# United States Patent [19]

**Hardin**

[11] **3,824,860**

[45] **July 23, 1974**


[54] **TIME SCHEDULE CONTROLLER AND PARTS AND HOUSING THEREFOR**


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[73] Assignee: **Robertshaw Controls Company,** Richmond, Va.



[22] Filed: **Feb. 20, 1973**

[21] Appl. No.: **333,531**

**Related U.S. Application Data**

[62] Division of Ser. No. 187,641, Oct. 8, 1971, Pat. No. 3,730,427.

[52] **U.S. Cl.** ..... **73/431,** 116/129 B, 220/30

[51] **Int. Cl.** ..... **G01p 1/06**

[58] **Field of Search** ..... 73/431, 273; 220/30; 403/335, 354, 361; 58/56; 346/17; 64/4, 6



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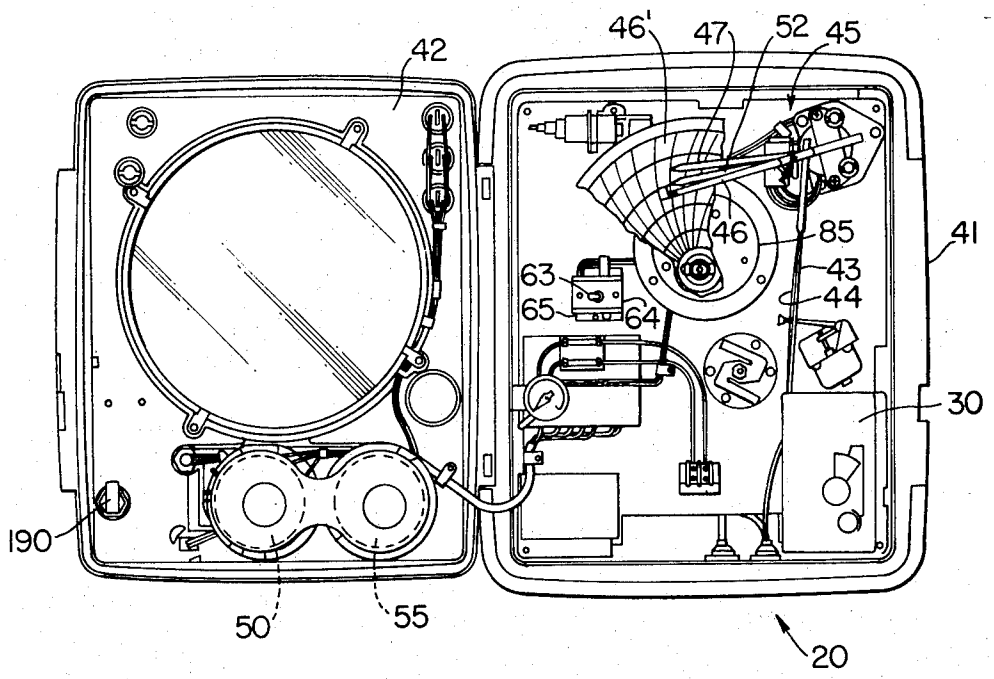
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*Assistant Examiner*—Daniel M. Yasich
*Attorney, Agent, or Firm*—Candor, Candor & Tassone



[57] **ABSTRACT**

A time schedule controller wherein the high limit index and the set point index respectively have members movable therewith and alignable in relation to each other only when the set point index reaches the setting of the high limit index. An actuator for terminating the operation of the set point index in the rate of rise thereof is only actuated when the alignable members of the high limit index and the set point index that are operatively associated therewith are in their aligned relation thereof.


**5 Claims, 15 Drawing Figures**



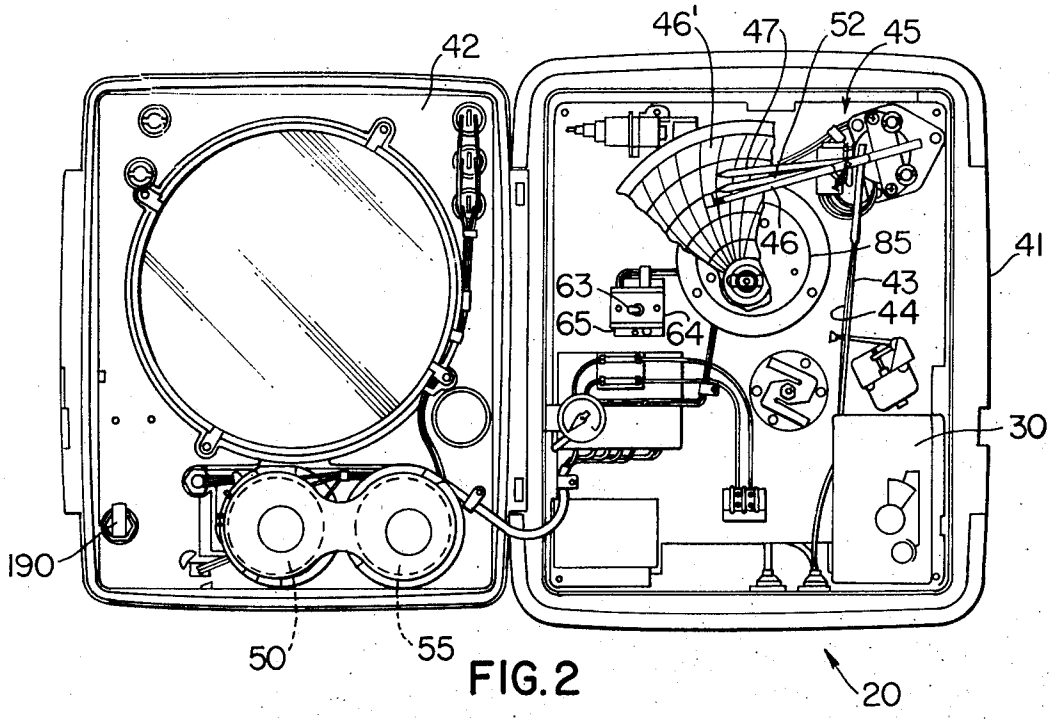

42
46'
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FIG. 2

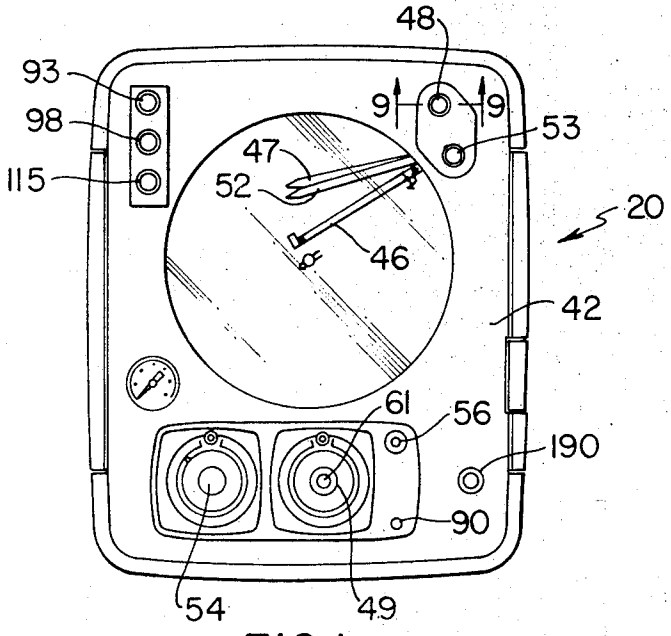

48
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FIG. 1

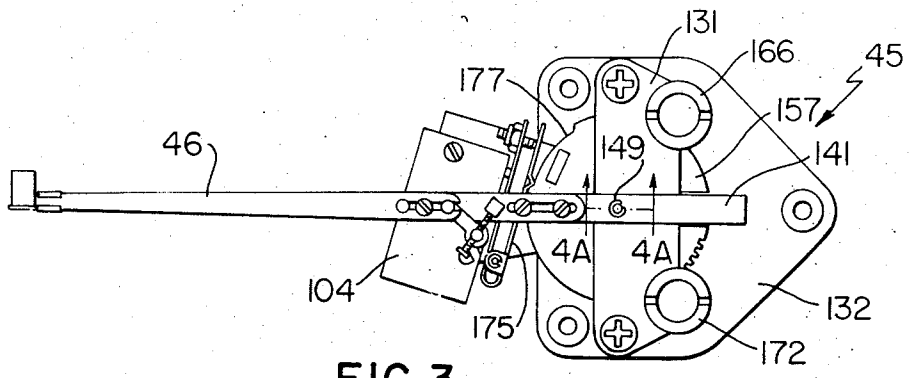



FIG. 3

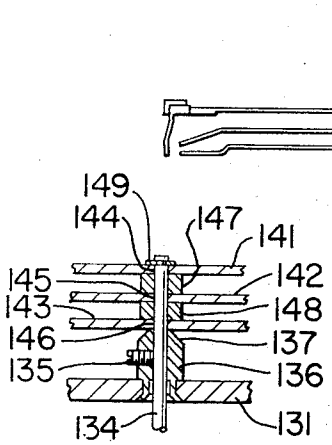



FIG. 4A




FIG. 4

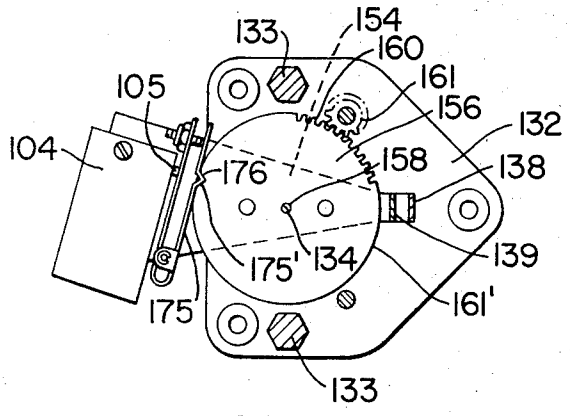



FIG. 5

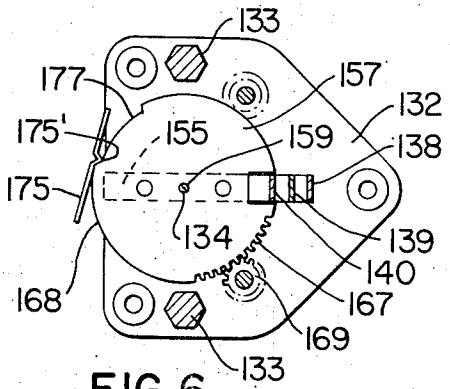



FIG. 6

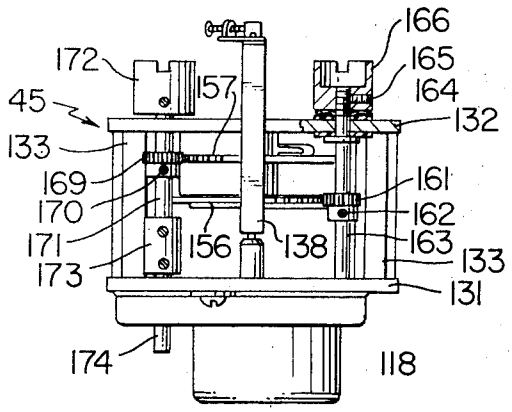



FIG. 8

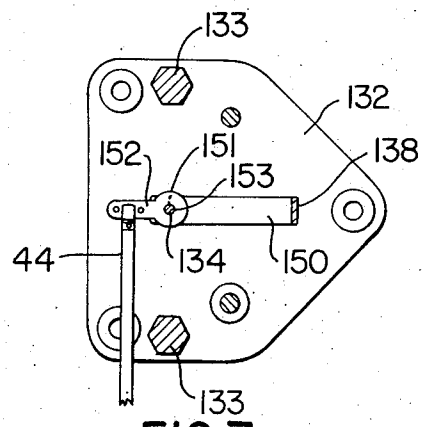



FIG. 7

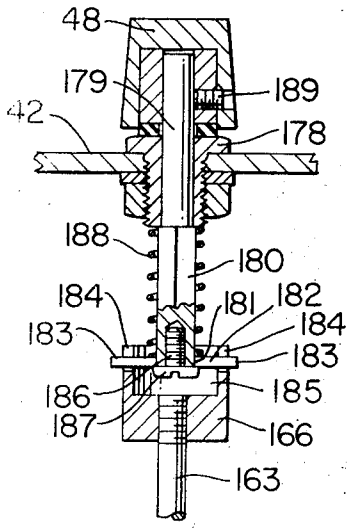



FIG. 9

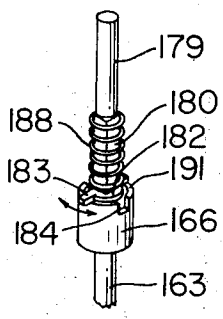



FIG. 10

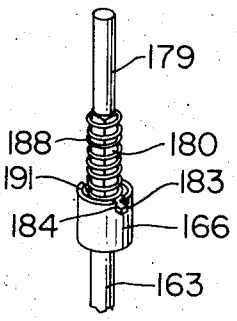



FIG. 11

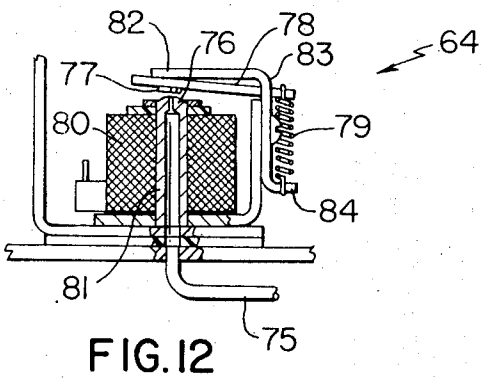



FIG. 12

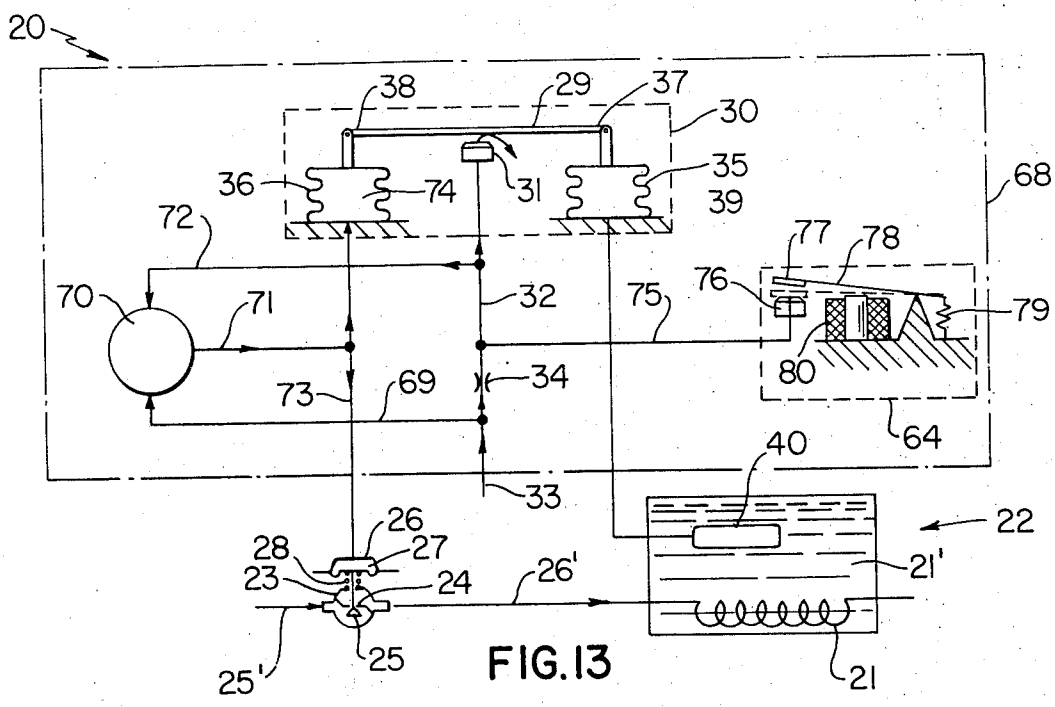

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FIG.13

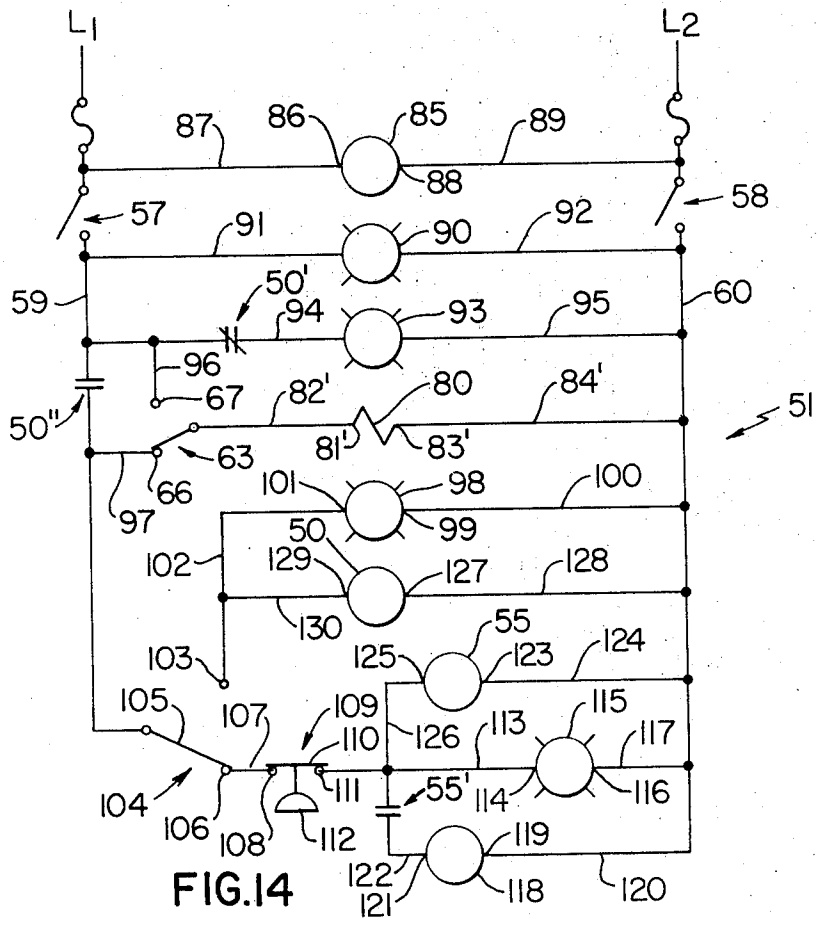

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FIG.14

# TIME SCHEDULE CONTROLLER AND PARTS AND HOUSING THEREFOR

This is a division of application, Ser. No. 187,641, filed Oct. 8, 1971, and now U.S. Pat. Ser. No. 3,730,427.

## BACKGROUND OF THE INVENTION

Time schedule controllers have been provided wherein each controller is adapted to be set for an initial starting condition of and for a controlled rate of rise of a set point index thereof so that a controlled device, such as a heat exchanger, will have the output effect thereof until the set point index reaches a set high limit index point at which time the controller will automatically cause the output effect of the controlled device to remain at the high limit thereof for a period of time as set by a hold timer of the controller followed by an automatic shutdown of the operation of the controlled device at the end of the predetermined hold period of the controller. Various means have been provided in such time schedule controllers to accomplish these automatic functions.

## SUMMARY

This invention provides an improved time schedule controller of the above-described type having improved means for controlling the manual or automatic sequence of operation thereof.

This invention also provides an improved time schedule controlled system as well as improved parts for such a time schedule controller or the like.

In particular, one embodiment of the time schedule controller of this invention, wherein a high limit index is adapted to be set at a desired condition and the rate of rise of the set point index is adapted to be selected so that the controller will tend to maintain an output effect of a controlled device at the selected rate of rise of the set point index until the output effect reaches the set condition of the high limit index, comprises means movable with the high limit index and the set end point index and alignable in relation to each other only when the set point index reaches the setting of the set high limit index. Actuator means are provided for terminating the operation of the set point index in the rate of rise thereof when the actuator means is actuated, the alignable means of the high limit index and the set point index being operatively associated with the actuator means to actuate the same only when the alignable means are in the aligned relation thereof. In the embodiment of the time schedule controller of this invention, the alignable means of the set point index comprises a rotatable cam member movable in unison with the set point index and the alignable means of the high limit of the set high limit index comprises an electric switch movable with the high limit index so that the cam member of the set point index will only actuate the electric switch when the same is aligned with the electric switch, as will be apparent hereinafter.

The time schedule controller of this invention also has improved means for setting the indexes thereof in the desired initial set positions thereof.

Accordingly, one of the objects of this invention is to provide an improved time schedule controller having one or more of the novel features set forth above or hereinafter shown or described.



Another object of this invention is to provide an improved time schedule controlled system utilizing such a time schedule controller or the like.

Another object of this invention is to provide improved parts for such a time schedule controller or the like.

Other objects, uses and advantages of this invention are apparent from a reading of this description, which proceeds with reference to the accompanying drawings forming a part thereof and wherein

## DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of the time schedule controller of this invention.

FIG. **2** is a view similar to FIG. **1**, with the front cover of the time schedule controller in an open position thereof and with certain parts inside the time schedule controller being broken away.

FIG. **3** is an enlarged, fragmentary view of the bridge and pen assembly of the controller of FIG. **1**.

FIG. **4** is a side view of the bridge and pen assembly of FIG. **3**.

FIG. **4A** is an enlarged fragmentary cross-sectional view taken substantially on line **4A—4A** of FIG. **3**.

FIG. **5** is a fragmentary, cross-sectional view taken on line **5—5** of FIG. **4**.

FIG. **6** is a fragmentary, cross-sectional view taken on line **6—6** of FIG. **4**.

FIG. **7** is a fragmentary, cross-sectional view taken on line **7—7** of FIG. **4**.

FIG. **8** is an end view of the bridge and pen assembly of FIG. **3**.

FIG. **9** is an enlarged, fragmentary, cross-sectional view taken on line **9—9** of FIG. **1** and illustrating the index adjusting means of the time schedule controller of this invention.

FIG. **10** is a fragmentary, perspective view illustrating the operation of the adjustment means of FIG. **9**, with the adjustment means being in one position thereof.

FIG. **11** is a view similar to FIG. **10** and illustrates the adjustment means being in another position thereof.

FIG. **12** is a fragmentary, cross-sectional view illustrating a solenoid operated valve means for the control system of the time schedule controller of this invention.

FIG. **13** is a schematic view illustrating the control system that is operated by the time schedule controller of this invention.

FIG. **14** is a schematic view illustrating the electrical circuit for the time schedule controller of this invention.

## DESCRIPTION OF ILLUSTRATED EMBODIMENT

While the various features of this invention are hereinafter described and illustrated as being particularly adapted to control the output temperature effect of a heat exchanger means, it is to be understood that the various features of this invention can be utilized singly or in any combination thereof to provide a time schedule control for other types of systems as desired.

Also, it is to be understood that the various parts of the time schedule controller of this invention can be utilized in other types of control instruments or devices, if desired.

Therefore, this invention is not to be limited to only the embodiment illustrated in the drawings, because

the drawings are merely utilized to illustrate one of the wide variety of uses of this invention.

Referring now to FIGS. 1, 2 and 13, the time schedule controller of this invention is generally indicated by the reference numeral 20 and is utilized to control the output temperature effect of a heat exchanger 21, FIG. 13, forming part of the controlled system of this invention that is generally indicated by the reference numeral 22 in FIG. 13.

The controlled system 22 includes a main steam valve 23 having a valve seat 24 for interconnecting a source of steam 25 to a conduit 26 leading to the heating coil of the heat exchanger 21, the valve seat 24 being opened and closed by a valve member 25 being positioned relative to the valve seat 24 by a pneumatically operated actuator 26 in a manner well known in the art whereby an increase of pneumatic pressure in the chamber 27 of the pneumatically operated actuator 26 will cause the valve member 25 to be moved further away from the valve seat 24 to admit more steam to the heat exchanger 21 and, conversely, a decrease in the pneumatic pressure in the chamber 27 of the actuator 26 will cause the valve member 25 to be moved closer to the valve seat 24 under the force of a compression spring 28 to decrease the amount of steam being directed to the heat exchanger 21. Thus, the output temperature effect of the heat exchanger 21 increases as the valve member 25 moves farther away from the valve seat 24 and decreases as the valve member 25 moves toward the valve seat 24.

While the particular process being heated by the heat exchanger 21 can vary, the heat exchanger 21 in FIG. 13 is illustrated as heating a dye bath 21' for dyeing textiles and the like.

As illustrated in FIG. 13, the controller 20 for the system 22 includes a balance beam 29 of a proportional mechanism 30 that is well known in the art and is therefore schematically illustrated in FIG. 13 as having a vent opening device or nozzle 31 for a conduit 32 that is adapted to be supplied fluid pressure from an external source 33 and has a restrictor 34 therein. The balance beam 29 is positioned relative to the vent or nozzle opening 31 by a process bellows construction 35 and a feedback bellows construction 36 respectively interconnected to opposed ends 37 and 38 of the balance beam 29. The process bellows 35 has the fluid in the chamber 39 thereof adapted to be expanded and contracted in relation to the sensing of the output temperature effect of the heat exchanger 21 by the sensing bulb 40 disposed in the process bath 21'. Thus, should the output temperature effect of the heat exchanger 21 exceed the particular output temperature effect setting of the process bellows 35, the resulting expansion of the fluid in the chamber 39 causes the balance beam 29 to move away from the vent opening 31 a certain amount to vent a greater portion of the fluid pressure in the line 32 than before and, thus, causes a venting of some of the fluid pressure in the chamber 27 of the pneumatic actuator 26 for the valve means 23 in a manner more particularly hereinafter described so as to move the valve member 25 closer to the valve seat 24 and thereby decrease the amount of steam being directed to the heat exchanger 21 to tend to maintain the output temperature effect thereof to the level as set by the bellows construction 35. Conversely, should the output temperature effect of the heat exchanger 21 fall below the set temperature of the process bellows 35, the fluid in the chamber 39 contracts so as to move the beam 29 closer to the vent opening 31 31 and increase the pressure of fluid in the conduit 32 and, thus, increases the pressure of the fluid in the chamber 27 of the pneumatic actuator 26 so as to move the valve member 25 farther away from the valve seat 24 and thereby permit an increased flow of steam through the heat exchanger 21 to increase the output temperature effect thereof.

Thus, the positioning of the balance beam 29 relative to the vent opening 31 tends to maintain the output temperature effect of the heat exchanger 21 at the output temperature effect setting for the process bellows 35.

Such proportional mechanism 30 can be seen inside the casing 41 of the controller 20 in FIG. 2 where the cover 42 of the controller 20 has been moved to the open position and, in a manner well known in the art, the temperature setting of the process bellows 35 and/or proportional mechanism 30 is under the control of a set point index link 43 that is adapted to automatically change the temperature setting of the proportional mechanism 30 upon movement of the set point index link 43 to change the output temperature effect of the heat exchanger 21 that is being controlled by the proportional mechanism 30 in a manner hereinafter described. Also, the process bellows construction 35 and/or proportional mechanism 30 is adpated to position a process pen link 44 of the controller 20 in relation to the actual output temperature effect of the heat exchanger 21 as being sensed by the bulb 40 even though the output temperature of the heat exchanger 21 may be at that particular time different than the intended setting thereof by the particular position of the set point index link 43.

In general, the controller 20 of this invention includes a bridge and pen assembly 45 which has an ink pen arm 46 positioned by the process pen link 44 so as to record on a rotatably driven chart 46' of the controller 20 the actual output temperature effect of the heat exchanger 21 in the process bath 21' before, during and after the operation of the heat exchanger 21. The pen and bridge assembly 45 also includes a high limit index or pointer 47 which is adapted to be set as a desired high limit temperature setting that the output temperature effect of the heat exchanger 21 is to reach by a selector knob 48 on the cover 42 of the casing 41 in a manner hereinafter described so that when the output temperature effect of the heat exchanger 21 reaches the output temperature setting of the high limit index 47, the controller 20, in a manner hereinafter described, will hold such output temperature effect for a predetermined length of time as set by a hold timer adjustment knob 49 that controls the setting of a hold timer motor 50 that is illustrated in FIG. 2 as well as in the electrical circuit 51 for the controller 20 in FIG. 14.

The bridge and pen assembly 45 includes a set point index or pointer 52 which is adapted to be set at a desired starting output temperature effect for a time schedule control of the system 22 by the controller 20 by an adjusting knob 53 on the cover 42 of the controller 20 in a manner hereinafter described, such setting of the set point index 52 setting the position set point index link 43 to initially set the proportional mechanism 30 to tend to maintain the output temperature effect of the heat exchanger 21, when the system 22 is

subsequently set into operation, at the initial output temperature effect setting of the index **52.**

A rate of rise adjustment knob **54** on the cover **42** of the controller **20** is adapted to be set at a desired rate of rise of temperature so that once the set starting temperature effect of the heat exchanger **21** has been reached, the index **52** will cause the output temperature effect of the heat exchanger **21** to continuously rise at the set rate of the knob **54** until the output temperature effect of the heat exchanger **21** reaches the high limit output temperature effect setting of the index **47.** When the high limit output temperature effect is reached, the same will then be held by the controller **20** for the length of time set on the hold timer **50** by the knob **49.** The rate of rise adjusting knob **54** of the controller **20** sets the rate of rise timer motor **55** of the circuit **51** at the desired rate of rise setting thereof for the previously described purpose.

The cover **42** of the controller **20** includes a manually operated, electrical power on-off switch button **56** which controls a pair of switches **57** and **58** in the circuit **51** and respectively disposed in the fused power source lines $L_1$ and $L_2$ so that when the button **56** is moved to an "on" position thereof, the switches **57** and **58** respectively close and interconnect the fused power source lines $L_1$ and $L_2$ to leads **59** and **60.** However, when the button **56** is moved to the "off" position thereof, the same opens the switches **57** and **58** to respectively disconnect the power source lines $L_1$ and $L_2$ from the leads **59** and **60.**

A start cycle button **61** is provided on the cover **42** of the controller **20** and, when pushed to start a particular cycle of operation in the manner hereinafter described, will cause the hold timer **50** of the circuit **51** to latch the normally closed relay contacts **50'** in an open position thereof while latching the normally open relay contacts **50''** in a closed condition thereof.

A selector switch **63** and an electro-pneumatic (E/P) valve **64** are combined in one assembly **65** inside the casing **41** of the controller **20** as illustrated in FIG. **2** with the selector switch **63** being illustrated in the circuit **51** of FIG. **14** as being movable from the automatic setting position thereof illustrated in FIG. **14** against a contact **66** to a manual position thereof against a contact **67** for a purpose hereinafter described. However, when the selector switch **63** is moved to the automatic position illustrated in FIG. **14,** an operator can control the system **22** by the controller **20** by merely setting the high limit index **47** by the knob **48** to the temperature at which the set point index **52** is to stop at the end of its travel and the set point index **52** is then positioned to the desired initial temperature setting by the knob **53.** The operator then adjusts the timer **55** by the knob **54** to the desired rate of rise of temperature for the system **20** and adjusts the hold timer **50** by the knob **49** to the desired hold period of the final temperature whereby once the power switch **56** is in the "on" position and the start button **61** is actuated, the controller **20** will cause the valve **23** to operate the heat exchanger **21** in such a manner that once the initial output temperature effect of the heat exchanger **21** reaches the start temperature of the set point index **52,** the set point index **52** will be moved by the timer **55** in a manner hereinafter described at a set rate of rise to cause the heat exchanger **21** to have the output temperature effect thereof rise at a certain rate until the output temperature effect reaches the setting of the high limit index **47** at which time the timer motor **50** will then begin to operate and hold the output temperature effect of the heat exchanger **21** at the output temperature effect setting of the high limit index **47** for the length of time that the hold timer **50** has been set by the knob **49.** At the lapse of such hold time period, the control circuit **51** will then automatically shut down the system **22.**

It is well known that such time scheduled controlled systems can be utilized for various purposes, such as maintaining a dye bath for textiles and the like at the desired rate of rise in temperature and then at the desired hold temperature thereof for a pre-selected time period.

While one of the features of this invention is to provide improved means for the controller **20** to cause the controller **20** to perform the aforementioned time schedule control of the system **22** and such means is provided by the pen and bridge assembly **45** later to be described, it is believed necessary to further describe the system **22** and the circuit **51** in order to fully understand the operation of the controller **20** when utilizing the various features of this invention.

Accordingly, as illustrated in FIG. **13,** the system **22** has the portion thereof disposed within the dash-dotted rectangle **68** physically disposed within the casing **41** of the controller **20** wherein the conduit **32** for the supply pressure **33** has a branch conduit **69** leading therefrom in advance of the restrictor **34** for supplying supply pressure to a conventional amplifying pneumatic relay **70.**

The amplifying pneumatic relay **70** is adapted to direct its output pressure into a conduit **71** with such output pressure being proportional to but an amplification of the signal pressure being received thereby from a conduit **72** interconnected to the conduit **32** downstream from the restrictor **34.** Thus, the relay **70** senses and amplifies the pressure in the line **32** downstream from the restrictor **34** which pressure is in relation to the amount of opening or closing of the vent nozzle **31** by the balance beam **29** so that such output pressure in line **71** and being directed by the conduit **73** not only to the chamber **27** of the pneumatic actuator **26** for the main steam valve **23,** but also to the chamber **74** of the feedback bellows **36** is in relation to the amount of opening or closing of the nozzle **31** by the balance beam **29.** Thus, a movement of the beam **29** away from the nozzle **31** by the process bellows **35** sensing a temperature effect of the bath greater than the particular setting of the set point index line **43** causes a corresponding drop in pressure in the conduit **32** downstream from the restrictor **34** so that the amplifier **70** has its output pressure **71** correspondingly decreased whereby the valve member **25** moves closer to the valve seat **24** to decrease the output temperature effect of the heat exchanger **21.** However, since the pressure in the chamber **74** of the feedback bellows **36** correspondingly decreases, the same tends to move the beam **29** back toward the nozzle **31** to thereby increase the pressure in the line **32** and, thus, to the relay **70** to cause an increase in the output pressure **71** thereof to tend to open the valve member **25** away from the valve seat **24** whereby the feedback arrangement **36** tends to eliminate an overshooting of the control of the heat exchange **21** in a manner well known in the art. Thus, it is sufficient to state that the controller **20** for the system **22** is adapted to maintain the output temperature

effect of the heat exchanger **21** at the start temperature setting of the set point index **52** and maintain such output temperature effect at a rate of rise that the index **52** is being moved by the rate of rise timer **55** in a manner hereinafter described because the position of the set point link **43** determines the temperature setting for the proportional mechanism **30** at any one time in the operation of the system **22** by the controller **20.**

The conduit **32** downstream from the restrictor **34** of the system **22** is interconnected by a conduit **75** to a vent nozzle **76** that is opened and closed by a valve member **77** carried on a flapper armature **78** of the E/P valve **64.** The armature **78** is normally urged to an open position by a spring means **79** in FIG. **13** and an electrical coil **80,** when energized, is adapted to attract and pull the armature **78** downwardly in opposition to the force of the spring **79** and have the valve member **77** close the vent opening **76** as long as the coil **80** is energized. However, when the coil **80** is de-energized, the spring means **79** moves the valve member **77** away from the vent opening **76** to open the conduit **32** so that no pressure build-up can occur in the line **32** and, thus, in the output line **71** of the relay **70** so that the main steam valve **23** will automatically close by the force of the spring **28** whenever the vent nozzle **76** is in an open position. Thus, it requires the energizing of the coil **80** to close the vent nozzle **76** in order to permit the main steam valve **23** to be operated by the controller **20** in the manner previously described.

The E/P valve **64,** while illustrated schematically in FIG. **13,** is illustrated in detail in FIG. **12** and it can be seen that the vent nozzle **76** thereof comprises a tubular member **81** passing through the center of the electrical coil **80** and the armature of flapper **78** when moved to the open position by the spring **79** abuts against a stop arm **82** of an L-shaped frame member **83** that has one leg **84** thereof interconnected to the tension spring **79** with the other end of the tension spring **79** being interconnected to the armature **78.** Thus, when the coil **80** is energized, the armature **78** is pulled downwardly to close the upper end of the tube **81** and permit a pressure build-up in the line **75** and, thus, in the main control line **32** for the reasons previously set forth.

As illustrated in FIG. **14,** the coil **80** for the E/P valve **64** is adapted to have one side **81'** thereof interconnected by a lead **82'** to the selector switch **63** and the other side **83** thereof interconnected by a lead **84'** to the lead **60** of the circuit **51.**

A chart drive motor **85** is adapted to have one side **86** thereof interconnected to the power source lead $L_1$ by a lead **87** and the other side **88** thereof interconnected by a lead **89** to the power source lead $L_2$ so that whenever the controller **20** is plugged into a power source, such as a conventional **110** volt alternating current source, the chart **46'** of the controller **20** is driven by the chart drive motor **85** at a continuous rate so that the ink pen **46** continuously records thereon the actual sensed output temperature effect of the process bath **21'** even though the controller **20** is not operating the heat exchanger **21** and the main steam valve **23** is disposed in its closed position. A pilot light **90** is placed across the leads **59 60** by leads **91** and **92.** Similarly, an end of cycle light **93** is placed across the leads **59** and **60** by leads **94** and **95.** However, the lead **94** has the normally closed relay contacts **50'** therein for a purpose hereinafter described and the contact **67** for the selector switch **63** is interconnected by a lead **96** to the lead **94** intermediate the main lead **59** and relay contacts **50'.** The contact **66** for the selector switch **63** is interconnected to the lead **59** by a lead **97.**

A hold light **98** has one side **99** thereof interconnected to the lead **60** by a lead **100** while the other side **101** thereof is interconnected by a lead **102** to a normally open contact **103** of a limit switch **104** which forms part of the pen and bridge assembly **45** later to be described.

A switch blade **105** of the switch **104** is interconnected to the lead **59** and normally is disposed against a contact **106** to electrically interconnect the lead **59** to a lead **107** that is interconnected to a contact **108** of a pneumatically operated switch **109.** The switch **109** has its switch arm **110** normally bridging the contact **108** with a contact **111** as long as the pneumatic sensor **112** thereof senses that the output pressure from the relay **70** to the pneumatically operated valve **23** does not exceed a full open pressure which in the system **22** is a pressure above 15 psi. Since the control range for the output pressure from the relay **70** to the steam valve **23** is normally 3 to 15 psi, the switch **109** is normally disposed in its closed position bridging the contacts **108** and **111** unless the same senses a pressure above 1 psi.

The contact **111** is interconnected by a lead **113** to one side **114** of a rate of rise light **115** while the other side **116** thereof is interconnected by lead **117** to the lead **60.** A drive motor **118** for moving the set point index **52** in a manner hereinafter set forth has one side **119** thereof interconnected by a lead **120** to the lead **60** and the other side **121** thereof interconnected by a lead **122** to normally open relay contacts **55'** of the rate of rise timer motor **55.** The rate of rise timer motor **55** opens and closes the contacts **55'** on a percentage of time basis during the running of the rate of rise timer motor **55** so that the closing percentage of the contacts **55'** may be varied by the setting of the rate of rise adjustment knob **54** on the controller **20** whereby the timer **55** will operate the drive motor **118** in an on and off manner to move the set point index **52** at the desired rate of rise thereof as will be apparent hereinafter.

The rate of rise timer motor **55** has one side **123** thereof interconnected to the lead **60** by a lead **124** while the other side **125** thereof is interconnected to the lead **113** by a lead **126** that is also connected to one side of the normally open relay contacts **55'** of the timer motor **55.** The hold timer motor **50** has one side **127** interconnected by a lead **128** to the lead **60** while the other side **129** thereof is interconnected by a lead **130** to the lead **102.**

As illustrated in FIGS. **3-8,** the bridge and pen assembly **45** includes a pair of bridge members or frame plates **131** and **132** for mounting the bridge and pen assembly **45** in the controller casing **41,** the upper bridge member **131** being supported on the lower bridge member **132** by a plurality of posts **133.** A cylindrical pin **134** is carried by the bridge plates **132** and **131** and does not rotate relative thereto as the same is held in place by set screws such as at **135,** FIG. **4A.** A bushing **136** is carried by the upper bridge member **131** and has the pin **134** passing therethrough beyond the top beveled surface **137** thereof.

The pen **46,** the high limit index **47** and the set point index **52** respectively have U-shaped parts **138, 139**

and 140 with the upper arms 141, 142 and 143 thereof provided with openings 144, 145 and 146 passing therethrough and receiving the portion of the pin 134 that projects beyond the bushing 136, as illustrated in FIG. 4A. Spacers 147 and 148 are respectively disposed on opposite sides of the intermediate arm 142 of the high limit index 47. The arms 141–143 are held in the stacked relation illustrated in FIGS. 4 and 4A by a retaining ring 149 and the pin 134 is adjusted such that a gap of approximately 0.010 of an inch exists between the pen arm 141 and the retaining ring 149 when all of the leverage members 141–143 are in the downward position, as illustrated in FIG. 4, whereby sufficient end play is provided to prevent any possibility of binding of the leverage members 141–143 in their rotation on the pin 134.

The U-shaped member 138 for the pen 46 has the lower arm 150 thereof provided with an opening 151 passing therethrough and receiving the pin 134 intermediate the bridge members 131 and 132, as illustrated in FIG. 7. A link 152 also has an opening 153 passing therethrough and receiving the pin 134 with the link 152 being fastened to the arm 150 of the pen assembly 46 so that movement of the link 152 by the interconnected process pen, link 44 will cause the pen 46 to pivot or rotate on the pin 134 and mark across the chart 46′ as the chart 46′ is being driven by its drive motor 85.

The lower legs 154 and 155 of the U-members 139 and 140 for the indexes 47 and 52 respectively receive the pin 134 through suitable openings therein with such arms 154 and 155 respectively being riveted as illustrated to gear-cam members 156 and 157 likewise disposed for rotation on the pin 134 at openings 158 and 159 passing respectively therethrough.

The gear-cams 156 and 157 can be produced from like stampings or can be slightly modified from each as will be apparent hereinafter. However, such gear-cam members 156 and 157 respectively rotate with the indexes 47 and 52 on the pin 134 so that the gear-cam members 156 and 157 comprise alignable members for the indexes 47 and 52 as will be apparent thereinafter.

As illustrated in FIG. 5, the cam-gear member 156 for the high limit index 47 has a part 160 of the outer periphery 161′ thereof formed with gear teeth thereon which are adapted to be disposed in meshing engagement with a pinion gear 161 fastened by a set screw 162, FIG. 8, to a shaft member 163 rotatably carried by the bridge members 131 and 132 and having an extension 164 passing through the upper bridge member 131 and being fastened by a set screw 165 to a knob member 166 adapted to rotate the shaft 163 in a manner hereinafter set forth.

Similarly, the cam-gear member 157 for the index 52 has a portion 167 of the outer periphery 168 thereof provided with gear teeth disposed in meshing relation with the gear teeth of a pinion gear 169 fastened by a set screw 170 to a shaft 171 mounted for rotation between the bridge plates 131 and 132 and likewise having a knob member 172 on the upper end thereof for adjusting the rotational position of the shaft 171 in a manner hereinafter described. However, the shaft 171 is also coupled by a coupling member 173 to an output shaft 174 of the set point drive motor 118 carried on the lower bridge member 132 as illustrated whereby when the drive motor 118 is energized in the circuit 51 of FIG. 14, the geared down output shaft 174 thereof rotates the shaft 171 and, thus, the pinion gear 169 to drive the cam-gear 157 about the pin 134 and, thus, rotate the index 52 about the pin 134 in unison therewith.

The arm 154 of the U member 139 for the high limit index 47 extends beyond the cam gear member 156 thereof and carries the limit switch 104 in fixed position thereon, the limit switch 104 having an operating plunger 105 which when in its out condition makes contact with the contact 106 of the circuit 51 and when caused to move inwardly by a cam follower 175 thereof being forced out of a recessed cam part 176 of the outer periphery 161′ of the cam gear member 156, as illustrated in FIG. 5, causes the switch blade 105 of FIG. 14 to be moved out of contact with the contact 106 and placed into contact with the contact 103 for a purpose hereinafter described.

The cam follower arrangement 175 is so constructed and arranged that the same does not ride on the outer periphery 161′ of the cam gear member 156 for the high limit index 47 but is movable into the recessed cam area 176 thereof. However, the cam follower 175 does ride in the elongated cam portion 177 of the gear member 157 when the same is rotating relative thereto.

The cam wheels or members 156 and 157 are so constructed and arranged that the cam follower 175′ of the cam assembly 175 will be midway between the highest and lowest level of its cammed position as it rides out of the recess 177 of the member 157 toward the outer periphery 160 thereof when the indexes 47 and 52 are at their point of coincidence so that the snap acting switch 104 can be made to trip at the exact point of coincidence of the indexes 47 and 52. Further, both indexes 47 and 52 are capable of causing the switch 104 to trip as the result of the movement of the cam follower assembly 175 being driven toward the switch 104 by the ramping action of the cam gear 157 of the set point index 52 as it rotates clockwise in FIG. 6 and the point of switch actuation will be the alignment of the assemblies 47 and 52 to force the cam follower 175′ out of the cam 176 of the gear cam 156 for the high limit index 47 and tend to ride on the high portion of the outer periphery 161′ of the rear cam 157 of the set point index 52.

Therefore, it can be seen that when the high limit index 47 has been set to a desired position thereof by the rotation of the pinion gear 161 rotating the cam gear member 156 and, thus, the high limit index 47, the switch 104 is being positioned therewith so that the set point index 52 when driven by the motor 118 into a position of coincidence with the high limit index 47 will have its cam 157 operate the snap switch 104 to move the contact from the contact 106 to the contact 103 for a purpose hereinafter described to start the hold time of the control circuit 51.

As previously stated, movement of the set point index 52 by the motor 118 causes the set point link 43 that is interconnected to the set point index 7 to adjust the proportional mechanism 30 to cause the output temperature effect of the heat exchanger 21 to follow the new setting of the index 52 as the same is being driven toward the high limit setting of the index 47 at which point the indexes 52 and 47 will be in coincidence so that the cam-gear 157 can operate the limit switch 104 from the position illustrated in FIG. 14 to open the

contact 106 and close the contact 103 for a purpose hereinafter described.

In order to initially adjust the positions of the shafts 163 and 171 to respectively set the high inlet position for the index 47 and the starting position for the set point index 52, the adjustment knobs 48 and 53 on the cover 42 of the controller casing 41 are formed in a like manner to respectively control the inside knobs 166 and 172 on the shafts 163 and 171.

Since such structure is identical, only one such structure is illustrated in FIGS. 9–11 and, since the same comprises the adjusting knob 48 for the high limit index 47, it is to be understood that like structure is provided for the knob 53 to adjust the initial position of the set point index 52.

As illustrated in FIG. 9, the cover 42 has a sleeve 178 passing therethrough and receiving a cylindrical portion 179 of a rectangularly cross sectioned rod 180 that has the non-cylindrical portion thereof extending below the sleeve 178 and passing through a rectangular opening 181 in a plate 182 having a pair of outwardly directed, diametrically disposed tangs 183 adapted to respectively be received in diametrically opposed notches 184 formed through the knob 166 for the shaft 163 while the remainder of the plate 182 is received in a central recess 185 in the knob 166, as illustrated in FIG. 9. The plate 182 is held on the rod 180 by a threaded fastening member 186 and is urged against the head 187 of the threaded fastening member 186 by a compression spring 188 disposed between the sleeve 178 and the plate 182, as illustrated in FIG. 9, whereby the plate 182 is adapted to move up and down on the rod 180 in opposition to the force of the compression spring 188.

As illustrated in FIG. 9, the adjustment knob 48 is fastened to the cylindrical portion 179 of the rod 180 by a set screw 189 so that the knob 48 will rotate in unison with the rod 180.

After the cover 42 has been in the open position illustrated in FIG. 2 and, thereafter, is moved to its closed position as illustrated in FIG. 1 and locked in such position by suitable locking means 190, FIG. 1, should the tangs 183 of a plate 182 for a particular adjusting knob 48 and 53 be out of register with the slots 184 in the cooperating knob 166 or 172, as illustrated in FIG. 10, the tangs 183 merely engage against the upper surface 191, as illustrated in FIG. 10, permitting the plate 182 to telescope on the rod 180 in opposition to the force of the compression spring 188 in order to permit the cover 42 to move to its fully closed position. Thereafter, the operator merely rotates the particular knob 48 or 53 at least a quarter of a turn in any direction and the tangs 183 of the plate 182 will snap into the slots 184 under the force of the compression spring 188 in the manner illustrated in FIG. 11 as the same come into alignment with the notches 184 so that the interconnection between the outer knob 48 or 53 on the cover 42 to the respective inner knob 166 or 172 is a simple operation merely thereafter requiring rotation of the knobs 48 and 53 lock the tangs 183 in place. Thereafter, the knobs 48 and 53 will respectively adjust the indexes 47 and 52 in the manner previously described to set the same at the desired beginning positions thereof for a controlled operation for the system 22 as now to be described.

When the operator presses the power button 56 for the controller 20 to move the same to an "on" position thereof, the switches 57 and 58 are moved to their closed positions to interconnect the fused power source lines $L_1$ and $L_2$ to the leads 59 and 60 whereby the pilot light 90 is now turned on as the same is placed across the power source leads $L_1$ and $L_2$. If the selector switch 63 is in its "manual" position so as to be away from the contact 66 and against the contact 67, the coil 80 of the E/P valve 64 will be energized to close the valve member 77 against the vent nozzle opening 76 of the tubular member 81 whereby output pressure is provided from the relay 70 to the conduit 73 for controlling the main steam valve 23.

However, if an automatic operation for the controller 20 is provided, the selector switch 63 is disposed in the "automatic" position illustrated in FIG. 1 whereby the switch 63 is closing against the contact 66 so that current cannot be directed to the solenoid 80 until the normally opened relay contact 50'' are closed. Since the contacts 50'' are in the open position when the hold timer motor 50 is not timing and the contacts 50' thereof are in the closed position, as illustrated in FIG. 14, as is true before the beginning of each process run, the end cycle light 93 will be initially on as the same is energized through normally closed contacts 50'.

The operator then sets the high limit index 47 through the knob 48 to the desired temperature at which the set point index 52 is to stop at its end of travel. The set point index 52 is then positioned by the knob 53 to the desired initial temperature setting that the controller 20 is to control the heat exchanger 21. Thus, the limit switch 104 is moved to a certain position when the high limit index 47 is so moved to a set position and the cam gear 157 for the set point index 52 is moved to a certain beginning position thereof so that the cam follower 175' is in its outermost position whereby the limit switch 104 has its blade 105 against the contact 106, as illustrated in FIG. 14.

The operator then adjusts the rate of rise adjustment knob 54 to the desired rate of rise temperature that the set point index 52 is to control the heat exchange 21 in reaching the high limit temperature setting of the high limit index 47. The operator then sets the hold timer knob 49 to the desired length of time that the high limit temperature for the heat exchanger 21 is to be maintained by the controller 20.

After all of the aforementioned selections have been made, the operator then depresses the start button 61 which acts on the hold timer 50 to latch the contacts 50' in an open position thereof and the contacts 50'' thereof in a closed position thereof whereby the end of cycle light 93 now goes out.

If the selector switch 63 is in the "auto" position illustrated in FIG. 14, the coil 80 of the E/P valve 64 will now be energized since the contacts 50'' are closed allowing the steam valve 23 to open to begin to heat the desired process material by the heat exchanger 21. As long as the pressure operated switch 109 is closed, electrical current is applied to the rate of rise timer motor 55, rate of rise light 115 and set point drive motor 118. However, the running time of set point drive motor 118 is regulated by the closing interval of the contacts 55' which is a function of the percentage of the operation of the timer 55 whereby the average rate at which the set point index 52 is driven by the timer motor 118 up scale by the motor 118 toward the hih limit index 47 is determined by the setting of the knob 54 for the rate of rise selection.

If the pneumatically operated switch **109** should open, the rate of rise timer **55** and set point drive motor **118** cannot run and the set point index **52** will not rise. The pressure operated switch **109** is usually calibrated to open only at output pressures above **15** psi and the control range of output pressure for the controller **20** is normally 3 to 15 psi. On the reverse acting steam valve **23**, the output pressure increases in the chamber **27** when more heat is demanded and most steam valves are wide open at pressures exceeding 15 psi. When the process is incapable of rising at the rate of movement of the set point index **52**, the output pressure will exceed 15 psi and will cause the pressure operated switch **109** to open. By appropriate choice of proportional band setting and/or pressure switch setting, the actual permissible process lag may be varied according to need.

The rise of the set point index **52** by the timer motor **118** will continue in the manner previously described to cause the output temperature effect of the heat exchanger **21** to continuously increase until the switch **104** is tripped by the alignable members **157** and **156** for the indexes **52** and **47** being coincident as previously described so that the blade **105** of the switch **104** now moves away from the contact **106** and is placed against the contact **103.** Such position of the switch **104** completely disconnects the set point drive motor **118** and timer **55** from across the power source $L_1$ and $L_2$ to terminate further up scale movement of the set point index **52** and, thus, increase of output temperature effect of the heat exchanger **21.**

At this time, the power source **61** and **62** is now applied to the hold light **98** and to the hold timer motor **50** whereby the timer motor **50** will continue to run for the time period as set by the knob **49** so that the output temperature effect of the heat exchanger **21** is maintained at the high limit temperature setting of the high limit index **47** for this timed period as the set point index **52** is now stationary at this high temperature setting so as to maintain the controller **30** at the high temperature setting through the now stationary link **43** thereof.

When the hold timer **50** runs down, the hold timer contacts **50'** and **50''** are reversed so that the contacts **50'** now close and the contacts **50''** open whereby the end of cycle light **93** is turned on, the hold light **98** goes off and the timer motor **50** stops running.

If the selector switch **63** is in the "automatic" position as illustrated in FIG. **14**, the E/P valve coil **80** is now de-energized since the contacts **50''** are open and the controller output pressure falls to zero through the movement of the valve member **77** away from the valve nozzle **76** of the E/P valve **64** and the heat exchanger **21** will now return the process to a "shut down" condition thereof.

However, if the selector switch **63** was in a manual position so that the same was against the contact **67** rather than against the contact **66,** the coil **80** for the E/P valve will remain energized even though the timer motor **50** is turned off and the process will not shut down whereby shut down must then be affected by the use of the power switch **56** being turned to the "off" position at the discretion of the operator.

Therefore, it can be seen that a unique means is provided for providing an automatic cycle of operation of the controller **20** to control the system **22** in such a manner that the rise of the set point index **52** from an initial setting thereof to a high temperature setting coincident with the setting of the high limit index **47** will cause the heat exchanger **21** to be held at such high limit output temperature effect for a timed period so that when the timed period has elapsed, an automatic shut down of the process will be completed. Also, it can be seen that improved parts for such a time schedule controller have been provided.

While the form of the invention now preferred has been disclosed as required by the patent statutes, other forms may be utilized all coming within the scope of the appended claims.

What is claimed is:

**1.** In an instrument for measuring a condition and having a casing and door means for pivotally opening and closing said casing, said door means having an adjusting member thereon and said casing having the condition adjustable member therein for being adjusted by said adjusting member when said door means is closed, the improvement wherein said adjusting member has outwardly directed tangs and said adjustable member has slots therein for receiving said tangs when said tangs are aligned therewith and said door means is closed whereby said adjusting member and said adjustable member are coupled together for rotation in unison relative to said instrument.

**2.** In an instrument as set forth in claim **1,** the further improvement wherein said tangs of said adjusting member are axially movable thereon.

**3.** In an instrument as set forth in claim **2,** the further improvement wherein said tangs are biased to one position relative to said adjusting member by a compression spring.

**4.** In an instrument as set forth in claim **3,** the further improvement wherein said adjusting member includes a shaft, said tangs having a body member telescopically disposed on said shaft.

**5.** In an instrument as set forth in claim **4,** the further improvement wherein said body member and said shaft are keyed together so that said body member is axially movable relative thereto while rotatable in unison therewith.

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