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(54) EFFECTIVE VALUE CONVERTING CIRCUIT

(71) We, YOKOGAWA ELECTRIC WORKS, LTD., a Japanese Company, of 9-32 Nakacho 2-Chome, Musashino-shi, Tokyo 180, Japan do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an effective-value converting circuit adapted to convert an a-c input voltage or current into a d-c signal proportional to the effective value of the input.

For measurement of an a-c voltage or current, normally available is a rectifier type instrument which rectifies an a-c input by a rectifier and then feeds it to a moving-coil type meter to indicate the input value. In such a rectifier type instrument, it is possible to achieve a high sensitivity and a high accuracy since the principle of operation is the same as that of the moving-coil type meter. By virtue of this merit, the rectifier type instrument is widely employed for measuring a-c voltage or current. When a sine-wave a-c input having an effective value I_{in} is fed to this instrument, its pointer indicates the mean value $(2\sqrt{2}/\pi)I_{in}$ of the input current I_{in} . In general, as the a-c value used practically is the effective one, it is ordinary that the scale of the rectifier type instrument is graduated to show a value obtained through multiplying the intrinsic indication by a form factor $(\pi/2\sqrt{2})$ so that the sine-wave effective value I_{in} is directly readable. Due to such principle of operation, the form factor fails to become $\pi/2\sqrt{2}$ in the rectifier type instrument when there is any distortion in the a-c input waveform to be measured, hence causing an indication error. In order to attain accurate measurement of the a-c input without undesired influence of distortion, an effective-value indicating type instrument is necessary. To meet this requirement, there is available a moving-iron type meter which is capable of directly indicating the effective

value of the a-c input to be measured, thereby causing no waveform error unlike in the rectifier type instrument. On the other hand, while the moving-iron type meter features the above-described merit, an extremely high sensitivity is not achievable in its construction. Furthermore, it has another disadvantage that an indication error may occur depending on the frequency of an input to be measured. Thus, there exist some demerits in both the rectifier type and moving-iron type instruments serving as a-c measuring means.

Recently an improved effective-value converting circuit has become available, in which an a-c input to be measured is rectified by a rectifier circuit and then is fed to a nonlinear circuit consisting of resistors and diodes and a capacitor so as to obtain a d-c output signal proportional to the effective value of the a-c input. By connecting this effective-value converting circuit with a moving-coil type meter to indicate the a-c input, it is possible to accomplish a high-sensitivity, high-accuracy instrument free from waveform error, that is, an improved a-c measuring instrument having advantages of both the conventional rectifier type and moving-coil type instruments. However, in the effective-value converting circuit employing a nonlinear circuit, the d-c output signal obtained in the case of a low input is not satisfactory in its linearity, as will be described afterward. Accordingly, in constituting an a-c measuring instrument through combination of the above effective-value converting circuit with a moving-coil type meter, there arises a problem that its scale graduations fail to be uniform. Concerning the unsatisfactory linearity, the condition is the same as previously described when the conventional rectifier type instrument is used and even worse when the moving-iron type instrument is used. Although the rectifier type or moving-iron type instrument has various demerits as already mentioned, problematical points are

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minimum in the a-c instrument using an effective-value converting circuit with a nonlinear circuit. Therefore, on condition that the problem of linearity is solved, the instrument equipped with an effective-value converting circuit is considered to be ideal for measurement of a-c voltage or current.

The principal object of the present invention is, in an effective-value converting circuit employing a nonlinear circuit, to provide an improvement having excellent linearity by reforming the linearity of a d-c output with respect to an a-c input.

Another object of the invention resides in providing an improved effective-value converting circuit having uniform scale graduations in an instrument constituted through combination of a moving-coil type meter with an effective-value converting circuit including a nonlinear circuit.

And a further object of the invention is, in an instrument composed of a moving-coil type meter with an effective-value converting circuit including a nonlinear circuit, to provide an improved converting circuit having such characteristics that the scale graduations are uniform up to a certain input value and are suppressed for an input exceeding the said certain value.

According to the invention, an effective-value converting circuit comprises a rectifier circuit of which four arms are composed of diodes to rectify an a-c input, a temperature compensating diode connected between the output terminals of said rectifier circuit in series with a plurality of resistance elements set to break points in a piecewise linear approximation to a square law response between input and output current, a resistance element whose one terminal is connected with one output terminal of said rectifier circuit and whose other terminal is connected with the other output terminal of said rectifier circuit through an integrating capacitor to set an initial slope of the approximation, series circuits connected between said capacitor and the junctions between said break point determining resistance elements, said series circuits comprising diodes and resistance elements for setting subsequent slopes in the approximation, and a non-linearity compensating resistance element is connected in parallel between the input terminals of said rectifier circuit. According to another aspect of the invention the non-linearity compensating resistance element is connected between the output terminals of said rectifier circuit instead of between the input terminals of said rectifier circuit.

In order that the invention may be clearly understood and readily carried into effect, examples thereof will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an exemplary circuit diagram showing a conventional effective-value converting circuit;

Figures 2a and 2b are wave diagrams;

Figures 3 and 4 are graphs for explaining the operation of the circuit of Figure 1;

Figure 5 is a circuit diagram showing one form of an effective-value converting circuit according to the present invention;

Figure 6 is a graph for explaining the operation of the circuit of Figure 5;

Figures 7 and 8 are circuit diagrams showing two further forms of effective-value converting circuits according to the present invention; and

Figure 9 is a graph for explaining the operation of the circuit of Figure 8.

In the drawings, the reference symbols denote: R, R1—R9, R'8, R'9...Resistance elements; D1—D4...Diodes; C...Capacitors; M...Moving-coil type meter.

First a description will be given on a conventional effective-value converting circuit with a nonlinear circuit. Figure 1 is an exemplary circuit diagram of an a-c measuring instrument formed of a known effective-value converting circuit labelled as RMS and a moving-coil type meter labelled as M. In the effective-value converting circuit RMS, IT1 and IT2 are terminals to which an a-c input current I_{in} is applied; OT1 and OT2 are terminals from which a d-c output is obtained; CT is a current transformer; RE is a full-wave rectifier circuit whose four arms are composed of diodes; NL is a nonlinear circuit; R1—R3 are resistance elements set to break points in a piecewise linear approximation to a square law response between the input and output current of circuit NL; R4—R7 are resistance elements for determining the initial and subsequent slopes of the approximation in which R4 serves to determine the initial slope; D1—D3 are diodes for determining the break points of NL; D4 is a diode for effecting temperature compensation on the diodes D1—D3; C is an integrating capacitor; R8 is a series resistance element; and R9 is an output resistance element.

Input terminals IT1 and IT2 are connected to the primary coil of current transformer CT, and its secondary coil is connected to the input terminals of rectifier circuit RE. The positive (+) terminal of rectifier circuit RE is connected to one end of each of resistance elements R1, R4 and R5 at a junction point 10, while the negative (−) terminal of RE is connected to the output terminal OT2 of RMS. The other end of resistance element R1 is connected to one end of resistance element R2 at a junction point 20, while the other end of resistance element R2 is connected to one

end of resistance element R3 at a junction point 30, and the other end of resistance element R3 is connected to the output terminal OT2 through a diode D4 connected in the forward direction. The other end of resistance element R4 is connected to one end of capacitor C at a junction point 40, to which the other end of resistance element R5 is connected through a diode D1 connected in the forward direction. Similarly, one end of resistance element R6 and that of R7 are connected to the junction points 20 and 30 respectively, while the other ends of R6 and R7 are connected to the junction point 40 through diodes D2 and D3 connected in the forward direction. Furthermore, one end of resistance element R8 is connected to the junction point 40, while its other end is connected to the output terminal OT1 and also to one end of resistance element R9, whose other end is connected to the output terminal OT2 together with the other end of capacitor C1. And the moving-coil type meter M is connected between the output terminals OT1 and OT2.

In the effective-value converting circuit of Figure 1 where a moving-coil type meter M is thus connected, when a sine-wave input current i_{in} such as shown in Figure 2(a) is applied to the terminals IT1 and IT2, the input current is transformed suitably by means of current transformer CT and then is fed to rectifier circuit RE to become i_e through full-wave rectification. If the voltage produced by the rectified current i_e at the junction point 10 is represented as e_{10} , divided voltages e_{20} and e_{30} of the voltage e_{10} through resistance elements R1—R3 are produced at the junction points 20 and 30 respectively, where the voltage drop in the forward direction of said diode D4 for temperature compensation use is zero.

Currents i_1 — i_4 flow through resistance elements R4—R7 by voltages e_{10} , e_{20} and e_{30} , thereby charging the capacitor C.

$$E_c = \frac{1}{C} \int_0^T (i_1 + i_2 + i_3 + i_4) dt \quad (1)$$

where E_c represents a charge voltage and T is the period of the input current i_{in} . The capacitor C has sufficient capacitance for a ripple voltage not to be produced by a momentary charge caused by currents i_1 — i_4 .

Figure 3 illustrates the currents i_1 — i_4 graphically. As described above, capacitor C is charged until the charge voltage E_c due to the currents i_1 — i_4 is reached. This charge voltage E_c is kept constant in the steady-state condition. The graphs (a) through (d) in Figure 3 show the virtual gradients of the

currents i_1 — i_4 when they are individually varied respectively in the steady-state condition, that is providing the charge voltage E_c is maintained at a constant voltage value.

The current i_1 results from the potential e_{10} at the junction 10 plotted as a straight line (a) flows through resistance element R4 over the whole range of values of the charge voltage E_c . The capacitor C is charged by the d-c component of this current i_1 .

When the potential at the junction point 10 becomes larger than the charge voltage E_c , the current i_2 shown by (b) in Figure 3 flows through the diode D1, and the capacitor C is charged by the d-c component of the current i_2 .

Similarly, when the potentials at the junction points 20 and 30 become larger than the charge voltage E_c , the currents i_3 and i_4 flow through the diodes D2 and D3, and the capacitor C is charged by the d-c component of each of the currents i_3 and i_4 .

Accordingly, if each resistance value of the resistance elements R1—R7 is suitably chosen, the relation between the input current i_{in} and the total current ($i_s = i_1 + i_2 + i_3 + i_4$) is shown by a curve line (e) in Figure 3. This relationship is closely approximate to the following equations:

$$i_s = k_1 i_{in}^2 \quad (2)$$

where K_1 is a constant and where E_c is maintained at a constant voltage value.

When the effective input current i_{in} is varied, for example, reduced to half the voltages E_{10} — E_{30} become half and the charge voltage E_c in Equation (1) becomes half. The currents i_1 — i_4 respectively also become half in the steady-state condition, because the currents i_1 — i_4 flow into the capacitor C on the basis of the charge voltage E_c of the capacitor C, at the time when the input current i_{in} is reduced to half.

Accordingly, the total current i_s is also halved in the steady-state condition, which is shown as a curve line (f) in Figure 3. Namely, the relation between the input current i_{in} and the total current i_s , when the input current i_{in} is varied, is shown by the following equation:

$$i_s = \frac{K_2}{E_c} \cdot i_{in}^2 \quad (3)$$

where k_2 is a constant.

The charge voltage E_c of capacitor C is discharged as a discharge current i_m . The relationship between the discharge current i_m and the charge voltage E_c is expressed as

$$E_c = \frac{1}{C} \cdot \frac{1}{T} \int_0^T i_m dt \quad (4)$$

The average current, i_s is equal to the discharge current i_m , that is,

$$i_m = i_s \quad (5)$$

If an internal resistance of the moving coil type meter M including resistance elements R8 and R9 is denoted by R_M , the following equation is obtained:

$$\frac{E_c}{R_M} = [i_m = i_s] = \frac{K_2}{E_c} \cdot I_{in}^2 \quad (6)$$

Thus,

$$E_c^2 = R_M \cdot k_2 \cdot I_{in}^2 \quad (7)$$

In equation (7), E_c is a d-c value and I_{in} is an a-c value. Accordingly,

$$E_c = \sqrt{K_3 \frac{1}{T} \int_0^T I_{in}^2 dt} \quad (8)$$

where K_3 is a constant.

The above equation shows that the charge voltage E_c becomes a value proportional to the effective RMS value of the input current I_{in} .

$$i_m = i_s \quad (5)$$

If an internal resistance of the moving coil type meter M including resistance elements R8 and R9 is denoted by R_M , the following equation is obtained:

$$\frac{E_c}{R_M} = i_m = i_s = \frac{k_2}{E_c} \cdot I_{in}^2 \quad (6)$$

Thus,

$$E_c^2 = R_M \cdot k_2 \cdot I_{in}^2 \quad (7)$$

In Equation (7), E_c is a d-c value and I_{in} is an a-c value. Accordingly,

$$E_c = \sqrt{K_3 \frac{1}{T} \int_0^T I_{in}^2 dt} \quad (8)$$

where k_3 is a constant.

The above equation shows that the charge voltage E_c becomes a value proportional to the effective RMS value of the input current I_{in} . Consequently, the voltage drop caused across the output resistance element R9 by the d-c current i_m resulting from the capacitor terminal voltage E_c becomes proportional to the effective value of input current I_{in} . It means that when the moving-

coil type meter M is not connected, a d-c voltage proportional to the effective value of input current I_{in} is obtained from the output terminals OT1 and OT2. And in the case where the meter M is connected, it indicates the effective value of input current I_{in} .

As described hereinabove, since effective-value indication is effected in an a-c instrument where a moving-coil type meter is connected to an effective-value converting circuit using a nonlinear circuit NL, any distortion contained in the a-c input current I_{in} to be measured is substantially negligible in an indication error. And a high sensitivity is achievable owing to that the principle of operation is the same as that of the moving-coil type meter. In the converting circuit of Fig. 1, a temperature rise causes a decrease of the forward voltage drop in the diodes D1, D2 and D3 of nonlinear circuit NL, but also causes a compensating decrease of the forward voltage drop simultaneously in the diode D4. For this reason, the d-c output current i_m never varies with temperature. In other words, no indication error results from temperature fluctuation. Although the circuit of Fig. 1 has such features, there still exists a disadvantage as already mentioned that, within a range where the input current I_{in} is small, the d-c output current i_m fails to be in linear proportion to the input current I_{in} . This fact is based on the following reason. In a range where the rectified current i_e is small and the capacitor terminal voltage is low in the nonlinear circuit NL, diode D4 remains in a nonconducting state so that i_e passes through resistance element R4 to become a current i_m . When the capacitor terminal voltage rises beyond the forward voltage drop in diode D4, the rectified current i_e is diverted to the resistance element R4 and the series circuit consisting of resistance elements R1, R2 and R3. Consequently, after conduction of diode D4, the rate of increase of the d-c output current i_m against that of the rectified current i_e is lowered in comparison with the rate in the range where the capacitor terminal voltage does not exceed the forward voltage drop in diode D4. This relation is represented by the solid line in Fig. 4, where the dotted line plots an instance that i_m and i_e are in linear proportion. In this way, the relation between the a-c input and the d-c output is not linear in the effective-value converting circuit RMS (root mean square) shown in Fig. 1. Therefore, in an a-c instrument constituted by connecting a meter M to the effective-value converting circuit RMS of Fig. 1, the scale graduation of the meter M fails to have a uniform distribution in the manner that the graduation intervals tend to

be wider in a range of small input I_{in} than in a range of large input.

The purpose of the present invention resides in improving the effective-value converting circuit of Fig. 1 with a view to eliminating the above-described defects.

The circuit diagram of Fig. 5 shows an instrument formed by connecting a moving-coil type meter M to the effective-value converting circuit of the present invention. In this drawing, the same component elements as those in Fig. 1 are labeled with the same reference symbols, and repetition concerning them is omitted here. In Fig. 5, the point different from Fig. 1 is that a resistance element R is inserted and connected between the input terminals a and b of the rectifier circuit RE . In the effective-value converting circuit of Fig. 5 where a resistance element is inserted, d-c output current i_m comes into linear proportion to a-c input current I_{in} in the following manner. If the value of resistance element R is infinite (i.e. the same state as in the circuit of Fig. 1), input current I_{in} and rectified current i_e are in the relation of linear proportion. When the resistance element R is connected, the secondary current of current transformer CT is diverted thereto. Meanwhile, at the time of rectification in the rectifier circuit RE , two diodes are connected in series in the forward direction. These rectifier diodes remain in the nonconducting state unless a voltage drop greater than a fixed value occurs across the resistance element R . Therefore, in the case where the value of resistance element R is small and the input current I_{in} is also small, the voltage drop occurring across the resistance element R is insufficient to cause conduction of the rectifier diodes. The relation between input current I_{in} and rectified current i_e is plotted as (a) in Fig. 6. Since the current transformer CT can be regarded as a constant-current source, if the resistance element R has a large value, a great voltage drop is induced even by a current equivalent to the one supplied to the resistance element R in the case of a small resistance value. Accordingly, if this element R has a large value, a small input current I_{in} causes a flow of rectified current i_e . This relation is represented by (b) in Fig. 6, where the dotted line plots an ideal instance that the input current I_{in} and the rectified current i_e are in linear proportion. In comparison with this ideal straight line, practically the rectified current is accompanied by a negative error $-\Delta 1$ against the input current I_{in} for the reason mentioned above. The value of error $-\Delta 1$ varies in accordance with the value of resistance element R , as shown graphically in Fig. 6. In the meanwhile, as plotted in

Fig. 4, the d-c current i_m produces a positive error $+\Delta 2$ against the rectified current i_e . Therefore, if the value of resistance element R is so selected that the absolute value $|\Delta 1|$ of the negative error becomes equal to the absolute value $|\Delta 2|$ of the positive error, then $\Delta 1$ and $\Delta 2$ cancel each other to establish a relation of linear proportion between the a-c input current I_{in} and the d-c output current i_m . This output current flows from output terminals $OT1$ and $OT2$ and through resistance element $R9$. Accordingly, in a moving-coil type meter M connected to the output terminals $OT1$ and $OT2$ as illustrated, the deflection becomes linear with respect to the a-c input current I_{in} to be measured, and thus the graduation distribution thereupon is rendered uniform.

As described hereinabove, in an a-c instrument constituted by connecting a moving-coil type meter M to the effective-value converting circuit of the present invention, it is possible to attain a uniform distribution of graduations. Moreover, by virtue of its being effective-value indication type, no indication error occurs regardless of the waveform of a-c input current to be measured. Furthermore, an a-c instrument obtainable offers a high sensitivity and is free from such an indication error that results from temperature fluctuation.

Figure 7 is a circuit diagram showing another embodiment of the invention, in which an input voltage V_{in} to be measured is converted into an effective-value output i_m . In this circuit, R_s is a series resistance element, and R is a nonlinearity compensating resistance element already explained with reference to Figure 5. On the same grounds as stated for the circuit of Figure 5, the circuit of Figure 7 is capable of converting an a-c input voltage V_{in} into a proportional effective-value signal i_m with excellent linearity, and the scale graduations of a meter M connected thereto have a uniform distribution.

The circuit diagram of Figure 8 shows a further embodiment implementing the present invention. This circuit is formed by connecting a zener diode ZD and a resistance element $R9'$ additionally to the output terminal of capacitor C in the circuit of Figure 5. A resistance element $R8'$ is connected in series with the resistance element $R8$ and between $R9'$ and $R9$. In Figure 8, breakdown of zener diode ZD occurs when the capacitor terminal voltage exceeds the zener voltage of ZD . The relation between the a-c input current I_{in} and the d-c output current i_m is such as plotted graphically in Figure 9. Accordingly, an a-c instrument having compressed top-of-scale graduations is accomplished by connecting a moving-coil

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type meter M between the output terminals OT1 and OT2 as illustrated in Figure 8.

In each of the foregoing embodiments, a nonlinearity compensating resistance element R is connected on the input side of rectifier circuit RE. However, the same effect as that in the circuit of Figure 5 is also achievable if the element R is connected on the output side. Moreover, although three resistance elements (R1, R2, R3) are employed in the above embodiments for principally determining the break points, it is to be noted that the number of such elements is not limited to three alone, and an increased number of the elements generate more break points to bring the broken line closer to a square law characteristic, thereby, providing a high-accuracy effective-value converting circuit. In this case, according to the number of break points, it is necessary to increase the number of diodes D1, D2, D3 and that of resistance elements R5, R6, R7 serving to determine the shape of the curve. Furthermore, digital indication of an input is also attainable by using a digital voltmeter instead of the moving-coil type meter M employed in the above-described embodiments.

WHAT WE CLAIM IS:—

1. An effective-value converting circuit comprising a rectifier circuit of which four arms are composed of diodes to rectify an a-c input, a temperature compensating diode connected between the output terminals of said rectifier circuit in series with a plurality of resistance elements set to break points in a piecewise linear approximation to a square law response between input and output current, a resistance element whose one terminal is connected with one output terminal of said rectifier circuit and whose other terminal is connected with the other output terminal of said rectifier circuit through an integrating capacitor to set an initial slope of the approximation, series circuits connected between said capacitor and the junctions between said break point determining resistance elements, said series circuits comprising diodes and resistance elements for setting subsequent slopes in the approximation, and a non-linearity compensating resistance element connected in parallel between the input terminals of said rectifier circuit.

2. An effective-value converting circuit comprising a rectifier circuit of which four arms are composed of diodes to rectify an a-c input, a temperature compensating diode connected between the output terminals of said rectifier circuit in series with a plurality of resistance elements set to break points in a linear approximation to a square law response between input and output current, a resistance element whose one terminal is connected with one output terminal of said rectifier circuit and whose other terminal is connected with the other output terminal of said rectifier circuit through an integrating capacitor to set an initial slope of the approximation, series circuits connected between said capacitor and the junctions between said break point determining resistance elements, said series circuits comprising diodes and resistance elements for setting subsequent slopes in the approximation, and a non-linearity compensating resistance element connected between the output terminals of said rectifier circuit.

3. The effective-value converting circuit as defined in Claim 1 or 2, wherein a moving-coil type indicating meter is connected with the output side of said integrating capacitor.

4. The effective-value converting circuit is defined in Claim 1 or 2, wherein a zener diode and a moving-coil type indicating meter are connected in parallel with the output side of said integrating capacitor.

5. An effective value converting circuit substantially as hereinbefore described with reference to Figures 5 and 6 of the accompanying drawings.

6. An effective value converting circuit substantially as hereinbefore described with reference to Figure 7 of the accompanying drawings.

7. An effective value converting circuit substantially as hereinbefore described with reference to Figures 8 and 9 of the accompanying drawings.

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type meter M between the output terminals OT1 and OT2 as illustrated in Figure 8.

In each of the foregoing embodiments, a nonlinearity compensating resistance element R is connected on the input side of rectifier circuit RE. However, the same effect as that in the circuit of Figure 5 is also achievable if the element R is connected on the output side. Moreover, although three resistance elements (R1, R2, R3) are employed in the above embodiments for principally determining the break points, it is to be noted that the number of such elements is not limited to three alone, and an increased number of the elements generate more break points to bring the broken line closer to a square law characteristic, thereby, providing a high-accuracy effective-value converting circuit. In this case, according to the number of break points, it is necessary to increase the number of diodes D1, D2, D3 and that of resistance elements R5, R6, R7 serving to determine the shape of the curve. Furthermore, digital indication of an input is also attainable by using a digital voltmeter instead of the moving-coil type meter M employed in the above-described embodiments.

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1. An effective-value converting circuit comprising a rectifier circuit of which four arms are composed of diodes to rectify an a-c input, a temperature compensating diode connected between the output terminals of said rectifier circuit in series with a plurality of resistance elements set to break points in a piecewise linear approximation to a square law response between input and output current, a resistance element whose one terminal is connected with one output terminal of said rectifier circuit and whose other terminal is connected with the other output terminal of said rectifier circuit through an integrating capacitor to set an initial slope of the approximation, series circuits connected between said capacitor and the junctions between said break point determining resistance elements, said series circuits comprising diodes and resistance elements for setting subsequent slopes in the approximation, and a non-linearity compensating resistance element connected in parallel between the input terminals of said rectifier circuit.

2. An effective-value converting circuit comprising a rectifier circuit of which four arms are composed of diodes to rectify an a-c input, a temperature compensating diode connected between the output terminals of said rectifier circuit in series with a plurality of resistance elements set to break points in a linear approximation to a square law response between input and output current, a resistance element whose one terminal is connected with one output terminal of said rectifier circuit and whose other terminal is connected with the other output terminal of said rectifier circuit through an integrating capacitor to set an initial slope of the approximation, series circuits connected between said capacitor and the junctions between said break point determining resistance elements, said series circuits comprising diodes and resistance elements for setting subsequent slopes in the approximation, and a non-linearity compensating resistance element connected between the output terminals of said rectifier circuit.

3. The effective-value converting circuit as defined in Claim 1 or 2, wherein a moving-coil type indicating meter is connected with the output side of said integrating capacitor.

4. The effective-value converting circuit is defined in Claim 1 or 2, wherein a zener diode and a moving-coil type indicating meter are connected in parallel with the output side of said integrating capacitor.

5. An effective value converting circuit substantially as hereinbefore described with reference to Figures 5 and 6 of the accompanying drawings.

6. An effective value converting circuit substantially as hereinbefore described with reference to Figure 7 of the accompanying drawings.

7. An effective value converting circuit substantially as hereinbefore described with reference to Figures 8 and 9 of the accompanying drawings.

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