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A PROPOSAL FOR A NEW OHMMETER SCALE

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A PROPOSAL FOR A NEW OHMMETER SCALE

by
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Introductory pages - 2
Text - 4

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ABSTRACT

The basic reason for the non-uniformity of spacing of scale divisions of present ohmmeter scales is examined and a new scale based on the R.M.A. series of values is suggested as an improvement.

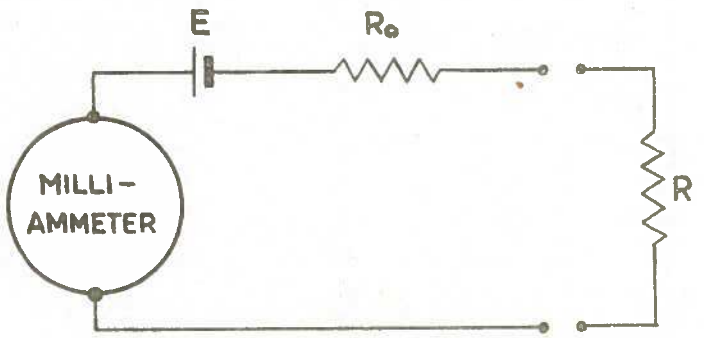
Report no. ERB - 195.

A PROPOSAL FOR A NEW OHMMETER SCALE

While the ohmmeter, consisting of a milliameter, a battery and a resistor in series, cannot be classed as a precision measuring instrument, it is one of the most commonly used instruments in electronic work.

Usually it is incorporated as one of the functions of a test analyser and the meter dial is provided with an ohms scale, as well as voltage and current scales.

It need hardly be pointed out that the ohms scale of present commercial instruments is highly non-uniform. Let us review the theory of the ohmmeter at this time so as to lay the ground work for the proposed new scale.



$$I_{\text{FULL SCALE}} = \frac{E}{R_o} = D(o)$$

$$D(R) = \frac{E}{R + R_o}$$

Fig. 1

Fig. 1 shows the essential components of an ohmmeter in their simplest form.

R_o is the total internal resistance of the instrument and is usually adjustable to compensate for variations in battery voltage and in the internal resistors themselves.

If the meter movement is a good one, the needle deflection will be proportioned to the current flowing. Then the deflection may be written as a function of the external or measured resistance, R,

$$D(R) = \frac{E}{R + R_o}$$

If the external resistance is zero (terminals shorted for zero set)

$$D(0) = \frac{E}{R_o}$$

The function $D(R) = \frac{E}{R + R_o}$ may be rearranged slightly as follows:

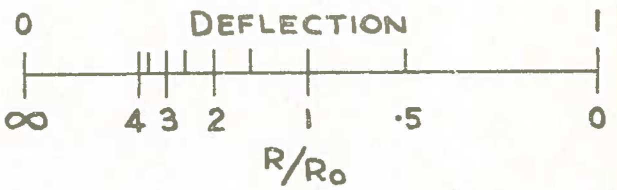
$$D(R) = \frac{E/R_o}{1 + R/R_o} = \frac{D(0)}{1 + R/R_o}$$

which is a more convenient form for numerical evaluation.

R/R_o	$1 + R/R_o$	$\frac{1}{1 + R/R_o}$
0	1	1.00
0.5	1.5	.67
1.0	2.0	.50
1.5	2.5	.40
2.0	3.0	.33
2.5	3.5	.28
3.0	4.0	.25
3.5	4.5	.22
4.0	5.0	.20

TABLE 1

$D(0) = 1$



N.B. Mid-scale deflection indicates measured resistance value equal to internal resistance, R_o.

Table 1 shows a sample scale with the usual equal resistance increments and the resulting non-uniform graduations. A typical commercial ohmmeter scale has the value 25 at midscale, has a graduation for every unit from 0 to 30, and for every two units for 30 to 60, every five from 60 to 100, every ten from 100 to 200, every 50 from 200 to 500, and a few semi-useless marks beyond.

One might be tempted to start with a uniformly graduated resistance scale and work backwards to find the appropriate resistance values, but there would be little to recommend this scheme over the one about to be proposed.

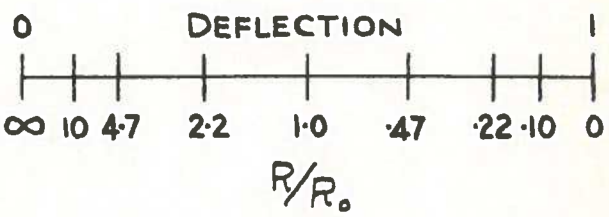
If, instead of equal increments of resistance, our new scale were to be based on the R.M.A. series of values, we would get the results shown in Table II.

R/R_0	$1 + R/R_0$	$\frac{1}{1 + R/R_0}$
0	1	1.00
0.10	1.10	.908
0.22	1.22	.820
0.47	1.47	.680
1.00	2.00	.500
2.2	3.2	.312
4.7	5.7	.175
10.0	11.0	.091

TABLE II

$D(0) = 1$

R.M.A. 40% values



While there are barely enough points to show the nature of this new scale, it will be seen (and can be easily proven) that the scale is symmetrical about the mid-scale point, and, although it is still non-uniform, the crowding is not so severe. In particular, the decade centered on the mid-scale point is quite uniform, and, if the multipliers are chosen in single decade steps, there will always be one reading inside the center decade.

The same attribute of electronic work generally, that makes the R.M.A. series of values desirable (viz. constant percentage tolerance), applies with equal force to the measurement of resistances and it is a rather fortunate coincidence that this also should make for a fairly uniform scale.

A more complete computation for the R.M.A. ten percent series of values is given in Table III, together with a sample scale.

It is not essential to make the internal resistance, R_o, a multiple of ten, as implied in all three scales illustrated, but so doing has the advantage that the scale multiplier becomes the numerical value of R_o. The scale may then be labelled simply R/R_o and the multiplier becomes a resistance, viz. R_o ohms.

TABLE III

R/R_o	$1 + R/R_o$	$\frac{1}{1 + R/R_o}$	R/R_o	$1 + R/R_o$	$\frac{1}{1 + R/R_o}$
0	1.00	1.000	1.2	2.2	0.454
0.10	1.10	0.908	1.5	2.5	0.400
0.12	1.12	0.892	1.8	2.8	0.357
0.15	1.15	0.870	2.2	3.2	0.312
0.18	1.18	0.847	2.7	3.7	0.271
0.22	1.22	0.820	3.3	4.3	0.232
0.27	1.27	0.777	3.9	4.9	0.204
0.33	1.33	0.751	4.7	5.7	0.175
0.39	1.39	0.729	5.6	6.6	0.151
0.47	1.47	0.680	6.8	7.8	0.128
0.56	1.56	0.641	8.3	9.3	0.107
0.68	1.68	0.595	10.0	11.0	0.091
0.83	1.83	0.546	∞	∞	0.000
1.00	2.00	0.500