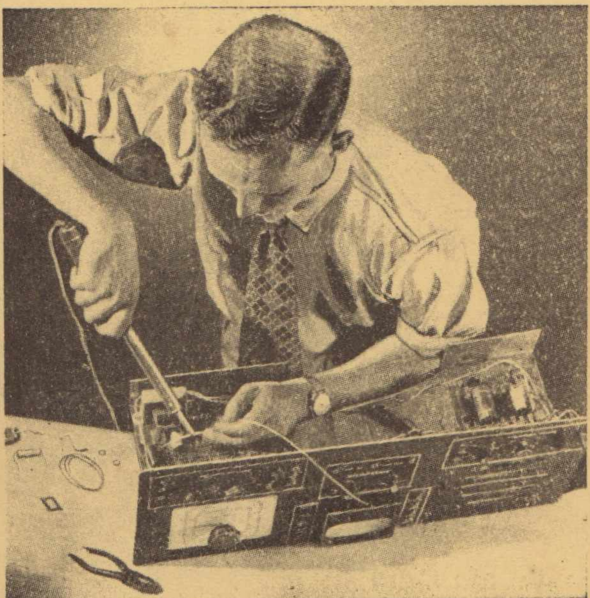
AUSTRALIAN RADIO & TELEVISION COLLEGE PTY. LTD.

PRACTICAL RADIO COURSE



of

HOME PRACTICAL INSTRUCTION

Lesson No. 2

THIS Radio Course of practical home instruction is the result of many years experience, and months of final experimental work by some of Australia's most competent Radio engineers. It is designed so that you acquire a thorough and most comprehensive practical Radio training by building up the kits which are supplied with these lessons. When the course is finished, and all the kits have been built up into the final unit, you will possess a complete professional outfit of Radio testing apparatus, which in itself is not only worth far more than the money you pay for it, but which will also enable value from the Radio work you can perform with it.

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<u>CAUTION</u>

THE TWO SLOTTED SCREW HEADS ON THE BACK OF THE METER CASE ARE <u>NOT</u> TERMINALS. THEY MUST NOT BE UNSCREWED.

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This Lesson will show you how to:–

HOME PRACTICAL INSTRUCTION

LESSON No. 2.

The principal feature of the second practical instruction kit is that you receive in it your permanent magnet moving coil meter which you will eventually combine with other parts to form a high quality multimeter. However, even before you completely construct the multimeter, you will be able to obtain quite a lot of useful experience with the parts contained in this kit, so that you will become familiar with the principles of electrical measurement and you will become practised at using your meter and reading the indications on its scale in carrying out the tests and experiments listed below.

LIST OF PARTS.

The parts contained in your second practical instruction kit are as follows:

1 0-500 microamp moving coil meter.
1 4½ volt battery.
1 2.5 volt flashlight lamp.
1 miniature lamp holder.
1 14.8 ohm resistor.
1 10,000 ohm resistor accurate within plus or minus 1%.

As most of the experiments to be conducted with this kit are based upon the use of the meter, a brief description will first be given of its construction and method of operation so that you will be able to use it more intelligently in making your tests.

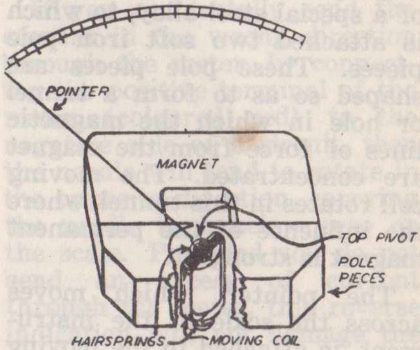

Fig. 1.

METER CONSTRUCTION.

There will probably be a strong temptation, on the part of many, to unscrew the cover of the meter case so as to examine the construction of the meter and to compare the construction with the following description. It would, however, be most unwise for you to attempt to unscrew the case of the meter so as to examine it, because of the fact that it is carefully sealed, before leaving the factory, to prevent the ingress of any moisture or dust which would impair the efficiency of operation. Furthermore, some of the parts in the instrument are just as delicate as those in a watch or clock and the slightest bump or damage to any of the internal parts could quite easily upset the accuracy of the instrument. Therefore, on no account should you open the case and attempt to examine or adjust the meter's mechanism.

The principle of operation is that inside the case there is a large permanent magnet, made of a special steel alloy, to which is attached two soft iron pole pieces. These pole pieces are shaped so as to form a tunnel or hole in which the magnetic lines of force from the magnet are concentrated. The moving coil rotates in this tunnel, where the influence of the permanent magnet is strongest.

The pointer, which moves across the scale of the instrument, is attached to the moving coil. The moving coil itself is a small rectangular winding of copper wire on an aluminium former. The coil has to be small enough so as to rotate in the tunnel formed in the magnet, without touching the sides. The coil is wound with extremely thin copper wire, only about 2/1000 of an inch in diameter and your meter coil comprises about 500 turns of this wire.

So that the coil may swing freely, and carry with it the pointer, it is pivoted by means of hardened steel pivots sharpened to a needle-like point. The points of these steel pivots fit into conical recesses in sapphire jewels because there is very little friction between a polished steel surface and a sapphire jewel. The jewels are mounted in the ends of fine screws which in turn are assembled into the main frame of the instrument. By the observation of a high degree of precision in the manufacture of these pivots and jewels and in their positioning and assembly in the construction of the meter, friction is kept to a neglibly small amount and the coil is quite free to swing to a position determined by the passage of current through it.

To hold the needle normally at zero and to provide an opposition against the tuning force of the electrical current to be measured, two hair springs are attached. These hair springs are thin spirals, very similar to those used in watches. One is attached to the top of the coil and the other to the bottom of the coil and both assist one another in normally holding the needle at zero on the meter scale. These hair springs have a second purpose also, they serve to provide a means for carrying the current to be measured to and away from the moving coil. In other words, the current to be indicated by the instrument passes from one of the terminals to the outside end of one of the hair springs, around through the turns of the hair spring to its inside, there it is soldered onto one end of the moving coil so that the current then passes around through the turns of the moving coil to its other end. This other end of the moving coil is attached to the inner end of the second hair spring so that the current then passes out through the second hair spring and away to the rest of the circuit through the other meter terminal. As a current passes through the turns of the moving coil it sets up a magnetic force around the coil and this force inter-acts with that produced by the permanent magnet to produce a turning effect. This effect causes the coil to rotate, carrying the needle with it, so that the needle registers the strength of the current by moving a certain number of divisions across the scale.

When current causes the coil to rotate, it has to deform both of the hair springs as these are endeavouring to hold the meter pointer at zero on the scale. The sensitivity of your meter is such that the needle will move right across to the extreme right hand end of the scale with 500 microamperes of current passing through it. If a smaller value of current is passed through the coil then the turning force produced by this smaller current is not enough to fully deform the hair springs and consequently the meter may only move a smaller distance across the scale. For example, 250 microamperes would produce half the turning force and this would only be sufficient to move the needle halfway across the scale. Similarly, other values of current will move the needle by a proportionate amount.

Naturally, if a current stronger than 500 microamperes is forced to flow through your meter, it will tend to turn the needle too far and this may result in damage to the meter, so always exercise the greatest caution to see that too much current is not passed through your meter, by carelessness, or an accidental connection.

If you accidentally send the current in the wrong direction through the meter, by connecting the positive terminal of the meter (coloured red) to the negative side of a circuit, then the needle will tend to rotate in the opposite direction, carrying the needle back below zero on the scale. Provided you do not send an excess of current through the meter, this reverse indication will not damage the meter in any way.

An instrument of this type will only measure direct current and should never be connected to a source of alternating current, such as the alternating current power mains, unless it is used in conjunction with a rectifier such as will be described in one of the later instruction papers.

Your meter is a precision instrument and it cannot be too strongly stressed that it is necessary to handle it with care so that it will retain its accuracy for a long period of time. You should always handle the meter carefully as any undue bumping or vibration may damage the polished surface of the pivots and jewels, you should always think carefully before connecting it to a circuit, so as to avoid electrical overload which would perhaps bend the pointer or if extremely severe, burn out the thin wire of the coil. No meter is foolproof, and if you carelessly apply an excess of voltage or current to it you will be certain to damage it, so always check your connections very carefully before applying current and ask yourself whether there is any chance of damaging the meter by the possibility of too much voltage or current being present.

METER SCALE

Your meter, as it is originally supplied to you, is quite unsuitable for measuring voltages and is in fact simply an ammeter, or more correctly, a microammeter, with a full scale value of 500 microamperes. This means that 500 microamperes of current must be passed through the coil to make it turn sufficiently to carry the needle right across to the end of the scale. If the meter were to be used only as an 0/500 microammeter it would only be necessary to mark the scale with one set of numbers terminating in 500 at the right hand end and with other progressively smaller numbers down to zero at the left hand end. However, a little later on, you will be converting this instrument into a multimeter with a wide variety of voltage, current and resistance scales and consequently the meter is supplied to you with the somewhat complex scale needed on a multimeter of this type, instead of a single scale range of 0/500 microamps. For the purpose of the experiments you will be conducting with this kit of parts you can entirely disregard all but one scale on the meter face. The set of graduations you will use will be the second row of graduations from the top. These are the ones marked "Volts, Mills D.C." If you examine this set of graduations you will find that there are 50 of them and that each fifth one is made a little longer than the others so that it may easily be distinguished. Later, when we convert our instrument into a multimeter, this set of graduations may be used for making measurements on one of several ranges. We may use these graduations for measurements up to 10 volts or milliamps, 50 volts or milliamps, 250 volts or milliamps, or 1,000 volts or microamps. Consequently, these various numbers are marked under the set of graduations at the right hand end. The proportionately smaller values of voltage or current, are marked in their respective positions across the face of the meter and their meanings will be quite clear from an examination. As mentioned earlier, you should at this stage completely disregard the upper graduations labelled "Ohms" and the lower sets of graduations marked "A. C. volts".

EXPERIMENT 1.

D.C. MICROAMPS.

A microammeter must only be used for measuring the value of current flowing in a circuit and must never be used, without the use of other additional parts, for measuring voltages. That is, it must never be directly connected to the terminals of a battery or any other source of voltage. However, if a battery is connected to a circuit containing sufficient resistance to restrict the value of current flowing to a few microamps, we may use our meter for measuring the intensity of this current flow.

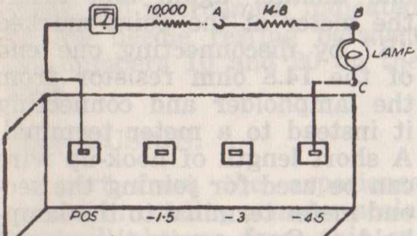

Fig. 2.

To provide some exercise in using our meter for the measurement of current intensity, let us connect the battery supplied, the 10,000 ohm resistor, the 14.8 ohm resistor, and the lamp altogether in a circuit as shown in Figure 2. It is best to solder the ends of the connecting wires of the resistors to one another and to solder one wire of the 14.8 ohm resistor onto the lampholder. The two wires connecting the meter to the battery and the meter to the 10,000 ohm resistor can be short lengths of hook-up wire. One length of hook-up wire can be soldered to the 10,000 ohm resistor. Its other end is bared for a distance of about 1" and is soldered to the right hand lug on the back of the meter. The other length of wire can be soldered to the second meter terminal and its other end attached to the clip on the battery by pressing downward on the clip, then passing the wire under the notched piece of brass showing. On releasing pressure on the clip it will spring up and grip the wire securely. Another short length of hook-up wire can be used for connecting the lamp to the other terminal of the battery.

To protect the meter against damage, the meter, resistors and lamp should all be connected to one another first and the battery connected on last of all. You will find, when the battery connections are made that the needle will move up the scale and will register the strength of current flowing in the circuit. You will probably find that the needle reaches about 9/10th of the way across the scale.

If the needle were to reach the extreme right hand end of the scale this would correspond to a current flow of 500 microamps but actually there is no number "500" at the right hand end of the scale. However, the number 50 appears in the second row of figures at the right hand end and it is quite easy to imagine this as 500, whilst the 40 should be regarded as 400, the 30, 300, and so on. Thus it will be seen that the needle comes to rest at a position between 400 and 500 microamps. There are ten small divisions between 400 and 500 on the scale so each of these will represent 10 microamps. Thus, if the needle rests on the first division above the 400 point this will be 410, whilst the second division would be 420 and so on. You will easily be able to measure the exact value of current flowing. With this small amount of current flowing, the lamp will not light, so do not worry over the fact that it does not glow.

To prove that the same amount of current flows in all parts of a series circuit, I now want you to insert the meter at various other points in the circuit to observe that the current has the same strength at all positions. To do this, disconnect the meter entirely from the circuit and then connect the left hand end of the 10,000 ohm resistor directly to the positive battery terminal. Next, separate the junction of the 10,000 ohm resistor and 14.8 ohm resistor at the point marked "A" on the diagram. You then connect one end of the 10,000 ohm resistor to one of the meter terminals whilst the other meter terminal is connected to one end of the 14.8 ohm resistor. You will now find that the needle again gives a registration of current and if you observe carefully you will see that the current has exactly the same strength at this point as it did at the first point in the circuit. If, during any of these experiments the meter needle tends to move to the left instead of up the scale, it simply means that you have reversed the connections to the battery or meter and you can make the needle move in the right direction by either exchanging the two battery connections or exchanging the two meter connections.

Next, remove the meter from the point marked "A" in the circuit, join the two resistors to one another again and insert the meter at the point marked "B" by disconnecting one end of the 14.8 ohm resistor from the lampholder and connecting it instead to a meter terminal. A short length of hook-up wire can be used for joining the second meter terminal to the lampholder. Once again the circuit will be completed, current will flow, and the same strength of current will be registered.

Now repeat this operation, by inserting the meter at the point marked C instead of that marked B and again observe that the current has the same strength.

When using the two outside terminals of the battery, as shown in Figure 2, you are employing the battery's full voltage of 4½ volts to drive current around the circuit. You should now repeat the experiments outlined above by using only 3 volts from the battery. This is done by moving the wire from the battery terminal marked "-4.5" to the next terminal, marked "-3". With only 3 volts in use, the current will not be as great and the needle will move only about two-thirds of the way across the scale to a point near where the figure "30" is marked. Of course, this corresponds to 300 microamps.

The next step is to repeat the experiments after having moved the lead from the -3 terminal of the battery to the one marked "-1.5". You will find that the current has become still weaker and now has a strength of about 150 microamps, indicated by the needle resting between the numbers 10 and 20 on the scale.

CONCLUSION.

Apart from the experience gained in reading a meter scale, you will observe from this experiment that the same value of current exactly flows at all points in a series circuit such as the one illustrated in Figure 2. Further, if there is a break at any point in a circuit such as this, the current will be prevented from flowing at any point in the circuit. The strength of current flowing in a circuit is dependent upon the strength of voltage forcing the current to flow. The stronger the voltage, the greater the intensity of current which will flow. The weaker the voltage, the less the current which will flow.

EXPERIMENT 2.

VOLTAGE MEASUREMENT.

Although the meter supplied to you is basically a microammeter, it can be converted into a voltmeter and employed for measuring voltages merely by connecting a resistor to it. To make your meter into a voltmeter capable of measuring direct voltages up to a strength of 5, connect one end of the 10,000 ohm resistor to one of the meter terminals and connect two lengths of flexible hook-up wire, each about two feet long, one to the other meter terminal and the other length to the unused end of the 10,000 ohm resistor. These connections are shown in Figure 3.

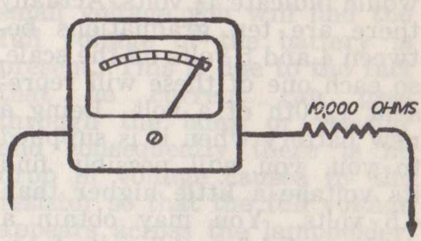

Fig. 3.

Your meter is now capable of measuring voltages and a value of 5 volts applied to it would send the needle across to the right hand end of the scale. Actually, there is no number "5" appearing at the right hand end of the scale but again, we will use the second row of numbers which actually terminates in 50 and we will disregard the nought so that the 50 we will imagine as being 5. Similarly, the 40 will become 4 and the 30 will be regarded as 3 and so on.

To measure the voltage of your battery, connect the two lengths of hook - up wire, marked with arrow heads in Figure 3, to the two outside terminals of the battery. If the battery is in good condition, it should have a voltage of approximately 4.5 volts and this will cause the needle to move nearly to the right hand end of the meter scale. The needle will come to rest about halfway between the numbers 40 and 50 on the scale. As I have already explained, these numbers really correspond to 4 and 5 volts so that if the needle is halfway between, this would indicate 4½ volts. Actually there are ten graduations between 4 and 5 volts on the scale, so each one of these will represent 1/10th of a volt. Being a new battery when it is supplied to you, you will possibly find its voltage a little higher than 4.5 volts. You may obtain a reading of 4.6 or 4.7 volts from it.

You should now measure the voltage of the other sections of the battery by connecting the ends of the hook-up wire between the various pairs of terminals. In some cases you will obtain a reading of 3 volts and in other cases a reading of approximately 1½ volts.

Your meter will now prove to be an accurate instrument for checking any other low voltage batteries you may have, such as flashlight batteries. Each cell of a flashlight battery should give an indication of about 1½ volts when in good condition, and you will find that the cells are not much use once their voltage drops below 1 volt.

On no account should you attempt to use your meter and resistor for measuring values of voltage higher than 5 volts. Never connect the meter and resistor to a radio B battery or any other battery which has a voltage greater than 5. Never attempt to measure voltage unless your meter itself is used in conjunction with a high value of resistance as shown in Figure 3.

EXPERIMENT 3.

FAULT-FINDING WITH A VOLTMETER.

A voltmeter is a very useful instrument for tracing faults in electrical circuits because frequently a fault causes the voltages in the circuit to be different to those normally existing. If you know what voltages should normally exist in a circuit when it is in good condition, then you will quickly be able to determine the faults by measuring with the meter to find out which voltages have changed and are no longer normal.

To provide a circuit on which to practise, connect together the battery, 14.8 ohm resistor and lampholder as shown in Figure 4. On screwing the lamp into the holder you will find that it glows dimly if all your connections are in good order.

The lamp used in this manner may represent the filament circuit of a radio valve.

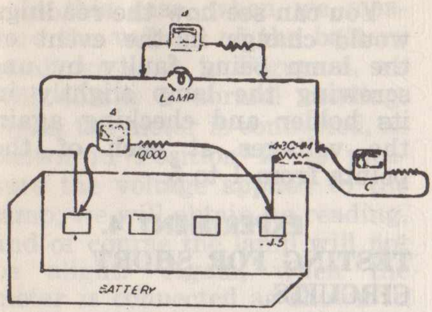

Fig. 4.

Now with your meter connected to the 10,000 ohm resistor as shown in Figure 3, so that it is a voltmeter, connect the two ends of the flexible wires, which should be 2 or 3 feet long, firstly to the two terminals of the battery as shown at A in Figure 4. If the meter shows full battery voltage of approximately 4½, you will know that the battery itself is in good condition.

Now move the voltmeter to B and touch the two sides of the lampholder. The meter in this case should register a voltage of approximately 1 volt. Make a careful note of the exact reading of the meter at this point.

Next move the voltmeter to C and measure the voltage drop across the 14.8 ohm resistor. If you add the voltage measured at this point to the voltage measured at position B you will find that the two added together exactly equal the voltage of the battery as measured at position A. Thus, you can see that the voltage of the battery divides between the various parts making up a series circuit like that of Figure 4.*

Now let us purposely introduce a simple fault into this circuit and you will see how the voltage indications change from the correct ones. Let us prevent the lamp from lighting by unscrewing it slightly in its socket. This will have the same effect as if a faulty lamp is used.

If you now make your measurements, you will find at position A that the voltage of the battery is still correct. At position B, instead of finding a small voltage you will find the full voltage of the battery is present. This is due to the fact that no current can pass through the lamp or resistor and consequently there is no drop in voltage caused by the resistor so that the full voltage appears across the lampholder, even though this voltage is unable to drive any current through the lamp itself.

When you connect the meter to position C you will find that no reading is obtained because of the fact that no current is passing through the 14.8 ohm resistor and therefore will not produce any drop in voltage across it.

Unfortunately, you cannot very well make the 14.8 ohm resistor defective to test and see what happens when this condition arises without actually damaging it. However, if this resistor were to be broken, you

* See A.R.C. Service Engineering Course Lesson 7.

would find on making your measurements that you would obtain full battery voltage at A, no voltage at B, because no current would be passing through the lamp, and you would obtain full battery voltage across the two ends of the resistor with the meter at position C.

Another slightly different method of using a voltmeter for locating a break in a circuit is illustrated in Figure 5. In this case, one of the flexible leads from the meter should be permanently connected to the positive terminal of the battery and the other flexible lead moved around the circuit from one

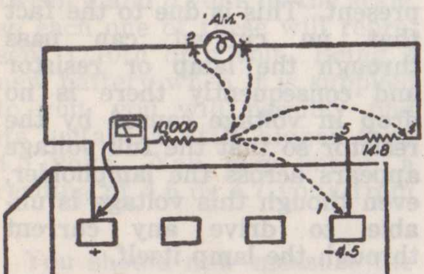

Fig. 5.

point to another as numbered on Figure 5. At position 1, you will check the battery voltage. If all of the other parts in the circuit are in good order, you will find at position 2 that you obtain no reading, at position 3 you will obtain a reading of approximately 1 volt, at position 4 you will obtain a similar reading, while at position 5 you obtain a reading of the full battery voltage.

You can see how the readings would change in the event of the lamp being faulty by unscrewing the lamp slightly in its holder and checking again the voltages at each of the points from 1 to 5.

EXPERIMENT 4.

TESTING FOR SHORT CIRCUITS.

To examine the effect of a short circuit, let us use the 14.8 ohm resistor, lamp and battery in similar fashion to that in diagram 4, with the exception that we deliberately introduce a short circuit in the form of a wire connecting with the right

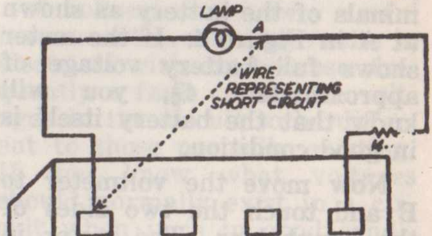

Fig. 6.

hand side of the lamp to the positive terminal of the battery as shown by the wire in Figure 6. When this short circuit is introduced, current from the battery will not pass through the lamp but will take the alternative path through the short circuit to the point marked A and then will pass on back through the 14.8 ohm resistor to the battery.

In this case, when we measure the voltage of the battery as shown at A in Figure 4, we will obtain a normal reading. When the meter is connected, as shown in Position B, to measure the voltage applied to the lamp, we will obtain no reading, and of course the lamp will not be alight. Again, when the meter is connected as shown in position C, we will obtain a reading of full battery voltage because the full voltage of the battery is reaching the 14.8 ohm resistor without having to drive current through the resistance of the lamp.

Previously, when we had an open circuit in the lamp, by unscrewing it in its holder, we obtained full battery voltage when measuring across the lamp in position B of Figure 4. On this occasion, when there is a short circuit across the lamp, as shown in Figure 6, we obtain no reading across the lamp. You will see that the different types of faults reveal themselves by the fact that different voltage indications are obtained when they exist.

EXPERIMENT 5.

CONTINUITY TESTER.

For tracing out the circuits of a radio set or other electrical equipment, and for testing some of the parts, a continuity tester is a very useful instrument. This will reveal when there is a complete path for current through any portion of a complex circuit. A simple continuity tester may be made by employing a $1\frac{1}{2}$ volt section of the battery and the lamp connected together as shown in Figure 7.

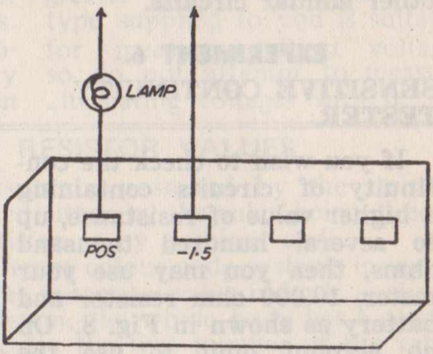

Fig. 7.

By using two lengths of flexible hook-up wire, connect the battery and lamp to any electrical circuit and if there is a continuous path of low resistance, then current will pass through the lamp and cause it to light. If there is a slight amount of resistance in the circuit, the lamp will light dimly. On the other hand, if there is a complete open circuit or a very high resistance path the lamp will not light at all.

The lamp supplied with your kit is rated at $2\frac{1}{2}$ volts and it is permissible to use it for a short period of time with 3 volts applied from the battery. However, it is not advisable to use it for very long under these conditions, and on no account should you connect the lamp across the full $4\frac{1}{2}$ volts of the battery or it will burn out and be of no further use to you.

A continuity tester of this

nature is quite useful for checking the windings in an electric motor or for testing coil windings in radio receivers, and other similar circuits.

EXPERIMENT 6.

SENSITIVE CONTINUITY TESTER.

If you wish to check the continuity of circuits containing a higher value of resistance, up to several hundred thousand ohms, then you may use your meter, 10,000 ohm resistor and battery as shown in Fig. 8. On no account omit to use the 10,000 ohm resistor, otherwise your meter will be damaged.

When the two long flexible leads indicated by the arrow-

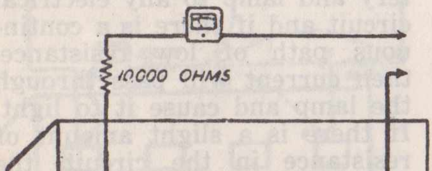

Fig. 8.

heads in Figure 8 are touched to a circuit of low resistance you will find that the needle will move right across to a position corresponding to the full battery voltage, i.e. about $4\frac{1}{2}$ on the scale. On the other hand, when the leads are connected to an open circuit, through which no current can flow, naturally, the meter needle will stay at zero. Again, if the two leads are touched to a circuit containing several thousand ohms of resistance, the needle will take up a position somewhere along the scale.

A continuity tester of this type is quite useful for checking not only resistors in radio receivers but also transformers, coil windings, headphones, loudspeakers and many other parts. If you have an assortment of radio parts on hand, you should test them with the unit and observe the results you obtain. You can also use it for testing the continuity of other electrical appliances such as lamps, irons, electric motors, toasters and other such pieces of equipment.

At this stage, you will not be able to make use of the graduations around the top of your meter face because we have not yet built the instrument up into a proper ohmmeter. Later on, we will, by the use of a slightly more complex circuit, make our meter into an actual ohmmeter for measuring the exact values of these resistances.

In using the continuity tester shown in Figure 8, if you check the continuity of the lamp and the 14.8 ohm resistor you will find that the needle will register almost full battery voltage in each case because both of these items have a very low value of resistance.

A great deal of valuable practical experience can be obtained in using meters and reading meter scales from the experiments outlined above. In order to safeguard your meter, always keep in mind the following points. Never use your meter as it is supplied to you, for measuring values of current higher than 500 microamps. Never use your meter to measure voltage or as a continuity tester without using in addition to it a high value of resistance such as the 10,000 ohm resistor supplied. Even with the 10,000 ohm resistor do not attempt to measure values of voltage greater than 5. A meter of the type supplied to you is suitable for measuring direct voltage, so do not attempt to measure alternating voltages with it.

INDICATION OF RESISTOR VALUES

The number of ohms resistance possessed by the resistors supplied in these kits is indicated either by the value being directly printed on the body of the resistor or by a colour code.

There are two slightly different colour code systems in use although the colours have the same numerical value in both, as shown by the table below. In one system, the whole body has a general background colour which indicates the first number of the value. One end is coloured to indicate the second number and about one third of the way along the resistor from the uncoloured end is a dot or band of colour to show the number of noughts which follow.

In the second system, the body is a natural light brown or white colour and there are three coloured bands around the resistor near one end. Starting from the end near the coloured bands, the first band indicates the first number, the second band the second number and the third band the number of noughts. Occasionally, a fourth band, coloured gold or silver is used to show whether the resistor is within 5% or 10% of its labelled value.

RESISTOR COLOUR CODE

Body Colour or First Coloured Ring	First Figure	End Colour or Second Coloured Ring	Second Figure	Dot Colour or Third Coloured Ring	Remaining Figures
Black	0	Black	0	Black	–
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0,000
Green	5	Green	5	Green	00,000
Blue	6	Blue	6	Blue	000,000
Violet	7	Violet	7	Violet	0,000,000
Grey	8	Grey	8	Grey	00,000,000
White	9	White	9	White	000,000,000

EXAMPLE

A resistor of 250,000 ohms would have a red body or first coloured ring indicating that the first figure was 2, a green end or second ring indicating that the second figure was 5, and a yellow dot or third ring indicating that there are four noughts. Similarly a 25,000 ohm resistor would have a red body or ring and green end or ring and an orange dot or ring. In this case the dot would indicate that there are only three noughts after the first two digits.

Lesson No. 2

Wherever possible, the College will supply resistors coloured or printed exactly as in the parts lists and diagrams of the various lessons but sometimes, where a lesson mentions a 50,000 ohm resistor you may be supplied with one marked 47,000 or for a 250,000 ohm resistor you may be supplied with one marked 220,000 or 270,000 but in all cases you can be sure that these slight variations from the originally intended values will not affect the results of your experiments in any way.

International Preferred Values.

Instead of continuing to make resistors in an almost infinite range of sizes, manufacturers are now tending to standardise on preferred values each of which is an even ten per cent. or twenty per cent. higher than the one below it. For example, taking just those values between 10,000 and 100,000 ohms, resistors in the ten per cent. series with actual values between 9,000 and 11,000 ohms will all be marked 10,000 ohms. Those between 10,800 and 13,200 will all be marked 12,000, etc. The table below indicates the marked or preferred value and the actual values likely to be experienced.

Preferred Value.	Actual Value.	Preferred Value.	Actual Value.
10,000	9,000—11,000	39,000	35,100—42,900
12,000	10,800—13,200	47,000	42,300—51,700
15,000	13,500—16,500	56,000	50,400—61,600
18,000	16,200—19,800	68,000	61,200—74,800
22,000	19,800—24,200	82,000	73,800—90,200
27,000	24,300—29,700	100,000	90,000–110,000
33,000	29,700—36,300		

The same principle applies for all other values above and below those shown above.

After a period you may find that the pointer on your meter does not quite return to zero at the left hand end of the scale, or it may drop slightly to the left of the zero mark. This need cause no alarm because the small black button on the front of the meter case allows the pointer to be set accurately to zero. Slight rotation of this button either way will effect the necessary adjustment.

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