United States Patent [19]

Ishizawa et al.

[11] **3,758,968**

[45] **Sept. 18, 1973**

[54] **APPARATUS FOR CONTROLLING THE OPERATING TEMPERATURE OF A CONTINUOUS FLAT PRESS**

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[22] Filed: **Apr. 24, 1972**

[21] Appl. No.: **247,044**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 887,230, Dec. 22, 1969, abandoned, Continuation-in-part of Ser. No. 175,371, Aug. 26, 1971, abandoned.

[30] **Foreign Application Priority Data**

Dec. 29, 1968 Japan 43/96480

[52] **U.S. Cl.** **38/15**

[51] **Int. Cl.** **D06f 71/34**

[58] **Field of Search** ....
38/14–43; 100/93 P, 38; 236/1.7, 92

[56] **References Cited**

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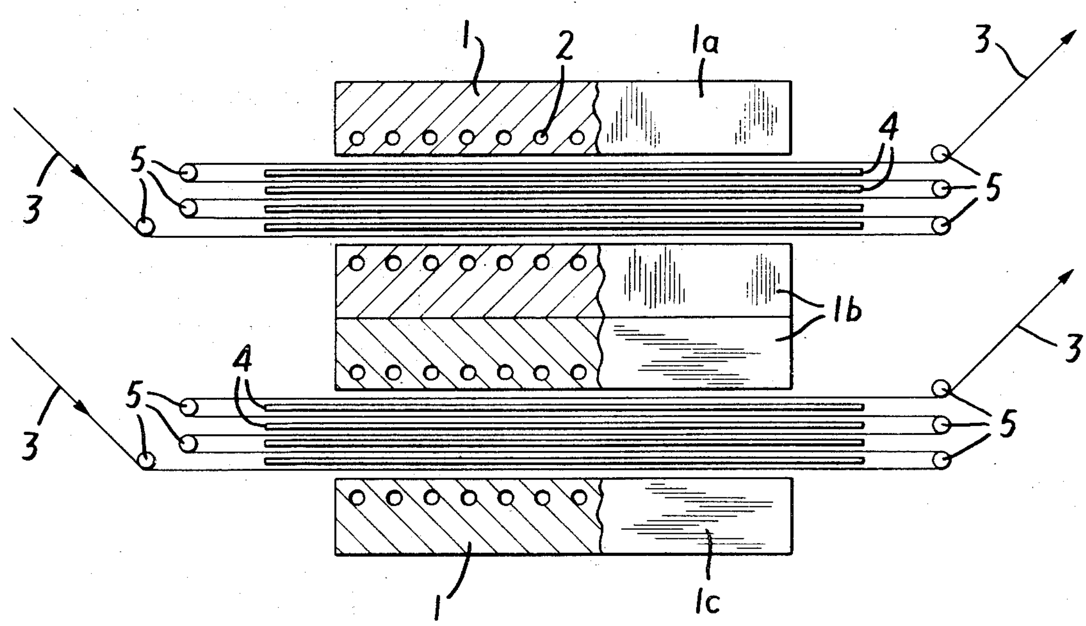
Primary Examiner—Geo. V. Larkin
Attorney—Robert E. Burns et al.

[57] **ABSTRACT**

A method of pressing a fabric in a press at a given temperature. The temperature at which a fabric is pressed is set by developing a voltage corresponding to and representative of a desired or given temperature. A second voltage is developed and varied in response to a signal developed by sensing the press plate temperature and developing from the two first-mentioned voltage signals an integrated reference voltage signal that seeks to approximate the voltage representative of the desired temperature for pressing. This reference voltage is compared with another voltage developed by sensing the varying temperature of steam within a pressing plate of the press by which the pressing of the fabric is to be effected.

19 Claims, 9 Drawing Figures



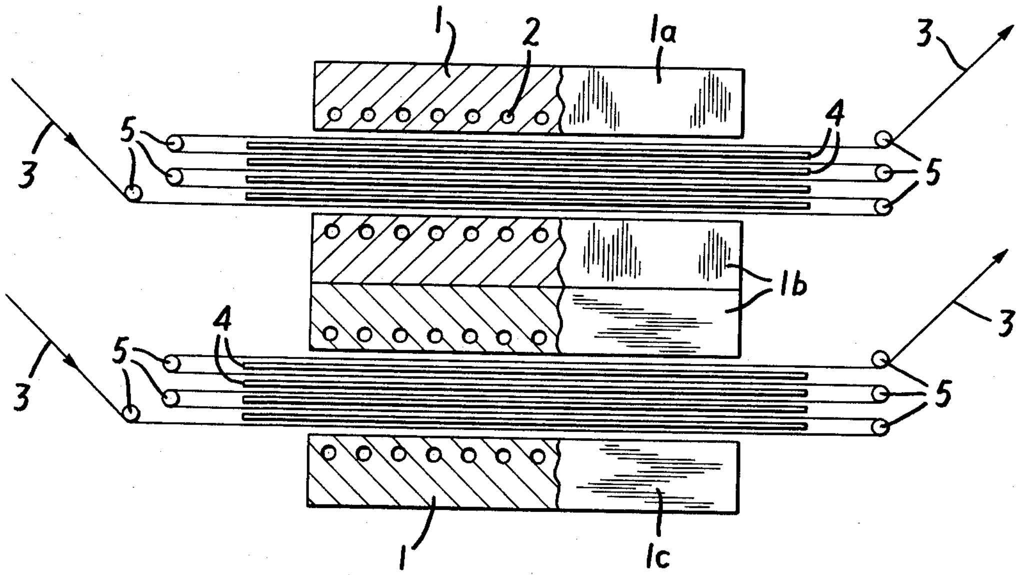


FIG. 1

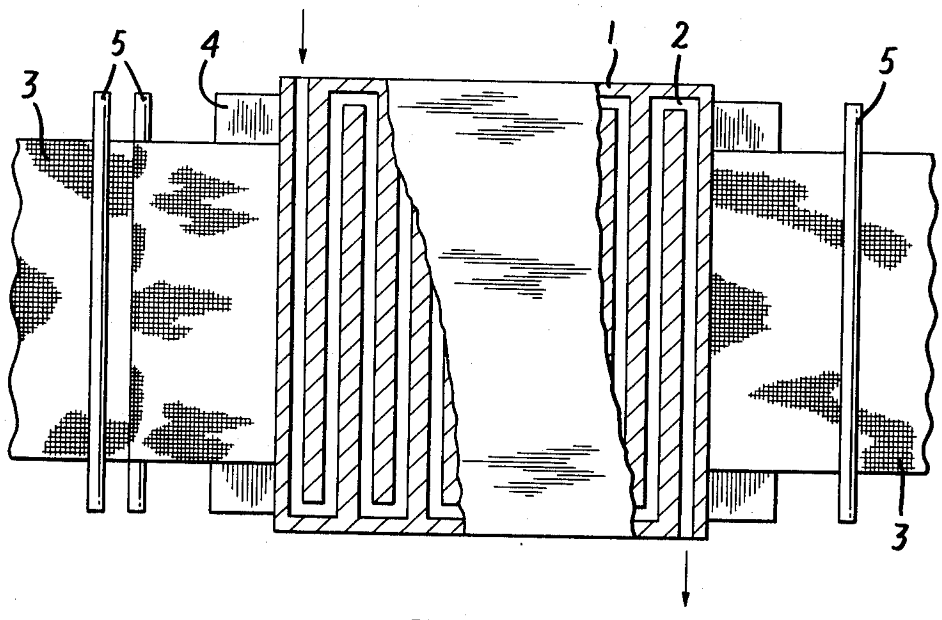


FIG. 2

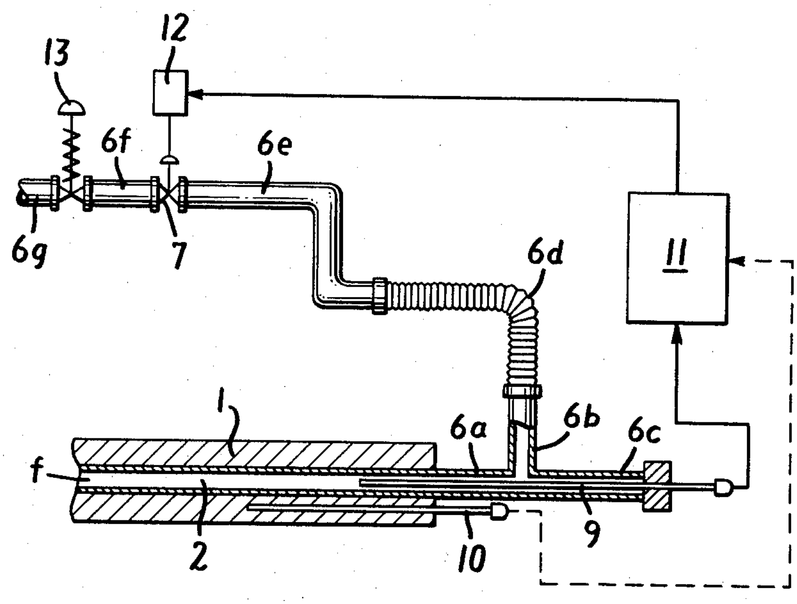

12
13
6f
6e
6g
7
6d
11
1
6a
6b
6c
f
2
9
10

FIG. 3

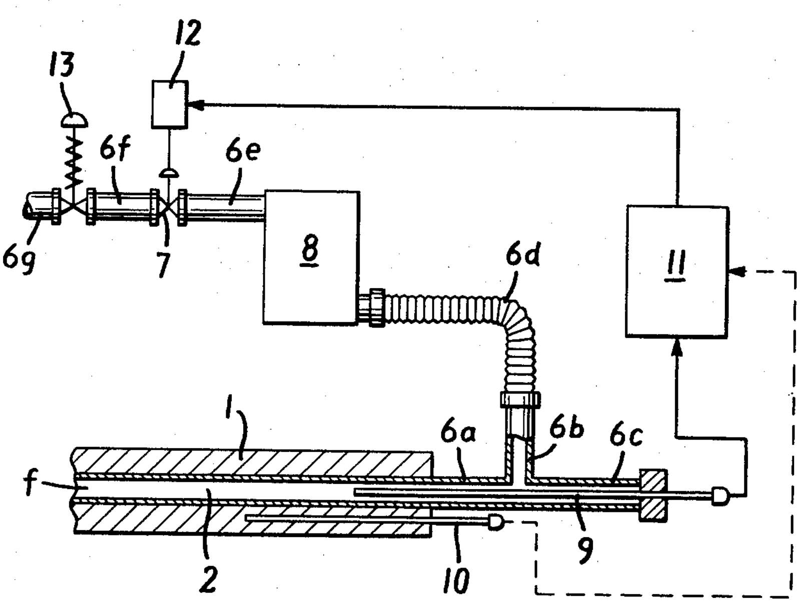

12
13
6f
6e
6g
7
8
6d
11
1
6a
6b
6c
f
2
9
10

FIG. 4

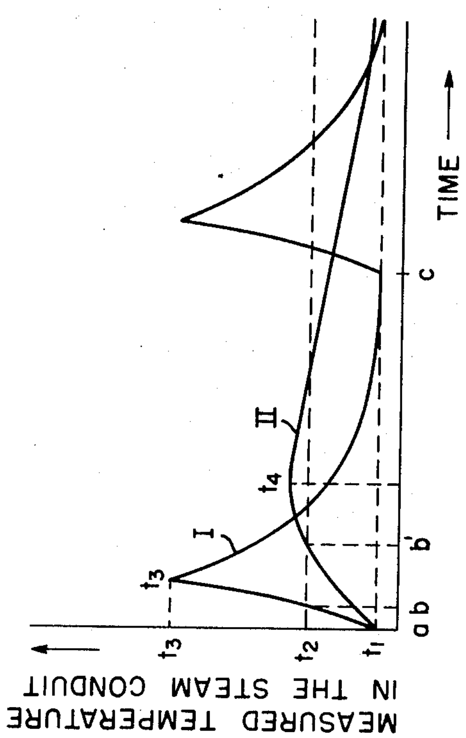

MEASURED TEMPERATURE IN THE STEAM CONDUIT
TIME
I
II
a b b' c

FIG. 5

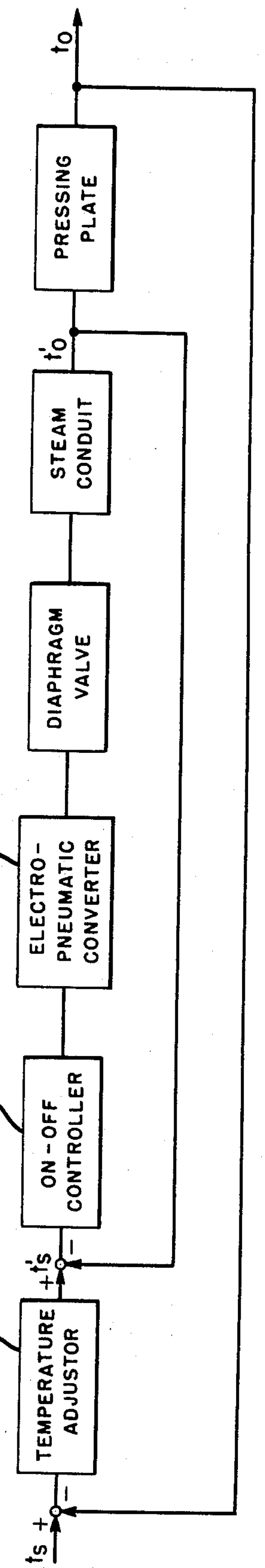

TEMPERATURE ADJUSTOR
ON-OFF CONTROLLER
ELECTRO-PNEUMATIC CONVERTER
DIAPHRAGM VALVE
STEAM CONDUIT
PRESSING PLATE
33
34, 35
12

FIG. 6

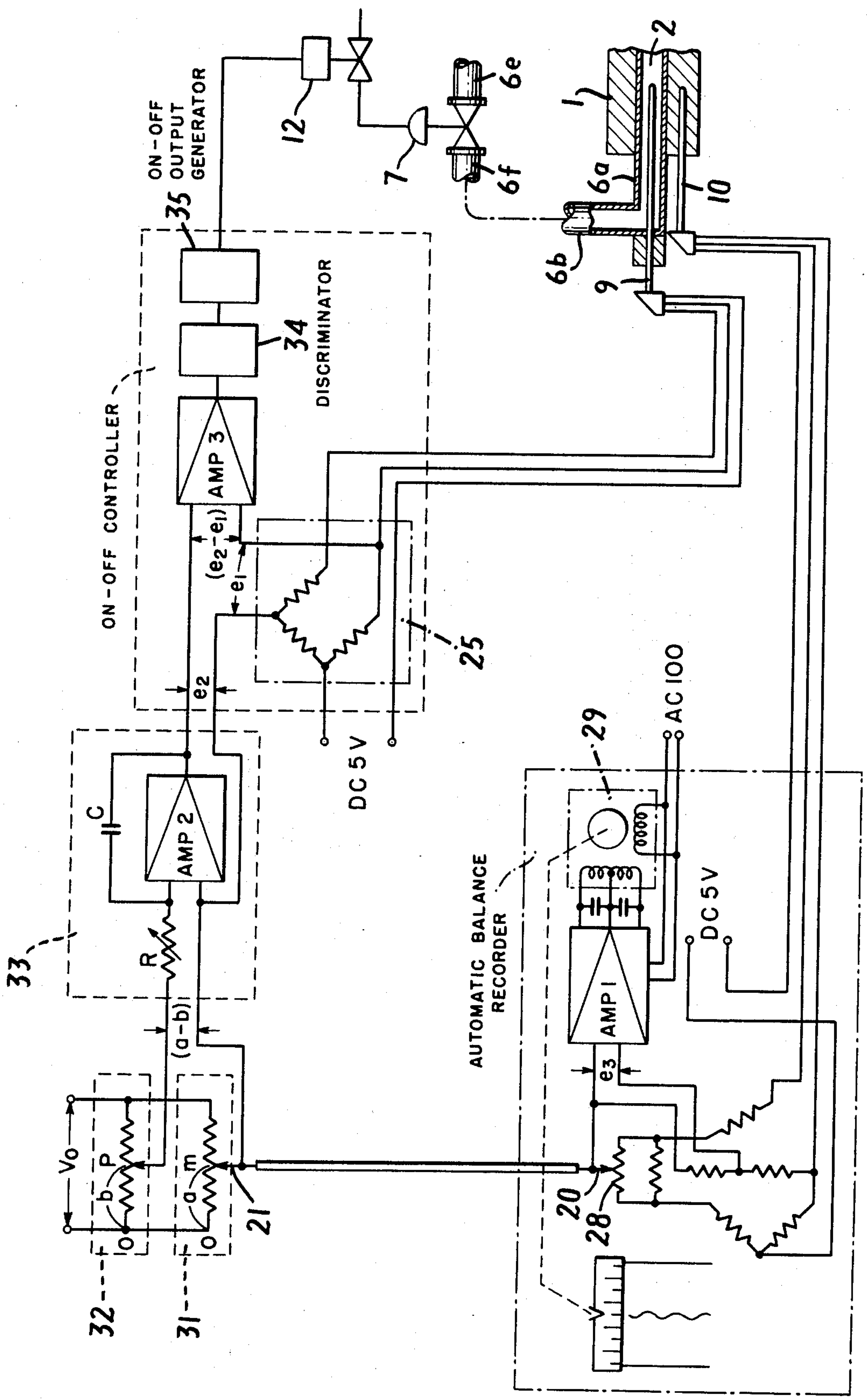

ON-OFF OUTPUT GENERATOR
DISCRIMINATOR
ON-OFF CONTROLLER
AMP 3
AMP 2
AMP 1
AUTOMATIC BALANCE RECORDER
DC 5 V
AC 100
(e_2-e_1)
e_1
e_2
e_3
$(a-b)$
C
R
Vo
P
m
a
b
o
1
2
6a
6b
6e
6f
7
9
10
12
20
21
25
28
29
31
32
33
34
35

FIG. 7

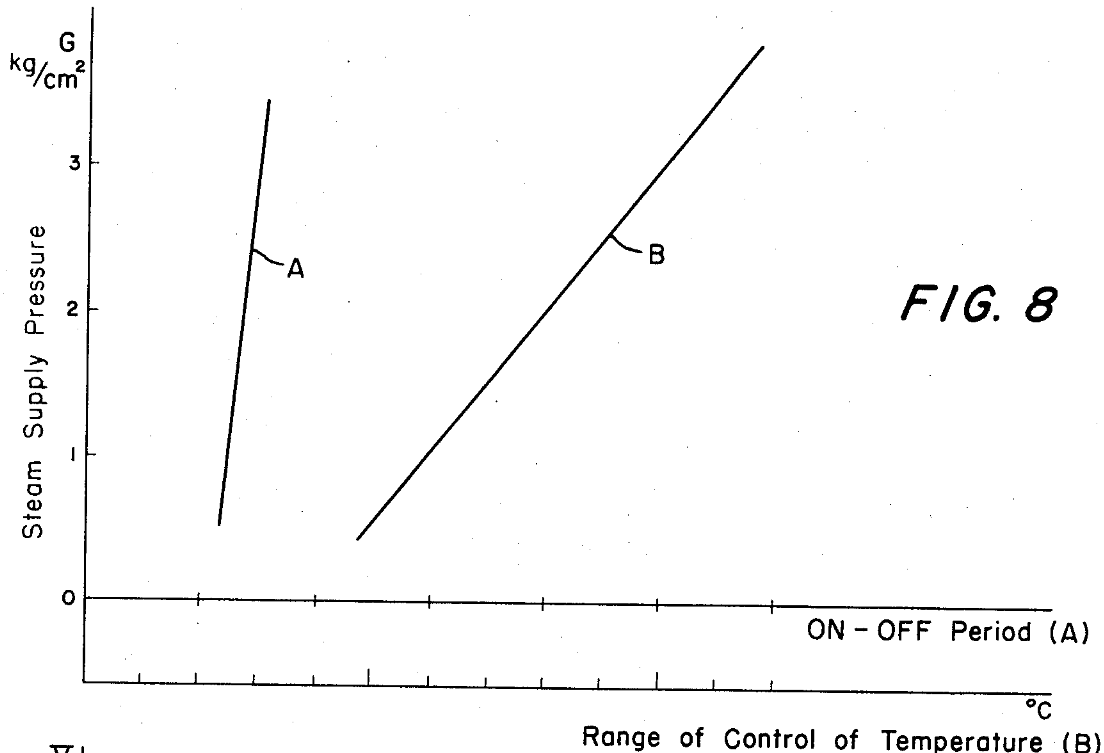

G
kg/cm²
Steam Supply Pressure
3
2
1
0
A
B
ON - OFF Period (A)
°C
Range of Control of Temperature (B)

FIG. 8

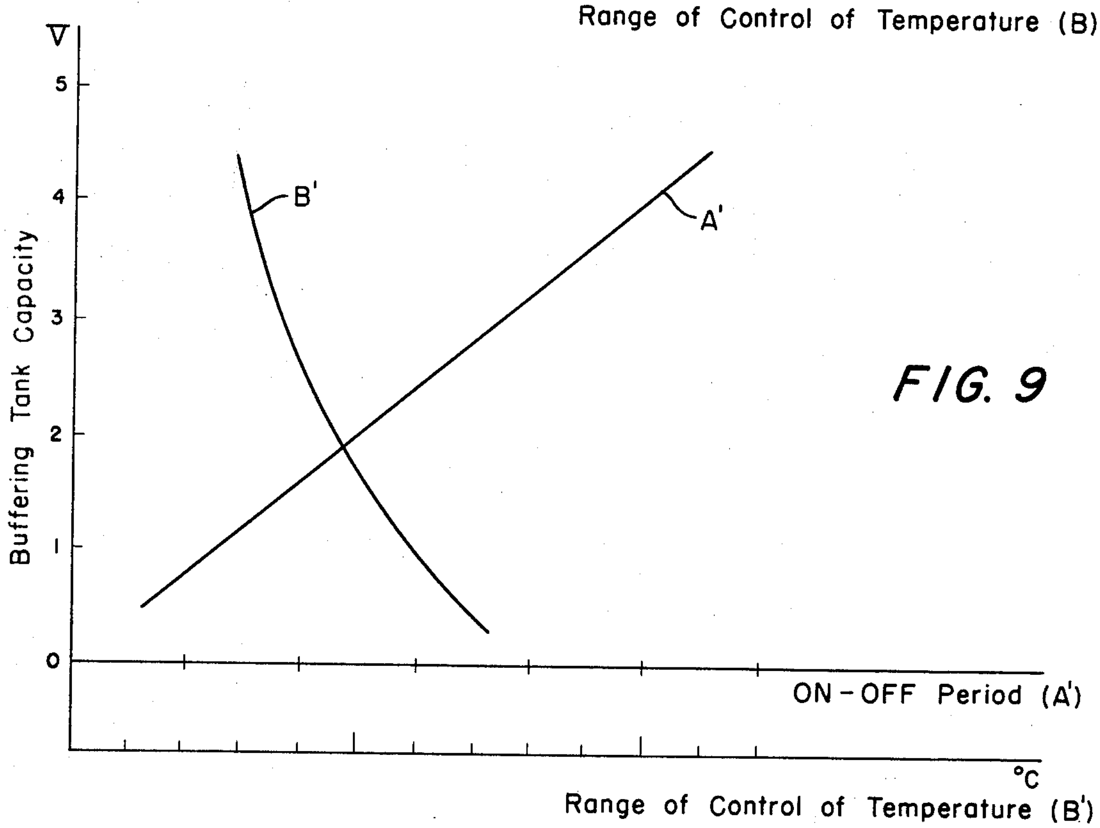

V
5
4
3
2
1
0
Buffering Tank Capacity
B'
A'
ON - OFF Period (A')
°C
Range of Control of Temperature (B')

FIG. 9

APPARATUS FOR CONTROLLING THE OPERATING TEMPERATURE OF A CONTINUOUS FLAT PRESS

This is a continuation-in-part of our applications, Ser. Nos. 887,230, filed Dec. 22, 1969 and 175,371 filed Aug. 26, 1971 and now abandoned.

The present invention relates to a method and apparatus for controlling the operating temperature of a continuous flat press utilizing steam as a heating medium.

Generally, in the finishing process of textile fabrics, such as worsted or woolen fabrics, certain union fabrics made of worsted or woolen yarn or blended yarn containing the same synthetic fibers, pressing of the fabrics is applied for glazing, providing dimensional stability and improving the hand or "feel" of the fabric. It is well-known that a "paper pressing method" has been used for the above-mentioned purpose and a fairly long time is required to complete the above-mentioned paper pressing operation. To eliminate the above-mentioned drawback involved in the paper pressing method, a now well-known continuous flat press, such as the "Hattersley Pickard-Flat Press," was developed and this machine is now used for continuous pressing operations. In a unit operation a fabric is held by a pair of pressing plates under a heated condition while one of the pressing plates is urged toward the other pressing plate by utilization of pneumatic or oil pressure. Next the fabric, which has just been pressed, is advanced forward by a predetermined distance while the holding action by the two pressing plates is released. In the above-mentioned continuous flat press, pressure, temperature, humidity contained in the fabric and operating time are very important factors for carrying out the pressing operation. Of these important factors, control of the temperature of the pressing operation is most essential.

In the conventional flat press it is well-known that the temperature of the pressing plate is controlled by using a "Proportional" or "Proportional plus integral" control system comprising means for detecting the surface or inside temperature of the press plate and means for regulating the quantity of steam supplied into the steam conduit formed in the pressing plate in accordance with a signal from the termperature detecting means by an actuating diaphragm valve or motor valve mounted on a steam-supply conduit. However, in the above-mentioned control system, since a fairly long time is required to effect the above-mentioned quantity regulation of the steam to the pressing plates because of the heat transmission mechanism of the pressing plate, a time lag in the response of the control system is not negligibly small for controlling the surface of inside temperature of the press plate in a practically uniform condition.

The principal object of the present invention is to provide an improved method and apparatus for effectively controlling the operating temperature of a continuous flat press by applying thereto an on-off control system.

Other objects and features of the invention will more fully appear from the following description and the accompanying drawings and will be particularly pointed out in the claims.

FIG. 1 is a schematic diagram of the main portion of a continuous flat press, partly in section,

FIG. 2 is also a schematic elevation of the main portion of the continuous flat press shown in FIG. 1,

FIG. 3 is a side elevation view, partly in section of an embodiment of a steam supply means together with a device for measuring temperature according to the present invention,

FIG. 4 is a side elevation view of a modified embodiment of the steam supply means shown in FIG. 3,

FIG. 5 is an explanatory diagram showing the transient response of the temperature control system according to the invention which carries out the operation of the continuous flat press, according to the invention,

FIG. 6 is a block diagram of an automatic control system according to the invention,

FIG. 7 is a schematic of a temperature adjustor in FIG. 6,

FIG. 8 is a plot of curves for explaining the operation of the apparatus and method according to the invention,

FIG. 9 is a plot of other curves for explaining the operation of the apparatus and method according to the invention.

For better understanding of the present invention the principle of the control method of the present invention is hereinafter illustrated. Referring to FIGS. 1 and 2 a fabric 3 is passed between two movable papers 4 to and fro by guide rollers 5 five times so that five thicknesses may be pressed at one time. When the rollers 4 and fabric 3 are not moving, pressure is applied, and after a given time the pressure is released and the papers fall apart; in the above-mentioned operation a top pressing plate 1a, an intermediate pressing plate 1b and a lower pressing plate 1c are heated by steam which is supplied into a meandering conduit formed in each plate.

The following linear differential equation is approximately obtained, provided that the heat transmission from steam to the pressing plate is considered as fixed.

$$\rho.C_p.V.\ (d\theta/dt) = U.A(\theta_o - \theta) \qquad (1)$$

where,

- θ represents temperature of the press plate in °C,
- θ_o represents temperature of the heat medium (supply steam) in °C,
- ρ represents a specific weight of the pressing plate in kg/cm^3,
- C_p represents a specific heat of the press plate in Kcal/kg °c,
- V represents an apparent capacity of the heat medium from its supply source to a position for detecting temperature in m^3,
- U represents a coefficient of the heat transmission between the steam conduit and the pressing plate in $Kcal/m^2.hr.°C$,

A represents a heat transmission area between the steam conduit and the pressing plate.

Now a relation $T = (\rho C_p.V/U.A)$ is assumed. Consequently, the following equation can be obtained:

$$T\ (d\theta/dt) = \theta_o - \theta$$

That is, T is a time constant representing the speed of the heat transmission. Therefore:

$$T = (\rho C_p.V/U.A) = (K/U.A) \qquad (2)$$

From the above-mentioned equation it is well understood that the larger U is and the smaller K/A is, the snaller T is, in other words, the better the heat response.

In the conventional flat press wherein the temperature of the pressing plate is controlled by applying a control system which comprises means for detecting the surface or inside temperature of the pressing plate and means for regulating the quantity of the supply steam into the steam conduit which is formed in the pressing plate in accordance with a signal of the temperature detecting means, the heat capacity (K) from its supply source to a position for detecting temperature is so large that T becomes very large, in other words, the time constant of the heat transmission becomes very large. Therefore, it is inevitable that a P or PI control system must be applied to obtain a uniform operating temperature condition of the continuous flat press. Moreover, to make the factor T small in the equation (2), it can be considered that the cross-sectional area of the steam conduit is enlarged so that the heat transmission area A between the steam conduit and the pressing plate is enlarged. However, certain limitations prohibit the enlarging of the factor A because of the construction of the flat press. Therefore, it is impossible to make the factor U.A in the equation (2) large.

The only way to make the factor T small is by making the factor K small. In other words, if the point for detecting the temperature is set in the steam conduit, the above-mentioned purpose can be attained. The principle of the present invention is based upon the above-mentioned result of analysis. By applying the above-mentioned priciple to the control method of the operating temperature of the flat press, the indicial response of the control system is improved considerably. Therefore, the operating temperature of the continuous flat press can be satisfactorily controlled by applying a simple on-off control system instead of utilizing a P or a PI control system.

An apparatus for controlling the operating temperature of a continuous flat press according to the present invention is hereinafter illustrated.

Referring to FIG. 3, each pressing plate **1** is provided with a meandering conduit **2** formed therein for supply of steam thereto. The conduit **2** is connected to a steam supply conduit **6***a*. The supply conduit **6***a* has two branch conduits **6***b* and **6***c*. One branch conduit **6***b* is connected to a main conduit **6***f* for supplying steam through a flexible conduit **6***d*, a conduit **6***e* and a control valve **7**. The control valve **7** is operated automatically by a motion of an actuator **12**. The branch conduit **6***c* is provided with a thermometer **9** which is inserted thereinto so that the tip portion of the thermometer is directly inserted into the meandering conduit **2**. Another thermometer **10** is disposed in the pressing plate **1** parallel to the surface of the pressing plate.

Before carrying out the operation, temperature of the pressing plates **1** is predetermined so as to satisfactorily treat the fabric **3**. Next, temperature in the steam conduit **2** is defined so that the desired temperature of the pressing plate **1** can be obtained. The temperature in the steam conduit **2** is controlled by comparing the temperature detected by the thermometer **9** with the above-mentioned predetermined temperature in the steam conduit **2**. In other words, the above-mentioned predetermined temperature of the steam conduit **2** is a reference input of the control system according to the present invention. The output signal of the thermometer **9** is transmitted to a control device **11** provided with an on-off control relay. The output signal of the on-off control relay of the control device **11** is transmitted to the actuator **12**, a conventional solenoid may be used as the above-mentioned actuator. Therefore, when the detected temperature is higher than the reference input, the actuator **12** closes the valve **7** so that the supply of steam into the steam conduit **2** is stopped. While on the other hand when the detected temperature is lower than the reference input, the opposite occurs. By the above-mentioned on-off control operation the temperature in the steam conduit varies in accordance with the cycling operation of the control valve **7**.

It is natural that the temperature of the pressing plate **1** is lower than that in the steam conduit **2** because of the radiation of heat therefrom. However, the temperature of the pressing plate **1** indicated by the thermometer **10** in the pressing plate **1** does not vary considerably because of the large time constant T. In other words, the above-mentioned temperature variation in the steam conduit is integrated so that only the average value is indicated by the pressing plate thermometer **10**. Therefore, if the indication of the pressing plate thermometer **10** is not in the desired condition, the reference input of the control system is adjusted so that the operation temperature of the continuous flat press is easily obtained in the desired uniform condition. This adjustment of the reference input may be operated by a manual or automatic control system. In the latter case the output signal of the thermometer **9** should be compared with a desired temperature of the pressing plate **1** by conventional means for comparing the detected temperature with the desired temperature, and the output signal of the above-mentioned comparing means is applied to the control device **11** so that the reference input is adjusted.

Referring to FIGS. **2**, **4** and **5**, since the steam conduit **2** formed in the pressing plate shown in FIG. **2** is a very long meandering conduit or path and if the steam is supplied into the conduit **2** under high pressure, it is impossible to prevent the occurrence of back pressure so that the temperature in the steam conduit **2** is raised at an entrance portion thereof. The cross section or capacity of the steam conduit is too small and its meandering path offers resistance to the flow of the steam. In FIG. **5** a curve **1** represents the above-mentioned condition showing a distinct variation of temperature in the steam conduit **2**. That is, when the steam is supplied in to the steam conduit **2** under high pressure in accordance with an actuating signal corresponding to a lower control limit of the temperature t_1, (hereinafter referred to as an on-signal temperature) the above-mentioned back pressure occurs in the conduit at the entrance portion thereof so that the temperature in the entrance portion of the conduit is rapidly raised and becomes the upper control limit of temperature t_2 (hereinafter referred to as an off-signal temperature). However, even after the supply of the steam into the conduit is stopped, the temperature in the steam conduit is continuously raised and reaches a peak temperature t_3. Thereafter the temperature gradually or exponentially lowers and becomes an on-signal temperature t_1 after time C. Next, the supply of steam is again commenced into the steam conduit **2**. In the above-mentioned cycle of the on-off control operation, the time for supplying the steam into the conduit 2 is represented by $\overline{ab}$.

It is preferable to reduce the above-mentioned temperature variation in the steam conduit in order to carry out the pressing operation satisfactorily. To attain the above-mentioned desired result it is preferable to supply the steam into the steam conduit in a buffered or damped condition. In FIG. 4 showing another embodiment of the steam supply means, a steam storage tank 8 is connected to the conduits 6*d* and 6*e*. Other elements having the same functions as those of elements shown in FIG. 3 are represented by the same numerals. The steam storage tank 8 is used for buffering the steam supply, that is, the steam supplied from the steam supply conduit 6*f* through the control valve 7 is first supplied into the steam storage tank 9 which has a comparatively large capacity. Next, the steam is supplied into the steam conduit 2. Therefore, the steam pressure is properly buffered before being supplied into the steam conduit 2 in accordance with the capacity of the tank 8 so that the steam is smoothly supplied into the meandering steam conduit 2 and the occurrence of the back pressure in the steam conduit is prevented.

The curve II in FIG. 5 represents the above-mentioned case utilizing the tank 8. As it is clearly shown in FIG. 5, the time from the on-signal temperature t_1 to the off-signal temperature t_2, which corresponds to the time $\overline{ab}$ in the curve II, is longer than that of the time $\overline{ab}$ in the curve I. However, the absolute value of the peak temperature t_4 in the curve II is remarkably lower than that of the peak temperature $_3$ in the curve I, and the frequency of the on-off operation is also less than the frequency in the curve I. As illustrated above, in this modified embodiment the absolute value of the peak temperature t_4 is lowered and the frequency of the on-off control operation is also reduced. Therefore, the control operation of the operating temperature of a continuous flat press can be satisfactorily carried out so that an excellent pressing effect upon the fabric can be achieved.

In the method according to the invention for automatically regulating a reference input corresponding to a desired temperature and thereby automatically regulating the temperature of the press, the apparatus of the invention has an on-off control system 11 shown in FIGS. 3 and 4. One example of the overall control system is illustrated in block form in FIG. 6. The control system functions to maintain the proper pressing plate temperature by alternately opening and closing the control valve 7 according to a result obtained by comparing a signal corresponding to or representative of the temperature in the steam conduit with a reference input or set point in order to maintain the surface temperature of the pressing plate 1 at a predetermined and desired temperature.

In FIG. 6, t_s represents the pressing plate temperature desired, t'_s the temperature established by the ON-OFF controller which controls the temperature in the steam conduit, t'_o the temperature in the steam conduit, t_o the temperature of the pressing plate. The temperature t_o and t'_o are determined by the thermal load and the thermal conductivity of the pressing plate. Then the temperature t_o can be made coincident with the temperature t_s desired by changing the temperature established by the ON-OFF controller and thereby changing the temperature in the steam conduit.

In the block diagram of the servo-control system shown in FIG. 6, when the temperature of the pressing plate t_o deviates from the desired temperature t_s, the difference in temperature between t_s and t_o is fed back to the temperature adjusting means (hereinafter referred to as the temperature adjustor) and its output becomes the signal corresponding to a reference input or set point of the ON-OFF controller which controls the temperature in the steam conduit by controlling the steam supply into the steam conduit. When the temperature t_o in the steam conduit varies, the temperature t_o of the pressing plate also varies; consequently, the temperature of the pressing plate can be controlled within an allowable range of variation thereof by controlling the temperature in the steam conduit.

FIG. 7 shows one embodiment of the thermal control system shown in the block diagram of FIG. 6. Referring to FIG. 7, the pressing plate 1 is heated by the steam which is supplied via the steam conduit 2 via the control valve 7. The temperature t'_o in this steam conduit 2 is detected by a thermometer 9 composed of platinum resistance material. This thermometer 9 is connected to a converter 25 which is included in the ON-OFF controller and converts the value of electric resistance to a voltage. In the ON-OFF controller, the above-mentioned converter 25 compares the converted voltage e_1 and established value e_2 which corresponds to the target temperature t'_o in the steam conduit 2, the difference of these voltages e_1 and e_2 is amplified by an amplifier AMP-3 and characterized as to whether the difference is positive or negative by a discriminator 34, and the ON-OFF signal resulting from the discrimination is generated as an output of the ON-OFF controller 35. The output of the ON-OFF controller 35 is converted to an ON-OFF pneumatic signal by an electro-pneumatic converter 12. This ON-OFF pneumatic signal is supplied to the control valve 7 which controls the supply of steam into the steam conduit 2.

On the other hand, the temperature t_o of the pressing plate is detected by a thermometer 10 composed of platinum resistance material. This thermometer 10 is connected to an auto-balancing recorder which records the temperature of the pressing plate. This auto-balancing recorder includes an auto-balancing mechanism using a servomotor 29 which rotates in accordance with the variation of the resistance of the thermometer 10, and displaces automatically a brush 20 of the potentiometer 28 so as to bring the input e_3 of the amplifier AMP–1 to zero, that is, the balanced condition. Accordingly, the position of the brush 20 corresponds to the value of the resistance in the thermometer 10, that is, to the value of the temperature of the pressing plate.

The brush 20 is connected directly to a brush 21 of a potentiometer 31, and the brush 21 displaces with the brush 20. The sliding resistor 24 of a potentiometer 32 is connected in parallel with the sliding resistor 22 of the potentiometer 31.

The object of the potentiometer 32 is to establish the desired temperature of the pressing plate by the position of the brush 23. In this case, the relation between the position of the brush 23 and the temperature to be established is predetermined. Namely, when the position of the brush 23 is established at point P as shown in FIG. 7, the voltage difference across OP is b, and when the position of the brush 21 is at point n, the voltage difference across on is a. When the voltage a is equal to the voltage b, the temperature indicated by the position of the brush **20** in the auto-balancing recorder becomes the temperature established by the position P of the brush **23.**

The voltage difference (b–a) between the voltage b across OP in the potentiometer **32** and the voltage across *om* in the potentiometer **31** is supplied to the input terminal of an integrator **33** which is composed of a resistor R, a capacitor C and an amplifier AMP–2. The integrator **33** integrates the input voltage (b–a) with a time constant determined by the resistance R and the capacitance C, and the output e_2 of the integrator **33** is supplied to the ON-OFF controller as an establishing voltage.

The example shown in FIG. **7** is only one example of the embodiment of the present invention, and the same result can also be obtained by the methods or apparatus as described below:

a. A thermistor, thermo-junction element, liquid expansion element, etc., can be used as the thermal sensitive element which detects the temperature in the steam conduit or pressing plate.

b. A pneumatic recorder which records automatically the input electric signals such as the variation of the value of the electric resistance or the thermal electro motive force by converting these electric signals into a pneumatic signal also can be used as the automatic balancing recorder.

c. A controller which converts input electric signals to a pneumatic signal and controls the pneumatic signal in an ON-OFF manner can also be used as the ON-OFF controller.

d. As the temperature establishing adjuster using an integrator, an apparatus which amplifies the input voltage difference signal (a–b) which is the result of comparing the input signals in the potentiometer becomes balanced automatically by the servometer so as to bring the value of said difference input signal to zero, couples the rotation of the servo-motor to another potentiometer and establishes the output voltage of said potentiometer as the settling voltage of the ON-OFF controller, can be utilized.

The pressing plate **1** is required to possess sufficient mechanical strength to press the fabric under high pressure. One example of the size of the iron pressing plate **1** is a plate having a width of 1,200 mm with a length 1,800 mm and a thickness of 60 mm. If the diameter of the meandering steam conduit **2** disposed in the pressing plate **1** is too large, the strength of the pressing plate **1** is lessened. So the diameter of the conduit **2** must be restricted and this necessarily limits the volume of the conduit **2.** In the type of pressing plate having the dimensions as above described a conduit path having an inner diameter on the order of 20 mm will allow the pressing plate to have sufficient mechanical strength. Thus if the pressing plate has a width and length as indicated above, the length of the conduit can be about 20 meters; consequently the volume of the conduit is about 7 liters.

If the volume of the steam conduit **2** in the pressing volume, is small, the response speed, that is the time constant of the control system, is small and conversely if the length of the conduit **2** is large the time lag, that is the dead time of the control system, is large so that the quality of the characteristic features of the control system cannot be satisfied. The above-mentioned quality is represented by the controllable range of temperature. When the value L/T, where L represents the dead time and T represents the time constant, exceeds a certain value, it is very difficult to make the controllable range of temperature small. Therefore, in the event that the pressing plate cannot utilize a steam conduit **2** having a sufficiently large volumn, the time constant T is very small. In the system according to FIG. **3** the time constant T is in the order of 1.2 seconds and the dead time L in the order of 0.4 seconds. Consequently, L/T is 0.33. Generally it may be considered that the best value of L/T for effective on-off control should be less than 0.1. Accordingly it is clear that the quality of the control system shown in FIG. **3** cannot be improved if L/T equals 0.33 which is greater than 0.1.

The range of control of temperature results of apparatus and method according to the invention are illustrated in FIG. **8** where a linear curve A represents the characteristic curve of the on-off period while a linear curve B represents a characteristic curve of the controllable range of temperature plotted with the ordinate as steam supply pressure in grams. The curves in FIG. **8** were obtained from an on-off control system of the type shown in FIG. **3** under the following conditions:

1. The diameter of the conduits ***6a,6b,6d,6e,6f*** and ***6g***was three-fourths inches.
2. The control valve **7** was a three-fourths inch valve having a flow ratio *CV*= 7.5.
3. The pressure of the supply steam was from 0.5 to 3.5 Kg/cm².
4. The temperature in the conduit **2** of the pressing plate was 110°C.

From a study of these curves it can be seen that the control·lable range of temperature can be improved a little by regulating the pressure of the supply steam; however, even if the steam pressure is changed to 0.5 Kg/cm², the controllable range if 5°C so that the system does not satisfy optimum control requirements and the on-off control period is very short. In other words the frequency of the on-off control action is sufficiently high that the life of the control device will be shortened thereby. Preferably the life of the on-off control device should be in the order of 0.5 to one million operations of the control valve **7.** If the period of the on-off control action of the system is 12 seconds and the system is operated for 24 hours each day, the control device, and more particularly, the ultimate control element, the valve **7,** will break down after continuous operation for 70 to 140 days. To eliminate the drawback of short on-off periods, it is necessary to make the value of *L/T* of the control system smaller. That is, *L* should be increased and T decreased.

Generally very fine temperature detectors or tranducers having a small heat capacity are used in apparatus of this type in order to restrict the time lag caused by the detectors. However, in a pressing plate which is alternately displaced up and down and on which a temperature detector is mounted, the detector or transducer is subjected to an impact force so that it is impossible to use a very fine temperature detector or sensor. Moreover, it is necessary to protect the temperature sensor by encasing it; consequently, there is a certain limit to the increase of the time constant of the control system that must be taken into consideration. One of the easiest ways to control the time constant of the control system favorably is to enlarge the volume of the steam conduits. However, the construction of the pressing plate 1 restricts this technique. Thus if a storage tank 8 is mounted in a position between the supply conduits 6d and 6e as shown in FIG. 4, the volume of the supply conduits downstream from the control valve or changeover valve 7 can be enlarged so that the time constant T can be increased.

The results obtained by using a control system of the type shown in FIG. 4 are illustrated in FIG. 9. In FIG. 9 the curve A′ represents an on-off period while the curve B′ represents the range of controllable temperature. It can be seen from a study of the curves that if the volume V of the storage tank 8 is three times the volume of the steam conduit 2, the range of controllable temperature is about two-thirds that of the embodiment shown in FIG. 3 and the on-off period will be about 3.3 times that of the embodiment shown in FIG. 3. Thus the life of the control valve 7 is increased by the same ratio.

What we claim and desire to secure by Letters Patent is:

1. In a press for pressing a fabric by a continuous flat press provided with a plurality of pressing plates, a control method for controlling the temperature of said pressing plates being heated by supplying steam into conduit means formed therein by controlling supply of steam, comprising:

a. developing a first signal representative of a desired temperature of pressing plates of a press at which a fabric is to be pressed;

b. developing in conjunction with the temperature of supply steam to said pressing plate a second signal corresponding to said desired plate-temperature, said second signal corresponding to a set point;

c. sensing the temperature of said supply steam and developing a third signal varying with variations of the temperature of said steam and representative of the temperature of said steam;

d. comparing said signal with said second signal and developing therefrom a control signal for controlling flow of supply steam to said pressing plates to maintain said pressing plates at a temperature for effecting said pressing of said fabric at said desired temperature;

e. directly on-off controlling said supply steam flow under control of said control signal to maintain said desired temperature;

f. while sensing the temperature of said pressing plates developing a fourth signal representative of the temperature of said pressing plates, comparing said fourth signal with said first signal, and adjusting said set point in accordance with a result of said comparison as necessary.

2. A control method for controlling the temperature of pressing plates of a continuous flat press according to claim 1, further comprising buffering pressure of said supply steam before supply to said pressing plates.

3. A control method for controlling temperature of pressing plates of a continuous flat press according to claim 1, wherein all steps are carried out automatically.

4. A method of pressing a fabric comprising, developing a voltage signal representative of a desired temperature at which a fabric is to be pressed, sensing the temperature of a press plate for pressing the fabric and developing a signal representative of the temperature of the plate, developing in conjunction with said desired temperature signal and the signal representative of the plate temperature a reference electrical signal, sensing the temperature of steam in the press and developing an electrical signal varying with variations of the temperature of said steam and representative of the temperature of the steam, comparing the reference electrical signal and the electrical signal representative of the temperature of the steam and developing therefrom a control signal for controlling flow of steam to said plate to maintain the press plate at a temperature for effecting said pressing of said fabric at said desired temperature, and directly on-off controlling said steam flow under control of said control signal to maintain said desired temperature.

5. A method of pressing a fabric according to claim 4, including counteracting a temperature rise at the press plate due to restriction of the flow of steam thereinto.

6. A method of pressing a fabric according to claim 5, including counteracting variations of temperature and pressure of said steam by buffering temperature and pressure variations during "on" periods of said steam flow.

7. A method of pressing a fabric according to claim 4, in which the steam flow and temperature thereof in said press plate are maintained substantially equalized in each "on" period.

8. In combination, a flat press for pressing a fabric at a desired temperature having cooperative pressing plates provided with steam conduits disposed therein, a steam supply source, a control valve connecting each of said steam conduits to said steam supply source, an on-off system for supplying and controlling a supply of steam to said pressing plates and the temperature of the pressing plates, comprising: means for actuating said control valve; means for developing a first signal representative of the temperature of supply steam supplied to said pressing plates; means for developing a second signal representative of temperature of said pressing plate; means for on-off controlling said actuating means; comparison means for comparison of said second signal with a predetermined signal corresponding to said desired temperature of said pressing plate; means developing said predetermined signal; means for adjusting a set point of said on-off control means in accordance with an output of said comparison means; and means in said control means developing an output signal thereof to operate said actuating means in accordance with a difference signal obtained by comparison of said first signal with said set point.

9. The combination according to claim 8, wherein said means for developing a first signal is a thermocouple.

10. The combination according to claim 8, wherein said means for developing a first signal comprises a resistance thermometer bulb and a resistance-voltage transducer.

11. The combination according to claim 8, wherein said means for developing a second signal is a thermocouple.

12. The combination according to claim 8, wherein said means for developing a second signal comprises a resistance thermometer bulb and a resistance-voltage transducer.

13. The combination according to claim 8, wherein said comparison means comprises an automatic balancing recorder having a movable brush, a first potentiometer provided with a brush connected to a brush of said

recorder, and a second potentiometer applied a voltage equal to a voltage of said first potentiometer.

14. The combination according to claim **8,** wherein said adjusting means is an integrator.

15. The combination according to claim **8,** wherein said on-off controlling means comprises an electric circuit for comparing said first signal with an output of said adjusting means, an amplifier for amplifying an output of said electric circuit, a logic circuit to measure a plus or minus value of an output of said amplifier and developing an output therefrom, an on-off signal generator actuated by the output of said logic circuit.

16. In combination, a press for pressing a fabric having pressing plates; steam supply means to supply steam to said pressing plates to maintain them at a desired temperature; means to develop an electrical signal representative of a desired temperature at which said pressing plates are to be maintained; means including transducer means sensing the temperature of the steam supplied at said pressing plates developing automatically an electrical signal corresponding to the temperature of said steam supplied at said pressing plates; means including transducer means sensing the temperature of a pressing plate developing automatically a varying electrical signal corresponding to and representative of the temperature of said pressing plate; a control system having means receptive of said signal corresponding to said temperature of said steam at said pressing plate, means receptive of said varying signal including said means to develop said signal representative of said desired temperature including means developing a control signal controlling "on" and "off" periods of said steam supplied to said pressing plates to maintain said pressing plates at said desired temperature, and means responding to said control signal controlling supply of said steam from said supply source to said pressing plates for periods maintaining said desired temperature of said pressing plates.

17. In a process for pressing a fabric by a continuous flat press provided with a plurality of pressing plates, an automatic control method for controlling the temperature of each of said pressing plates being heated by supplying steam into conduit means formed therein, comprising firstly selecting a reference temperature based upon the characteristics of the fabric to be pressed, setting said reference temperature in said conduit means as a reference input corresponding to the desired temperature of said pressing plate, detecting the temperature of steam in said conduit means directly, on-off controlling of said steam supply into said conduit means in accordance with a signal resulting from a comparison between said reference input and said detected temperature, measuring the temperature of said flat press directly, comparing said temperature of said flat press with said desired temperature of said flat press and adjusting said input in accordance with the result of said comparison.

18. An automatic control method for controlling temperature of pressing plates of a continuous flat press according to claim **17,** further comprising buffering the pressure of said supply steam before supplying steam into said conduit means.

19. An automatic control method for controlling temperature of pressing plates of a continuous flat press according to claim **17,** including carrying out all operations automatically.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,758,968 Dated September 18, 1973

Inventor(s) KAZUTOMO ISHIZAWA, YASUNORI NAGATA, YOSHIAKI UEMATSU and JUNNOSUKE ABE

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

In the Heading of the Patent, item [76] Inventors:

The names of the second and fourth listed inventors should be corrected as follows:

"YASUNOR NAGATA" should read --YASUNORI NAGATA--,

"UUNNOSUKE ABE" should read --JUNNOSUKE ABE--.

Signed and sealed this 5th day of March 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents