

Dec. 14, 1943.

E. SHIPTON

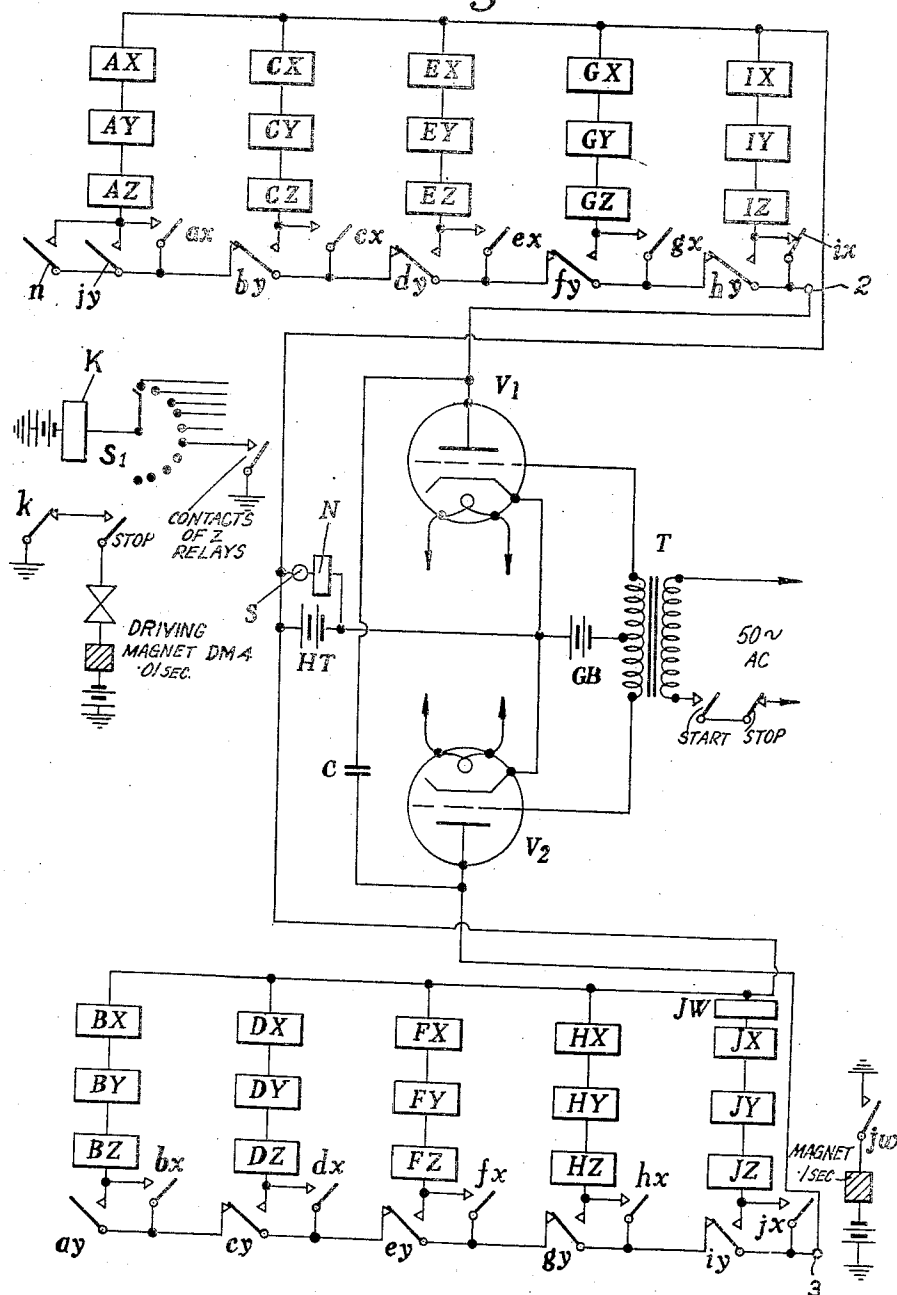
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TIMING DEVICE

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4 Sheets-Sheet 1

Fig. 1.



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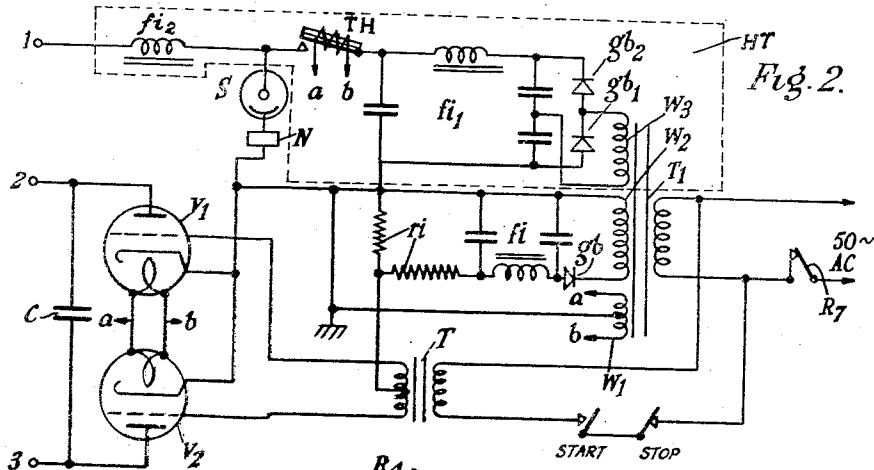
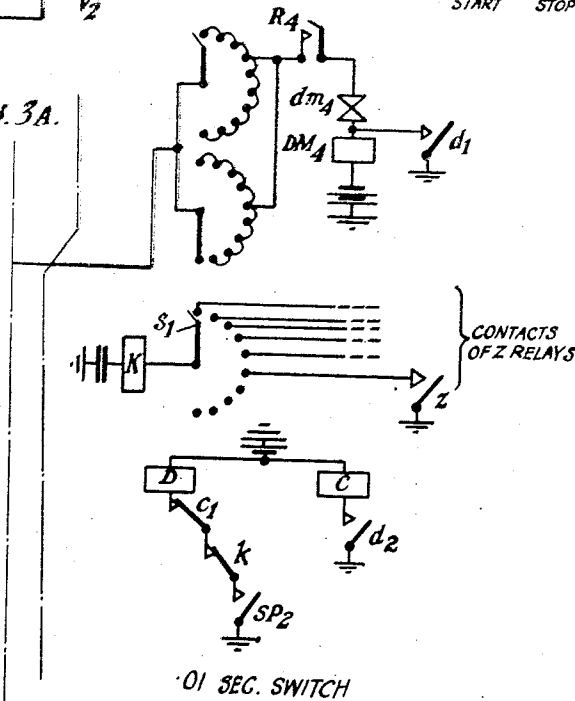


Fig. 3A.



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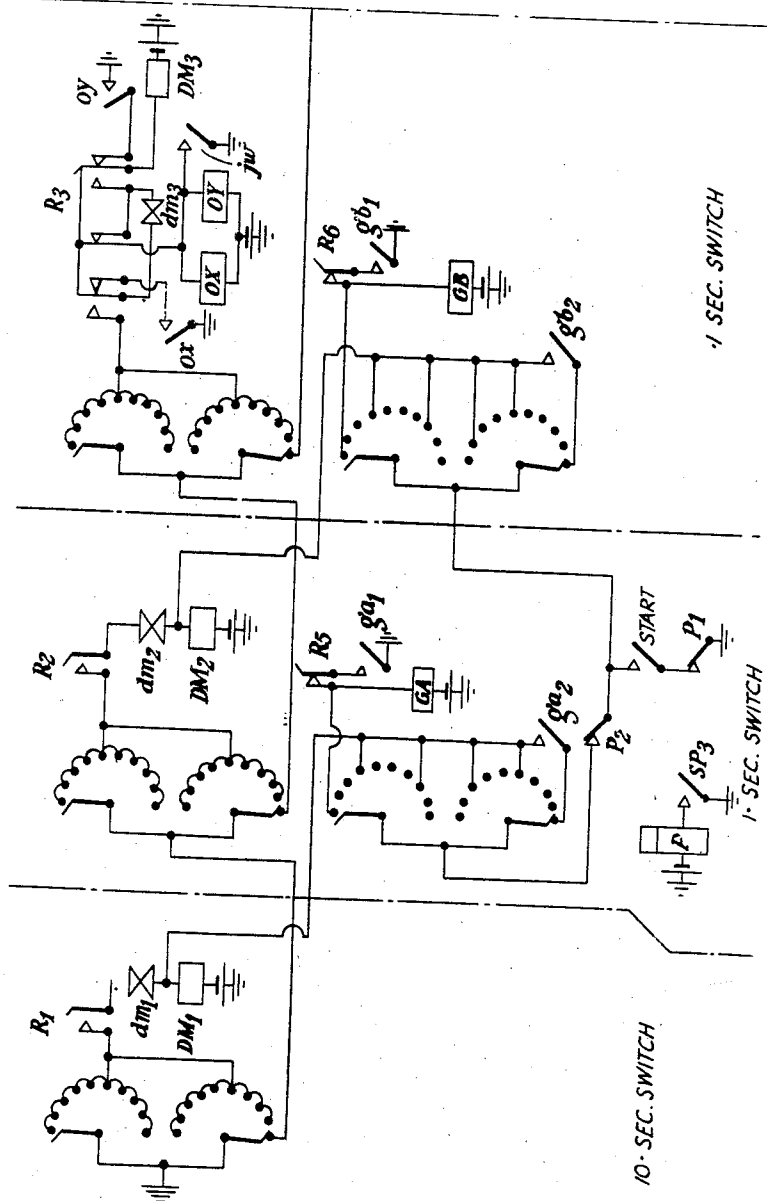
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Fig. 3.



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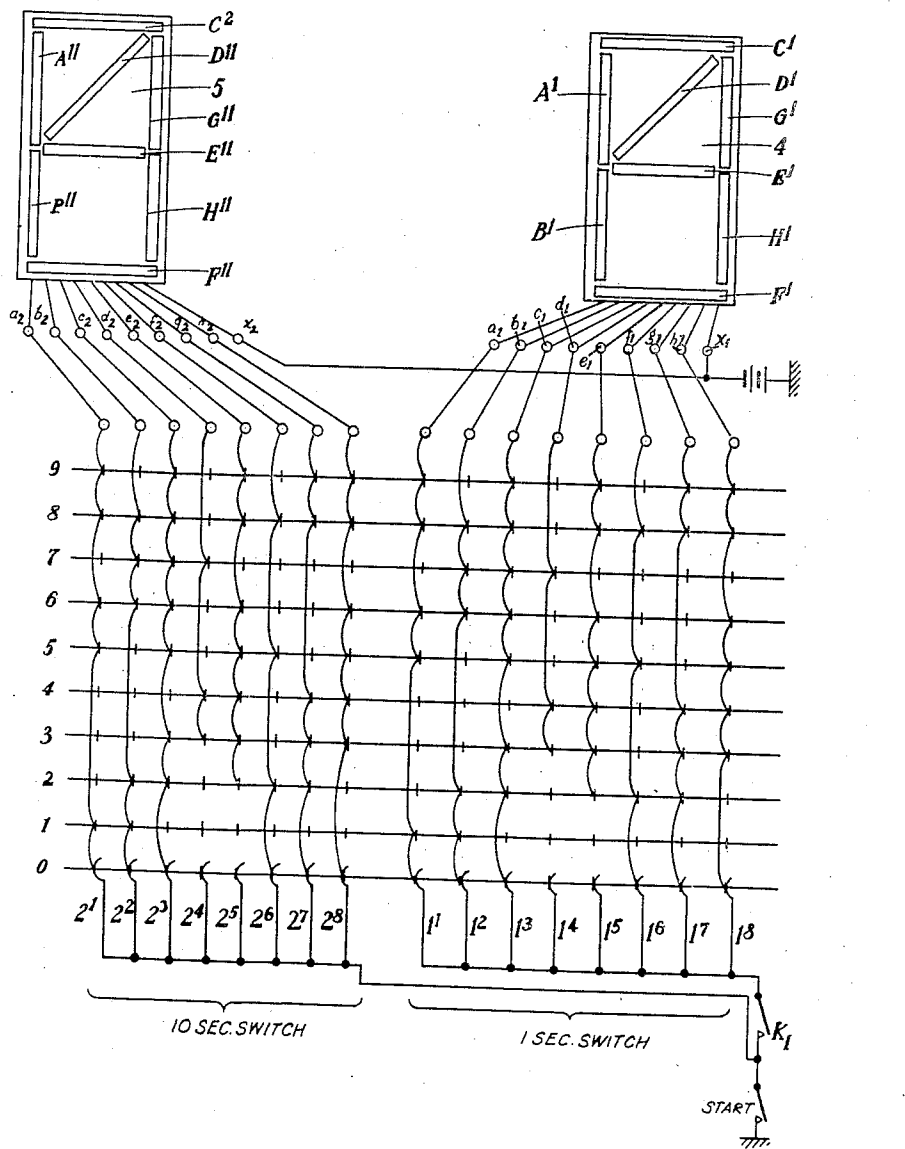
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Fig. 4.



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UNITED STATES PATENT OFFICE

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TIMING DEVICE

Edward Shipton, London, England

Application April 21, 1939, Serial No. 269,244
In Great Britain April 25, 1938

10 Claims. (Cl. 161—15)

The present invention relates to an electrical circuit arrangement suitable for indicating time.

In the specification of my prior British Patent No. 466,861, I have described a numerical time indicator comprising a field of lamps or illuminated strips which are illuminated in various combinations to indicate numbers, and a rotary switch having a plurality of contact banks and associated wipers which are stepped round by a stepping magnet, the contacts being connected to indicate various numbers in accordance with the position of the wipers, the electrical impulses for operating the magnet being fed thereto at regular intervals of time.

The present invention relates to an improvement or modification of such an arrangement and also to a circuit arrangement for producing the timed impulses.

According to the present invention a numerical time indicator comprising a field of lamps or illuminated strips which are illuminated in various combinations to indicate numbers, is constructed to indicate very short periods of time, such as 100ths of a second, thus providing a "stop watch" which may be used for automatically timing races, such as dog races and other sporting events, where a timed accuracy of this degree is important.

Since it is impossible to operate selecting switches at such high speeds, a feature of the invention consists in causing the high speed impulses to operate relays or other quick acting devices which mark positions on the contacts of selecting switches, such as rotary switches, so that, when the impulses are stopped, a definite contact is marked corresponding to the last relay or the like to operate. A switch is then operated, preferably simultaneously with the operation of the stopping switch, to start the selector switch hunting to find the marked contact, upon which contact it stops. Corresponding to this position the lamps of the indicator are illuminated to give a corresponding indication.

From another aspect, therefore, the invention consists in employing the impulses which are too fast to operate the rotary switches to mark positions thereon, and subsequently to cause a rotary switch to hunt to find the marked contact when the high speed impulses are stopped.

A further feature of the invention consists in a "stop watch" wherein the time registered is automatically indicated on an indicator comprising a field of lamps or illuminating strips, which are illuminated in various combinations to in-

dicade the various numbers. Preferably this indicator comprises gas discharge tubes, such as neon tubes. Alternatively, mechanical indicators may be used. A still further feature of the invention consists in a control unit for the indicator of such a "stop watch" whereby a plurality of such indicating devices at different places may be simultaneously operated from the single control unit.

Another feature of the invention consists in the use of an automatic telephone switch for operating the lamps or illuminated strips in such a "stop watch."

A further feature of the invention consists in using the positive and negative halves of 50-cycle mains supply current, preferably time controlled mains, for furnishing the 100th second impulses for operating a time indicator for indicating 100ths of a second. This is preferably effected by employing two gas filled relays arranged in opposition, one of which is actuated by the positive half cycle and the other by the negative half cycle.

A still further feature of the invention consists in a control circuit arrangement employing two gas discharge relays in opposition and connected to a source of alternating current, the circuit arrangement associated being such that the gas discharge relays are automatically energised and de-energised alternately.

The numerical indications may be switched in to indicate the time period measured after the control unit has stopped, or, alternatively, some of the denominations may operate continuously during the operation of the control unit, the remaining denominations being switched in after the control unit has been stopped. Of course, all the denominations could be indicated during the operation of the control unit, but since the lamps indicating the 10ths second and 100ths second would merely indicate a blur, it is preferable that these should only be illuminated after the control unit has been stopped.

In order that the invention may be more clearly understood an embodiment thereof applied to an electrical "stop watch" for indicating 100ths of a second will now be described with reference to the accompanying drawings, in which:

Fig. 1 shows a circuit diagram of an embodiment according to the invention,

Fig. 2 shows some details either omitted from, or only indicated diagrammatically in, Fig. 1,

Figs. 3 and 3A show the interconnection between some of the wipers of the rotary switches and

associated relays and the like to illustrate the operation of the switches, and

Fig. 4 shows other wipers of some of the switches shown in Figs. 3 and 3A for actuating time indicating units.

Referring first to Fig. 1, the 100th second impulses are produced from the 50-cycle time controlled mains which are fed to a transformer T, the extremities of the secondary winding of which are connected to the grids of two gas discharge relays V_1 and V_2 . The midpoint of the secondary winding is connected to the cathodes of the two tubes through a grid bias source GB and the output of each tube is fed through two series of relays. Also connected across the two anodes is a condenser C.

In the quiescent state, the grid control voltage of each gas-filled relay is sufficiently negative to prevent the flow of anode current. Immediately the "start" switch is closed, 50-cycle alternating current is applied to the grid transformer. The control voltage on each grid will, therefore, be increased and decreased alternately depending upon the potential induced across the two halves of the secondary winding of the transformer T respectively.

The alternating potential difference across these two halves of the transformer secondary is arranged such that when it is in opposition to the normal grid control voltage, the negative bias on the grid is reduced to a value below that at which the relay strikes, and anode current will, therefore, commence to flow. Once the anode current supplied from a source HT of high tension current commences to flow it will continue at a steady value independent of any variation of the grid bias until the relay is re-set. When the valve strikes the anode current reaches its steady value practically instantaneously.

When the valve is re-set the time taken for the anode current to collapse is dependent upon the de-ionisation time of the valve and this may vary according to the characteristics of the circuit. As in this particular application the anode current is kept small and is only flowing intermittently for short periods, the de-ionisation time of the valve is very short and for practical purposes it may be considered as instantaneous.

The method used to re-set the gas filled relays is as follows. Assuming current to be flowing in the relay V_1 but not in relay V_2 , the condenser C will then become charged through the load (that is the chain of relays in the anode circuit of V_1) to the potential difference across the load connected in the anode circuit of the relay V_1 . When relay V_2 is struck by variation of its control voltage the condenser C will discharge through it, the potential of the condenser momentarily opposing the potential on the anode of the relay V_1 . The anode current through V_1 will, therefore, be interrupted. The capacity of the condenser C is arranged such that its discharge time is slightly longer than the de-ionisation time of the valve. The valve will, therefore, be completely de-ionised and the grid regain control before the anode voltage is restored to normal.

Simultaneously the alternating voltage across the secondary of T is building up such as to make the grid of V_1 increasingly negative with respect to the cathode, and this voltage is superimposed on the normal grid control voltage. However, the normal grid control voltage is, in itself, sufficiently negative to prevent the anode current through V_1 re-starting. Obviously, therefore, the flow of anode current through V_1 will be inter-

rupted until the negative potential on the grid is again reduced to the striking voltage.

When V_1 is again struck V_2 will be extinguished in a similar manner and the foregoing sequence of operation will continue so long as alternating current is applied to the transformer T.

By means of this arrangement the current is switched alternately through the chain of relays in the anode circuits of the relays V_1 and V_2 . As the resetting of each gas relay is dependent upon the striking of the other gas relay and also since the striking of this relay is dependent upon the reduction of the normal grid control voltage by an induced potential difference in the grid circuit, then on discontinuing the 50-cycle alternating current applied to the grid transformer, the last operated gas filled relay will not be extinguished but will continue its discharge, thereby locking up any relays which may constitute the load in its anode circuit. Furthermore, since it is the striking of one relay which extinguishes the other, there is no intermediate period in which neither relay is operating.

The main supply may, of course, be used for providing current for the heaters, grid control voltage and anode potential as will now be more fully explained with reference to Fig. 2. The 50-cycle alternating current is supplied to a transformer T_1 , having three secondary windings W_1 , W_2 , W_3 . The winding W_1 is connected to the points a and b of the heaters of the relays V_1 and V_2 , the mid-point of the winding W_1 being earthed. The winding W_2 furnishes, by means of a rectifier gb , a filter circuit f_1 and resistances r_1 , the negative bias for the grids of the relays V_1 and V_2 . The winding W_3 furnishes, by means of rectifiers gb_1 and gb_2 and filter circuits f_1 and f_2 , the high tension anode current to the relays V_1 and V_2 , the terminals 1, 2 and 3 of the circuit shown in Fig. 2 being identical with the points 1, 2 and 3 shown in Fig. 1. A thermostat TH is provided in the high tension supply leads to the anodes in order to delay connection of the anode supply until the heaters are fully heated.

Across the high tension supply leads there is provided, as indicated in Figs. 1 and 2, a neon stabiliser S of known construction which serves two purposes. Firstly, as the stabiliser S is shunted across the high tension source HT it prevents the voltage on the anodes of the relays V_1 and V_2 from rising above the normal working voltage which is important since there is a definite relation between the anode voltage and the grid control voltage, that is, for any given anode voltage there is a definite minimum control voltage which will prevent anode current flow. It is, therefore, necessary to prevent surges in the anode voltage in order to guard against any unwanted operation of the gas-filled relays. Further, it is important for the efficient performance of the fast operated relays in the anode circuits of the gas-filled relays that their operating current should be maintained steady within reasonable limits. As is known, a neon stabiliser is a gas discharge valve having a neon filling. The discharge strikes at a predetermined value of the voltage across the valve and substantially prevents any rise of the voltage beyond the predetermined value.

The second function of the neon stabiliser is in conjunction with the relay N (see Figs. 1 and 2) which ensures that the recording always starts off at the A group of fast relays. It will be seen that in the quiescent state the anode circuits of both gas-filled relays V_1 and V_2 are broken at the various y contacts. As soon as the anode

supply is switched on by the thermostat, the voltage under no load conditions is sufficient to cause the neon stabiliser S to strike and the current through it will operate relay N which closes its contact *n* (see Fig. 1) to prepare the A group of relays, thus ensuring that this group is the first to be operated. As soon as the recording commences the current taken by the recording relays reduces the current through the neon stabiliser S to the point where the relay N releases and all subsequent operation of the A group of relays takes place in the normal sequence.

In the anode circuit of each gas filled relay is connected a series of high speed recording relays. Relay groups A, C, E, G, I (see Fig. 1) form one series and relay groups B, D, F, H, J form the other. Each relay group prepares the circuit for the next in succession, that is group A prepares the circuit for group B, and group B for group C and so on, and it will be seen, therefore, that as each relay is operated for one 100th of a second the operation of the complete series A to J will take one tenth second. Relay group J operating prepares the circuit for relay group A and so the sequence is repeated successively throughout the recording.

Immediately the race starting device is operated, the "start" relay contact in the primary circuit of the transformer T closes. As previously explained the grid control voltage on the two gas-filled relays is varied at 50 cycles causing anode current to flow in each alternately. The first gas-filled relay to discharge is V₁ over the contact *n*. The relays AX, AY, AZ are thus operated. Relay AX is fast to operate and closes its contact *ax* to provide a locking circuit guarding against the release of contact *n*. Relay AY prepares the circuit for the B group of relays by closing its contact *ay* but this group will not operate at this stage as no discharge is taking place through the gas-filled relay V₂. Relay AZ operates its contact *az* (not specifically shown but being one of the contacts designated contacts of Z relays, see left hand side of Fig. 1 and right hand side of Fig. 3A) to provide a marking potential on the first contact on the bank of the 100th seconds rotary switch S₁.

When the gas-filled relay V₂ strikes as previously explained, gas-filled relay V₁ is extinguished. Relays BX, BY and BZ are therefore operated and relays AX, AY and AZ released. All the Y relays, however, are slightly slow to release and as all X relays are fast to operate, BX will operate to close its contact *bx* and lock up the B group of relays before contact *ay* opens. Relay BY prepares the circuit for the C series by closing its contact *by* but again this C group will not operate since now no discharge is taking place through the gas-filled relay V₁. Relay BZ provides a marking contact on the second contact of the bank of the rotary switch S₁.

The foregoing sequence of operations is continued for each group of relays, each Y relay preparing the circuit for the next group, each X relay locking its own group, and each Z relay marking the appropriate contact on the bank of the 100th seconds rotary switch. At the end of the chain, relay JY prepares the circuit for the A group and so the sequence is repeated until the "stop" contact in the primary circuit of the transformer T is operated.

On each operation of the J group of relays, relay JW operates (see Figs. 1 and 3) and its contact *jw* operates to step-up the 10th seconds rotary switch by one step. When the contact *jw*

is closed the relay OX (Fig. 3) operates and is locked up over its contact *ox* and interruptor springs *dm₃*. Relay OY is operated in parallel with relay OX and energises over its contact *oy* the driving magnet DM₃. When the magnet DM₃ is energised the interruptor springs *dm₃* are opened, the tenth seconds rotary switch makes one step and the relays OX and OY are de-energised.

At each 10th step of the 10th seconds rotary switch, the driving magnet DM₂ of the units seconds rotary switch is energised from earth over contact P₁ the closed "start" contact, the wiper and bank of the tenths second switch. When the tenths second switch makes its next step this circuit is broken, DM₂ is de-energised and causes the units seconds switch to make one step. At each tenth step of the units seconds switch the driving magnet DM₁ of the tens seconds switch is energised from earth over contact p₁, the closed "start" contact, contact p₂ and wiper and bank of the units seconds switch. When this switch makes its next step the connection is broken, DM₁ is de-energised and the ten seconds switch makes one step. If longer time periods are to be indicated, further rotary switches are provided for indicating the units minutes and the tens minutes and so on, and the method of stepping-up the switches of higher denominations may be effected as explained in the specification of my British Patent No. 466,861.

The switches used are normal 25 point switches with staggered wipers, thus giving over two consecutive banks, 50 contact points for a complete revolution of the wipers. The homing contact for the wipers is also the 50th contact, and whilst an impulse must be sent to the next switch each time the wipers pass over this contact, an impulse must not be sent when the wipers are in their home position. To achieve this, contacts *ga₂* and *gb₂* actuated by relays GA and GB respectively are provided. These contacts keep the impulse circuits open in the home position of the wipers. When the wipers of the tenths second and units seconds switches move off their home position onto the first contacts of their banks, the relays GB and GA respectively are energised and lock up over the contacts *gb₁* and *ga₁* respectively, closing also the contacts *gb₂* and *ga₂*, thus enabling the impulses to be sent when now the wipers pass over the 50th contact.

When the "stop" switch is operated the last operated relay group in the series A to J locks up, the Z relay of this group providing a marking potential on the bank of the wiper S₁, (see Figs. 1, 3 and 3A, Fig. 1 being somewhat diagrammatical), which is a wiper of the hundredth second switch. The stop switch closes also the contacts *sp₂* and *sp₃*. The contact *sp₂* completes the circuit for a relay D, which closes contact *d₁* and thus energises the driving magnet DM₄. Relay D also closes contact *d₂* which completes the circuit for relay C. When relay C operates contact *c₁* is opened and relay D is released, thereby contact *d₁* is opened and the driving magnet DM₄ of the hundredth second switch is de-energised, whereupon this switch makes one step. Contact *d₂* is also opened and thus relay C is de-energised, *c₁* is closed and relay D is again energised. Relays D and C thus continue to operate alternately stepping the hundredth second switch each time its driving magnet DM₄ is de-energised. When the wiper S₁ reaches the contact marked by a Z relay, relay K operates and

contact k disconnects the circuit for relay D and prevents further movement of the hundredth second switch.

If it happens that at the end of the recording either or both of the tenths and the hundredths second switches stand on the tenth, twentieth, thirtieth, fortieth or fiftieth step, the stepping circuit of the next switch is completed and its driving magnet energised. Since the switches make only a step when the driving magnet is de-energised contact sp_3 is provided to effect the de-energising of the driving magnet. When the stop switch is actuated the contact sp_3 is closed and relay P is operated opening the contacts p_1 and p_2 which disconnect the driving magnets DM_1 and DM_2 of the ten seconds and units seconds switches thus allowing either or both of these switches to complete the final step if their driving magnets were just energised at the moment the stop switch was actuated.

The operation of the "start" and "stop" contacts may be manual or automatic by means of photo-electric or other suitable known devices. The starting and stopping impulses may be purely transient effects persisting for a few microseconds only, or the duration of the operation causing the device to start may persist after the receipt of the impulse causing it to stop. On the other hand the time interval recorded can be that for any single operation provided only that the instant of starting and stopping the operation can be converted into electrical impulses.

In order to prepare the apparatus for use again, a re-set switch is operated which restores all the rotary switches to a normal position and resets the discharge relays V_1 and V_2 . The reset switch actuates the contacts R_1 to R_4 shown in Figs. 3 and 3A and contact R_7 shown in Fig. 2. All the contacts R_1 to R_7 operate simultaneously in the manner now to be described. While in the drawings all the switches and contacts are shown in their initial position, it will be appreciated that when the reset switch is actuated a particular time interval has been recorded and the switches and contacts are in their working position as described above.

By closing the contact R_1 earth is extended from the ten seconds wiper through the interruptor springs dm_1 to the driving magnet DM_1 which is energised. When DM_1 is energised the interruptor springs dm_1 open and DM_1 is de-energised. The ten seconds switch makes one step and the interruptor springs dm_1 are closed again. This cycle of operation continues until the switch reaches its home position.

In the home position of the ten seconds switch, earth is extended to the wipers of the units seconds switch, and since contact R_2 is closed the units seconds switch is driven home in the same manner as just described with regard to the ten seconds switch. When the units seconds switch reaches its home position earth is extended to the tenths second switch. As will be seen from Fig. 3, the contacts R_3 change the stepping circuit of the tenth second switch to a circuit similar to those employed for the ten seconds and units seconds switch. The tenths second switch is driven home in the same manner as the preceding time switches, and when the tenths second switch has reached its home position earth is extended to the hundredths second switch which in turn steps home while contact R_4 is closed. The contacts R_5 and R_6 unlock the relays GA and GR respectively. Contact R_7 (see Fig. 2) interrupts the current sup-

ply to the discharge relays V_1 and V_2 . Thereby the X, Y and Z relays which were locked by their corresponding x contact (see Fig. 1) are released. The start, stop and reset switches are finally brought into their original position, either manually or automatically, and the arrangement is again ready for use.

The time interval recorded by the arrangement illustrated in Fig. 3 is indicated by a numerical time indicator, comprising four indicating units, each unit being controlled by one of the four time switches.

Fig. 4 shows the two units 4 and 5 controlled by the units seconds switch and the ten seconds switch respectively and their connections to these switches, the units for the tenths and the hundredths second switches and their connections to these switches being similar to the unit 4 and its connections. The units 4 and 5 have each 8 lamps $A^1, B^1 \dots H^1$, and $A^{11}, B^{11} \dots H^{11}$ respectively. One terminal of each lamp is permanently connected through a terminal x_1, x_2 respectively to one pole of a battery the other pole of which is earthed. The other terminals of the lamps are connected to terminals $a_1, b_1 \dots h_1$, and $a_2, b_2 \dots h_2$ respectively. Each unit is adapted to display the numerals 1, 2, ..., 9 and 0, when the appropriate lamps are lighted. For example, numeral 1 is displayed when the lamps A and B are lighted, numeral 2 when the lamps C, G, E, B and F are lighted, numeral 7, when the lamps C, D and B are lighted. It will be readily appreciated how any of the other numerals can be obtained.

Each of the time switches has eight additional wipers and corresponding rows of contact (not shown in Fig. 3). In Fig. 4, the eight additional wipers of the units seconds switches are indicated by $1^1, 1^2 \dots 1^8$, and those of the ten seconds switch by $2^1, 2^2 \dots 2^8$. The corresponding rows of contacts are shown developed on the plane of the drawing and the wipers will step vertically from one contact to the next, but it will be understood that in the actual construction the contacts shown will be arranged in semi-circular banks, and the wipers will rotate about a shaft at the centre of the banks. Moreover, whilst I have shown, for simplicity, each wiper associated with a row of 10 contacts, in actual construction each wiper will comprise two arms each of which is associated with a bank of 25 contacts, the arrangement being such that for a complete revolution of the wiper fifty contact points are obtained for each wiper.

The arrangement shown in Fig. 4 operates as follows: When the start switch is operated the wipers $2^1, 2^2 \dots 2^8$ are earthed and unit 5 displays numeral 0. As soon as wipers $2^1, 2^2 \dots 2^8$ have made their first step, the numeral 1 is displayed and so on. The unit 5 is thus operating continuously while the time is recorded. The contact k_1 is operated by the relay K (see Fig. 3), that is to say after the stop switch has been actuated and the hundredth second switch has found its marked position. When contacts k_1 is closed earth is extended to the wipers $1^1, 1^2 \dots 1^8$ which causes the numeral corresponding to the position of these wipers to be displayed.

It should be understood that the mains supply circuit (shown in Fig. 2) for the discharge relays V_1 and V_2 , including the neon stabiliser and the thermostat, the circuit arrangements shown in Fig. 3 for the ten seconds and units seconds switches, the circuits shown in Fig. 3

for resetting the arrangement, and that part of the arrangement which is illustrated in Fig. 4, in themselves form no part of my invention.

It should be clearly understood that the drawings are given for explanatory purpose and by way of example only and that modifications of the specific embodiment described and illustrated are possible without departing from the scope of my invention which is defined by the appended claims.

I claim:

1. An electric timing device comprising means for generating timed impulses, a series of impulse responsive devices, means for successively actuating said devices by said impulses, a stop switch, means for marking that impulse responsive device which was last actuated when the stop switch is operated, an indicator, and means for operating the indicator in accordance with the marked impulse responsive device.

2. A stop watch comprising an operating mechanism, means for starting said mechanism, means for stopping said mechanism, a visual indicator comprising a plurality of indicating units for different denominations, means for actuating at least one of said units continuously during the operation of said mechanism, and means for actuating at least one of said units only after the stopping means have been actuated.

3. An electric timing device comprising means for generating a train of timed electric impulses, a series of impulse responsive devices, means for actuating each impulse responsive device in turn by successive impulses in said train, a starting switch, control means for ensuring that a certain impulse responsive device of said series is the first to be operated after actuation of said starting switch, a stopping switch, means for marking that impulse responsive device which was last actuated when the stopping switch is operated, an indicating device and means for operating said indicating device in accordance with the marked impulse responsive device.

4. An electric stop watch utilising positive and negative halves of a 50 cycle alternating current for furnishing hundredth of a second impulses, in which there is provided a first series of impulse responsive devices, each of which is responsive to an impulse corresponding to a positive half-cycle, a second series of impulse responsive devices each of which is responsive to an impulse corresponding to negative half-cycle, and means for operating the impulse responsive devices in each series successively.

5. An electric stop watch utilising positive and negative halves of a 50 cycle alternating current for furnishing hundredth of a second impulses, in which there is provided a first series of impulse responsive devices, each of which is responsive to an impulse corresponding to a positive half-cycle a second series of impulse responsive devices each of which is responsive to an impulse corresponding to a negative half-cycle, means for operating the impulse responsive devices in each series successively and means for operating an indicating device in accordance with the last impulse responsive device operated when the stopping switch is operated.

6. An electric stop watch according to claim 5, wherein the positive and negative half-cycles of

the alternating current are distributed to the first and second series of impulse responsive devices by means of a control circuit comprising a pair of oppositely connected gas-filled relays arranged to be actuated one by the positive and the other by the negative half-cycles of the alternating current source, together with means for deionising one relay substantially immediately upon the ionisation of the other.

7. An electric stop watch according to claim 5, wherein the positive and negative half-cycles of the alternating current are distributed to the first and second series of impulse responsive devices by means of a control circuit comprising a pair of gas-filled relays alternately energised at each half-wave of the alternating current, an anode in each relay, a discharge path interconnecting the two anodes, the arrangement of the path and relays being such that the path is charged when one of the relays is energised and discharged through the other relay when that relay energises, thereby causing a potential to be established on the anode of the one relay momentarily opposing its anode potential whereby that relay is de-ionised substantially immediately.

8. An electric stop watch according to claim 5, wherein the positive and negative half-cycles of the alternating current are distributed to the first and second series of impulse responsive devices by means of a control circuit comprising a pair of gas discharge relays connected in opposition, an anode in each of said relays, and a discharge path, including a condenser, interconnecting the anodes of said relays.

9. An electric stop watch according to claim 5, wherein the positive and negative half-cycles of the alternating current are distributed to the first and second series of impulse responsive devices by means of a control circuit comprising a pair of gas discharge relays connected in opposition, an anode in each of said relays, and a discharge path, including a condenser, interconnecting the anodes of said relays, the capacity of said condenser being such that its discharge time is slightly greater than the de-ionisation time of either relay.

10. An electric stop watch according to claim 5, wherein the positive and negative half-cycles of the alternating current are distributed to the first and second series of impulse responsive devices by means of a control circuit comprising in combination a transformer having primary and secondary windings, a first gas discharge relay, an anode, a control grid and a cathode within said relay, a circuit connection between said grid and one end of said secondary winding, a circuit connection between said cathode and a neutral point on said secondary winding, a second gas discharge relay, an anode, a control grid and a cathode within said second relay, a circuit connection between said grid of said second relay and the other end of said secondary winding, a first circuit connection between said anodes and including the anode-cathode path of the relays and the series of impulse responsive devices responsive to currents flowing in said anode-cathode paths, and a second circuit connection between said anodes including a condenser.

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