

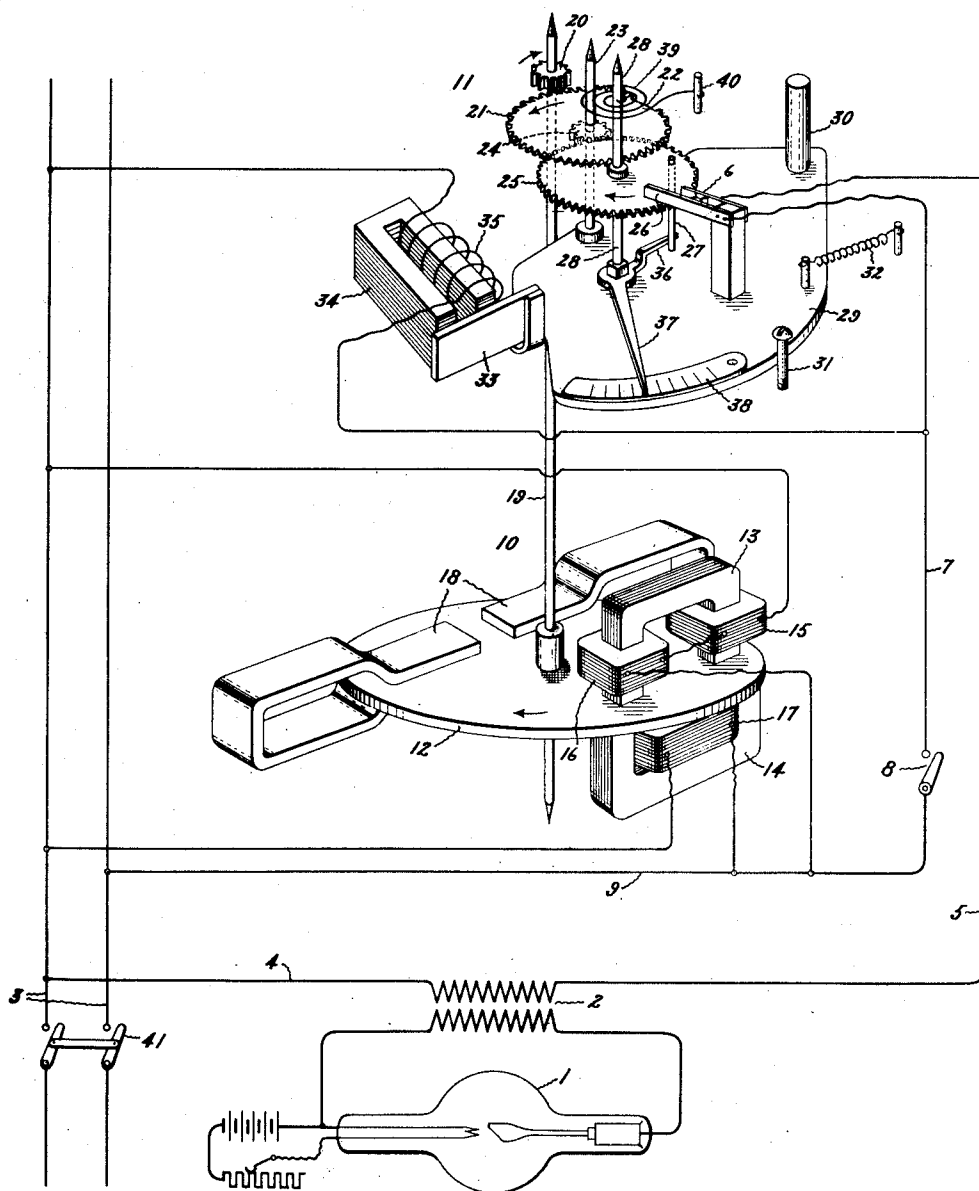
Oct. 12 , 1926.

1,603,049

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AUTOMATIC CONTROLLER

Filed Jan. 4, 1922



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AUTOMATIC CONTROLLER.

Application filed January 4, 1922. Serial No. 526,994.

My invention relates to automatic controlling devices and its principal object is to provide a controlling device which may be set to operate after an interval, together with
5 means for modifying the interval according to a variable of an electric circuit. A more specific object of my invention is to provide an automatic device for opening an electric circuit, which device may be set to
10 operate at time intervals which are inversely proportional to the square of the voltage of the circuit. Certain other features of my invention are applicable to time switches in general as will appear as the description
15 proceeds.

The features of my invention which I believe to be novel will be pointed out in the appended claims. The details of construction and the method of operating a switch in
20 accordance with my invention will be understood from the following description taken in connection with the accompanying drawing.

In the following description I have chosen to illustrate my invention as a device for
25 timing the duration of an X-ray exposure in X-ray apparatus of the type shown in the copending application of William D. Coolidge for X-ray apparatus, Serial No. 395,088, filed July 9, 1920 and assigned to the same assignee as this invention. The X-ray
30 effect produced by a timed exposure will depend upon the square of the voltage applied to the terminals of the X-ray tube. If this
35 voltage is variable, it is important that the time of exposure be inversely proportional to the square of the voltage if consistent and accurate results are to be obtained. In the
40 application of my invention I provide an electric motor, the speed of which is proportional to the square of the applied voltage, for opening the circuit of the X-ray
45 tube after an interval which is proportional to the time required for a given exposure under conditions of normal voltage modified by the actual voltage conditions.

Referring now to the drawing, 1 indicates an X-ray tube which is supplied with energy through the transformer 2 from supply lines
50 3. One terminal of the transformer primary

is connected to one side of the supply through wire 4 and the other primary terminal is connected to the opposite side of the line through wire 5, automatic time switch 6, wire 7, manual starting switch 8 and wire 9.
55 The inverse voltage squared timing device for controlling the switch 6 consists essentially of two parts; first a motor designated in general by the numeral 10, the speed of which is directly proportional to the square
60 of the applied voltage, and second; a train of gears designated in general by the numeral 11, which is arranged so that it may be placed in driving connection with the motor. The motor 10 is similar in operation
65 to the well known induction watt hour meter and consists of a disc 12 of conducting material such as copper rotatably mounted in the air gap formed between the magnetic
70 pieces 13 and 14. The magnetic piece 13 comprises the core of two reactive coils 15 and 16 connected in series across the supply line 3. Magnetic piece 14 comprises an E-shaped core having a resistance coil 17 wound
75 on its middle leg also connected across the source of supply 3. The current flowing in each of these circuits will be proportional to the voltage of the source 3 which also supplies the X-ray tube 1. The shifting
80 magnetic field produced by the interaction of these magnetic structures sets up currents in the copper disc 12 and causes the same to rotate in a well understood manner. Drag
85 magnets 18 of the proper strength are provided to limit the speed of the disc 12 to the proper value by imposing a load thereon directly proportional to the speed of the disc. The combination of the torque producing
90 element and the drag magnet causes the disc to rotate at a speed directly proportional to the square of the voltage of the source 3. Since in the present case an alternating current source of supply is provided for the
95 X-ray tube, the motor element is an alternating current motor. However, it will be understood that a direct current motor having similar speed-voltage characteristics may be provided in cases where the translating
100 device to be controlled is supplied from a direct current source. The disc 12 is mounted

ed upon and drives a shaft 19 supported in suitable bearings not shown. The shaft 19 also carries a pinion 20 adapted to engage and drive the gear train of the switch operating device 11.

The switch operating gear train comprises a gear 21, which has a mutilated portion 22 and is mounted on a shaft 23. The shaft 23 carries a gear 24 meshing with the switch operating gear 25. One of the contacts of the switch 6, which is normally closed, is carried on a spring arm 26 which stands in the path of movement of the upper end of a pin 27 carried by the gear 25, so that when the pin 27 is moved into contact with the arm 26 by the rotation of gear 25 in the direction shown by the arrow, the switch contact 6 will be separated and the switch opened. The directions of rotation of the motor element and the various gears for accomplishing this result are shown by the arrows. The gear train is normally disengaged from the spur gear 20 as illustrated. When the gear 21 is brought into engagement with spur gear 20, in a manner to be explained presently, the pin 27 will be rotated against arm 26 and the switch 6 opened. The gears are arranged so that just after the switch 6 has been opened the mutilated or blank portion 22 of the gear 21 comes opposite spur gear 20 and further rotation of the gear train comprising gears 21, 24 and 25 is prevented. The shafts 23 and 28 which carry the last mentioned portion of the gear train are mounted in a movable structure comprising a pair of parallel plates one of which is shown at 29, the upper plate being omitted for the purpose of exposing the parts of the switch operating mechanism. This structure, which will hereafter be referred to as the plate 29, is pivoted at 30 so as to be swung in a plane perpendicular to the motor shaft 19. The plate 29 is normally held against a stop 31 by means of a spring 32 with the gears 20 and 21 out of engagement. The plate 29 also carries a support for the switch contacts 6. The plate 29 carries the armature 33 of an electromagnet 34, the operating coil 35 of which is adapted to be closed by the switch 8 to connect this coil across the source of supply 3. The armature 33 is normally held away from its seat by the spring 32, but when the switch 8 is closed the electromagnet 34 draws its armature 33 to its seat, swinging plate 29 on its pivot 30 to bring gear 21 into driving engagement with gear 20, thereby placing motor 10 in driving connection with the switch operating mechanism.

In order that the operation of the switch 6 may be timed to give an exposure of a predetermined definite value, means are provided for setting the switch operating gears in a position to bring pin 27 a definite distance away from arm 26. This setting

means comprises a stop arm 36 provided with a pointer 37. This pointer and stop arm are pivoted around the lower end of shaft 28 so that the stop 36 is in the path of movement of the lower end of switch operating pin 27 and the outer end of the pointer cooperates with a scale 38 on plate 29. This pointer 37 and stop arm 36 may be rotated around shaft 28 and is provided with friction means for holding it in any position to which it may be adjusted. When the gears 20 and 21 are out of engagement the switch operating gear train is rotatably biased in the opposite direction to that in which it is driven by the motor, by means of the light spiral spring 39. The inner end of this spring is fastened to the shaft 28 and its outer end to a stationary pin 40 held in the movable plate 29. Thus when the gear train is disengaged from the pinion 20 the pin 27 is held against stop 36, and by moving the pointer 37 about its pivot the switch operating gear train is rotated and the pin 27 may be set any desired distance away from the arm 26. The scale 38 is calibrated and marked in suitable units which correspond to the time required to operate the switch 6 after the switch 8 has been closed under conditions of normal voltage. This scale might also be calibrated in values of X-ray exposure. The left hand end of the scale corresponds to zero time and if the pointer 37 is moved to that point from the position shown, the stop 36 will move pin 27 into contact with arm 26 so that any further movement of pin 27 in the same direction will cause the switch 6 to open. If each division of the scale represents 10 seconds the setting shown in the illustration is such that the switch 6 will be opened 40 seconds after switch 8 is closed, provided the voltage supplied to the motor remains normal during the interval. If the voltage is above normal, however, the motor speed will be faster and the switch will be opened quicker. In like manner, if the voltage is low, the motor will run slower and the switch will remain closed a longer time. As has been previously pointed out the motor 10 is designed to have a speed proportional to the square of the applied voltage, consequently, the time during which the switch 6 and the circuit of the primary of transformer 2 remains closed, will be inversely proportional to the square of the applied voltage for any given setting.

A complete cycle of operation will now be explained: Assuming the parts are in the position shown, the line switch 41 is first closed energizing motor 10 which immediately starts in the direction of the arrow on the disc 12 and runs at a speed proportional to the square of the voltage. The pointer 37 is then moved to the point on the scale corresponding to the value of the exposure desired. This movement will cause the pin 27 to be moved a correspond-

ing distance away from arm 26 and the mutilated portion 22 of the gear 21 a corresponding distance away from a position opposite pinion 20. The apparatus is now in condition to take the exposure which is started by the closing of switch 8 which completes the supplied circuit comprising conductor 4, transformer 2, conductor 5, switch 6, conductor 7, switch 8 and conductor 9. When switch 8 is closed two things happen; first, the primary transformer 2 is energized and the X-ray discharge takes place in the tube 1; second, the circuit of operating coil 35 of electromagnet 34 is closed causing its armature 33 to be drawn to its seat, rotating plate 29 about pivot 30 and bringing the gear 21 into engagement with the pinion 20, the latter of which is now being driven by the motor 10. The switch operating gear train is now driven in the direction shown by the arrows and pin 27 approaches arm 26 at the same time the mutilated portion 22 of gear 21 approaches pinion 20, at speeds proportional to the square of the voltage which happens to exist on the supply lines at this time. This same voltage is also supplied to the primary of transformer 2 so that the switch 6 is opened at just the right instant to give the correct exposure irrespective of the voltage. Immediately thereafter, the mutilated portion 22 runs into the pinion gear 20 and the gear train stops. The operator may then open the switch 8 at his leisure which causes the deenergizing of the electromagnet 34. The spring 32 then swings the plate 29 about pivot 30 disengaging the gear train from pinion 20 which is immediately rotated by spring 39 into a position determined by the setting of the pointer 37 and the apparatus is ready for another exposure. It will be noticed that the mutilated portion 22 not only stops the gear train after the switch 6 has been opened but also prevents this switch from being closed again until the circuit has been opened at 8. By means of this apparatus an unskilled operator may obtain accurate and consistent results without danger to the patient or the X-ray tube such as might be caused by excessive voltages. After the operator has once adjusted the pointer 37 and closed the switch 8, he may devote his entire attention to his patient without being bothered by watching a voltmeter or watch. The motor operated switch also prevents an underexposure, by prolonging the time the desired amount when the voltage is below normal.

My invention has been illustrated in connection with a motor having a speed characteristic which is directly proportional to the square of the voltage. However, it will be understood that in certain cases the nature of the load might be such that it would

be desirable to open or control the circuit in a time directly or inversely proportional to some other variable such as the first power of the voltage, the frequency, the current consumed by the load itself, etc in which case I would design the motor with the proper speed characteristic to produce the desired result.

Although I have illustrated my invention in connection with an alternating current source and an X-ray tube, it will be evident that the same operating mechanism might be used with a direct current motor of the watt hour type to control the operation of an electric heating circuit, for example, and the contacts at 6 might control the operating switch of such a circuit through a relay or relays where the current to be controlled is heavy or the voltage too high to be broken directly. By providing an automatic line switch in series with switch 41 controlled through a relay from the contacts 6, I might dispense with the electromagnet 34 and the disengaging feature of the gears and shut the motor down at the same time the circuit of the tube is opened, in which case the motor would be started simultaneously with the exposure by closing the switch 41. In some cases it might be desirable to provide two or more sets of contacts similar to the one shown at 6 arranged to be progressively operated by the same switch operating means.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A time limit circuit controller comprising a switch, an operating mechanism therefor adapted to be moved in one direction to actuate the switch to one position, a motor for actuating the mechanism, means for moving the mechanism in the opposite direction to allow the switch to move to another position, a normally disengaged gear drive between the motor and the mechanism, means for engaging the gear drive comprising an electromagnet, and means arranged after the switch has been actuated by said motor operated mechanism to prevent further movement of the mechanism while the motor and the electromagnet are energized comprising a mutilated portion in one of the gears of the driving connection.

2. A time limit circuit controller comprising a normally closed switch, an operating mechanism therefor adapted to be moved in one direction to open the switch, resilient

means for moving the mechanism in the opposite direction to allow the switch to close, an induction disc motor for moving the mechanism in the direction to open the switch, a normally disengaged gear drive between the motor and the mechanism, an electromagnet having a pivoted armature arranged on movement to the attracted position to effect the engagement of the gear drive, and means arranged after the switch is opened to prevent further movement of the mechanism in the switch opening direction while the motor and the electromagnet are energized comprising a blank portion in one of the gears of the driving connection.

In witness whereof, I have hereunto set my hand this 29th day of December, 1921.

CHESTER I. HALL