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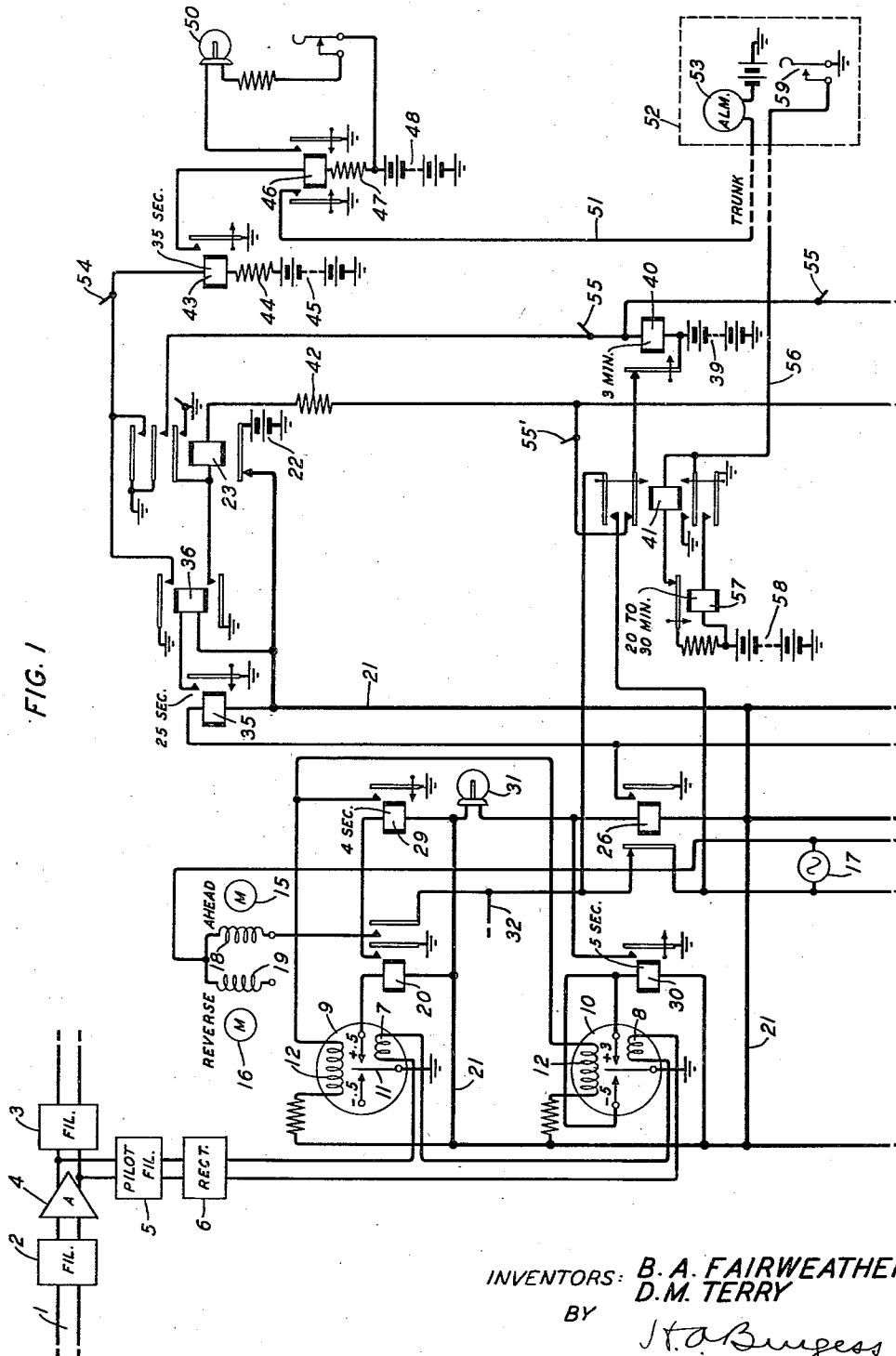
B. A. FAIRWEATHER ET AL

2,251,044

REGULATOR SYSTEM

Filed Aug. 22, 1940

2 Sheets-Sheet 1



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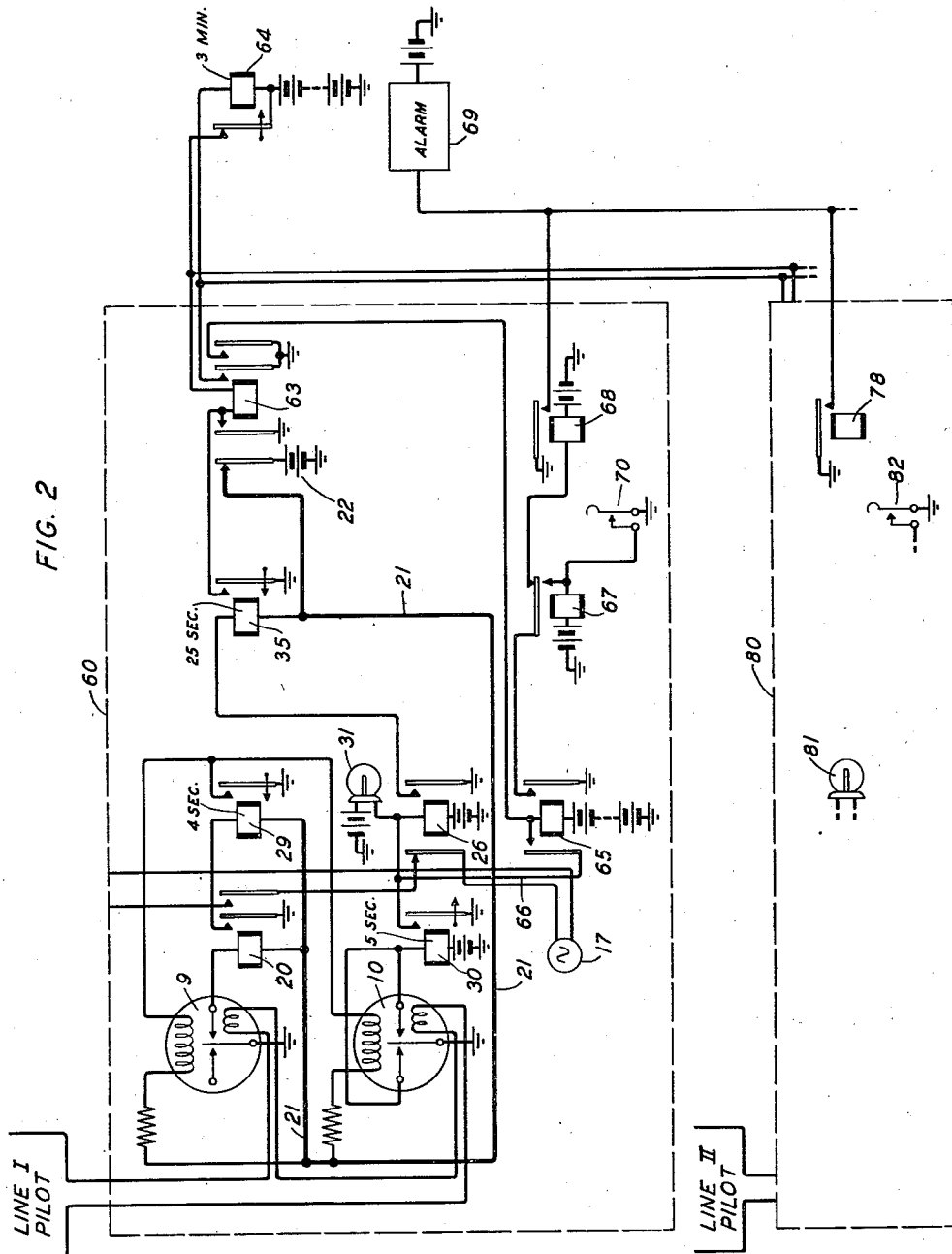
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UNITED STATES PATENT OFFICE

2,251,044

REGULATOR SYSTEM

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3 Claims. (Cl. 177-311)

The present invention relates to regulating systems for transmission lines and particularly to improvements in such systems for increasing their reliability and efficiency.

While the invention is capable of general application it will be disclosed specifically in connection with an automatic gain control system for a carrier current line in which the gain of an amplifier in the line is automatically controlled in response to level changes on the line so as to maintain the transmission level substantially constant.

It is customary in systems of this kind to have a number of unattended repeater stations along the line between attended points, such as main repeater stations or terminals. It is desirable to make the apparatus at the unattended stations relatively simple and highly reliable in operation. In a known type of system the apparatus at an unattended station comprises an automatic gain control mechanism for the repeaters and an alarm circuit for disabling the regulating mechanism under abnormal line conditions and transmitting an alarm to the nearest attended station. The abnormal conditions may be brought about by sleet storms, severe wet weather conditions or the formation of ice on the lines. It is desirable that the alarm be actuated as soon as an abnormal condition develops and maintained as long as the abnormal condition continues. It is important from the standpoint of reliability that the alarms should be given only when there is actually an alarm condition.

It is usual to employ a small 24-volt storage battery at the unattended stations to furnish operating current for the various relays and similar devices and to employ a larger battery of 150-volts to supply cathode heating current and plate voltage to the repeaters.

In accordance with the present invention, efficiency and reliability are increased by means of special alarm control circuits which reduce unnecessary operation of the regulating and alarm circuits to a minimum. This has several important effects. First, the battery drain on the 24-volt battery is reduced to a minimum, thus permitting the use of a relatively small size battery with safety. Second, by reducing the wear and tear on the regulating and alarm operating mechanism, faulty operation is minimized and reliability improved.

In the case of a main station, it is also desirable to reduce battery drain even though larger size batteries are usually employed at attended stations than at unattended stations. It

is also desirable to reduce unnecessary operation of the relays and other mechanism to save wear and tear and particularly to reduce the "clacking" of the special relays used for alarm and regulation control, of which there may be a large number, covering many systems, at a terminal or main repeater station.

The nature of the invention and its various objects will be more clearly brought out in the following detailed description together with the accompanying drawing, in which:

Fig. 1 is a circuit diagram in simplified schematic form of the regulator apparatus at an unattended station; and

Fig. 2 shows a similar diagram of the regulating apparatus at a main station.

While the invention is not restricted to the use of specific regulator apparatus, the following description will assume that the regulating equipment is of the general type disclosed in Terry Patent 2,084,115, June 15, 1937, in that a sensitive relay and a relatively insensitive relay, both of special construction, are employed to control the regulating operations and to distinguish between normal and abnormal transmission conditions on the line.

Referring to Fig. 1, a portion of transmission line 1 is shown leading through filters 2 and 3 and amplifier 4. This line may comprise the eastward side of a repeater, for example, in which filters 2 and 3 are the directional filters for separating the eastward channels from the westward channels in accordance with the usual practice. In the output of amplifier 4, pilot frequencies are received by means of pilot filter 5 leading to rectifier 6, the output of which includes in series the operating windings 7 and 8 of the two relays 9 and 10. These relays are assumed to be of the special type disclosed in the Terry patent and to consist of an armature 11 which can be moved to the right or the left under the control of the operating winding, where it remains in contact until it is restored to mid-position by a plunger (not shown) operated by restoring winding 12.

Relay 9 is relatively sensitive and closes its contacts in response to a level change of plus or minus 0.5 decibel. This relay controls the gain regulation.

Relay 10 is relatively insensitive and does not close its contacts except for a change of transmission level of minus 5 decibels or plus 3 decibels. This relay controls the alarm circuit.

The regulating mechanism is not shown complete herein but is assumed to be of the same

type as disclosed in the Terry patent except for the use of delayed action pulsing relays instead of cam controlled contacts for timing the operating cycle, as will be described. The regulation itself is carried out under control of two motors indicated at 15 and 16 (which may in practice be a single motor with two separate fields) rotatable in opposite directions and driven from a common source of alternating current shown at 17. When source 17 is connected in circuit with field winding 18 of motor 15 the regulator is advanced, reducing the gain. When source 17 is connected in circuit with field winding 19 of motor 16 the regulator is retarded. The motors may be assumed to move an arm for regulating the attenuation of a network in the line as disclosed in the Terry patent.

So long as the line level conditions remain within the regulating range, relay 9 may become operated but relay 10 does not operate. For an increase of line level the pilot current increases in strength and relay 9 closes its right-hand contact energizing relay 20 from ground at the armature 11 of relay 9 to the battery bus 21 which leads eventually to the 24-volt battery 22 through back contacts of relay 23. Relay 20 in operating connects source 17 in circuit with winding 18 of motor 15 to move the regulator ahead, this circuit extending through back contact of relay 26 in the alarm control circuit. Relay 20 also energizes relay 29 which, however, requires a period of 4 seconds to close its contact. The motor 15 is allowed, therefore, to rotate for a period of 4 seconds at the end of which relay 29 closes its contact and energizes the restoring winding 12 of relay 9 to restore the relay tongue to its mid-position. The circuit for the restoring winding is from ground at the armature of relay 29 through winding 12 to battery bus 21. When the tongue 11 of relay 9 leaves its right-hand contact, relay 20 immediately releases and restores relay 29. If the movement of the regulator has not fully compensated for the assumed increase in line level, relay 9 again closes its right-hand contact and the foregoing cycle of operations is repeated. This action continues until the pilot current through winding 7 has such value that the tongue 11 of relay 9 remains in its central position. It will be understood that for a decrease of line level of .5 decibel relay 9 would close its left-hand contact and a relay similar to 20 but not shown would cause motor 16 to operate to readjust the line level to normal value. For simplicity of showing, the mechanism for doing so has been omitted but can be supplied by duplication of the circuits shown or by reference to the Terry patent cited.

If the line level changes by as much as minus 5 decibels or plus 3 decibels, relay 10 closes one or the other of its contacts and energizes relay 30 over a circuit from ground, contact of relay 10, winding of relay 30 to battery bus 21. Relay 30 immediately attracts its armature and causes relay 26 to operate and an alarm lamp 31 to light to indicate an alarm condition in case a visiting attendant happens to be at the station at the time. Relay 26 at its left armature opens the energizing circuit for the regulating motors, thus preventing any attempted regulation. (This relay controls the supply of operating current for both motors, the branch for motor 16 being indicated at 32.) Relay 26 at its right-hand armature and contact closes an energizing circuit for alarm delay relay 35 which requires 25 seconds to close its contact.

The relays having considerable delay in their operate or release time may be of any suitable construction, such as plunger and dash-pot type, one example being a relay known to the trade as the "Adlake" relay manufactured by the firm of Adams and Westlake, Elkhart, Indiana. This relay contains an iron plunger floating in a mercury pool, the surface of the mercury rising or falling as the armature is moved and the rate of movement of the surface of the mercury being controlled by partially trapped gas. Such a relay can be adjusted to various operate or release times.

The immediate effect of occurrence of abnormal transmission level as above indicated is, therefore, to stop the regulating action, to light the alarm lamp 31 and to start energization of alarm delay relay 35 which after a delay of 25 seconds closes its contact and energizes relay 36.

Relay 36 over its lower armature energizes relay 23 by a circuit which extends to 150-volt battery 39 over the back contact of relay 40 and the back contact of relay 41 and resistance 42. Relay 23 locks up to ground over its upper inner armature and front contact. Relay 23 at its lower armature and contact cuts battery 22 off from battery bus 21, thus depriving all of the relays energized from the 24-volt battery 22 from their operating current. Relay 23 at its upper middle armature and front contact closes an energizing circuit for relay 40 to battery 39 but this relay requires 3 minutes to break its back contact.

Relay 36 when it operates also closes a circuit at its upper armature for energizing relay 43 through resistance 44 to the 150-volt battery 45 (which in reality is the same battery as 39). Relay 23 upon energizing substitutes a ground for this circuit at its uppermost armature and front contact so as to maintain relay 43 operated after battery 22 is cut off from bus 21 deenergizing relay 36. Relay 43 in energizing causes relay 46 to operate over resistance 47 to 150-volt battery 48 (which in reality is the same battery as 39). Relay 46 at its right-hand armature closes circuit for lamp 50 causing this lamp to light and at its left-hand armature supplies ground over conductor 51 which leads over the trunk to the distant attended station diagrammatically indicated at 52 where alarm 53 is actuated.

It will be noted that relays 40 and 43 are common to a number of repeaters or lines which may pass through the unattended station, this being indicated by the branch conductors at 54, 55 and 55'. The lamp 31 is individual to the repeaters 2, 3, 4, whereas the lamp 50 is common to a group of repeaters or lines but does not indicate the particular repeater or line on which an alarm condition exists. Likewise, the alarm 53 is common to the group of repeaters or lines at the unattended station, which group may comprise part or all of the repeaters or lines at the unattended point.

At the end of the 3-minute interval, relay 40 opens its back contact, thereby cutting off current from relay 23 which immediately restores and reapplies current from battery 22 to battery bus 21. Relay 23 in deenergizing also opens the energizing circuit of relay 40 which immediately closes its back contact. Relay 23 also opens the energizing circuit for relay 43 but this relay will not open its contact for a period of 35 seconds.

If at this time the alarm condition has ceased, the tongue of relay 10 is open and the regulator circuit will proceed to function normally and

after a period of 35 seconds relay 43 will release its armature (provided there is not an alarm condition on some other circuit holding this relay operated over conductor 54) and alarms 50 and 53 will be canceled by deenergization of relay 46. When relay 29 first closes its contact after the battery comes back on the circuit, it supplies restoring current to the restoring coil 12 of relays 9 and 10. Relay 30 will release after 5 seconds, opening the circuit through relay 26 and lamp 31. The lamp extinguishes and relay 26 restores operating current from generator 17 to the control circuit for the regulating motors.

However, if at this time the alarm condition still exists, relay 10 will be energized as before and relays 30 and 26 in succession will cause energizing current to be applied to the winding of relay 35 which after 25 seconds will cause relays 36 and 23 to energize in turn, thus reapplying ground to the winding of relay 43 before that relay has had time to open its contact. The alarm indication is thus maintained at 50 and at 53. Relay 23 as before cuts off battery supply to the battery bus 21 and restarts the 3-minute interval which is determined by the operating time of relay 40.

In this way during a prolonged alarm condition the alarm circuit relays are deprived of current for approximately 3 minutes out of each 3½ minute period but the indication of the alarm condition is maintained continuous.

In case an attendant at station 52 desires that the regulator continue functioning during an abnormal line level condition, he may close key 59 and supply ground over the trunk conductor 56 to winding of relay 41, back contact of relay 57 to 150-volt battery 58 (which may be the same battery as 39). Relay 41 immediately energizes and at its upper armature and front contact closes a shunt around the back contact of relay 26, thus preventing that relay from disabling the energizing circuit for the regulating motors. Relay 41 at its inner upper armature and back contact opens the energizing circuit of relay 23, thus preventing that relay from depriving the regulating and alarm circuits of 24-volt battery supply. Relay 41 locks itself up over its inner lower armature and front contact and also closes an energizing circuit for relay 57 at its lowermost armature but relay 57 is so adjusted as to require from 20 to 30 minutes to open its rest contact. This period, of course, may be widely varied as desired. In case the alarm condition exists for longer than the 20 or 40-minute interval, relay 57 will open its contact and restore relay 41, which then allows the alarm circuit to function as above described.

In the usual practice the repeater comprising the filters 2 and 3 and amplifier 4 is accompanied by a similar repeater for repeating in the opposite direction. It is assumed that such other repeater would have its own pilot channel regulating and alarm circuits, which may be duplicates of those shown, but certain of the apparatus of Fig. 1 is common to both repeaters as is indicated by the extension of the various leads downward at the bottom of the figure.

Referring to Fig. 2, the broken line rectangle 60 includes regulating and alarm circuits individual to line I at a terminating or attended repeater station, while the broken line rectangle 80 comprises similar apparatus individual to line II. This station also includes certain apparatus common to all of the lines or to a group of lines as indicated to the right of enclosures 60 and 80.

Considering the apparatus associated with line I, this will be recognized by similarity of reference characters to be similar, in general, to that of Fig. 1. For example, relay 9 controls the regulation and relay 10 is the alarm relay. The regulation may proceed exactly as described in the case of Fig. 1. In an alarm condition, relays 30, 26 and 35 and lamp 31 operate as before. At the end of the 25-second interval relay 35 energizes relay 63 in series with the back contact of relay 64 which requires 3 minutes to attract its armature. Relay 63 at its outer left armature and back contact cuts battery 22 off from battery bus 21 and its inner left armature closes a locking circuit for itself to ground. Relay 63 at its inner right armature starts the energization of relay 64 which, as stated, requires 3 minutes to operate its contact. Relay 63 at its outer right armature closes a circuit for relay 65 which at its left armature is locked up on ground from relay 30. It should be noted that battery on relays 30 and 26 has not been cut off by relays 63 and that lamp 31 is maintained operated. Relay 65 at its right-hand armature closes a circuit for relay 68 over the back contact of relay 67 and relay 68 on energizing actuates alarm 69 which may be a bell or other audible alarm.

At the end of the 3-minute interval relay 64 opens its contact and deenergizes relay 63 which reapplies battery to battery bus 21. If the alarm condition is still existent, relays 30 and 26 which will have continued in operation along with lamp 31 will after a period of 25 seconds reoperate relay 35 which again starts the 3-minute interval determined by the time required to operate relay 64. Relay 65 continues in operation during the alarm condition, in fact until relay 10 has been restored for 5 seconds.

If an attendant desires to silence the alarm 69 he may close key 70, energizing relay 67, which opens the circuit of relay 68, thus breaking the alarm circuit provided no alarm is present on the other lines to which alarm 69 is common. Individual circuit lamp 31 continues in operation during alarm condition along with relays 30, 26 and 65. Relay 67 locks itself up over front contact of relay 65. One advantage of this arrangement is that the alarm 69, which may be a bell audible throughout the main station, can be silenced without extinguishing the lamp 31 which continues to glow identifying the particular line that is in trouble.

It will be observed from the foregoing that if an alarm condition exists on line II lamp 81 in rectangle 80 is illuminated, relay 78 is energized and the alarm 69 is sounded. Also, relay 64 starts to energize and the same cycle of operations is carried out as in the case of rectangle 60. The operator by depressing key 82 can silence the alarm 69 but identifying lamp 81 remains lighted.

In a station comprising a large number of lines the clacking of the restoring plunger on relays 9 and 10 is not only very disturbing but an unnecessary amount of such operation produces useless wear and tear on the relays themselves. The circuits described reduce this to a minimum and at the same time conserve drain on the battery. This latter feature is not as essential at a main station as at an unattended station, since 24-volt batteries of large load capacity are commonly used at main stations. However, it is advantageous even in these cases to reduce battery drain as much as possible.

The invention is not to be construed as limited

to the specific circuits that have been disclosed since these are to be taken as illustrative rather than limiting. The scope of the invention is defined in the appended claims.

What is claimed is:

1. In a level regulating system for a transmission line, a regulator operating in response to line current to maintain constant transmission level, a control circuit therefor, an alarm and a circuit for operating the same in response to abnormal level conditions on said line, a battery for furnishing current to said control circuit and alarm circuit, and means to reduce drain on said battery during abnormal line level conditions comprising means energized independently of said battery for setting said alarm into operation and maintaining it operated and for cutting off battery supply to said control circuit and alarm circuit, including means for periodically restoring said battery supply for short periods to test whether said abnormal line level condition persists.

2. In a regulating system, a regulator having a normal range of adjustment including a plurality of relays and an operating circuit therefor, an alarm and an alarm circuit including a plurality

of relays, means for bringing said alarm circuit into operation only when said normal range of adjustment is exceeded, a battery for furnishing operating current to the operating circuit of said regulator relays and to said alarm circuit, and means for conserving drain on said battery during an alarm condition comprising timing mechanism energized independently of said battery, and means initiating operation of said timing mechanism in response to an alarm condition, said timing mechanism including means for cutting off battery supply to said regulator operating circuit and to said alarm circuit for relatively long recurrent intervals and restoring battery supply to said regulator operating circuit and alarm circuit for intervening relatively short periods.

3. The combination according to claim 2, including means for operating said alarm in response to an alarm condition and continuously for the duration of said alarm condition, said last means being controlled in part by said timing means.

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