

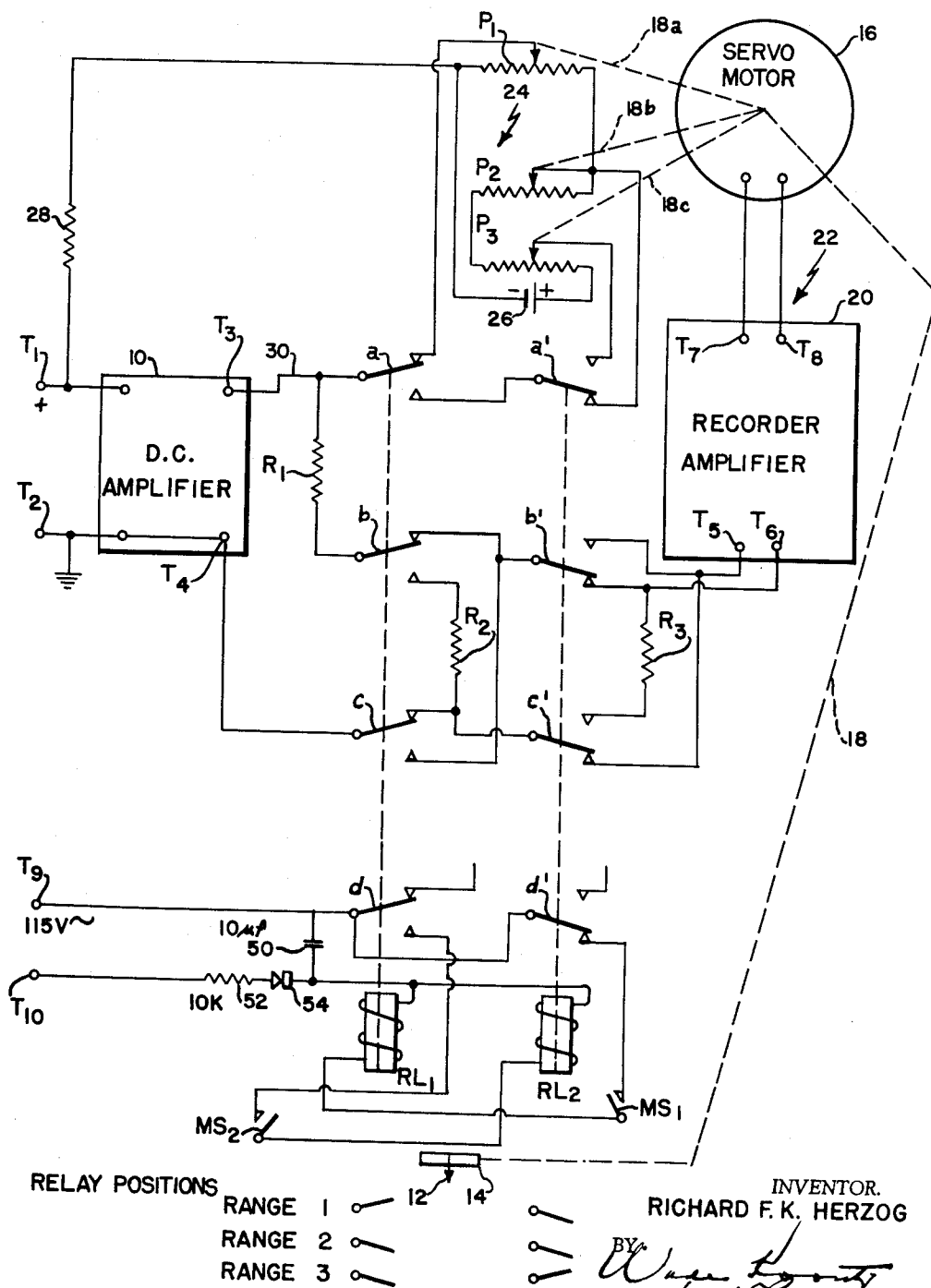
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MULTIPLE-RANGE RECORDER SWITCHING DEVICE

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MULTIPLE-RANGE RECORDER SWITCHING DEVICE

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The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon. This application is a continuation-in-part of my application Serial No. 546,295, filed November 10, 1955.

The present invention relates to the measurement and recording of an unknown input signal, and more particularly, to a switching device for a recording device.

Multiple-range recording devices have been used to extend the range of automatic recorders, which are necessarily limited by the length of travel of the writing element from one extreme to the other. In some recorders, utilizing multiple ranges, the writing element is actuated by increasing input signals until the element contacts a limit switch and then a range of lesser sensitivity is introduced whereby the writing element swings back to zero and records for a period within the new range. These recorders are unsuitable because of the loss of signal recording during the retrace period of the writing element. These recorders are thus unsuitable for recording input signals that vary irregularly in magnitude or in certain applications where it is desirable to record over the entire input signal period.

Some multiple-range recorders utilize aspects to overcome disadvantages of the recorders previously mentioned. These recorders utilize a suitable switching device energized by contact between either of two limit switches disposed at either end of the travel path of the writing element to control the magnitude and polarity of the input to the recorder, thereby eliminating the need for the writing element to start at zero each time the element travels the distance to its limited position. Stepping relays, actuated by each of the limit switches upon contact of the writing element therewith, are often employed to control the magnitude of the input signal to the recorder device. A relay, responsive to the periods when a corresponding stepping relay is energized, is often employed to actuate a device for controlling the polarity of the input to the recording device to have the writing element reverse direction over the recording medium in a subsequent range of operation.

Modifications of multiple-range recording devices have tended to make them elaborate and intricate and have necessitated the use of protective relay devices to prevent damage caused by the writing pen stopping in a fixed position, manual reset devices for adjusting the range of operation of the device, and time delay devices for controlling the energization period of certain current sensitive devices.

The present invention describes an improved automatic multirange switching device for any conventional recorder which is of simple construction, reliable, and inexpensive, without any sacrifice in accuracy desirable in such a device.

It is an object of the present invention to describe an improved automatic multi-range switching device which is suitable for a novel dual feedback recorder device.

It is also an object of the present invention to describe an improved automatic multi-range switching device which is adaptable to cooperate with other electrical as-

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pects of the recording device to control the operation of the recording device.

It is also an object of the present invention to describe an improved automatic multi-range switching device which controls the sensitivity of various recording ranges included in the device with input signals of varying magnitude.

It is also an object of the present invention to describe an improved automatic multi-range switching device for simultaneously controlling the direction of travel of the writing element of a recorder device and for selecting a suitable sensitivity for the recording range being covered by a servo-driven writing element.

Accordingly, the present invention describes an automatic range switching device for a multi-range recorder. The switching device includes two current-sensitive devices each of which is connected to a limit switch or position-sensing means disposed at the extremities of the travel path of a writing element driven by a servo device and alternately energized by contact between the writing element and a sensing means. The current-sensitive devices are normally poled opposite to each other and are arranged to cooperatively provide an electrical path for the output of an input-signal amplifier to the input of the servo device, and to control the polarity of the input to the servo device. Additionally, the current-sensitive devices are connected to a dual feedback circuit to provide an electrical path for feeding a portion of the output of the amplifier to the input thereof and to select a suitable compensating voltage for cancelling the output of the amplifier, and simultaneously controlling the sensitivity of the servo device. Thus, the writing element is driven in one direction until it contacts a sensing means and energizes a current-sensitive device. The writing element is then driven through a second range in a reverse direction until it contacts another sensing means whereupon the writing element is driven through a third range in a reverse direction or in the direction it was driven initially. In each range of travel, however, the switching device selectively provides the amplifier device with feedback voltages which are adjusted to control the sensitivity of the servo device for the three ranges covered by the writing element. At the end of the last range no further switching occurs unless the magnitude of the input signal causing the servo motor to drive the writing element through the last range changes sufficiently to drive the servo motor in a reverse direction.

The foregoing objects, features, and general description of the invention, and others will be more clearly understood and made evident by referring to the following detailed description taken in conjunction with the accompanying drawing wherein a recording device utilizing the switching device of the present invention is shown schematically.

Referring now to the drawing there is shown a conventional D.-C. amplifier 10 having input terminals T₁ and T₂ and output terminals T₃ and T₄, T₂ and T₄ being connected at the same ground potential.

Unknown input signals are applied to terminals T₁ and T₂ for energization of the recording device and subsequent recording by means of a writing stylus or element 12 carried by a carriage 14, which is energizably connected to a shaft driven by the rotor of a servo motor 16 in a manner well known to persons skilled in the prior art for driving the carriage to effect a suitable movement of the writing stylus with respect to a recording medium (not shown) but driven perpendicular thereto. The line 18 indicates that the servo motor drives the carriage 14.

The output appearing between terminals T₃ and T₄ is coupled to contacts a and c and through an anti-hunt or balancing resistor R₁, connected to the contact a, to con-

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tact *b* of a current-sensitive device RL_1 . This device may conveniently be a ratchet-type relay the contacts of which do not return to their original positions after the relay is de-energized. It is to be understood that the relay RL_1 being of the ratcheting type, operates to maintain the respective contacts in circuit closing position, after each current application to the winding thereof, even though each current application is only momentary, and returns the respective relay contacts to the opposite position only upon a new application of current to the said winding. A current-sensitive device RL_2 similar to RL_1 and whose contacts are poled opposite to those of RL_1 has contacts thereof *a'*, *b'*, and *c'* connected to contacts *a*, *b*, and *c* in a manner to provide an electrical path from output terminals T_3 and T_4 to input terminals T_5 and T_6 of a servo recording amplifier 20, which together with the servo motor 16 comprises a servo device 22, via resistor R_1 and contacts *b* and *b'*, and contacts *c* and *c'*. This is the electrical path for energizing the servo device in range 1.

The contact *a* is also connected to the slider arm of a potentiometer P_1 of a feedback circuit 24, comprised of serially connected precision potentiometers P_1 , P_2 , and P_3 and direct-current source 26. The slider arms of potentiometers P_1 , P_2 , and P_3 are also driven by the rotor shaft of the servo motor 16, as is indicated by lines 18*a*, 18*b*, and 18*c*. This rotor also drives the carriage 14 and the writing element 12 as described previously. The function and description of this aspect of the embodiment being described will be given subsequently. At this point it is desirable to point out that in range 1, being considered, a portion of the output of the amplifier is fed back to the input of said amplifier via the slider arm and a portion of the resistor of potentiometer P_1 , and through a limiting resistor 28. This feedback voltage prevents the input signals to the amplifier from overdriving the amplifier initially, rendering the amplifier unresponsive for a recovery period, and until the servo motor can follow the change in magnitude of the input signal. Thus, the circuit comprised of a lead 30, contact *a*, a portion of potentiometer P_1 , and resistor 28 comprises a first electrical feedback loop. Additionally, the input signal to recorder amplifier 20 results in an output at terminals T_7 and T_8 thereof which energizes servo motor 16, causing rotation thereof, and subsequent movement of all the slider arms and the writing element 12. A compensating voltage from the source 26 is subsequently coupled to the input of the amplifier, depending on the setting of the slider arm in range 1, to cancel the output of the amplifier. Balance is obtained when the input and output voltages of the D.-C. amplifier 10 are zero and the voltage drop across the resistor 28 is completely compensated by the compensating voltage. Thus, the electrical-mechanical loop connected to the output of D.-C. amplifier 10 and including resistor R_1 , contacts *b*, *b'*, *c*, and *c'* of RL_1 and RL_2 connected to terminals T_5 and T_6 of the recorder amplifier 20, the servo motor 16, the feedback device 24, the source 26, and the resistor 28 connected to the D.-C. amplifier provide precise compensation to cancel the output of said D.-C. amplifier.

Assuming for the purposes of explanation, that an input signal of increasing magnitude is applied to terminals T_1 and T_2 and the switching device is adjusted for operation in range 1, the writing element will be driven, for example, from left to right, until it contacts and closes a position-sensing means MS_1 , disposed on the right side in the travel path of the writing element. Means MS_1 has one terminal thereof connected through contact *d'* of relay device RL_2 to one side of a capacitor 50, and another terminal connected to the solenoid of relay RL_1 , which is connected to another side of the capacitor 50. Thus, when means MS_1 is closed, the solenoid is effectively placed across the capacitor 50.

An alternating-current source (not shown) is preferably available at terminals T_9 and T_{10} . A large resistor

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52 and a selenium rectifier 54 are connected between the terminal T_{10} and one side of the capacitor 50. The other side of the capacitor is connected directly to terminal T_9 . The selenium rectifier generates a D.-C. voltage for energizing the relay devices RL_1 and RL_2 . The resistor 52 and the capacitor 50 comprise a time-delay device for purposes to be described subsequently. Thus, when the writing element closes means MS_1 , relay RL_1 is energized by a short D.-C. pulse generated by the rectifier 54 and the switching device is put in range 2.

In range 2, the output of the D.-C. amplifier is coupled through resistor R_1 , contact *b*, and anti-hunt resistor R_2 connected between contacts *b* and *c'* and terminal T_5 of the recorder amplifier 20, and common ground is connected through contacts *c* and *b'* to terminal T_6 of recorder amplifier 20. It should be noted at this point that the input polarity to the recorder amplifier is reversed from the input in range 1 so that the writing element is driven from right to left. The writing element is driven in this direction until it contacts position-sensing means MS_2 , disposed on the left side of the writing element, and which has one terminal thereof connected through contact *d* to the terminal T_9 and another terminal thereof connected to the solenoid of relay device RL_2 which is connected to the junction of the capacitor 50 and the rectifier 54. Thus, the solenoid of relay RL_2 is also energized by a short D.-C. pulse when the means MS_2 is closed.

Additionally, since contacts *a*, *b*, and *c* of relay device RL_1 and contacts *a'*, *b'*, and *c'* of relay device RL_2 are down in range 2, the electrical feedback voltage is coupled from the D.-C. amplifier through contacts *a* and *a'*, the slider arm of potentiometer P_2 , potentiometer P_1 , and resistor 28 to the input of the D.-C. amplifier. The magnitude of the feedback voltage is dependent upon the magnitude of the input voltage and the additional resistance included in the electrical path between the output and input of the D.-C. amplifier. Since the slider arms have been repositioned by the servo motor, the magnitude of the compensating voltage from the source 26 is also changed in an increasing direction to cancel the output of the amplifier.

Returning now to the operation in range 3, which is assumed to be the last although not necessarily so, contacts *a*, *b*, and *c* of relay device RL_1 are down, but contacts *a'*, *b'*, and *c'* of relay device RL_2 are up. Thus, the input to terminal T_6 of recorder amplifier 20 can be traced through resistor R_1 , contact *b*, resistor R_2 , contact *c'*, another anti-hunt resistor R_3 , and the common ground is connected to terminal T_5 through contacts *c* and *b'*. Once again the input polarity to the recorder amplifier is reversed from what it was previously and the writing element is driven from left to right. Additionally, the output of D.-C. amplifier 10 is fed through contacts *a* and *a'*, the slider arm of potentiometer P_3 , potentiometers P_2 and P_1 , and resistor 28 to the input of D.-C. amplifier. In this range the feedback voltage and the compensating voltage will depend upon the positions of the slider arm of potentiometer P_3 as mentioned previously for the ranges to have a sensitivity other than that of ranges 1 and 2, as for example, a sensitivity of $\frac{1}{400}$.

Relay devices RL_1 and RL_2 change the range setting through contact *a* to the slider arm of potentiometer P_1 in range 1, and through contacts *a* and *a'* to the slider arms of potentiometers P_2 and P_3 in ranges 2 and 3, respectively. Additionally, as described the relay devices cooperate to control the polarity of the input to the recorder amplifier 20 to drive the writing element in the proper direction for each of the ranges. Also, the relays select the proper balancing sensitivity in the input circuit of the recorder amplifier by including resistors R_1 , R_2 , and R_3 therein in the appropriate range to prevent hunting or oscillation of the servo device.

In a similar but directly opposite manner, for input signals of decreasing magnitude occurring during the

coverage of any range and which have sufficient duration for the servo device to follow the change in magnitude, the servo device reverses its direction of travel and the writing element is driven in a reverse direction from the direction it would have traveled if the change in the input signal had not occurred. Also, in the event that the input signal increases beyond the coverage of the last or third range the writing element will not record until the input signal decreases and comes within the third range. This phenomenon is not a limitation on the use or application of the recording device for as with all devices the operation is most suitable for specific input signals, and the sensitivity of the various ranges may be adjusted to obtain suitable data within the overall coverage of the device.

It has been found that if the recording medium used has 100 divisions thereon, and the sensitivity of the servo device is 1, $\frac{1}{10}$, and $\frac{1}{100}$, the means MS_2 should be positioned at 10 divisions.

The circuitry components will, of course, be so coordinated in electrical values that, during the periods when the writing pen contacts a means MS_1 or MS_2 and the slider arm of the potentiometers P_1 , P_2 , or P_3 is connected into the feedback circuit, the potential at the slider arm included in the circuit will be matched to the potential of the slider arm removed from circuit.

In an alternate form of a multi-range recorder within the scope of the present invention, the recorder may be modified to record input currents by connecting the input signal to the suitable voltage divider or range-shunt circuit for the various ranges to be employed in the device or the output of an input-signal amplifier can be connected thereto and an identical switching device to that described previously may be used in conjunction with the range-shunt circuit to control the operation of a servo device. In an embodiment of this type, the balancing resistors R_1 , R_2 , and R_3 would not be needed as their function is taken over by the resistances in the range-shunt circuit, and also the three precision potentiometers may be replaced by one suitable potentiometer driven in a like manner.

Reversing the direction of the writing pen in the manner previously described has these advantages. There is practically no dead time after each range change, and the balancing time for covering all three ranges is only three times as long as the normal full-scale balancing time of the recorder. These advantages are forthcoming from a combination of the control or selectivity exercised by the switching device over the novel dual feedback loops employed to cancel the output of the D.-C. amplifier.

Accidental actuation of one of the position-sensing means twice instead of once is prevented by the large resistor 52 and the capacitor 50. This unwanted condition may be caused if the noise level of the input signal is extremely high. The values of the resistor and the capacitor are chosen to have a time delay introduced so that only one switching action of the relay devices RL_1 and RL_2 results from actuating means MS_1 and MS_2 more than once in rapid succession within half a second.

Having described the operating principles of an embodiment of the present invention, it is realized and understood that other modifications thereof will suggest themselves to persons skilled in the prior art without departing from the spirit and scope of the invention. Accordingly, it is desirable that the scope of the present invention be determined by the appended claims.

What is claimed is:

1. A multirange recording device comprising amplifying means responsive to input signals the magnitude of which is to be recorded; a servo drive device responsive to the output of the amplifying means; a writing element driven along a preselected travel path by said servo drive device; a first and second sensing means disposed in the travel path of said writing element; switching means responsive to said first and second sensing means to con-

trol the direction of drive of said servo drive device, said switching means including a first and second ratchet relay, each of said relays having a first pair of two-position contacts and second two-position contacts, said first sensing means controlling the energization of said first relay and said second sensing means controlling the energization of said second relay, the first and second relays upon energization thereof each operating to reverse the position of their associated two-position contacts; feedback means connected between the input and output of said amplifying means, said feedback means including a plurality of variable impedances and said second two-position contacts of said first and second relays; coupling means between said servo drive device and said plurality of variable impedances to control the variation of said impedances, said second two-position contacts of said first and second relays being arranged to interconnect one of said plurality of variable impedances for control of said feedback means and to then select a different one of said plurality of variable impedances for such control upon the energization of each of said relays; and means interconnecting the pair of two-position contacts of said first and second relays with the output of said amplifying means and the input of said servo drive device whereby the interconnection of the output of said amplifying means to the input of said servo drive device is reversed in polarity whenever said first or second relays are energized by said first or second position sensing means.

2. A multirange recording device which automatically reverses direction of the travel of a writing element as the signal to be recorded passes from one range to another preselected range, said device comprising in combination; amplifying means responsive to the signal to be recorded; a servo device responsive to the output of said amplifying means; a writing element driven by said servo device along a preselected travel path; feedback means disposed between the input and output of said amplifying means; sensing means located in the travel path of said writing element and providing signals when contacted by said writing element; switching means responsive to the signals developed by said sensing means to reverse the direction of travel of said writing element by reversing the direction of rotation of said servo drive device, said switching means including relay means having a pair of two position contact means and an additional two-position contact means, the energization of said relay means being controlled by the signals provided by said sensing means, which energization reverses the position of all of the two-position contact means associated with the relay means from a first position to a second position; means connecting said pair of two-position contact means of said relay means between the output of said amplifying means and the input of said servo drive device whereby the energization of said relay means and the subsequent reversal of position of said pair of two-position contact means reverses the polarity of the interconnection of the output of said amplifying device to the input of said servo drive device thereby reversing the direction of drive of the servo device and said driven writing element; said feedback means including a plurality of variable impedance means controlled by said servo drive device and said additional two-position contact means, said additional two-position contact means connecting one of said plurality of variable impedance means for variable control of said feedback means and selecting a different one of said plurality of impedance means upon the energization of said relay means and the corresponding reversal of position of said additional contact means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,561,372	Hillman	July 24, 1951
2,661,260	Salzman	Dec. 1, 1953