LOCATION OF UNDERGROUND CABLE FAILURES

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SUMMARY

This note presents a description of procedure to be followed in locating short circuits and grounds in underground non-metallic armoured cable, such as is generally used for field circuits on airports The procedure described involves the use of little equipment beyond that which is normally available or can readily be improvised

INTRODUCTION

Non-metallic armoured parkway cable is almost exclusively used for underground feeders and circuits on airports in the United States Such cables are used for boundary circuits, contact circuits, approach light feeders and circuits, instrument approach system feeders, radio feeders, floodlight feeders, and feeds to obstruction lighting They have a long life expectancy when installed in the ground, but when disturbed by subsequent construction, are frequently subject to damage Joints and splices are also subject to breakdown and failure

Such cables are customarily thousands of feet in length, and are generally unmarked Any failure results in serious impairment to the operation of the airport, and the maintenance force must be able to locate such failures quickly, so that service may be restored with a minimum loss of time

The Civil Aeronautics Administration Experimental Station has been using a considerable amount of underground cable on development projects at Indianapolis From the failures experienced a method and technique have been developed for quickly locating underground cable faults This technique has been developed on unshielded cables only, so the methods described will not necessarily apply in the case of lead-encased or steel-taped cables

PROCEDURE

Causes of Faults

In general, cables themselves are able to withstand considerable aging without trouble Most trouble comes from poorly made splices and from physical damage to cable during excavation It is therefore desirable to have on hand a map giving exact location of cable and cable splices When failure occurs the map can be consulted and an inspection of the cable route will probably reveal the location of the fault

Kinds of Faults

There are several kinds of faults that cause trouble on a line, namely short circuit between several conductors in a cable, high voltage ground, and low voltage ground. Slightly different techniques are required for determining these faults Usually, if the trouble is underground, a line is found to be both short-circuited and grounded The generation of heat by the current, if a short circuit continues and the current is allowed to flow under high voltages, will eventually burn off the insulation between the conductor and ground, thus the cable will be grounded.

A high voltage ground is herein defined as one that will carry current at low voltages but breaks down under high voltages Obviously, such a ground is not a good one.

A low voltage ground is a fault wherein the cable is well grounded at the fault and breaks down under low as well as under high voltages.

Determining the Type of Fault

If test instruments are not conveniently at hand a test may be made for a short circuit between two conductors by connecting a small lamp in series with 120 volts and the two exposed wires of the cable at either terminus If they are short-circuited, the current obviously will pass along one conductor all the way to the fault and back along the other conductor causing the lamp to light.

A method for determining a ground if test instruments are not available is to apply 120 volts between ground and one side of the line, running the "hot" side through several 200-watt lamps in series-parallel to give a sufficiently large test current. See Figure 1. Then at the other end of the cable connect a small lamp between ground and the "hot" wire If the lamp burns dimly, or not at all, the wire is either grounded or open, or both. If the lamp burns with full brightness, that wire is probably good and the test should be repeated for the other wire, after first making the proper connections of the other line to the 120-volt supply.

A megger applied across both sides of the line will show approximately zero ohms resistance if there is a short circuit. Applied between one line and ground it will read infinity if the line is not grounded, but if the line is grounded, it will read a definite number of ohms, which is approximately the resistance of that portion of the earth through which the current travels. If a megger is not available, an ohmeter can be used to get the desired information.

If these tests show the cable to be neither short-circuited nor grounded whiles the fuses continue to blow when 2300 volts are applied, the trouble is obviously a high voltage ground.

The locating of any fault in a multiple conductor cable can be facilitated by breaking down the insulation to such an extent that a low voltage ground will develop at that point At the CAA Experimental Station a 5-KW 230-volt gasoline engine generator is used at one end of the line for this purpose, in connection with a 2300/230 volt transformer. One side of the 2300-volt transformer winding is grounded and the other side is tied to the partially grounded conductor. Then low voltage is applied to the 230-volt primary from the generator and gradually increased to 230 volts, thereby putting 2300 volts between ground and the conductor. See Figure 2. The same results may be obtained by applying 115 volts between one line and the midpoint of the low voltage winding of the transformer After a few minutes of high voltage the primary current should suddenly increase, indicating that the insulation has broken down. The current should be allowed to continue a while to make sure that a good "ground" has been made

A meeger applied now should indicate a ground and possibly a short circuit, as the wires will sometimes fuse together at the fault if the current is allowed to continue for a sufficient period.

It should then be possible to locate the trouble by means of an exploring loop.

Locating the Fault

First, an induction detector, or "bicycle wheel" loop should be used to locate the position of the cable. The one used at the CAA Experimental Station consists of a hardwood wheel (24" diameter) around the rim of which is wound approximately 4500 feet of #36 silk-covered copper wire. Attached to this wheel is a small amplifier using a grid leak detector circuit with a 6-volt "A" battery, a 45-volt "B" battery, and a set of head phones. See Figure 3 and Figure 5. A spark coil is used to put a signal between the line that is grounded and the ground.

See Figure 4 The operator then carries the loop near the ground and walks along the line of the cable listening to the signal It will be loudest when directly above the cable when the plane of the loop is held in the same plane as the cable

If the cable is grounded, the signal will stop or fade out approximately at the fault This spot can be checked by putting the signal on the line from the other end. If it fades out at the same place, the fault has been located.

The signal usually fades out toward the end of a good cable, making a fault near the end of the line difficult to find by the above method Generally, however, faults can be located within plus or minus one foot even though the cable is buried thirty inches

Sometimes when the line resistance cannot be broken down lower than about 5000 ohms to ground (because of generator limitation) and there is a substantial resistance, say 20,000 ohms, between conductors, the high frequency signal of the spark coil tester will travel beyond the fault and make fault location inaccurate In such cases it is helpful to change from the spark coil to a single 60-cycle signal from the engine generator unit, applied between the line and ground in the same manner as in breaking down the line

As the location of the trouble is narrowed down the operator should go over the section of line under question very carefully with the loop, listening for any variation in tone and remembering, as stated before, that the signal will sometimes die out near the end of a good line. It may also fade at sharp bends in the line Any places giving questionable change in sound should be probed, and particular attention should be paid to places where old splices are known to be

Lacking other apparatus, a skilled operator can frequently locate grounds by means of a small portable type radio set, substituted for the "bicycle-wheel" loop In the absence of any other signalling device, the grounded line may be connected to a spark plug of an automobile and the motor left running to give the signal These methods are useful in locating either a fault in a cable or the position of a good cable.

An odor peculiar to burning insulation may emanate from the ground nearest the trouble, and if one is so fortunate as to dig near enough to the fault this odor can be detected easily With snow on the ground a melted patch may be observed over the fault, provided the cable is not buried too deeply and provided the current has burned through ground for a long enough time Unfortunately, cable faults cannot be depended upon to occur only when snow is on the ground.

It is a good idea when installing long runs of cable (several thousand feet or more) to place cut-outs at intervals over the circuit so that the cable can be sectionalized and a signal placed at either end of a section, thus facilitating the finding of faults

In many cases it is possible to arrange for help from the local utility company Such companies usually have the necessary instruments and men experienced in cable servicing, and they are generally very willing to assist in clearing up trouble on their customers' lines

In general, either the methods outlined or variations of these methods will suffice to locate the source of cable failure, and with enough practice cable problems quickly can be solved as they develop

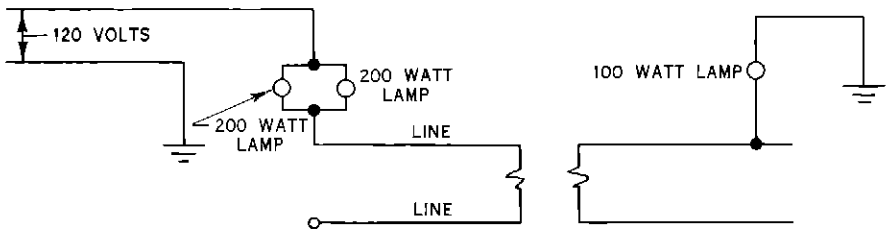

Figure 1

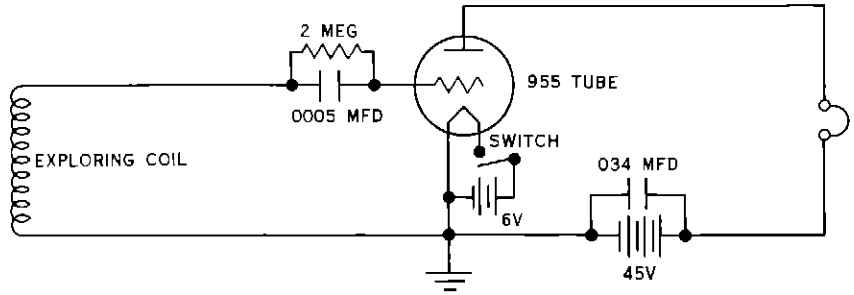

Figure 3

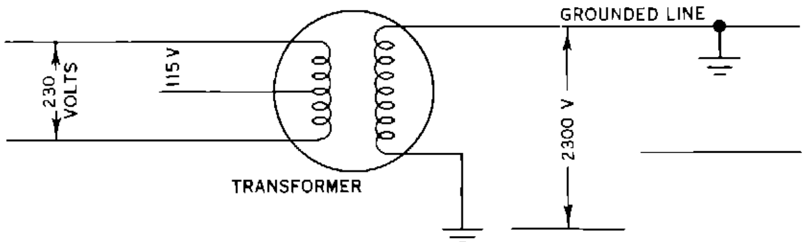

Figure 2

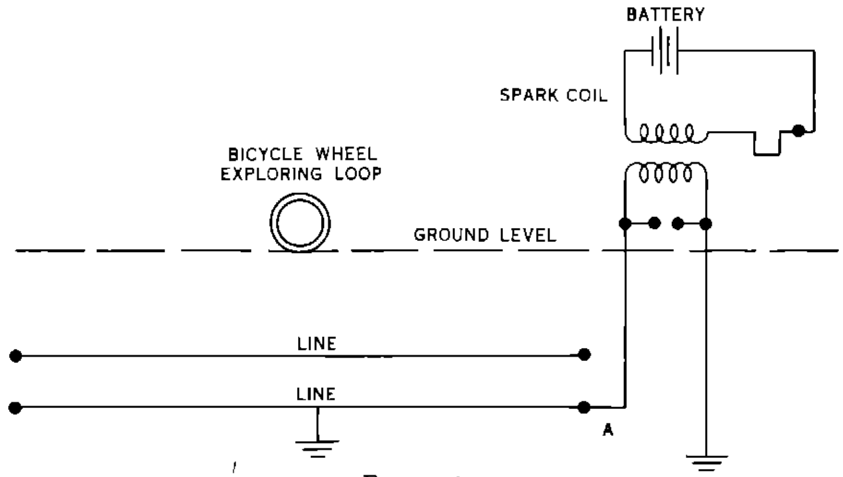

Figure 4

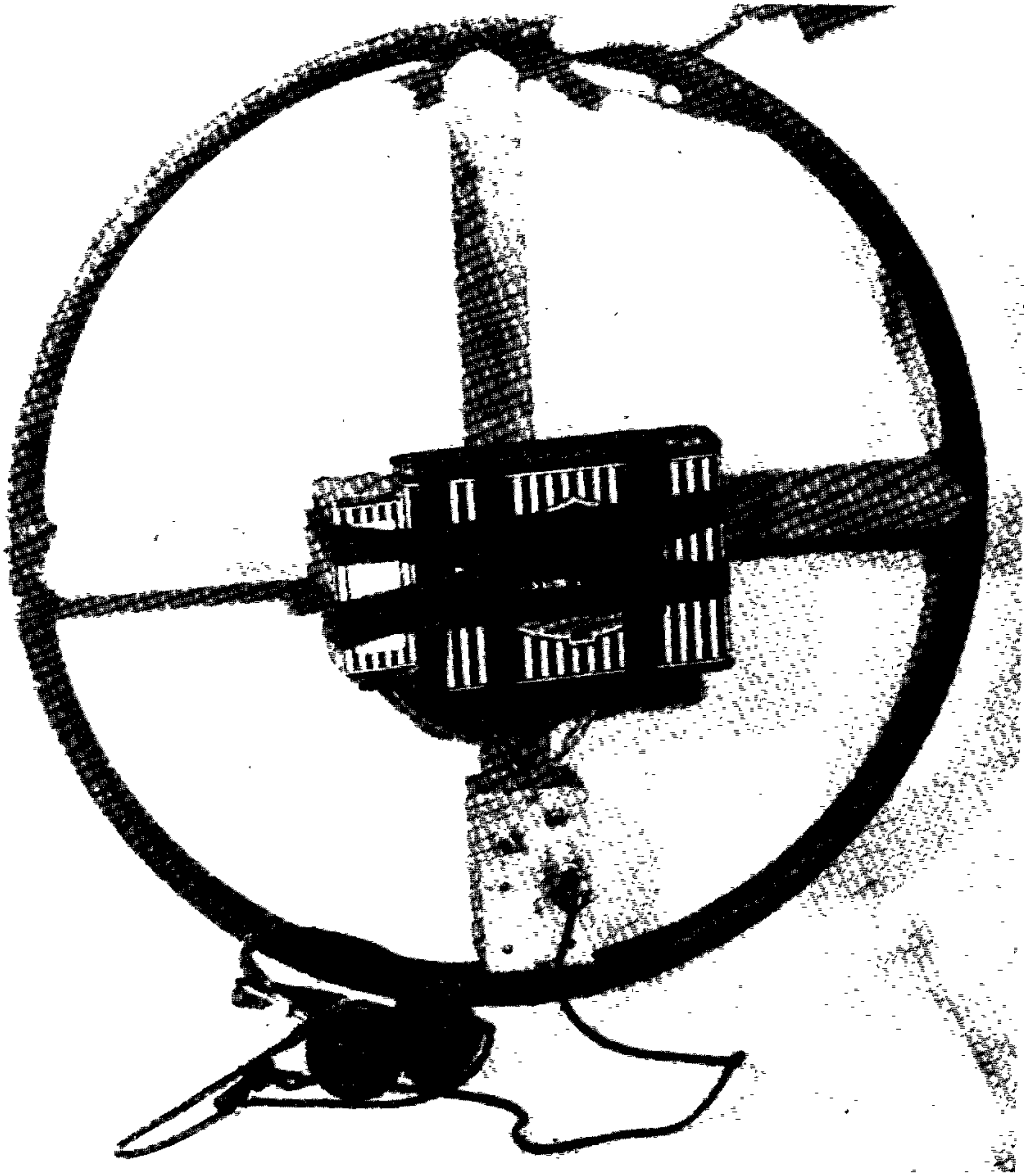

Figure 5