

April 1, 1947.

L. M. PLYM

2,418,424

ELECTRICAL MEASURING DEVICE

Filed June 1, 1944

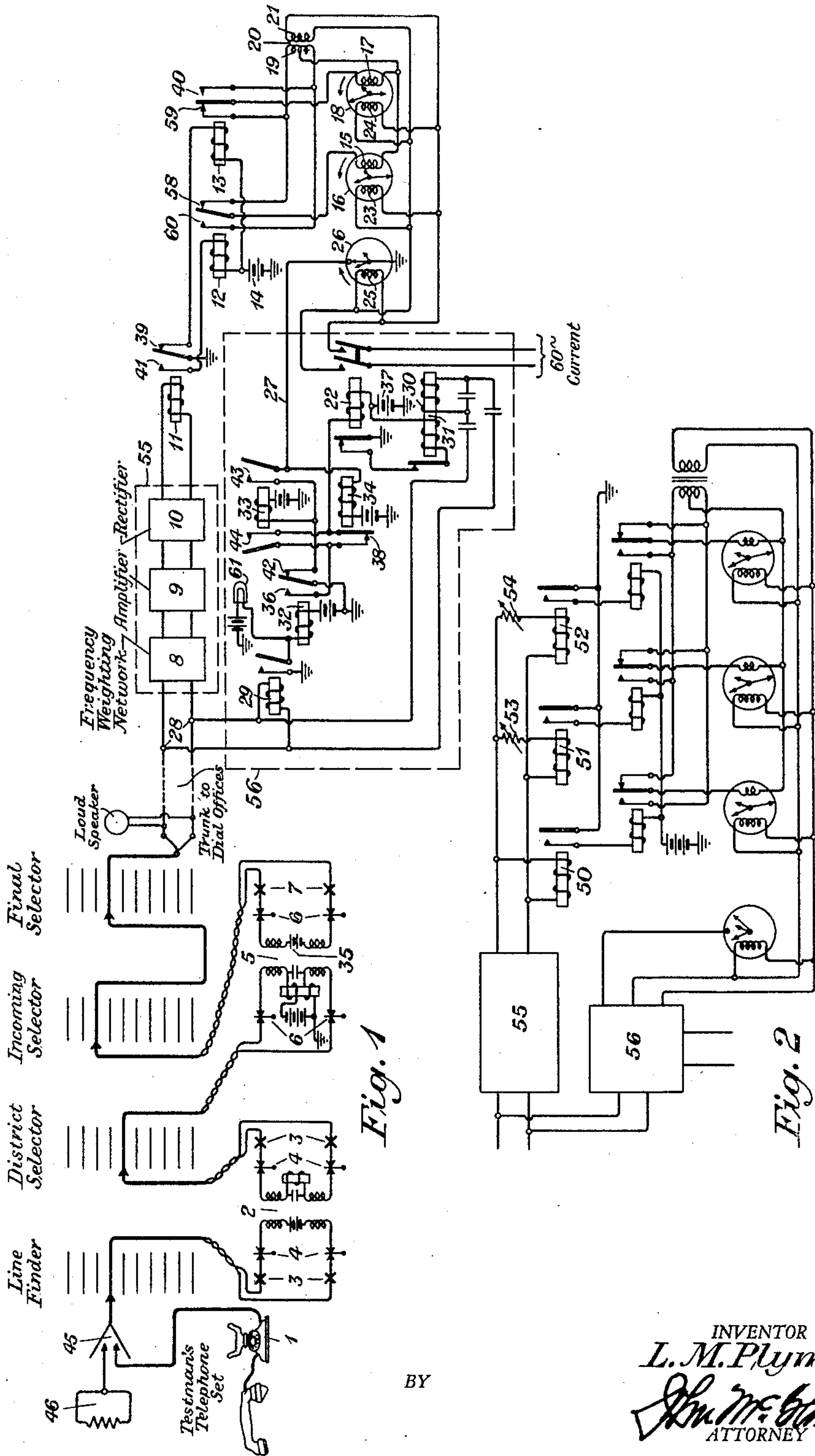


Fig. 1

Fig. 2

BY

INVENTOR
L. M. Plym
ATTORNEY

T 179-175
X 324-68
X 324-28
X 340-253

324

Patented Apr. 1, 1947

2,418,424

UNITED STATES PATENT OFFICE

2,418,424

ELECTRICAL MEASURING DEVICE

Lester Marshall Plym, Glen Ellyn, Ill., assignor
to American Telephone and Telegraph Com-
pany, a corporation of New York

Application June 1, 1944, Serial No. 538,292

11 Claims. (Cl. 161—15)

1

This invention relates to electrical measuring devices, and particularly to means for recording and evaluating variables such as sound, telephone circuit noise and volume levels.

In the operation of a telephone system as, for example, the panel type of automatic system, the normal speech currents transmitted thereover are subject to variations, owing to the presence in the system of a multiplicity of contacts, which variations appear as noise in any sound-producing apparatus, such as a telephone receiver connected to such a system. In order to determine the noise-producing characteristics of a system and thereby to evaluate and compare various systems it has been customary in the past to have a testman at a given central office dial a pre-selected line to which a noise-measuring set was connected at a distant office. Another testman, at the distant office, would then measure the variations in level of the current produced by the multiplicity of contacts in the circuit. Upon completing the recording of this measurement, the second testman would then notify the first testman, who would then break down the test connection and dial another pre-selected line. The present invention not only eliminates the need for the second testman but also renders unnecessary the clerical work now required in the determination of figures of merit for the circuits being tested and greatly reduces the time required in the making of such tests, the entire operation being performed solely by the testman who originates the calls.

By means of this invention it is possible to determine a figure of merit for a given apparatus or circuit in terms of the per cent. of time that given levels of noise or volume have been exceeded; also, to make convenient comparisons with a similar figure of merit for other apparatus or circuits at any time; and, furthermore, to eliminate the human element in taking readings and to reduce clerical work in determining figures of merit involving fluctuating values.

Other objects of this invention will be apparent from the following description, when read in connection with the attached drawing, of which Figure 1 shows schematically the manner in which the invention is employed in connection with an automatic telephone system of the panel type; and Fig. 2 is a variation of the measuring apparatus shown in Fig. 1.

As shown in Fig. 1 the testman's telephone set 1 is adapted to be connected to the bank of contacts of the line finder, the connection including a switch (represented symbolically by 45) under

2

the control of the testman by which either the telephone set or a terminating network 46 may be connected to the bank of contacts of the line finder. As there shown, the contacts of the said finder are, in turn, connected to the bank of contacts of the district selector, the connection including the repeating coil 2 and also a plurality of commutator contacts 3 and a plurality of sequence switch contacts 4. The district selector is, in turn, connected to the bank of contacts of the incoming selector by a circuit that includes the repeating coil 5 and sequence switch contacts 6 and the commutator contacts 7. The incoming selector is connected to the bank of contacts of the final selector which, in turn, is connected by a trunk to the measuring circuit in which the present invention is embodied. Across the trunk is connected a loud-speaker 47, the purpose of which will presently be described. Any or all of the multiplicity of contacts cause variations in the currents transmitted thereover, which variations appear as noise in the telephone receiver at the subscriber's station. The measuring circuit includes a frequency weighting network 8, an amplifier 9 and a rectifier 10, which form part of a noise-measuring set 55 indicated by the dotted rectangle. The output of the rectifier is connected to a relay 11, the armature of which is grounded. The inner contact 41 of relay 11 is connected to the winding of relay 12 and the outer contact 39 is connected to the winding of relay 13, both of which windings are connected to the battery 14. The armature of relay 12 is connected to a terminal of a winding 15 which has been added to clock 16. In a similar fashion, the armature of relay 13 is connected to a winding 17 which has been added to clock 18. Windings 15 and 17 are provided to make the clocks reversible. These windings are together connected to the midpoint of the winding 19 of the transformer 20. The upper terminal of winding 19 is connected to the outer contact 58 of relay 12 and the inner contact 59 of relay 13. The lower terminal of winding 19 is connected to the inner contact 60 of relay 12 and the outer contact 40 of relay 13. The primary winding 21 of that transformer is connected through the right-hand contacts of relay 22 to a source of 60-cycle current which is supplied to the operating windings 23 and 24 of clocks 16 and 18 and also to a similar winding 25 of the clock 26. The second hand of the latter clock is grounded and is arranged to ground conductor 27 at the end of one complete rotation of the second hand, the purpose of which will be presently stated. It should

3

be noted that all of the clocks may be any of the well known types of electrically operated, self-starting clocks modified as indicated above. The reversing windings replace the motor field pole shading slugs normally employed in electrical clocks. Bridged across the input conductors of this measuring circuit at the point 28 is a circuit that includes the winding of relay 29, the winding 30 of buzzer 31, and the relays 32, 33 and 34 the function of which will later be described.

The manner in which the apparatus, in which this invention is embodied, is employed for the measurement of abnormal variations of current in an electrical network, such as are manifested in the form of noise in an automatic telephone system, is as follows: The testman will establish a call by dialing over the automatic telephone system to effect the connection to the test trunk or line to which the measuring circuit is connected. Thereupon he will operate the switch 45 to disconnect his telephone set and to connect the network 46 to the contacts of the line finder. This eliminates from the measurement of noise, such noise as might otherwise be picked up by the telephone set 1, and, at the same time, maintains the continuity of the connection established by the dialing operation. As soon as that connection is established by the final selector, current from the battery 35 will flow through the winding of relay 29 and cause it to operate. Thereupon relay 32 will operate and the lamp 61 will be lighted. Upon the closing of contact 36 of relay 32, a circuit will be established from the battery 37 through the winding of relay 22, contact 38 of relay 34, and contact 36 to ground, assuming that the second hand of clock 26 is not at that instant in contact with the terminal of the conductor 27 within the said clock. The operation of relay 22 effects the closing of its right-hand contacts and thereby applies 60-cycle operating current to the left-hand windings of the clocks 26, 16 and 18 and also to the circuit connected to the transformer 20. Normally the hands of all of those clocks will tend to move in the clockwise direction, but, for reasons hereinafter fully stated, the direction of motion of the hands of clocks 16 and 18 will be reversed by a reversal of current in the windings 15 and 17 with respect to the current in windings 23 and 24.

If, after a call is established, variations in the noise current occur which exceed a given value, relay 11 will be operated by the current from the rectifier 10 and its right-hand contact 39 will be opened, but contact 41 will not be closed unless the current exceeds another and higher fixed value. The circuit containing the winding of relay 13 will be opened and, in consequence, the armature of that relay will fall back against contact 40. The effect of that is to reverse the direction of the current flowing in winding 17 of clock 18 and that in turn causes a reversal of direction of motion of the hands of that clock, which will continue as long as the current through the winding 17 remains reversed. When the rectified current applied to the relay 11 reaches the higher fixed value mentioned above, its armature will move to its contact 41 and relay 12 will be operated. The movement of its armature to its contact 60 will reverse the direction of the current flowing through the winding 15 of the clock 16. Such reversal of current causes a reversal of direction of the hands of that clock which will continue as long as the armature of relay 12 remains on its contact 60. The hands of the clock 26 are never reversed in direction but continue to

4

rotate in clockwise direction until the second hand has completed one revolution. Thereupon, that hand will make contact with a terminal of conductor 27 within the clock, as shown in the drawing, and that will cause the operation of relay 34 by grounding its winding. Upon the opening of contact 38 relay 22 will be de-energized and as a result of that action, the 60-cycle power circuit will be disconnected from the windings of the clocks, thereby stopping their operation. The de-energization of relay 22 also closes the operating circuit of the buzzer 31 and a tone of the buzzer frequency will be transmitted from the winding 30 through the condensers and over the line to the loud speaker 47. The receipt of that tone by the testman indicates the completion of the test on that particular call.

The testman thereupon proceeds to break down the connection between the final selector and the measuring circuit, the result of which is to open the direct current path between the battery 35 and relay 29. Thereupon, the armature of that relay falls away from its contact and opens the circuits of relay 32 and of the lamp 61. The closing of contact 42 operates relay 33, which will be locked through a circuit that includes contact 43, conductor 27 and the ground connected to the second hand of the clock 26. The operation of relay 33 also closes its left-hand contact 44, but this produces no operating effect until the testman at the distant office dials over another line to establish another call, which he connects to the test trunk. Thereupon, current from the battery 35 will operate relay 29 and upon the closing of contact 36 of relay 32 a circuit will be established from the battery 37, through the winding of relay 22, contact 44 and contact 36 to ground, thus causing the operation of relay 22. 60-cycle current will thereupon be applied to the winding 25 of the clock 26 and thus set in rotation the hands of that clock. The rotation of the second hand opens its contact with the terminal within the clock of conductor 27 and opens the circuits of the windings of relays 33 and 34, thereby opening contacts 43 and 44 and closing contact 38. The closing of contact 38 will maintain a closed circuit for the winding of relay 22 (heretofore closed through contact 44 of relay 33) and thus insures the continuance of the supply of 60-cycle current to the clocks. Thereupon the measuring circuit will proceed to measure in the manner hereinbefore described—that is to say, when the noise currents generated by the multiplicity of contacts does not exceed the specified limits all the clocks will rotate in a normal direction. When the noise exceeds a lower prefixed limit the clock 18 alone will be reversed in direction, and when such current exceeds an upper prefixed limit, both clocks 16 and 18 will be reversed in direction. The clock 26 will operate always in one direction to indicate the total elapsed test time. Since the clocks have the same inertia or slowness in starting and the same amount of coasting when stopping in either direction of rotation, any errors due to starting and stopping are cancelled out. If T_{C1} equals the total testing time, as shown on the first or totalizing clock 26 and T_e equals the time of excessive noise current, that is, current above the specified limit, then the reading on the clock 18 will be

$$T_{C1} - 2T_e = T_{C2} \quad (1)$$

Therefore,

$$T_e = \frac{T_{C1} - T_{C2}}{2} \quad (2)$$

5

The per cent time of excessive current=

$$\frac{T_e}{T_{c1}} \times 100 \quad (3)$$

Substituting Equation 2 into 3 we have

Per cent time of excessive current=

$$\frac{T_{c1} - T_{c2}}{2 \times T_{c1}} \times 100 \quad (4)$$

which is the formula employed to determine the desired figure of merit from the clock readings.

The noise current impressed at the input terminals can be given evaluations in terms of per cent of time the current exceeded two levels by using the readings of the three clocks in Formula 4. For example, if the relay 11 were adjusted to open contact 39 at 25 db. of noise and to close contact 41 at 30 db. of noise and the clock 26 reads 5 hours and clock 18 reads 4 hours, while clock 16 reads 4½ hours, then the noise would be evaluated as:

$$\frac{5-4}{10} \times 100 =$$

10% of the time the noise exceeded 25 db.

and

$$\frac{5-4\frac{1}{2}}{10} \times 100 =$$

5% of the time the noise exceeded 30 db.

The arrangement shown in Fig. 2 differs from that shown in Fig. 1 in that it employs sensitive relays 50, 51 and 52 which are designed and adjusted to operate at specified levels, the adjustment being effected by the resistances 53 and 54 associated with the windings of relays 51 and 52. Those resistances provide a more satisfactory means of calibrating the relays than the mechanical adjustments necessary for the adjustment of relay 11 of Fig. 1. The arrangement shown in Fig. 2 may have any number of relays and associated clocks to evaluate the noise-producing currents at each of a plurality of levels, depending upon the power capability of the amplifier and rectifier 55. The apparatus designated 56 corresponds with that shown in Fig. 1 within the dotted lines also designated 56 and performs the same functions as those performed by the latter apparatus.

Although this invention has been described in connection with the measurement of variations in the magnitude of noise currents introduced by the contact resistance in a panel-type automatic telephone system, such description is purely illustrative and represents no limitation of use of the invention since it can be used not only in making similar measurements upon other types of automatic telephone systems, but also upon any electrical network in which variations in the level of the current may occur either periodically or at non-periodic intervals, such as speech or music channels, radio system and room noise.

While this invention has been described as embodied in particular forms and arrangement of parts, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a system for determining the percentage of time an electrical current exceeds a predetermined limit, the combination with a plurality of timing devices of means to set in operation each of the said devices and means to reverse the direction of operation of one of said timing devices throughout the entire period in which

6

the said current exceeds the predetermined limit, and switching means controlled by another of said timing devices to effectively stop the operation of each timing device at the end of a given period of time.

2. In a system for determining the percentage of time an electrical current exceeds a predetermined limit, the combination with a source of current whose deviations from a predetermined limit are to be measured of switching means operated whenever the said current exceeds the said limit, and a plurality of timing devices, all of which are set in operation by a direct current superimposed on the current whose deviations from normal are to be measured, one of said timing devices being adapted to register the total time elapsed and the other being arranged to be reversed in direction of operation during each period of excess current whereby the percentage of time of excess current may be determined.

3. In a system for determining the percentage of time a varying electrical current exceeds a predetermined limit, the combination with a source of such current, of means to rectify said current, a plurality of timing devices normally operated in synchronism and switching means operable by the said current whenever it exceeds the said limit to reverse the direction of operation of one of said timing devices during the time in which the switching means remains thus operated.

4. In a system for determining the percentage of time a varying electrical current exceeds a predetermined limit, the combination with a plurality of transmission circuits each having therein means for causing variations in the current transmitted thereover of an electrical timing circuit adapted to be connected to any one of the transmission circuits and disconnected therefrom upon completion of the timing operation, the said timing circuit having therein a timing device to indicate the duration of the variations in current, and selecting means associated with the said transmission circuits to automatically connect the said timing circuit to any one of said transmission circuits whereby the duration of the variations from normal of the said current upon the selected transmission circuit may be determined, and means controlled by the said timing device and operable at the completion of a timing operation to transmit a signal to indicate such completion.

5. The method for determining the percentage of time during which the current being transmitted over an electrical circuit may be varied due to the changing resistance of a plurality of contacts in the said circuit, which consists in transmitting a starting signal over the said circuit to start the operation of a recording apparatus, recording the total elapsed time of transmission of the current, simultaneously recording the elapsed time during which the current exceeded a given value, and automatically stopping both recording operations at the end of a given period of time.

6. The method for determining the percentage of time during which the current being transmitted over an electrical circuit may be varied due to the changing resistance of a plurality of contacts in the said circuit, which consists in recording the total elapsed time of transmission of the current, simultaneously recording the elapsed time during which the current exceeded a given value, and automatically stopping both recording operations.

7

7. The method for determining the percentage of time during which the current being transmitted over an electrical circuit may be varied due to the changing resistance of a plurality of contacts in the said circuit, which consists in recording the total elapsed time of transmission of the current, simultaneously recording the elapsed time during which the current exceeded a given value, automatically starting both recording operations and automatically stopping both recording operations.

8. In a system for determining the percentage of time an electrical current exceeds a predetermined limit, the combination with a source of current whose deviation from a predetermined limit during a given period of time is to be measured, of a timing device arranged to cumulatively record the length of time during which all of said deviations occurred, a second timing device to record the total elapsed time for making the measurement, and means to render the first mentioned timing device ineffective for further measurement after the expiration of the said given period of time.

9. In a system for determining the percentage of time during which the current transmitted over a circuit exceeds a predetermined limit, the combination with a source of current of a transmission circuit over which the current is transmitted, a measuring circuit having means to measure total elapsed time and also means to measure the time during which the current exceeds a predetermined limit, means to automatically connect the said measuring circuit to the transmission circuit and means controlled by the said measuring circuit to automatically transmit a signal to indicate the completion of a measuring operation.

10. In a system for determining the percentage of time during which the current transmitted over a circuit exceeds a predetermined limit, the

8

combination with a circuit for the transmission of an electrical current which may vary fortuitously, of a measuring circuit, means connected to the near end of the transmission circuit to automatically connect the measuring circuit to the far end of said transmission circuit, the said measuring circuit having means connected therewith to measure the total elapsed time during which the measurement is made and also means to measure the time during which the current varies from a given normal value, means controlled by the measuring circuit to automatically transmit a signalling current over the said transmission circuit to the said near end thereof upon the completion of the measuring operation and a signal-producing device at the said near end responsive to the said signaling current.

11. The method for determining the percentage of time during which the current being transmitted over an electrical circuit may vary from normal due to changing conditions within the said circuit, which consists in recording the total elapsed time of transmission of the current, simultaneously recording the elapsed time during which the current varied by a given amount from its normal value, automatically stopping both recording operations, and automatically transmitting over the said circuit a signaling current to produce an audible or visible signal to indicate the completion of the recording operations.

LESTER MARSHALL PLYM.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,216,730	Berger	Oct. 8, 1940