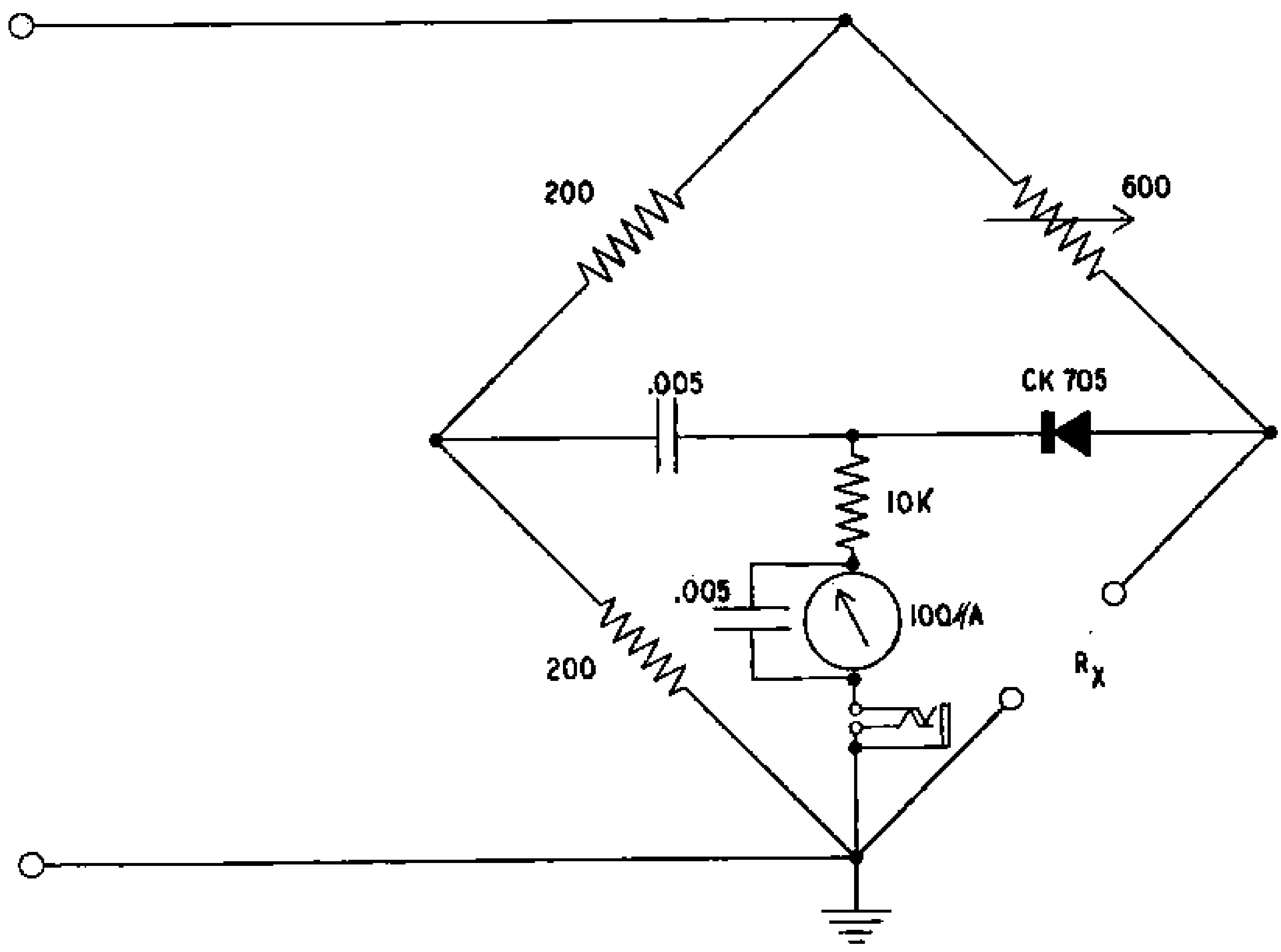
ASSEMBLY AND OPERATION OF THE
HEATHKIT ANTENNA IMPEDANCE METER
MODEL AM-1

SPECIFICATIONS

Frequency Range.	0-150 megacycles
Impedance Range.	0-600 ohms
Null Indicator.	100 μ ampere meter
Dimensions.	2 1/2" x 3" x 7"
Net Weight.	1 lb.
Shipping Weight.	3 lbs.



ANTENNA IMPEDANCE METER SCHEMATIC

INTRODUCTION

The Heathkit Antenna Impedance Meter model AM-1 is basically a resistance type SWR (standing wave ratio) bridge. However, one arm of the bridge has been made variable, thus greatly increasing the versatility of the original bridge circuit. By means of this modification, it is possible to measure radiation resistance and resonant frequency of an antenna, transmission line impedance, approximate standing wave ratio and optimum receiver input. It also can be used as a phone monitor and by connecting a tuned circuit and small antenna to the output terminals, it may be used as a field strength meter where high sensitivity is not required. The AM-1 may be operated from any low power RF source not exceeding 1/2 watt. The wide frequency range and portability of a grid dip meter such as the Heathkit GD-1B, make it ideal for use with the Antenna Impedance Meter. The AM-1 uses a specially tested potentiometer in the variable bridge arm to maintain calibration accuracy and to cover a range which will include the popular 600 ohm transmission feed lines.

CIRCUIT DESCRIPTION

The operation of the Antenna Impedance Meter may be understood by referring to the fundamental bridge circuit shown in Figure 1. R1 and R2 are of equal resistance and represent the fixed arms of the bridge. R3 represents the calibrated variable arm and R_x the unknown resistance of the antenna. When R3 is made equal to R_x, the current flowing through R1 equals the current flowing through R2 and the current in R3 equals the current in R_x. Under these conditions there will be equal voltage at points A and B. Consequently, no current will flow through the meter. This represents the balanced condition of the bridge and as R3 must equal R_x in resistance, the unknown antenna impedance is read directly from the calibration of R3. In the unbalanced condition where R3 does not equal R_x, the potential at point B will be higher or lower than point A depending upon whether R3 is smaller or larger than R_x and the meter will have current flowing through it. The AM-1 utilizes this basic principle adapted to measure impedances at radio frequencies. Figure 2 shows the basic schematic of the AM-1.

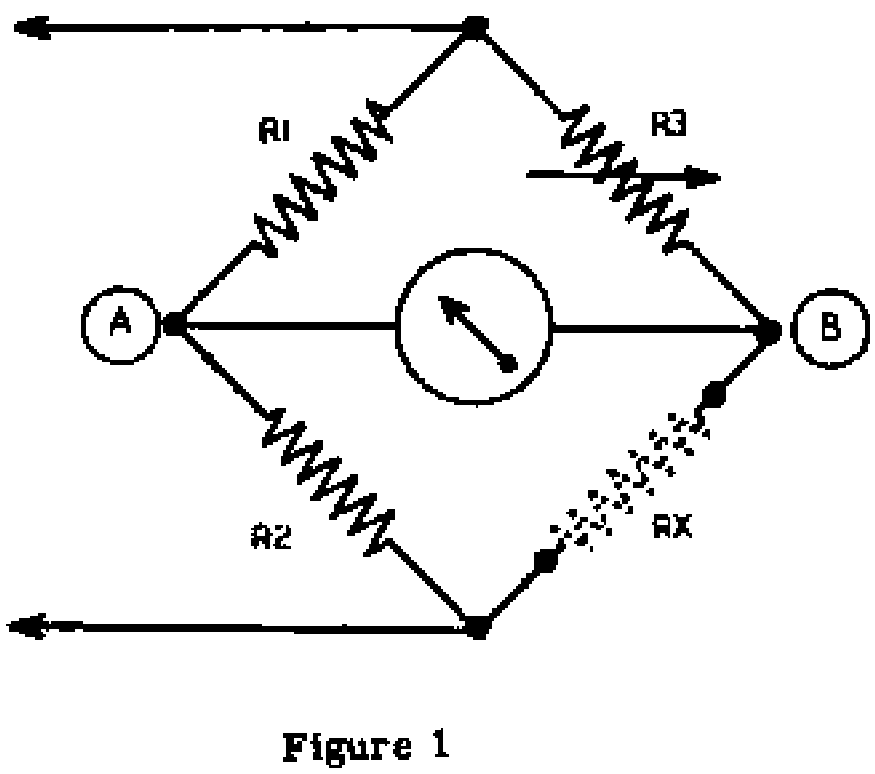


Figure 1

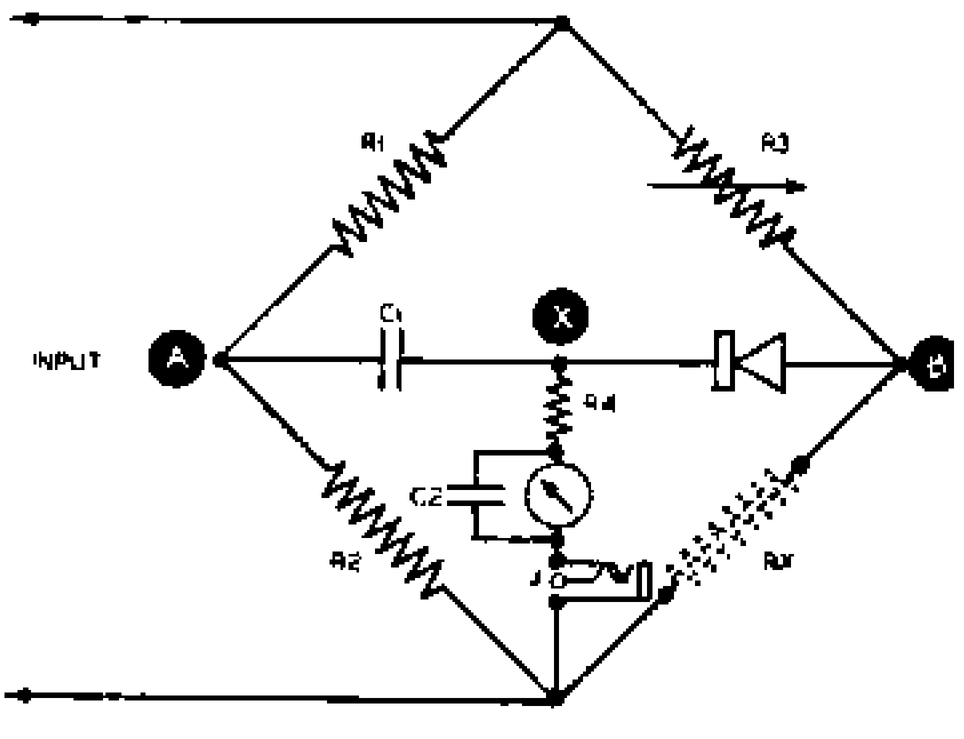


Figure 2

Again R1 and R2 are of equal resistance, consequently when R3 equals R_x, there will be no potential difference between points A and B, and no RF current will flow between points A and B. When the circuit is unbalanced, RF will flow between points A and B and will be rectified by the crystal diode, developing a DC potential at point X. This voltage flows through the meter to ground indicating the degree of unbalance of the circuit. As rectifiers of the type used show variations of resistance with change in applied voltage, a relatively large resistance R4 is placed in series with the meter to minimize this effect upon the response linearity. R4 and C2 also comprise a filter circuit for the meter. By plugging earphones into Jack J, the AM-1 may be used as a phone monitor.

( ) The unit is inserted into the case in such a manner that the dimples on the panel ends engage the small holes in the case ends and the bottom bracket slides between the binding post connections as shown in Pictorial 2.

( ) Connect the two ends of the 3 1/2" ground wire to the two binding post ground lugs (S). See Pictorial 2.

( ) Connect the two bare wires coming from P1 and P3 to the adjacent insulated binding post lugs (S).

( ) Install the rubber feet on the back cover as shown in Figure 5.

( ) Mount the back cover to the case by means of two #6 sheet metal screws.

( ) Turn the insulated shaft extension on the panel completely counterclockwise.

Figure 5

( ) Mount the dial on the shaft with the zero index on the dial coinciding with the panel index marker. Leave sufficient clearance between the dial and panel to prevent the dial scraping and tighten the set screw.

CALIBRATION PROCEDURE

Although the potentiometers used in this instrument have been subjected to special tests to assure linearity, there is still some variation in individual units. Consequently only coarse calibration figures are furnished on the dial and one side of the dial is frosted to facilitate easy marking by the kit builder.

( ) Before beginning calibration, rotate the dial through its range at least twenty or more times. This, in effect, "ages" the potentiometer by removing loose material on the resistance strip and tends to prevent future changes in resistance.

( ) Plug an open circuited phone plug into the phone jack. This isolates the meter circuit from the bridge circuit of the instrument which is necessary during calibration.

( ) Connect an accurate ohmmeter (or preferably a resistance bridge) between the two red terminals (the terminals connected across the potentiometer.)

( ) Rotate the AM-1 dial until the ohmmeter reads the desired resistance or the bridge is balanced and mark the point carefully with a pencil or pen on the frosted plastic of the dial. The dial may be marked at only the figures printed on it or these may be subdivided according to the kit builder's requirements.

( ) If an acrylic plastic spray such as Krylon is available, a light application to the dial after calibration will prevent smearing of the markings with use. Be sure to mask the rest of the instrument before spraying the dial and apply several light coats rather than one heavy coat to prevent runs.

OPERATION AND APPLICATION

The AM-1 may be operated from any low power RF source, not exceeding 1/2 watt. A grid dip meter makes an excellent driver for it. However, a VFO or an even higher powered transmitter may be used if the coupling is decreased sufficiently to prevent over-load of the AM-1. At frequencies above 15 megacycles, a one turn coupling loop is usually sufficient for obtaining maximum output from the grid dip meter. For lower frequencies, a two or three turn loop will be required. The position of the loop generally need only be at a point which produces approximately full scale reading on the Antenna Impedance Meter while the impedance dial is set near the expected impedance and while the output terminals are open. Because the variable potentiometer is linear, nulls toward the high impedance end of the scale will not appear as sharp as those at the lower end. In this case, it may be necessary to increase the coupling to the grid dipper. For best accuracy of frequency measurements, it is advisable to listen to the grid dip beat against some standard frequency while the instruments are set at the measured reading point. In the following discussion, the RF source will be referred to as the generator. Unless otherwise stated, the null is considered as zero meter reading and it must be kept in mind that this is not obtainable unless the measured impedance is resistive which in the case of an antenna or any other circuit made up of inductance and capacitive reactances, means it must be resonant at the frequency concerned. Incomplete nulls indicate the measured impedance is reactive. Before discussing antenna measurements, data on the readings of transmission lines will be first presented because they clearly indicate special characteristics of these lines and because certain definite lengths of lines will be used with some measurement procedures.

QUARTER WAVE LINES

To determine the electrical length of the quarter wave line, connect the line to the output terminals of the Antenna Impedance Meter. When using twin lead, do not let it lie on the ground, the floor, or on any metallic objects but see that it hangs clear. The case of the instrument should be ungrounded. Set the impedance dial at zero and leave the end of the line open. By varying the generator frequency, find the lowest frequency at which the null occurs. This may be initially approximated by the standard formula:

$$F_{mc} = \frac{246 \times V.P.}{L_{ft}}$$

The frequency indicated by the generator is then that at which the line is one-quarter wave length long, since the quarter wave open line will appear as a short circuit at its input terminals. Shift the generator frequency to any odd number of times the frequency just found and the null will again occur because the above characteristic holds true at odd quarter wave lengths. Now, as of general interest, leaving the generator set at the original frequency, connect a non-reactive resistor equal to twice the line surge impedance at the end of the quarter wave section. Rotate the AM-1 dial until a new null is noted. The generator frequency may have to be slightly retrimmed during this operation. The resistance reading then found will be half that of the line surge impedance;

$$Z_S = \frac{Z_O 2}{Z_r}$$

Where Z_S is the input impedance, Z_O is the line impedance and Z_r is the load impedance.

HALF WAVE LINES

Connect the line to the instrument as above but this time short the end of the line. With the AM-1 dial set at zero, find the lowest frequency at which the null occurs. This will be the half-way frequency of the line, since the half-wave line will repeat whatever is connected at its far end, which in this case is the short circuit. Any multiple length of the half wave will produce the same results. Now connect a non-reactive resistor of any value within the range of the AM-1 at the far end of the line. Rotate the dial for the new null, slightly readjusting the generator frequency if required. The indicated value shown on the impedance scale should be that of the test resistor, because as already shown, a half wave line will repeat its load.

TRANSMISSION LINE SURGE IMPEDANCE

Connect a section of line, open at its far end, to the AM-1 and find the frequency at which it is one-quarter wave length long, as described above. With the generator frequency left set, connect a non-reactive resistor at the far end of the line and find the new null by rotating the impedance dial. Using this reading, the line impedance may be calculated from $Z_O = \sqrt{Z_S \times Z_r}$. The inverted impedance may fall outside the range of the instrument if the test resistor value is too far different from that of the line impedance. A different size test resistor must then be employed. Suggested resistor values when the line impedance is approximately known are 30 or 100 ohms for lines of near 50 to 70 ohms, 50 or 200 ohms for these near 100 ohms, and 200 or 600 ohms for those near 300 ohms.

ANTENNA RESONANCE AND RESISTANCE

It may seem strange to consider finding antenna resonance by any other means than the grid dip method when a grid dip is already on hand to use with the Antenna Impedance Meter. However, there are cases where a reading by the grid dip method is difficult to obtain, especially when the antenna is of low Q, or when the element diameter is large. In other situations it may be physically impractical to reach the point at the antenna required for accurate measurement. It is also often impossible to obtain sufficient coupling to a long wire or low frequency antenna, even if it were accessible for measurement. The AM-1 may be employed directly at the antenna or at a convenient point removed from the antenna. Resistance and resonance measurements may be made in one operation because the antenna impedance is resistive at resonance. Occasional reference to the standard antenna formula will materially aid in correlating readings. From the following data it will become apparent that the AM-1 may be used in several different ways, either separately or in other combinations to achieve the same paramount end result of getting the antenna tuned up and the transmission line matched for optimum results. The procedure to follow is a matter of convenience and depends upon the problems in each individual case.

HALF WAVE DIPOLE

If the center of the antenna is within reach when it is in its normal position, the AM-1 may be connected directly at the center, as shown in Figure 6. The center of the antenna must be open in order to connect it to the instrument. The leads at this point should be absolutely no longer than is necessary to make the connection. The binding post can be screwed down tight on the connecting leads and will be sufficient to hold the instrument. In any event, do not support the instrument by holding the case by hand because this will produce serious unbalance. The frequency range to employ at the generator may be ascertained by first approximating the antenna frequency according to the standard formula:

$$F_{mc} = \frac{492 \times .95}{\text{Length in feet}}$$

Set the AM-1 dial near 50 ohms and vary the generator frequency until the best null is indicated. Then rotate the impedance dial until the complete null is realized. The generator frequency may have to be slightly readjusted before the complete null is found. The antenna resistance will then be indicated by the dial reading of the AM-1 and the antenna resonant frequency will be that at which the generator is now set. Resistance readings will vary between 10 and 100 ohms being

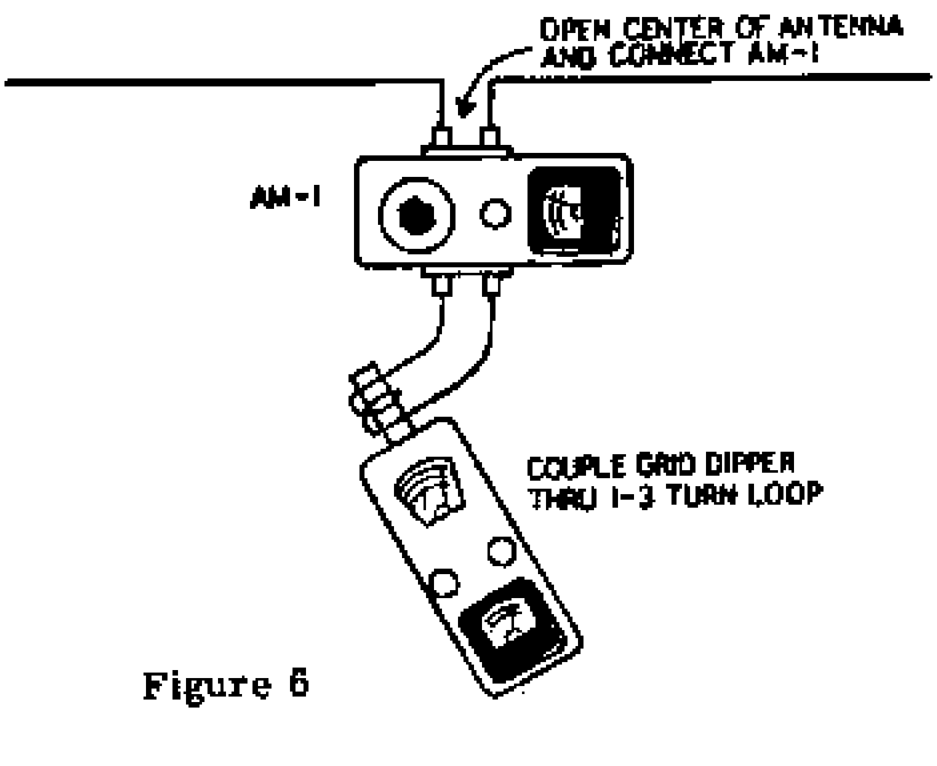


Figure 6

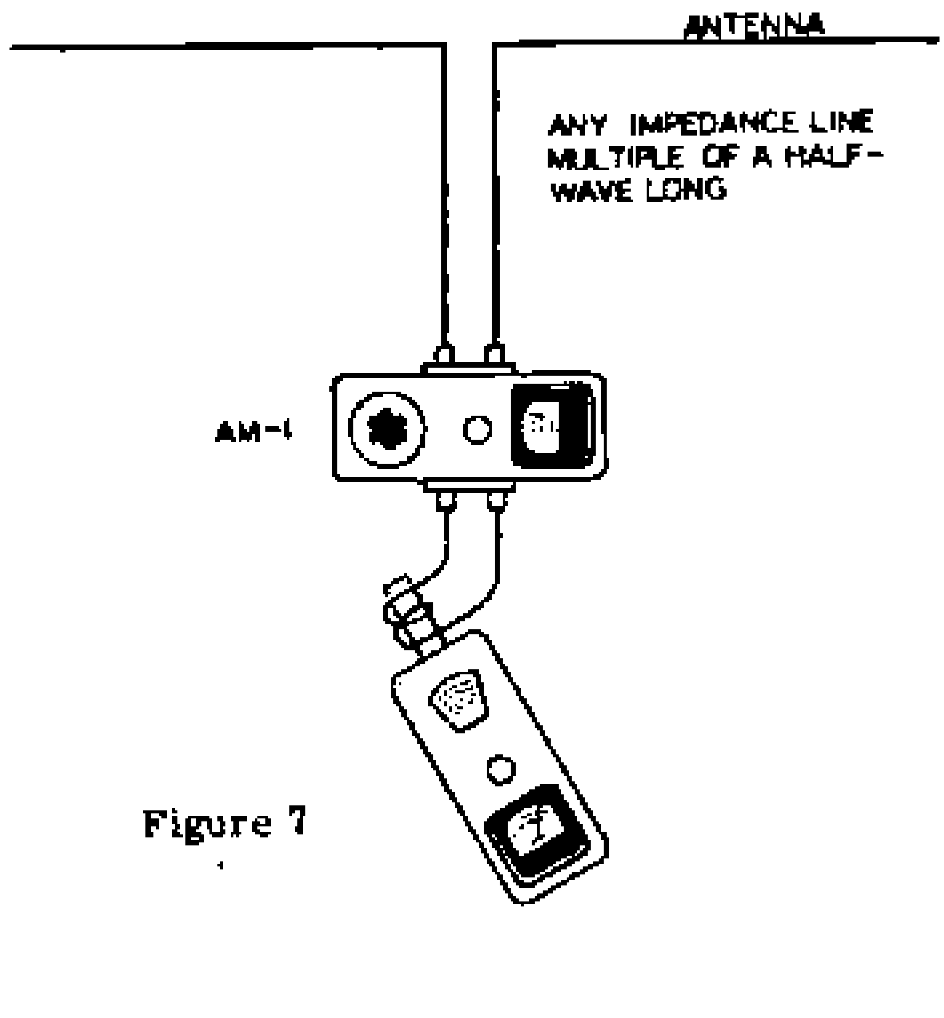


Figure 7

mainly dependent upon exact height above ground and upon nearby elements or other objects. Tests on half-wave antennas at various heights above ground have indicated close adherence to the standard curves of resistance versus height when the measurements were made under similar conditions. Do not expect indoor antennas to behave in the normal manner as their characteristics vary to a surprising extent. At frequencies above 50 mc, the readings are apt to be effected by the presence of the instrument at the center of the antenna and/or the presence of the person making the measurements. Readings will then have to be obtained at a point removed from the immediate proximity of the antenna. This will also be necessary when an antenna is inaccessible for direct readings. It was demonstrated earlier that a half wave line repeats its load as seen from the sending end. Thus a half wave line or any multiple thereof may be connected to the center of the antenna and the measurements may be made at the lower end of the line. See Figure 7. These readings will then be a duplicate of those obtainable directly at the antenna, regardless of line impedance as long as the line is an exact electrical half wave of the antenna frequency. Now the question may arise as to how the correct half wave length may be determined in view of the fact that the exact antenna resonant frequency is one of the unknowns to be measured. Although measurements of existing antennas may be desired, it is recommended that the antenna system be tuned or adjusted to a prescribed frequency in order to assure peak performance. This will generally be the eventual step anyway and it will simplify remote readings because the half wave line may be first cut to the specified frequency using the antenna impedance meter method, described earlier, following which the antenna may be trimmed to the correct frequency according to the readings obtained with the instrument at the lower end of the line. The best procedure for existing antennas is to calculate the antenna frequency approximately by the standard formula and then use this as the basis for ascertaining the frequency for the half wave line. The alternative method is to use a line of impedance near that of expected value of the antenna resistance. The mismatch will probably not be too great and the error will be slight. If the antenna is within reach and if a grid dip measurement is possible, the frequency may be found accordingly. It is obvious that this will apply mainly when the resistance only is to be read or when the resonant frequency is to be confirmed. Several precautions must be exercised when making remote measurements. The half wave line should run at a right angle away from the antenna for a distance of at least a quarter wave length to minimize unwanted coupling to the antenna. If open wire or twin lead is utilized, twist the line about one turn every two feet. This will tend to cancel out line unbalances to ground which may effect the reading, particularly since the AM-1 is in itself an unbalanced device. The case of the instrument should always be insulated from ground and it should be placed so as to minimize capacitance between the case and nearby grounded objects. Line unbalance may be checked by reversing the connections at the output terminals. Little change, if any, should be noted in the readings. With high frequency antennas it is usually best to employ a line several half waves long to reduce the effect of personal body presence. If the AM-1 meter should read above zero when the antenna or line is connected to the instrument, and when no generator signal has yet been applied, most likely RF energy is being picked up from some nearby broadcast station or other high power source. This has been experienced with several cases involving 3.5 mc antennas. Often just reversing the line is sufficient to drop the reading down to zero. If this does not rectify the situation, about the only other remedy is to wait for the interference to cease. By using headphones in the phone jack, the interfering signal may be identified.

FOLDED DIPOLES

Measurements may be made in the same manner as with the normal dipole. See Figure 8. The AM-1 or the half wave feed line should be connected to the normally open section at the center. If any frequency check is to be made by the grid dip method, the open center must first be shorted. Resistance readings of folded dipoles will generally run between 150 and 350 ohms. In some cases it may be possible to obtain a second null in the 500 ohm region at a slightly different frequency. This is due to the following. Refer to Figure 9. The overall length A determines the natural period of the antenna. However, each half of the antenna, sections B and C, are lines quarter wave long at a frequency which may differ slightly from the overall frequency depending upon the height above ground or upon the presence of other elements. With open wire or tubing this is usually not pronounced and is of little consequence but with a folded dipole made of twin lead, this effect will be quite apparent with a wider frequency difference due to the velocity of propagation factor of the twin lead. The frequency of the quarter wave section's being about 86% lower from that of the overall natural period. The net result of this situation narrows the frequency versus impedance response and the twin lead folded dipole then no longer embodie's as broad a characteristic as that of the open wire type. The correct antenna impedance meter reading will be the one found at the higher frequency. The usual suggested method of altering this situation is that of inserting a fixed capacitor in series with each shorted end. The capa-

Figure 8

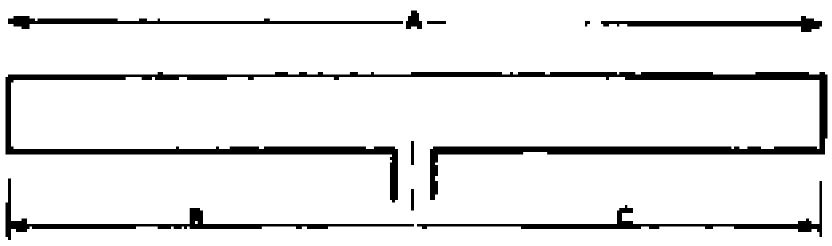


Figure 9

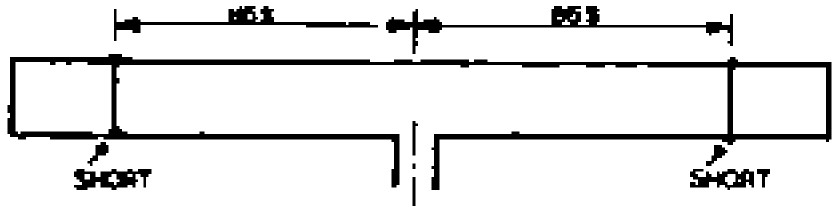


Figure 10

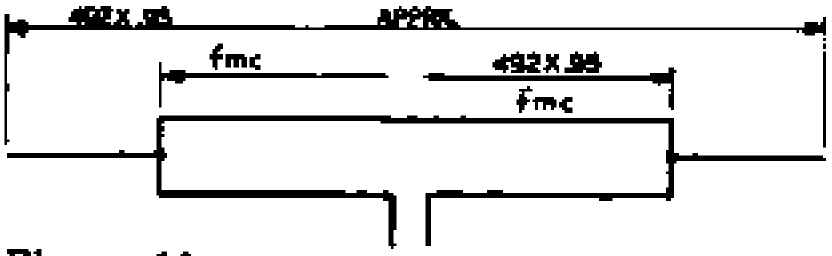


Figure 11

citance is dependent upon frequency, being approximately 7 $\mu\mu$f per meter. An alternative method which is more practical is to connect another short across each section at approximately 86% of the distance from the center as shown in Figure 10. The quarter wave sections will then be each nearly tuned to the overall natural period of the antenna and the impedance characteristic will be broadened. A corrected twin lead folded dipole may be easily and accurately set up through the employment of the AM-1. First cut a length of twin lead to an electrical length of a half wave at the desired frequency, using the instrument as described earlier. Then place permanent shorts across each end of the line and at the exact center open one side of the line for the feed point. Now add equal lengths of wire at each end of the twin lead so that the total length of the antenna will be slightly longer than calculated by formula. See Figure 11. Then using the Antenna Impedance Meter, connect it directly or remotely at the center, trim the end wires equally until resonance is indicated at the desired frequency. If remote measurements are to be made, and if the half wave line to be used is made of the same type twin lead, its length will naturally be the same as that of the section installed in the antenna. The properties of this antenna will be approximately the same as those of the ordinary dipole.

HARMONIC ANTENNAS

Antennas made up of any multiple lengths of half waves may be measured at the desired operating frequency by connecting the AM-1 either directly or remotely at any high current point. As an example, Figure 12 indicates the correct points when using a three half wave antenna. The resistance readings will be only for that at the particular point of measurement. Resonance for this antenna when measured at X_1 will be that of the third harmonic, while readings taken at the center point X will be those of the fundamental or any odd harmonic. Readings of other harmonics may be made at points determined by the theoretical location of current loops.

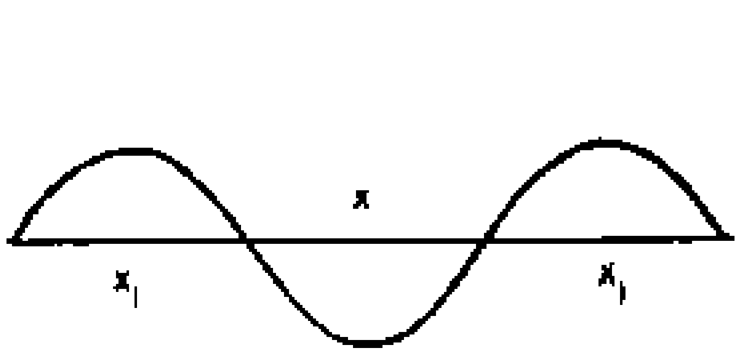


Figure 12

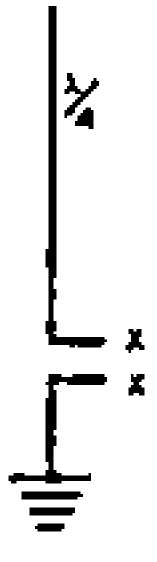


Figure 13

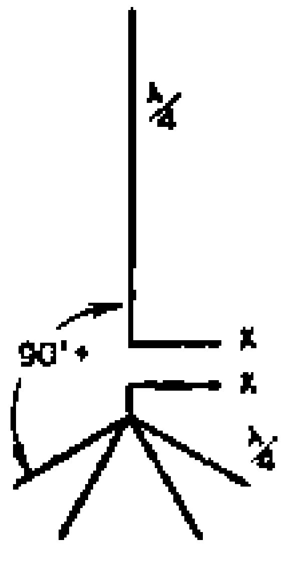


Figure 14

QUARTER WAVE VERTICAL AND GROUND-PLANE ANTENNAS

Connect the AM-1 or half wave line at the normal feed point between the base of the antenna and ground or radial as the situation may require. See Figure 13. The resistance reading will be approximately 35 ohms. Since the resistance at the feed point of the ground-plane antenna may be raised by dropping the radials to form a larger than 90° angle with the vertical element, the AM-1 is a handy device for determining the correct angle for the desired resistance in any specific case. See Figure 14. The limit obtainable is about 70 ohms at which point the radials will be folded all the way down so they too are vertical and the system then resolves into a form of coaxial antenna. Resonance of the vertical antenna may be adjusted by varying the length of the vertical portion and that of the radials if involved.

MOBILE ANTENNAS

Quarter wave mobile antennas may be measured for resonance and resistance in the same manner as employed with the vertical antennas. See Figure 15. The average antenna of this type will have about 45 ohms resistance providing a sufficiently close match for a 50 ohm line. Base or center loaded antennas may be likewise checked. Resistance readings will be in the 20 to 35

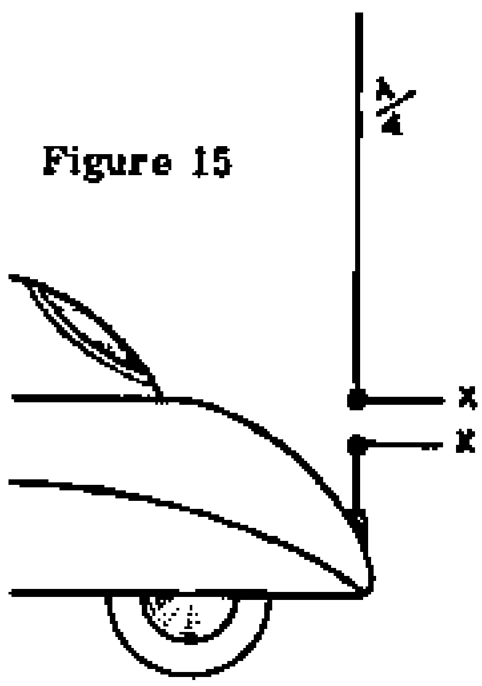


Figure 15

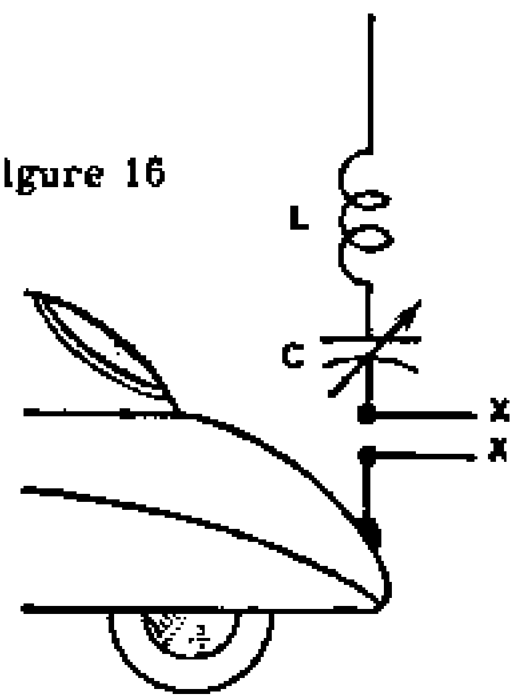


Figure 16

ohm regions. Refer to Figure 16. By correctly proportioning the antenna length in the ratios of L and C, the system may be adjusted so the feed point will have a resistance value to match either a 50 or 70 ohm line. The correct adjustments may be determined according to readings found with the AM-1.

PARASITIC BEAMS

Connect the AM-1 or half wave line at the center of the driven element as with any half wave antenna. Resistance readings will usually lie between 10 and 100 ohms, being dependent upon the exact spacing and tuning of the other elements. Resonance will also be dependent to some extent upon these factors which will make it difficult to calculate exactly the length of the half wave if needed for remote measurements. For this situation, the antenna system may be tuned up to a prescribed frequency with the line cut accordingly as previously suggested. However, in most cases the center of the driven element will be accessible, so the instrument may be used directly. Occasionally one or two slightly different frequencies may be indicated by the AM-1. This is due to reflections from other elements and must be analyzed in each individual case. With the beam correctly tuned, only one frequency will be indicated by a complete null at the true resonant frequency. As already stated, partial nulls indicate reactive impedance which will be the incorrect point to consider. It has been found generally good practice to resonate the driven element while the reflector is set at a length about 5% longer than this element and the director set about 5% shorter. The beam adjustment may then be left set since only little improvement will usually be gained over this arrangement by retuning the parasitic elements through the customary lengthy process of checking against field strength readings. But, if finite adjustments of the other elements is desired, it is suggested that the AM-1 be employed as a means of initially tuning the driven element. The parasitic elements may then be tuned in their usual manner with occasional checks being made for antenna resonance. This latter step may be made with the AM-1 used as a S. W. R. meter as will be subsequently explained.

ADJUSTING Q BARS

Q bars, as quarter wave transformers, often used as a matching device between an antenna and a transmission line, may be adjusted by connecting the AM-1 at the line end of the bars, with the other end being connected to the antenna. The spacing between the bars should then be adjusted to obtain the necessary impedance. They must first be cut to the correct length and the antenna must be resonant at the frequency to be used.

STANDING WAVE RATIO

If the meter indicates a complete null when the AM-1 is inserted into the transmission line, the indicated S. W. R. will be unity or 1:1. Ratios higher than 1:1 may be determined if the line is a multiple of a half wave long at the resonant frequency involved and if the antenna is resonant. Just rotate the AM-1 dial while slightly adjusting the generator frequency if required, until the null is found indicating the resistance of the termination. The S. W. R. may then be determined by:

$$\text{S. W. R.} = \frac{\text{Z load}}{\text{Z line}}$$

The instrument itself may be calibrated for various ratios but the readings will be inaccurate unless the above conditions prevail. Lines of other lengths will reflect an impedance different than that found at the termination and this impedance will be reactive particularly if the antenna is not resonant. The same difficulty of obtaining an accurate reading of S. W. R. other than 1:1 may be found with many current types of S. W. R. meters. As with other measurements, the ideal procedure is to tune up an antenna to a prescribed frequency while matching the line. This may be readily done with the AM-1 connected at the sending end of the line. In order to avoid confusing nulls, due to line resonances, it is suggested that the length of the line be held shorter than one wave length. Set the instrument dial at the line impedance and vary the generator frequency near that calculated for the antenna, until a null is observed. If this occurs at a point other than at the desired frequency, adjust the antenna until resonance is obtained at the correct frequency as indicated by the AM-1 null. If the null is incomplete and a variable matching device is being used, it should be adjusted until a complete null is realized at the resonant frequency. When a matching system such as the T match is employed, an antenna will often have to be resonated with each subsequent change in the setting of the T as the antenna will be affected by these changes. If no variable matching arrangement is used, and if the line is otherwise correctly terminated at the resonant antenna, the meter will indicate a complete null and the S. W. R. will be unity. Stress is again placed on the fact that the unity ratio cannot be obtained unless the line is not only terminated by an impedance equal to its own impedance, but also that this impedance must be resistive which in turn is not possible unless the antenna is resonant at the frequency involved. When the complete null is realized indicating a 1:1 ratio, the length of the transmission line should be altered by 1/8 or 1/4 wave length to verify the reading. If the S. W. R. has been correctly adjusted to unity, no change should be noted in the meter null.

RECEIVER INPUT IMPEDANCE

Connect the AM-1 to receiver input terminals and tune receiver to the frequency at which the impedance is to be determined. Set the generator at the same frequency and rotate the Impedance dial until the complete null is found. Retrim generator frequency if necessary. As with antennas, the input circuit must resonate at the frequency employed in order to read the resistive component. If the input circuit is tightly coupled as it is on many sets, two impedance readings at slightly different frequencies will be noted. One reading will be low between 10 and 20 ohms and the other reading will be anywhere from 50 to 500 ohms. The reason for this is that the reactance of the coupling loop between the generator and the input side of the AM-1 reflects upon the tuned input circuit of the receiver, the very low impedance reading being evidenced at this point. Although the loop reactance may be tuned out, moderate accuracy may be had by relying upon the higher reading.

PHONE MONITOR

By adding a short length, 6 to 12 inches, of wire to either the "hot" input or output terminals of the AM-1, and plugging a pair of earphones into the phone jack, the AM-1 may be used to monitor radio telephone transmissions, thus giving the operator an indication of the quality of his modulation.

FIELD STRENGTH METER

By placing a circuit tuned to the frequency of the transmitter across the output terminals of the AM-1 and adding a suitable length of antenna, the instrument may be used to a limited extent as a field strength meter. Although it has no built-in amplification, the high sensitivity of the AM-1 will allow it to be used as a relative field strength meter where the RF field strength is fairly high. With approximately a 100 $\mu\mu f$ variable condenser and a suitable plug-in socket, the normal grid dip meter coils may be used as the parallel tuned circuit for the field strength meter. A unique cause of TVI has been found to be rectification and re-radiation from natural objects such as furnaces, drain pipe spouting, etc. The AM-1 used as a field strength meter either with or without the tuned circuit, may be used to locate radiation from such objects. Grounding or bonding of the joints in these objects may then eliminate the source of TVI.

IN CASE OF DIFFICULTY

Due to the extreme simplicity of this kit, there is very little chance of trouble. However, a few possible indications of improper operation and their causes are outlined below.

INDICATION	CAUSE
Meter reads backwards.	1. Meter mounting on panel reversed. 2. Crystal diode connected backwards in circuit.
Low sensitivity.	1. 200 Ω resistor to ground open.
Meter will not indicate a null when properly operated.	1. 200 Ω resistor from potentiometer open.
Meter will not indicate under any conditions.	1. RF source in-operative. 2. Crystal diode defective. 3. Phone jack shorting blade not making contact. 4. Phone jack wired incorrectly. 5. Open 10 KΩ resistor.

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REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

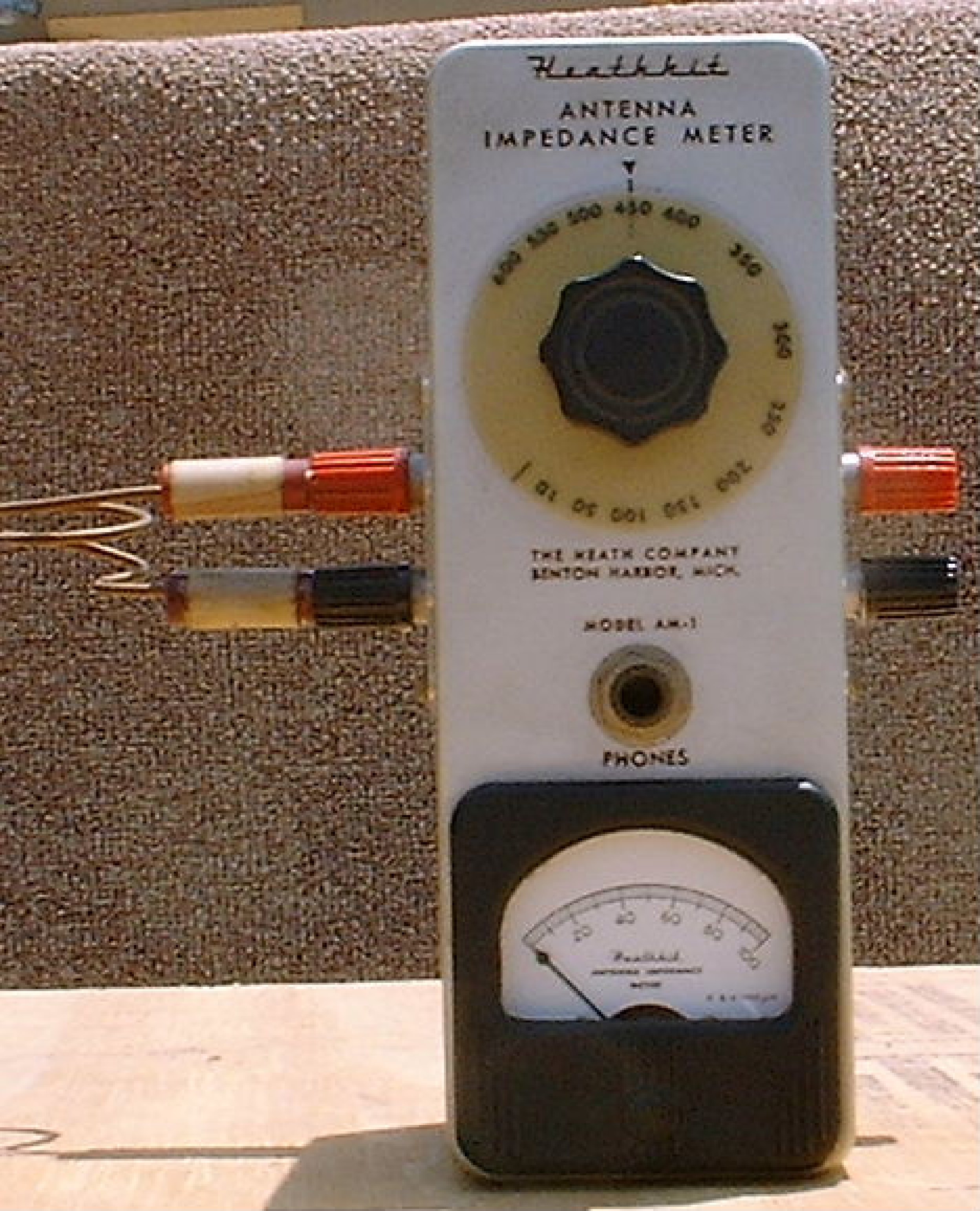
A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

PARTS LIST

PART No.	PARTS Per Kit	DESCRIPTION
Resistors-Condensers-Rectifiers		
1-20	1	10 KΩ resistor
2-83	2	200 Ω resistor 1%
10-34	1	600 Ω potentiometer
21-27	2	.005 μfd ceramic condenser
56-4	1	Crystal rectifier
Meters-Knobs-Insulators		
75-6	2	Polystyrene insulator
75-14	1	Polystyrene mounting plate
100-M16B	2	Binding post cap, black
100-M16R	2	Binding post cap, red
100-M39	1	Dial
407-24	1	100 μA meter
453-7	1	Insulated shaft extension
Sheet Metal Parts		
90-28	1	Cabinet
203-52F65	1	Panel
204-M60	1	Bracket front
204-M61	1	Bracket back

PART No.	PARTS Per Kit	DESCRIPTION
Hardware		
250-8	2	#6 x 3/8 sheet metal screw
250-10	6	6-32 x 1/2 screw
250-16	1	8-32 x 3/16 set screw
252-3	10	6-32 nut
252-7	2	Control nut
253-10	2	Control nickel washer
254-1	6	#6 lockwasher
255-2	2	#6 x 3/16 spacer
259-1	5	#6 solder lug
259-6	2	Solder lug, small
Miscellaneous		
261-1	4	Rubber feet
340-2	1	length Bare wire
436-4	1	Jack
427-2	4	Binding post base
595-79	1	Manual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