and for best results it must be used with an amplifier as shown in Fig. 2.

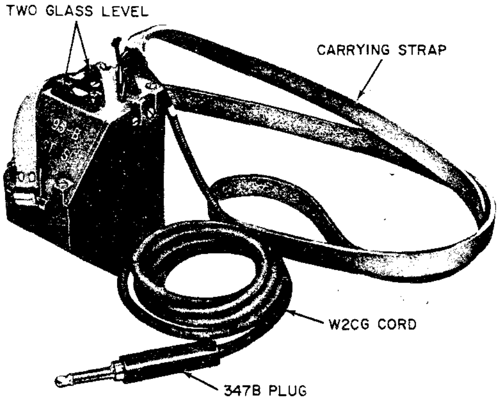


**Fig. 1—◆93B Test Set◆**

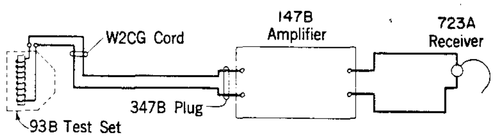


**Fig. 2—93B Test Set Used with 147B Amplifier**

## 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.

### Stray Current Method

**3.02** With the 93B test set held in vertical position as indicated by the spirit level, 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 3.06 thru 3.10.

**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 in Fig. 3, 4, and 5.

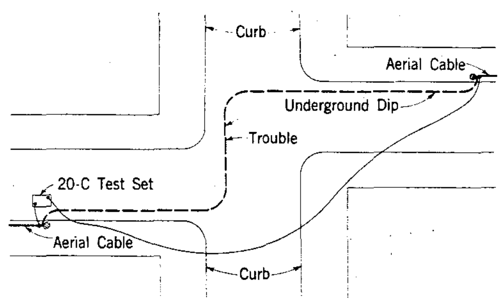


**Fig. 3—Direct Connection At Two Points**

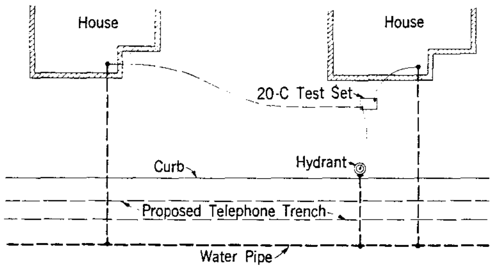


**Fig. 4—Direct Connection At Two Points—Conductors of Other Utilities**

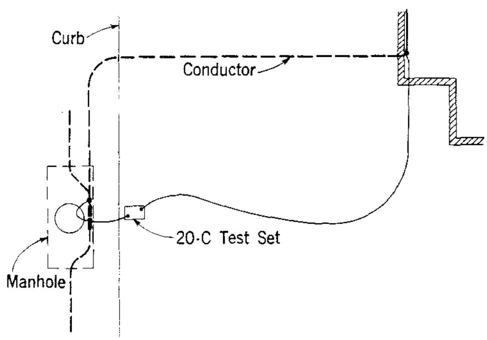


**Fig. 5—Direct Connection At Two Points—Buried Subsidiary Cable or Service Connection**

**3.08** ***One Direct Connection and One Ground Rod:*** Where the conductor is 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 in Fig. 6, then repeat test as outlined in Part 4.➧

**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

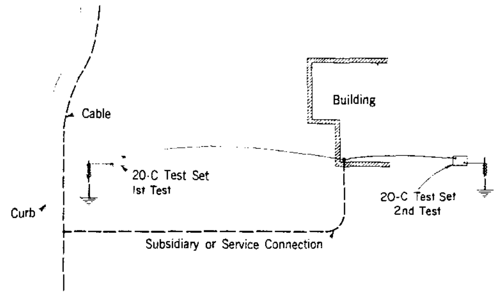


**Fig. 6—One Direct Connection and One Ground Rod**

the first rod and in a line approximately at right angles to the conductor, install a second ground rod, as illustrated in Fig. 7. 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.

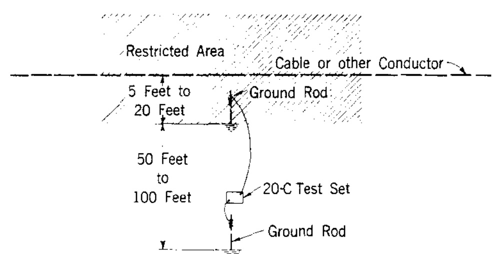


**Fig. 7—Two Ground Rod Connection**

**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 93B TEST SET

**4.01** When using the 93B 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. See Fig. 8.

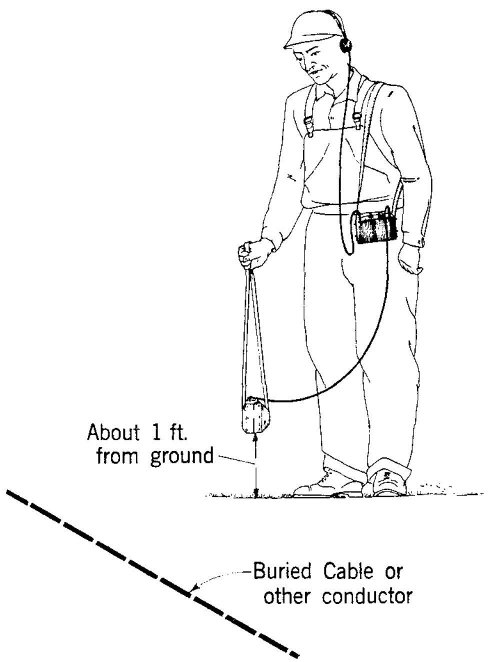


**Fig. 8—Locating and Tracing Conductors with the 93B Test Set**

**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 (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 in Fig. 9.

**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.

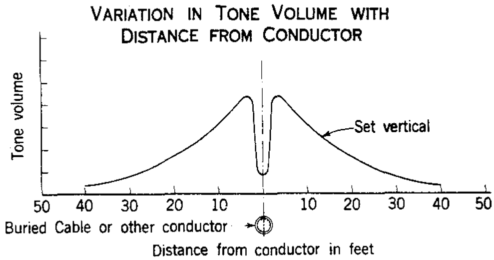


**Fig. 9—Variation of Tone Volume**

**4.04** Once the conductor location has been found, the route can be followed by walking along it and moving the ➧93B 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. DETERMINING DEPTH OF CONDUCTORS

**5.01** The approximate depth of a conductor can be determined as outlined:

(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 ▶93B test set◀ held so that its plane is parallel to the conductor, tilt the set until it is at an angle of 45 degrees with the vertical, as shown in Fig. 10. In the ▶93B◀ 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.

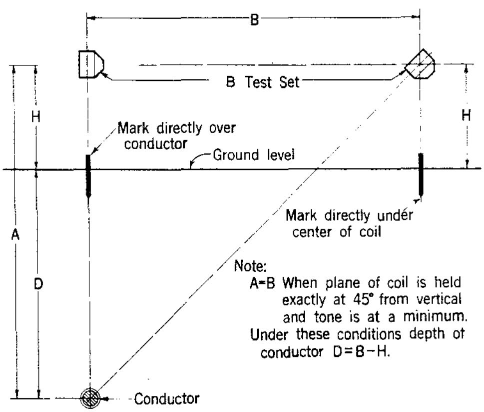


**Fig. 10—Determining Conductor Depth**

(b) ▶With the 93B set◀ 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 Fig. 10.

**5.02** When maximum accuracy is desired in measuring the depth of a conductor with the 93B 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 5.01 is followed except that the null points are found while the set rests on the level platform provided by the board.

**5.03** 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 $\pm 5$ degrees in the angle will result in an error of $\pm 1/2$ foot in the calculated depth. The diagram in Fig. 11 indicates the determination of depth over ground that is not level.

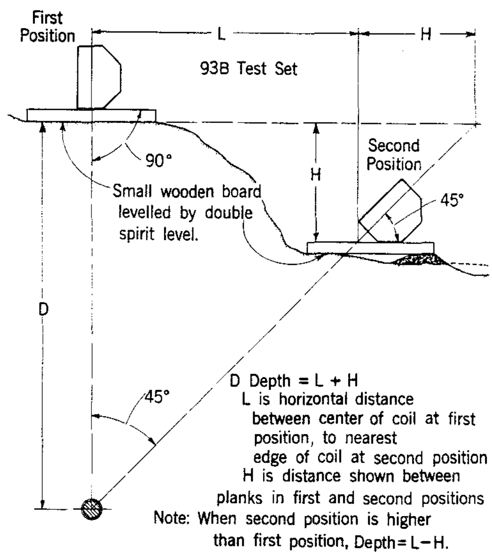


**Fig. 11—Depth Measurements over Ground That is Not Level**

**5.04** 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 manual excavation to prevent damage being caused by power operated equipment.

**5.05** 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.

## 6. SPECIAL CONDITIONS

**6.01** ***Two Conductors on Same Route:*** The 93B test set picks 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.

**6.02** 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 Fig. 12.

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

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

**6.05** ***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 manual excavation in those instances where power 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.

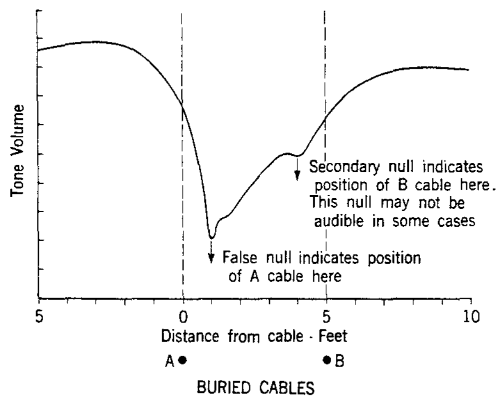


**Fig. 12—Two Conductors on Same Route**