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3,496,337

SEQUENCING CIRCUIT FOR POWER
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11 Claims

ABSTRACT OF THE DISCLOSURE

A control circuit for sequentially energizing heating mats in response to both conventional thermostats, and also in response to a desired range of supply line current. An ammeter in the supply line has a first and a second set of contacts which are set to open in response to current values which exceed a peak current and an operating current respectively. A first circuit, associated with the closing of both sets of contacts, energizes the heating mats successively through mechanical timers associated with each mat or group of mats. A second circuit, associated with the closing of only said first set of contacts, energizes only those mats already producing heat.

SUMMARY OF INVENTION

This invention relates to electric circuitry for controlling the operation of a plurality of electric power consuming devices, and deals more particularly with a circuit capable of sequentially energizing said devices until the current flow in a supply line exceeds a predetermined operating current, and for maintaining said devices on the line until the current flow exceeds a predetermined maximum, or peak current.

The object of the present invention is to provide a control circuit for operating a plurality of electrical power consuming devices, which circuit is made up of readily available inexpensive components.

A more specific object of the present invention is to provide a circuit of the foregoing character in which a current limit controlling ammeter, and a plurality of mechanical clock type timers, are electrically interconnected by use of a plurality of conventional relay to provide a control circuit heretofore thought to require more exotic vacuum tube or transistorized control circuits.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE 1 shows, in schematic fashion, a presently preferred embodiment of the present invention.

DETAILED DESCRIPTION

Turning now to the figure in greater detail, high current supply line, indicated generally at 10, comprises two conductors which represent a power line which may be single, double or three phase depending on the requirements of a particular installation. A limit controlling ammeter 20 is so arranged, with respect to the supply line 10, as to provide an instantaneous read out of the current therein. Preferably, the ammeter 20 comprises an alternating current instrument of the type having internal photo-electric cells which operate relays so as to open and close associated relay contacts corresponding to particular values of current. Such an instrument is manufactured by the Simpson Electric Co. and is currently sold by them to the trade under Model No. 334XA. This particular instrument has high limit and low limit contacts, represented in the drawing by the normally open limit switches LS-1 and LS-2 respectively. The high limit switch, or contact LS-1, is preferably preset to open with

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a current of over 360 amperes, while the low limit switch, or contact LS-2, is corresponding set to close should the current drop below 280 amperes, or substantially 80% of 360 amperes.

The supply line 10 is electrically connected to a plurality of power consuming devices, which devices comprise heating units 12, 14, 16 and 18, through a plurality of contacts 23, 25, 27 and 29 associated with the contactor relays CR-6, CR-7, CR-8 and CR-9, respectively. Each of the heating units may be individually thermostatically controlled by conventional thermostats as indicated at T-1, T-2, T-3 and T-4. The contactor relays CR-6, CR-7, CR-8, and CR-9 are provided in a control circuit, to be described, and it is noted that line 22, associated with contactor relay CR-6, closes associated relay contacts 23, 23 causing heating unit 12 to operate provided only that heat is called for by the thermostat T-1. So too, whenever electrical energy is available in branch line 24, contactor relay CR-7 will be energized closing its contacts 25, 25 and activating heating unit 14. Contacts 27, 27 and 29, 29 control the operation of heating units 16 and 18 respectively in response to the provision of electrical energy in the branch lines 26 and 28 respectively.

In accordance with the present invention, each of the above mentioned branch lines 22, 24, 26 and 28 of the control circuit is adapted to be energized in a particular order when both LS-1 and LS-2 are closed, and to remain in an energized condition once having been energized when LS-2 opens and LS-1 remains closed. A first, or holding circuit, to be described is associated with the latter condition. In order to accomplish the sequential energizing of each of the above mentioned branch lines 22, 24, 26 and 28, a plurality of mechanical timing devices 30, 32 and 34 are provided in a second, or arming circuit, associated with the closing of both LS-1 and LS-2.

When both LS-1 and LS-2 are closed, it will be apparent that the current in the supply line 10 is below the operating current so that additional heating units can be placed on the line without the probability of exceeding the maximum, or peak current, mentioned above. More particularly, when LS-1 and LS-2 are closed, branch line 36 is energized, energizing a primary control relay CR-5 closing its associated contacts 38 and energizing control relay CR-1 and closing contacts 43 in branch line 40. The normally open contacts 42 associated with control relay CR-1 will therefore close energizing branch line 28 placing heating unit 18 on the line.

Still with reference to the second circuit associated with the closed position of switches LS-1 and LS-2, a normally open set of contacts 44, associated with control relay CR-5 will also be closed initiating the mechanical operation of the clock-timer 30. When the timer 30 has timed out, as for example when a preset time of several minutes has elapsed, a set of timer contacts (not shown) closes, energizing control relay CR-2 and energizing branch line 22 associated with heating unit 12. Once the timer contacts associated with timer 30 have closed, the timer is returned to its initial position so as to be ready for another cycle of operation. Once control relay CR-2 is energized, its contacts 46 associated with the first circuit in electrical parallel with the timer 30 cause the branch line 22 to remain energized, provided only that LS-1 remains closed, and the thermostat T-1 continues to call for heat.

Still with reference to the second circuit mentioned above, the timer contacts associated with timer 30 are also used to initiate the next succeeding timer 32. The contacts 48 associated with control relay CR-5 are so arranged that before the timer 32 is initiated LS-2 must also be closed requiring that the current in supply line 10 be below the operating current level set in the current responsive ammeter. If the current in supply line 10 is

below the operating current the contacts 48 will be closed and if the timer contacts associated with timer 30 have been closed, timer 32 will be electrically initiated so as to time out after a predetermined number of minutes closing its associated contacts (not shown). Closing of the timer contacts associated with timer 32 energizes control relay CR-3 and energizes branch line 24 associated with heating unit 14.

Control Relay CR-3 has contacts 50 associated therewith which insure that once contactor or relay CR-7 in branch line 24 is energized, heating unit 14 will continue to operate and will be held on even though the current in the supply line 10 goes above the operating current level set in LS-2. This holding function is accomplished by the first circuit, mentioned above, which only requires that LS-1 be closed, and that heating unit 14 be operating in order to continue in operation as required by thermostat T-2.

To illustrate the pattern followed in the first and second circuits described above, a third timer 34 is shown in series with timer 32 for energizing branch line 26 associated with heating unit 16. This timer 34 operates in the same manner as the timers 30 and 32 just described, said timer 34 having contacts 52 associated therewith and with control relay CR-5 and having a control relay CR-4 with contacts 55 associated therewith in the first, or holding circuit.

In conclusion then it will be apparent that the control circuitry described herein permits the regulation of electric current for operating power consuming devices, such as heating units, with the supply line current maintained between well defined limits. Basically, this is accomplished by providing alternate circuits, one of which is closed whenever the current is below a first or maximum value, and the other of which is closed whenever the current is below a second or operating value. A plurality of mechanical clock type timers is provided in series in an arming circuit for sequentially energizing contactor relays CR-6, CR-7 and CR-8 until either the current exceeds the operating value, or until the thermostats T-1, T-2 and T-3 are satisfied. Having once been energized, each contactor relay remains energized even though the current level in the supply line 10 exceeds the operating value preset in LS-2 through a unique holding circuit associated with the arming circuit.

The peak current in line L-1 bears a readily predictable relationship to the maximum power level, in kilowatts, provided by the electric utility company at a particular rate. For example, if I_{max} =this peak current, E =line voltage, and K =a constant which is proportional to the power factor, it is well known that $P_{max}=EI_{max} K$. Since E and K are relatively constant, I_{max} can be seen to be directly proportional to P_{max} .

I claim:

1. Control circuitry for selectively connecting a plurality of electric power consuming devices to a supply line, said circuitry including means responsive to the current level in said supply line for closing a first circuit when said current is below a first value and closing a second circuit when the current is below a second value lower than said first value, contactor relays which are energized by said first and second circuits, said contactor relays having contacts associated with said supply line for connecting said devices thereto, a plurality of timers each of which is adapted to be electrically initiated and has contacts associated therewith which close upon the expiration of a predetermined time delay, all of said timers being arranged in series in said second circuit so that when one set of timer contacts closes a succeeding timer is initiated, each of said timer contacts upon closing serving to energize at least one of said contactors relays, and control relay means in said first circuit for maintaining said control relays in an energized condition once each is energized through said timer contacts in said second circuit, said contactor relays remaining so energized serv-

ing to hold said certain devices connected to said supply line.

2. Control circuitry as set forth in claim 1 and further characterized in that said timers are of a mechanical clock-type and can be preset manually to time out after any desired number of minutes.

3. Control circuitry as set forth in claim 1 and further characterized in that said current responsive means comprises an ammeter having switching means associated therewith, said switching means being in circuit with said first and second circuits for opening and closing said circuits in response to said current values in said supply line.

4. Control circuitry as set forth in claim 1 and further characterized in that said control relay means comprises a plurality of control relays one of which is energized whenever said first and second circuits are closed by said current responsive means, a control relay in series with each of said timer contacts, each of said last mentioned timer associated control relays having contacts in said first circuit which are in electrical parallel with associated timer contacts, said one control relay having contacts which close a branch of said second circuit to energize at least one of said contactor relays, and means for holding said one control relay in an energized condition once it has been so energized until said second circuit opens as a result of the current in said supply line exceeding said first value.

5. Control circuitry as set forth in claim 4 and further characterized in that said means for holding said one control relay in an energized condition comprises a primary control relay in said first circuit, said primary relay being energized whenever said first and second circuits are closed by said current responsive means, said primary relay being deenergized whenever said current exceeds said second value, and said primary relay having contacts in series with the contacts associated with each of said timers in said first circuit whereby said timer associated control relays can be successively energized to hold said contactor relays in an energized condition until said second circuit is opened by reason of said current exceeding said first value.

6. Control circuitry as set forth in claim 5 and further characterized in that said power consuming devices comprise heat generating mats, and a plurality of thermostats associated with said mats for regulating said contactor relays in response to the heating requirements of the space mats.

7. Control circuitry as set forth in claim 6 and further characterized in that said timers are of the mechanical clock-type and can be preset manually to time out after any desired number of minutes.

8. Control circuitry as set forth in claim 7 and further characterized in that said current responsive switching means can be preset to open and close said first circuit when said line current value is respectively above and below a maximum current (I_{max}) computed from the following formula:

$$I_{max} = \frac{P_{max}}{EK}$$

P_{max} =the maximum power level in kilowatts provided by the Electric Utility Company at a particular rate and above which power level a penalty charge is levied, and

E =the nominal line voltage, and

K =a constant related to the power factor.

9. Control circuitry as set forth in claim 8 and further characterized in that said current responsive switching means can be preset to open and close said second circuit when said second current value is respectively above and below an operating current (I) which is substantially 80% of I_{max} .

10. Control circuitry for a plurality of electric power consuming devices, said circuit including contactor relays

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for selectively connecting each of said devices to a supply line, means responsive to the current in said supply line for closing a first circuit and energizing certain of said contactor relays when the current is below a first value, said current responsive means also serving to close a second circuit when the current is below a second value lower than said first value, a plurality of timers each of which is adapted to being electrically initiated and has a set of contacts associated therewith which close upon the expiration of a predetermined time delay, all of said timers being arranged in series in said second circuit so that when one set of timer contacts closes a succeeding timer is initiated, and each of said timer contacts upon closing serving to energize at least one of said contactor relays so that said power consuming devices are sequentially connected to said supply line until said supply current exceeds said second value at which time said second circuit is opened and only those contactor relays in said first circuit are energized.

11. Control circuitry as set forth in claim 10 and 20 307—41; 219—485

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further characterized by control relay means in said first circuit for maintaining said contactor relays in an energized condition once each is energized through said timer contacts in said second circuit, said contactor relays which remain so energized comprising said certain contactor relays in said first circuit.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 45, "convention1" should read -- conventional --; line 50, "The Figure 1" should read -- The Figure --; line 68, "334XA" should read -- 3343XA --. Column 2, line 2, "corresponding" should read -- correspondingly --; line 16, "unit1" should read -- unit --; line 48, "reefreence" should read -- reference --; line 52, "clock-timer" should read -- clock-type timer --. Column 3, line 73, "control" should read -- contactor --. Column 4, line 24, "elast" should read -- least --; line 40, "contractor" should read -- contactor --; line 48, "space mats" should read -- space adjacent said mats --; line 60, after the formula insert -- , where; --.

Signed and sealed this 25th day of August 1970.

(SEAL)

Attest:

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