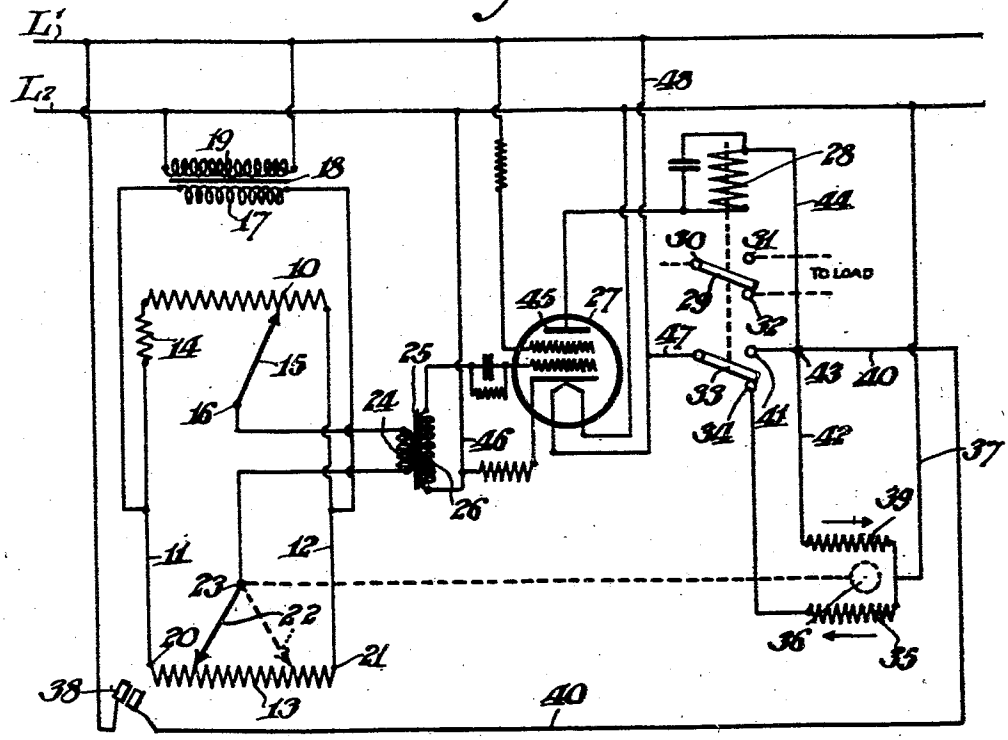
Jan. 21, 1947. W. L. HUNT 2,414,467

TIMING DEVICE

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Fig. 1.



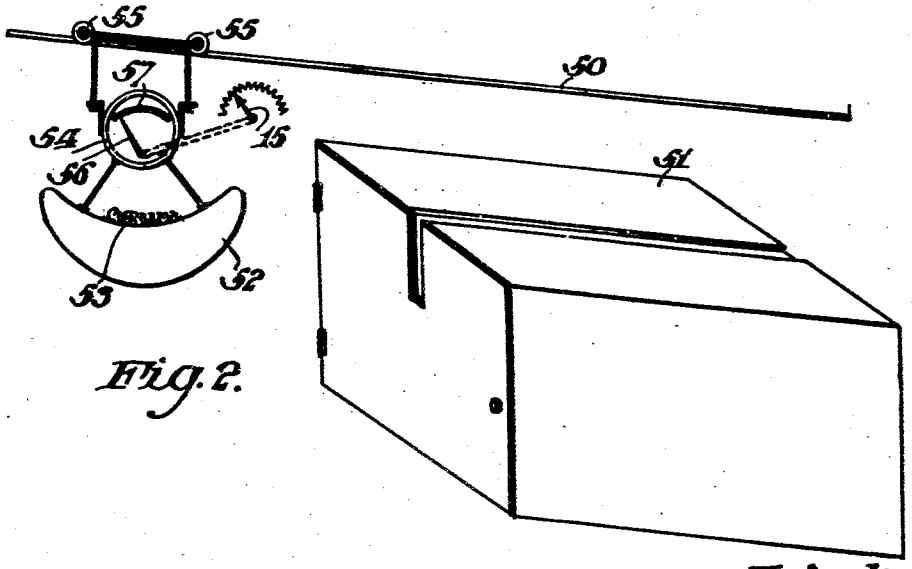


Fig. 2.

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TIMING DEVICE

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Fig. 3.

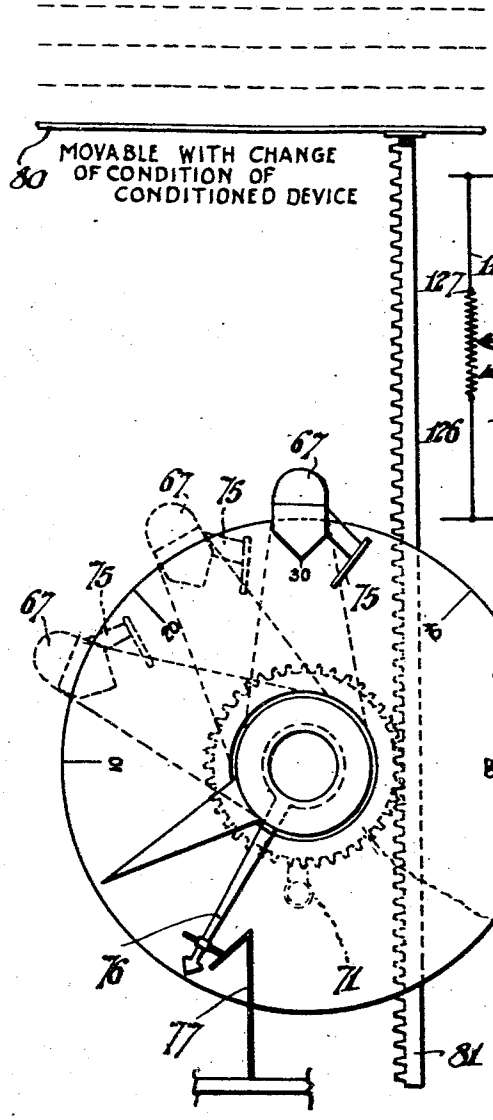


Fig. 5.

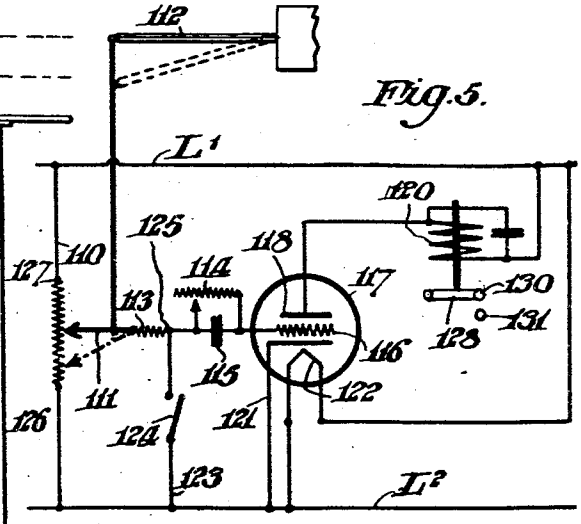
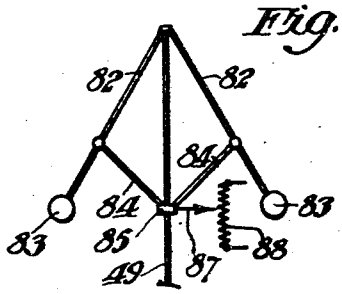


Fig. 6.



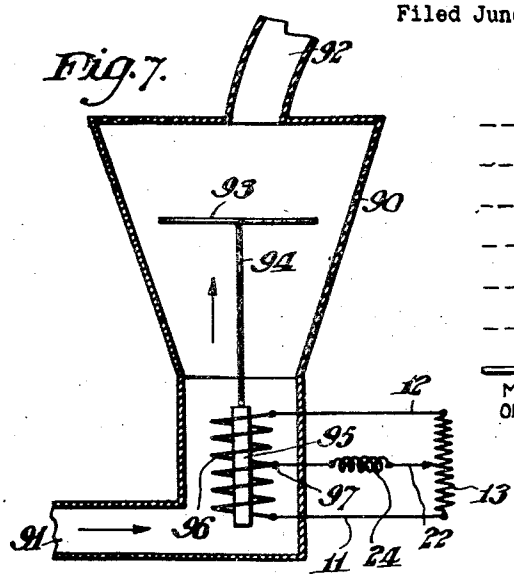
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Jan. 21, 1947. W. L. HUNT 2,414,467

TIMING DEVICE

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Fig. 7.



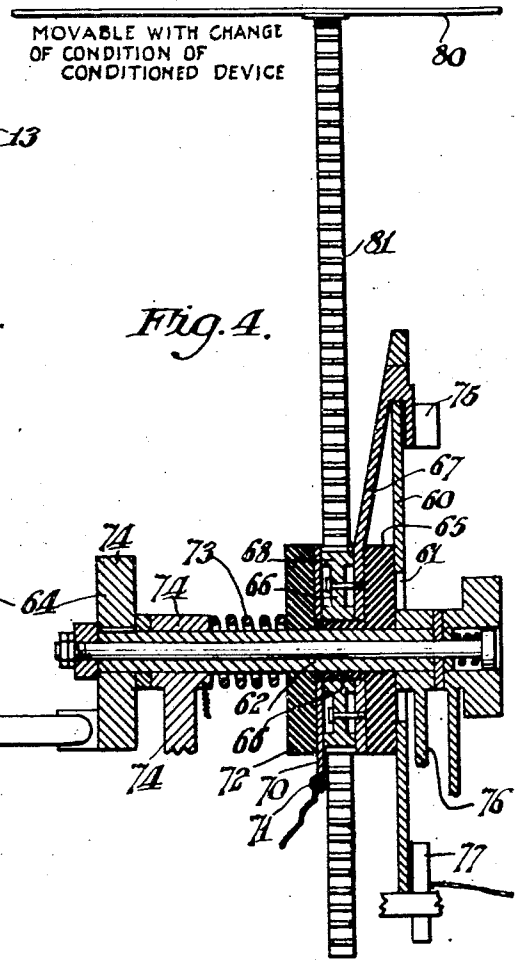


Fig. 8.

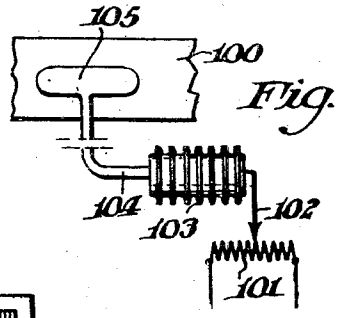


Fig. 4.

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Patented Jan. 21, 1947 2,414,467

UNITED STATES PATENT OFFICE

2,414,467

TIMING DEVICE

Walter Leslie Hunt, Philadelphia, Pa., assignor to Automatic Temperature Control Co., Inc., Philadelphia, Pa., a corporation of Pennsylvania

Application June 29, 1943, Serial No. 492,674

13 Claims. (Cl. 161—1)

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This invention relates to timing devices, and particularly to variable timers either of stop or repeat cycles.

In the art of timers, which has been very well explored in the past by various inventors and manufacturers, timing devices of great accuracy and of relative flexibility have been developed, whereby timed intervals of long or short duration have been manifested by electric circuit controlling functions or the like, but so far as known in every case, the variation in the timed interval has been a pre-set manual functioning, as a necessary preliminary or prerequisite to initiation of the step, operation, or method to be timed. If through some change in a variable condition in the processing step or in the material being worked, or the like, the manually pre-set timing becomes incorrect, it is too late, according to present timing systems, to change the timed interval or predetermined cycle. In other words, previous timing methods made the processing step dependent upon a predetermined manually set timed interval, whereas the timed interval should be a mere function of the actual specific processing step in progress, as modified by the attributes or condition of the work involved.

It is among the objects of this invention: to provide a timing system coupled with a device susceptible to variations in condition whereby the timed interval is an automatically set function of the variation in condition of the conditioned device; to improve the art of timers; to provide a novel form of timer; to provide an electronic timer of accuracy and ease of operation; to provide an electronically sensitive timer which is variable in setting through either manual or automatic means; to provide a variable timer operatively coupled with a conditioned device for automatically predetermining the timed interval as a function of condition of the device, which may be either electrically or mechanically coupled and in which the timing-interval producer may be adjacent to or completely remote from the actuating conditioned device; to provide a timing device of extreme simplicity and a minimum of component parts; to provide an automatic timing system arranged for actuation and preselection of timing interval by a variable condition of a conditioned device which is universally applicable to any device of variable condition; and other objects and advantages will become more evident as the description proceeds.

In the accompanying drawings forming part of this description:

Fig. 1 represents a diagrammatic illustration of

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a novel form of electronically controlled timer having a repeat cycle according to one form of the invention;

Fig. 2 represents a diagrammatic perspective of a specific application of a form of invention to a variable weight condition;

Fig. 3 represents a somewhat diagrammatic fragmentary front elevation of a mechanically controlled timer, representing a modification of the invention;

Fig. 4 represents a diagrammatic section partially in full lines of the mechanically controlled timer of Fig. 3.

Fig. 5 represents a diagram of a purely electronic timer of a stop cycle type according to a further modified form of invention;

Fig. 6 represents a fragmentary diagrammatic elevation of a governor controlled slidewire;

Fig. 7 represents a fragmentary diagrammatic section of a flow meter having an inductive coupling as the control of the bridge circuit;

Fig. 8 represents a fragmentary diagrammatic section through a conditioned device with an expansion controlled element for varying the bridge circuit.

In a simple but preferred embodiment of the invention, a bridge circuit is provided, the respective actuating and actuated components of which may be widely spaced and respectively may be located in juxtaposition to the instrumentalities which control the actuating component and those which at a remotely different point are to be controlled by the actuated component. Thus, an actuating slidewire 10 is provided, connected at the ends by legs 11 and 12, to the complemental actuated slidewire 13. For reasons to be explained, a small additional resistance 14 is in the connection 11 adjacent to the slidewire 10. The slidewire 10 is swept, relatively, by an actuating slidewire arm or pointer 15, illustratively pivoted for movement on an axis 16. The slidewire 10 and arm 15 and pivot 16 are, illustratively, located in the actuating condition-responsive element and are mechanically or electrically coupled thereto so that the relative position of the arm and slidewire is a direct function of the instantaneous condition of a conditioned device or unit. In the purely illustrative form of device shown in Fig. 2, slidewire arm 15 is directly coupled with a weighing scale, to be described, to position the slidewire as a function of the particular load on the scale. However embodied, it is the controlling factor of the timer, and is susceptible to variations in setting as functions of the variations or fluctuations of any condition of a device, whether the con-

ditions are of speed, in which the slidewire arm and slidewire are relatively adjusted by a governor or the like as indicated in Fig. 6, or of humidity, pressure, temperature, linear dimensions, however varied, such as length, height, width, or of hardness, or deflection, or weight, or flow, as indicated in Fig. 7, or any other condition.

The bridge circuit is energized by the secondary 17 of a transformer 18, the primary 19 of which is connected across the A. C. power lines, respectively L1 and L2. The actuated slidewire 13 of the timing instrument has a limited extent defined by the starting point for each timing cycle designated as "Min" at 20, and having a maximum limit designated by 21, toward which each timed cycle starts, but which is only attained if the predetermined timed interval requires such a maximum range of movement. The actuated slidewire pointer or arm 22, pivoted on a transverse axis 23, is shown, in a purely illustrative position, as slightly off the "min" or starting point 20, and is in electrical connection with the actuating slidewire arm or pointer 15 through the primary 24 of an input transformer 25. It will be understood that there will always be a current flowing through the primary 24 so long as the arms 15 and 22 occupy disproportionate settings on their respective slidewires, and that balance and termination of the flow only occurs when the pointer 22 has been moved, illustratively and for instance only, to the position approximately indicated in dotted lines in Fig. 1. At such mutually proportionate settings, the circuit is balanced and current flow through the primary 24 ceases.

In the illustrative form of circuit indicated in Fig. 1, the secondary 26 of the input transformer 25 is used to control the plate current from the tube 27, which controls the energization of the relay coil 28 and therefore both of the switch members 29 and 33. The upper switch member 29 controls the particular desired loads by means of a common terminal 30 and the alternate poles 31 and 32 of the load circuits, which are not shown in detail as any desired instrumentality or instrumentalities are to be controlled by these load circuits. The lower switch member 33, in the dropped out condition (shown), closes the line from power lead L1, switch 33, through pole terminal 34, through the "in" running field 35 of the synchronous reversible motor 36, and through the common return 37 to line L2. The circuit through the "out" running field 39 of motor 36 will be described later herein. The output shaft of the reversible synchronous motor 36, after passing through suitable reduction gears or the like (not shown) drives the actuated slidewire arm 22 on axis 23, in one direction or the other relative to slidewire 13, and the energization of the field 35 drives the arm 22 from wherever it happens to be in its range between "min" 20 and "max" 21 and specifically from the dotted line and full line positions shown, toward the minimum point 20. This is the "in," return, or rearward stroke of the timer, and the timing secured is that required to run the motor and through the reduction gearing to move the arm 22 inwardly from wherever the arm had stopped on its outward stroke. At the "min" point 20 of slidewire 13, a special limit switch 38 is provided, one side of which connects with power line L1, and the other side of which connects through a line 40 to the upper pole 41 of the lower switch of the relay, and through a line 42 through the "out" running field 39 of the motor 36, through common return 37 to the line L2. The line 40 intersects at 43 a relay coil connection 44 leading to the plate 45 of the tube after passing through relay coil 28.

As the start of a timing cycle is always from the point "min" at 20 on the slidewire 13, the actual initiation of the cycle is at the instant that the switch 38 is "made" by the pointer or arm 22. At this juncture of course the actuating pointer or arm 15 has been moved relative to slidewire 13 either automatically as a function of the instantaneous value of a particular condition of the conditioned device with which the timer is in operative association, or, in the broader aspects of the invention, by a manual setting of the actuating pointer and slidewire. With the pointer 15 at some condition-functional position relative to its slidewire, say to the position indicated in Fig. 1, and with the actuated slidewire pointer 22 at "min" setting, it will be clear that the flow across the bridge and through the primary 24 will be a maximum, so that if the plate circuit were closed, it too would be at a maximum. The closing of the switch 38 actually closes the plate circuit so that it flows from line L1, switch 38, connectors 40, 44, relay coil 28, plate 45, cathode connector 46, to the other power line L2. Thus, the closing of the switch 38 instantaneously energizes the relay coil 28 which snaps "in," and the lower switch member 33 thereof successively breaks the circuit through the "in" field 35 of the motor 36 by leaving pole 34, and then makes the circuit through the "out" field 39 of the motor by engaging pole 41. The power circuit through the "out" field will be clear, as with the relay "in" the circuit is from line L1, connector 48 and 47, switch 33, pole or contact 41, connector 42, "out" field 39 of the motor, through the common return 37 to the line L2. It is to be noted that the completion of the power circuit through the "out" field of he motor pursuant to movement of the relay "in," is accompanied by a continuation of the established plate circuit holding the relay "in," because the plate circuit is then from the line L1 through the filament connection 48 and connector 47 to switch 33, contact 41, connector 44, relay coil 28, plate 45, through the cathode connector 46 to the line L2. Thus, the relay is held in by the energization of the coil 28 as long as any current flows across the bridge through the primary 24. As there is a current flow until the motor driven slidewire arm 22 has attained substantially the same proportionate setting on its slidewire 13 as the actuating pointer or arm 15 occupies relative to its slidewire 13, except for the more or less slight modification of the position of pointer 22 because of the existence of resistance 14 in side connector 11 of the bridge circuit, the progress from maximum current flow in coil 24, to balance of the bridge and termination of the flow through coil 24 represents a timed interval comprising one-half of the total cycle of the timer.

If it be assumed that the condition of the device controlling the actuating pointer was such for instance, that a timed interval of twenty minutes was indicated, then the motor 36 will run for twenty minutes, in a purely illustrative case, from the time that the switch 38 is first closed, until the motor has moved the pointer 22 successively off from switch 38, permitting the latter to open, and onwardly in its "out" movement or stroke until the pointer has been moved to a point on its range between "min" at 20 and "max" at 21 respectively, at which the

bridge circuit attains balance. At this instant flow across the bridge terminates, the plate output stops, the relay coil 28 being deenergized the relay will snap or drop out, and the lower switch member 33 will leave upper pole 41, thus breaking the power circuit through the "out" field 39 of the motor and stopping the motor. The dropping out of the relay 28 precludes any reenergization thereof until limit switch 38 has first been closed. This completes the "out" stroke or running of the motor, and one-half of the cycle is completed, with the pointer 22 in the dotted line position.

By the dropping out of the relay controlled by the coil 28, the dropping of the switch 33 from contact or pole 41, synchronously and substantially simultaneously engages the switch 33 electrically with the lower pole or contact 36. This closes a circuit through the "in" field 35 of the motor, starting the second timed half cycle of running of the motor 36, which is only terminated after twenty minutes of running time (illustratively as before) by the attainment by the pointed 22 of the "min" position at 20, accompanied by the closing of the special limit switch 38. This circuit, as should be clear, is from line L1, connector 48, connector 47, switch 33, contact 34, through "in" field 35 of the motor 36, through common return 37 to the line L2.

Obviously, in the circuit thus far described, the system gives a repeat cycle, which continues to repeat until interrupted in a suitable manner. In order to insure a continuance of the repeated cycles, even during the time when the actuating arm or pointer 15 is at the zero end of its scale or range, adjacent to the side leg 11 of the bridge circuit, the preferably small resistance 14 is provided, which is such as to maintain a degree of unbalance in the bridge circuit so as to cause a timing cycle of operations of the actuated pointer 22, even when there is no actual timing cycle indicated by the conditions. Obviously, this small timed cycle may be of very short duration compared to the entire range available from the particular system, and simply insures that the repeat cycles do not come to a complete termination, so that a further change of condition will find the timer set and operating.

Of course, it will be evident in the form of invention thus far described, that the gearing and synchronism of the motor will be such that there will be a continuous repeat cycle each comprising a stroke or running "out", followed by an identical but opposite stroke or running "in," with the time duration of both being the same so long as conditions remain the same. In other words, there are preferably always two identically timed strokes in a cycle. The cycle can be continuous as described, or can be caused to stop at the end of the cycle. Similarly, it will be evident that for one-half of the complete cycle the relay will be held in, while for the identical complemental half, the relay will be dropped out. The provision of the upper switch member 29 will permit the establishment of two identically timed circuit controlling functions during each cycle.

It will be clear that although in the preferred form of the invention the actuating arm 15 on slidewire 10 is adjusted as an automatic function of a change in condition of some conditioned device with which it is operatively associated, it will be understod that in the broadest aspects of the invention, the particular timing derived from the electronic controlled circuit disclosed, for instance, can be achieved in a non-automatic functioning as in ordinary timers. Thus, it is contemplated that the actuating slidewire 10 and its pointer 15 may be relatively moved or have their resistances varied by manual settings. It is also contemplated that the relative position or electrical value of the slidewire arm 15 and the slidewire 10 may be accomplished as either a mechanical or electrical "follow-up" of any other form of angular motion, or as functions of the motion or the acceleration thereof, or as mere changes in electrical characteristics, or as a direct coupling to the condition-responsive member itself.

In the device shown illustratively in Fig. 2, a rail 50 is provided leading over a furnace 51 in which the contents of a scoop 52 are to be heat treated for a time directly proportional to the weight of the contents 53. A scale 54 is provided leading to a supporting rolling device 55 on the track 50. The weight of the particular load 53 of the material is registered or indicated by the pointer 56 on the dial 57. Let it be assumed that the pointer 56 is coupled mechanically or electrically if desired, to the controlling slidewire pointer or arm 15 so that the adjustment of the controlling slidewire arm is a direct function of the particular load 53 in the scoop. The timing cycle thus established is used to time the duration of exposure of the scoop and its contents to the heat of the furnace, and perfect heating is secured, as should be clear.

In the type of device discussed heretofore, a preferred and novel electronically controlled circuit has been disclosed, but in the broad aspects of this invention, the results can be approximated by certain mechanical timing assemblies, for which in a purely illustrative fashion reference may be had to Figs. 3 and 4 herein. In a Patent No. 1,978,947, issued to Johanson et al. on October 30, 1934, there was disclosed an electrically actuated time-controlled circuit-controller, in which there were two variables as to which timed control could be achieved. One was the duration of the timed cycle, between make and break of desired circuits, by which the time between make and make was variable, as was also the timed duration of a given circuit after it was made or established. This was arranged for either stop or repeat cycle operations and was a pioneering invention in this field and has been a highly successful development in the industry. It was a feature of one form of this invention that all controls were disposed in concentric relation about a common dial, and that there were manually settable devices moving about the common axis normal to the dial face, by which an arm, driven by a reversible synchronous motor, moved between a fixed contact and a variably positioned contact in a dial-sweeping timed motion, and so arranged that contact with the adjustably positioned contact reversed the motor to reverse the sweep of the arm toward the fixed contact. Additional concentric means was provided to control the duration of a circuit that was made at each end of the stroke of the motor driven arm. The disclosure of that patent has been skeletonized for inclusion herein by omitting certain portions which are inferentially included, in order to show, illustratively, the modifications by which the objects of this invention can be carried out in a more or less mechanical timer, as distinguished from the electronic timer of the earlier figures. As that timer has been developed in earlier embodiments, the timing cycle was a function of a manual presetting.

Referring to the two figures mentioned, a dial 60 is provided, if this should be necessary in an automatically functioning device, with a concentric axial aperture 61, through which extends the tubular drive shaft 62, driven by the reversible synchronous motor 63, through a lost motion connection 64. An insulating bushing 65 has a flange 66 against which the adjustable time controlling arm 67 is pressed, and is disposed behind the dial 60. The controlling arm 67 is integral with or keyed to a pinion gear 68 so that they turn together, and if desired, an electrical conductor disc 70, having a soldering terminal 71, is disposed upon the bushing 65 in intimate electrical contact with the pinion gear 66 and contact arm 67. An insulating disc 72 is provided for lateral abutment against the connector 70 and is pushed thereagainst to furnish a frictional resistance to movement by a compression spring 73 engaging between the abutting disc 72 and a fixed supporting bearing 74. The front of the dial 60 is overhung by a contact-making element 75 positionable at any desired setting angularly about the dial variable in setting as the actuated pinion gear is turned, as will be explained. The protruding frontal portion of the tubular shaft 62 carries the dial sweeping arm 76, in electrical connection with the shaft, and one line from the power circuit extends through the support 74 and through the tubular shaft 62 to the contact of the sweep arm 76. A fixed contact 77 is disposed at the zero, minimum or starting point of the dial, for instance, in position to be energized by the sweep arm 76 at the lower end or conclusion of its stroke in the second half of its two-part cycle, and contact 75 wherever it happens to be located as a result of a given response to a condition, is arranged to be energized at the upper end of its stroke.

A beam 80 is provided, which, diagrammatically, represents an element which is movable as a function of the variation in a given condition of a conditioned device including any of the conditions to which the electronically controlled circuit is responsive as described of Fig. 1. The beam 80 by any desired condition is caused to attain a certain position vertically on its range by the value of the condition, and this value is represented by the position of the rack 81 and the angular position of pinion gear 68 permanently in mesh therewith and moved thereby. Thus, the position of the time control arm 67 relative to the fixed contact member 77, as affecting the time during which the sweep arm 76 is traversing the dial face between contacts, is a direct function of the instantaneous value of the condition affecting the beam and rack setting. It will be understood that all reversing functions, circuit controlling functions and the like set up in the said patent to Johanson et al., will be present in the full description of Figs. 3 and 4, but are only omitted herein to avoid unnecessary explanation.

In the forms of invention so far described, the timing functions have been secured by the running of a reversible synchronous motor. This is preferred in a repeat cycle timer, although obviously other forms of systems could be availed of for this purpose. Obviously also a single stop half cycle or a complete stop cycle could be secured from the motor devices thus far disclosed. Within the purview of this invention, however, is the purely electronic timer device of Fig. 5.

Referring to Fig. 5, there is disclosed the power lines L1 and L2, having a voltage divider connection 110, the pointer arm 111 of which is controlled in its movement on the voltage divider, by any suitable condition-responsive mechanism, such for instance as the bi-metallic thermally responsive element 112. The pointer 111 of the voltage divider 110 leads through a resistance 113 to a time-adjustable bleed circuit 114, shunting a condenser 115 and leading to a grid 116 in a triode 117. The plate 118 of the tube leads through a relay 120 to line L1. The cathode 121 leads to line L2 while being heated by filament 122 as is usual. The time adjustment 114 is adjustable to vary the rate of bleed or discharge, and a line 123, containing switch 124, extends between line L2 and the condenser end of resistance 113, as at 125. It will be understood that as the voltage divider is actuated in accordance with a given variable condition, the arm 111 thereof is swung either toward line L2 or line L1. It will be clear that if it reaches point 126 of the voltage divider adjacent to line L2, there will be no charge impressed upon the condenser, as there is no difference in potential between one side of the condenser and the other, through the cathode. On the other hand, the movement of pointer 111 to point 127 adjacent to line L1 impresses a maximum charge on the condenser, as will be clear.

With a given condition of the device associated with condition-responsive element 112, and the arm 111 appropriately adjusted as a function thereof, the condenser is charged and remains appropriately charged and the tube remains conductive so long as switch 124 is open. As soon as switch 124 is closed, a timed interval is begun which maintains during the discharge of the condenser through the timed bleed shunt during which the tube is non-conductive. The discharge actuates the grid 116 and causes plate current to cease flowing and relay 120 drops out from the normal non-timing position shown in Fig. 5. To secure a controlling function, the relay controls a switch member 128 which from its engagement with upper contact or pole 130, with whatever circuits, if any, this may control, the switch member 128 is dropped into engagement with lower pole 131 to control a timed circuit which lasts until the condenser has been discharged and the plate current builds up and the relay pulls in. It will be clear that a variable timing is secured, due to the variable charging of the condenser, in turn due to variation in the position of pointer 111 relative to the resistance in voltage divider 110. The variable timing is also affected by the adjustment of the timing adjuster 114 governing the rate of bleed, as will be clear, but this adjustment is made to accord with conditions in the system and is usually not changed after an initial setting. It will be clear, however, that if desired, the condition-response may be made effective upon the adjustment 114 for varying the timed interval with a fixed and constant charge on the condenser.

It has been made clear that the source of the controlling moment may be any conditioned device, and that it is not necessary, with most forms of the invention, that the timing assembly and its control and controlled circuits be located in adjacency to the conditioned device, as it is merely a matter of length of electrical connectors to separate the actuating and actuated slidewire assemblies in an operative bridge circuit with part close to the conditioned device and part remote therefrom.

As a purely illustrative form of device caused to function by speed or relative speed, the dia-

grammatic device of Fig. 6 may be considered typical. Referring to this figure, a rotatable shaft 49 is provided carrying the links 82 with terminal weights 83 arranged to rise under centrifugal force against the constant of gravity, and by inner links 84 to raise a ring 85 carrying fixedly, for bodily movement, or by a suitable linkage arrangement with pivots (not shown), the movable pointer arm 87, relatively movable with respect to the resistance 88 in the bridge circuit of Fig. 1. In this illustrative case the pointer 87 and resistance or slidewire 88 are the exact counterparts of the actuating slidewire arm 15 and slidewire 10 of the bridge circuit of Fig. 1, and function the same.

It will be clear that in the creation of a bridge circuit it is not necessary that the control be by variable resistances, as variable inductances or the like may also be used with similar results. A diagrammatic illustration of this sort of circuit is disclosed in Fig. 7. In this typical installation, the conditioned device comprises a flow meter casing 90, through which fluid flows between inlet 91 and exit 92, and the float element 93 supports the floating core 95 through a rod 94, and the core is movable with relation to in the inductance coil 96 having a center tap 97 connecting with the actuated slidewire arm 22 of the bridge circuit slidewire 13 through the primary 24, as in Fig. 1, and the ends of the inductance coil connect with the slidewire 13 by side legs 11 and 12 as will be clear. The variation in inductance of the actuator core 95 and inductance 96 causes unbalance of the bridge circuit, requiring movement, in timed relation, of the slide wire arm 22 to balance the circuit, just as in Fig. 1.

As a further illustration of an operative assembly of elements within the purview of the invention, reference may be made to the disclosure of Fig. 8, in which a conditioned device is illustrated in fragmental form at 100. A slidewire or the like 101 is provided which is identical in functioning to slidewire 10 of Fig. 1, a pointer 102 is identical to actuating pointer 15 of Fig. 1, and is either suitably pivoted for movement (not shown), or may be carried bodily for movement on the free end of a bellows 103. The latter is in a closed tubular line 104 extending to the sealed bulbous element 105, and the state of compression or expansion of the bellows is a function of the internal pressure in the entire bellows system. Normally, with the device illustrated, the condition in or of the device 100 to which the bellows will respond will be temperature, but it may equally well be pressure. Any such assembly or combinations of assemblies of elements to control the actuator of the timer may be resorted to in accordance with the desired conditions.

It is an important phase of the invention, that the entire assembly of the timing circuit and related elements are universal in their applications and can be built into a compact unit that will fit every situation except for the specific actuating bridge circuit control used. It will be understood that the entire assembly of Fig. 1 except slidewire 10 and pointer 15 can be assembled in a unitary housing and assembly, with leads with which in due course, a controlling assembly of slidewire 10 and arm 15 can subsequently be operatively connected when the particular controlling actuating assembly necessary for a given installation, whether close to or remote from the conditioned device, and whether it comprises a variable resistance, inductance, or any other type of bridge-circuit controlling electrical assembly is provided. This universality of use is characteristic not only of the disclosure of Fig. 1, but also of the electronic timer assembly of Fig. 5.

It will be clear that it makes no difference in function of the device, whether the arms or pointers move relative to the slidewires, whether the slidewires move relative to the pointers, or whether both have a relative movement with respect to the other, and such alternative relative movements are within the contemplation of the invention and of the claims herein.

It will be appreciated that whether resistances, inductances, vacuum tubes or otherwise are used to form the bridge circuit, in each case what happens analogous to but not restricted to slidewire arm relative movement is a change of value, whether accomplished by movement or by purely electrical activity.

The great range of usefulness and the full list of advantages attaching to the invention herein, as well as the fact that the forms of invention disclosed herein are purely illustrative are not limitative, will be evident, and any change of form or modifications to accord with desirements for other exemplifications of the invention are to be construed as within the purview of this invention and the scope of the attached claims, unless the latter should be otherwise limited.

Having thus described my invention, I claim:

1. A timing device comprising means automatically movable pursuant to a change of condition of a conditioned device, a timing device having a cycle of operations of variable total length, and means varying the cycle in its total length as a function of the change of condition of said conditioned device.

2. A timing device comprising means automatically movable pursuant to a change of condition of a conditioned device, a timing system comprising a reversible synchronous motor having cycles of varying length each comprised of a stroke out and an equal return stroke in, and means operatively associating the said means with the device to vary the duration of the stroke out and therefore of the duration of the return stroke in as a function of the condition of the conditioned device.

3. A timing system which comprises in combination a device of variable condition, means of variable setting, means coupling the device and means in automatic driving relation to vary automatically said setting with said condition, and a timing device establishing a timing interval as a function of such setting.

4. A timing system comprising a unitary structure comprising a thermionic circuit, a relay in the plate output circuit, a reversible motor driving in a constant repeat cycle of movement, a slidewire of a bridge circuit, and a slidewire arm for the said slidewire in driven relation to the motor to secure a sweep of the arm relative to the said slidewire, with a connection controlled by the slidewire arm for controlling the thermionic circuit, so arranged that a complemental electrical unit of variable value can be subsequently attached to the unit to complete the bridge circuit and the control circuit to the thermionic system, and so that the change of value can be automatically effective upon the said complemental portion of the bridge circuit to control the timed output of the relay as a function of the change in value.

5. A timing device comprising means of variable electrical effectiveness automatically actuat-

able to change said effectiveness in accordance with a change of condition of a conditioned device relative to a predetermined condition, a timing device having a cycle of operations of variable total length, and means varying the duration of the cycle as a function of change of condition of such conditioned device.

6. A timing system operative to indicate a timed interval, means in said timing system adjustable to vary the duration of the timed interval indicated by the system, movable means arranged for operative association with a conditioned device the condition of which is variable relative to a predetermined condition and movable automatically as the condition of said device varies, and means coupling the movable means and the adjustable means for synchronous operation whereby the duration of the timed interval of the system is varied as a function of the condition of said device.

7. A timing system comprising in combination a conditioned device subject to change of condition relative to a predetermined condition, a timing device operative to indicate a timed interval, means in the timing device for varying the duration of the timed interval, and means automatically responsive to changes in condition of the conditioned device to synchronously actuate the means in the timing device to effect a timed interval which is a function of the deviation of instantaneous condition of said conditioned device from said predetermined condition.

8. A timing system having a first and a second slidewire, pointers for the respective slidewire and relatively adjustable thereon between a fixed minimum point and a variable maximum point, a transformer having a primary in circuit with the respective pointers for the respective slidewires and arranged to energize the primary in accordance with the unbalance of the bridge circuit, means comprising an electronic circuit including the secondary of said transformer, a thermionic tube in the electronic circuit, a double throw relay having an actuating coil in the output circuit of said tube, a motor having forward and reversing fields and the armature of which is in driving engagement with the pointer of said second mentioned slidewire in both directions of running controlled by said respective fields, an electrical network including the contacts of the relay and the respective fields of the motor and so arranged that when the actuating coil of the relay is energized a circuit is closed through the forward field of the motor and when deenergized a circuit is closed through the reversing field of the motor, means for relatively adjusting the pointer on the first mentioned slidewire between the minimum and maximum points thereon to establish a timing interval when the slidewire pointer of the second slidewire is at its minimum point to unbalance the bridge circuit and energize the actuating coil of the relay to initiate a timed interval of running of the motor forward until the pointer of the second slidewire has moved from its minimum point relatively on the slidewire to a point at which the bridge circuit is balanced and the actuating coil of the relay is deenergized, and which substantially instantaneously opens the circuit through the forward field of the motor and closes a circuit through the reversing field thereof and the pointer of the second slidewire is moved in a timed interval complemental of the first relatively to the second slidewire until it again attains its initial minimum position, and means for indicating the total time interval comprised of the forward stroke and the complemental reverse stroke of the pointer for the second slidewire as the timed interval of the timing system.

9. A timing system as recited in claim 8, characterized by the provision of supplemental switch means for energizing the coil of the relay to reverse the direction of running of the motor when the pointer of the second slidewire reaches its minimum point in the reversed running of the motor, for initiating a repetition of the timing running of the motor forward and reverse in a repetition of said total timing interval.

10. In a timing apparatus arranged for operative association with a source of electric potential, a bridge circuit comprising a pair of potentiometers connected in parallel across such source when operatively associated therewith and each having a contact adjustable thereover, a bridge output circuit connected between said adjustable contacts whereby voltage from such operatively associated source is impressed across said output only when said contacts are not similarly adjusted, a reversible, constant speed electric motor arranged to drive one of said contacts in either direction of adjustment, the other contact being arbitrarily adjustable, and an electrical network for controlling the energization of said motor, said network being responsively coupled with the bridge output and being operable to energize said motor from such operatively associated source for alternate forward and reverse operation to oscillate said motor-driven contact at a constant speed between a predetermined initial position and the position of zero bridge circuit output as determined by the position of said arbitrarily adjustable contact, whereby the position of the latter determined the time said motor operates in each direction in each cycle of its oscillatory motion.

11. In a timing apparatus as recited in claim 10, said network including a working circuit, and means in said network for automatically controlling said working circuit as a function of the time of running of the motor in one direction

12. In a timing apparatus as recited in claim 10, means in said network for automatically reversing said motor to initiate a repeat cycle of running to oscillate said motor-driven contact between its said predetermined position and the position of zero bridge circuit.

13. In a timing apparatus as recited in claim 10, a conditioned device susceptible to change in condition from a predetermined condition, and means coupling the device with the arbitrarily adjustable contact to automatically adjust same to establish the time said motor operates in each direction in each cycle.

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