Jan. 16, 1962 M. F. GADE ET AL 3,016,622

CONTROL SYSTEM FOR PAPER MACHINE DRIERS

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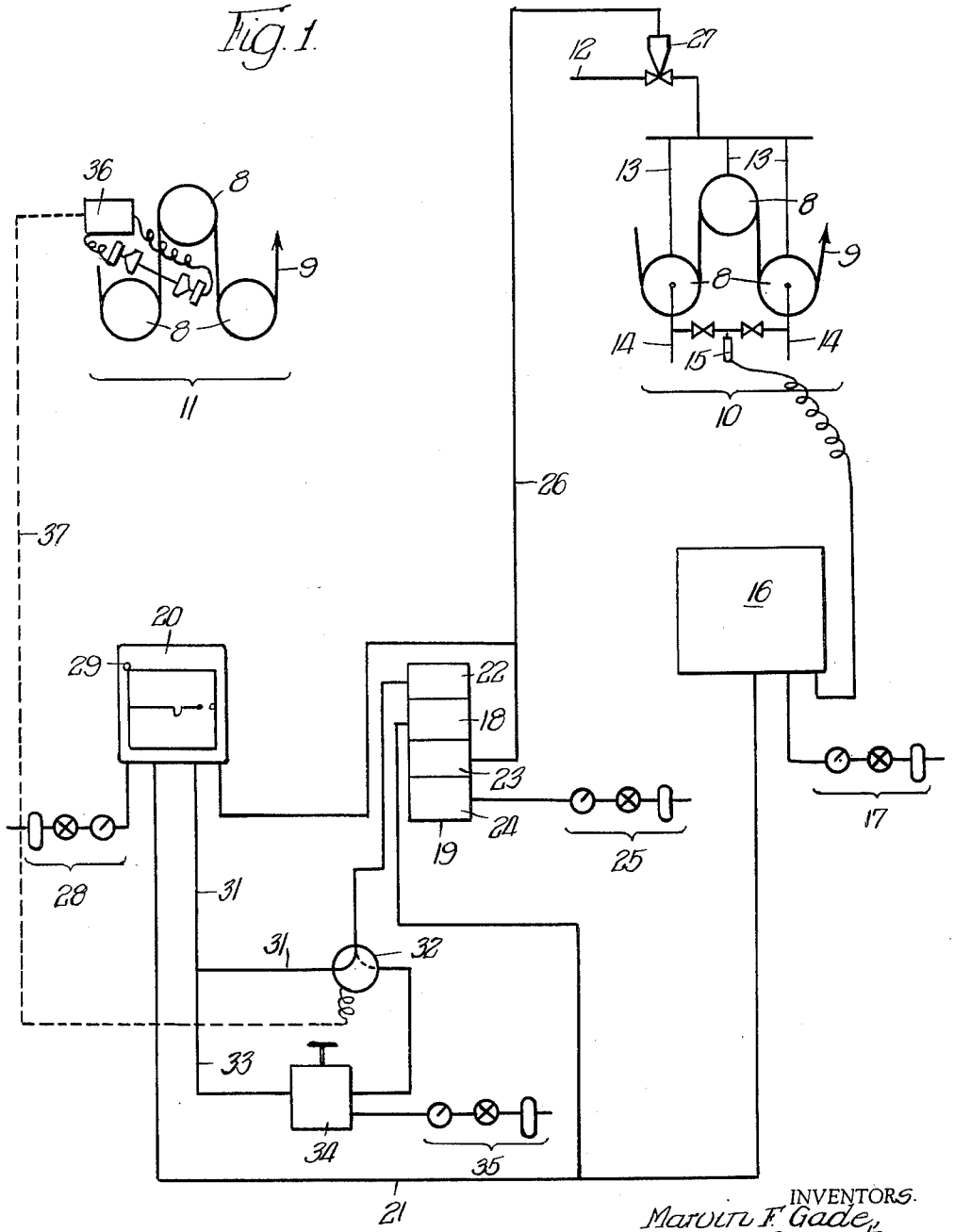
Fig. 1.



INVENTORS.
Marvin F. Gade,
George Garnet
McDonald Eastwood,

By Byron, Hume, Brown & Clement
attys

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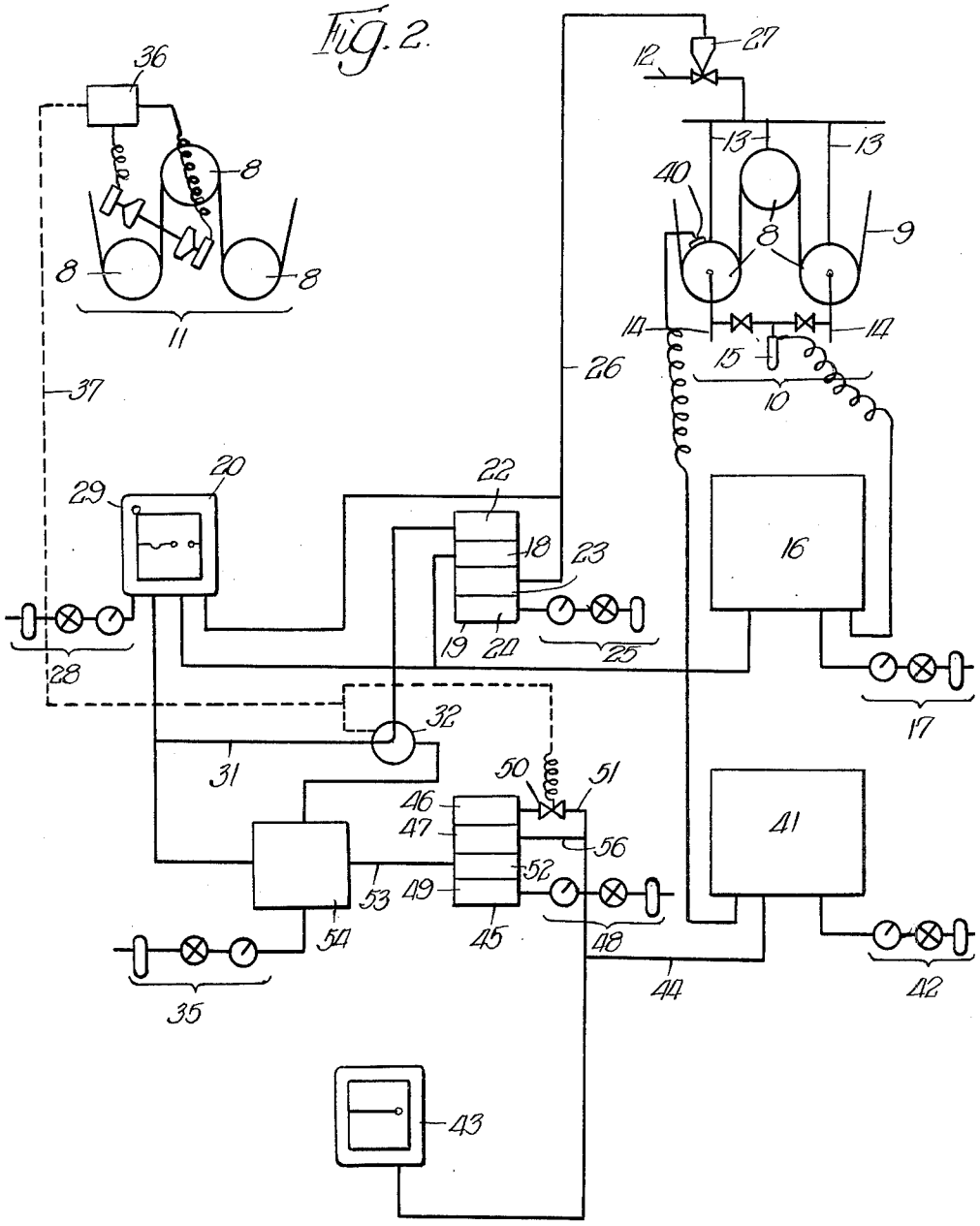
Fig. 2.



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McDonald Eastwood,

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Attys.

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CONTROL SYSTEM FOR PAPER MACHINE DRIERS

Marvin Francis Gade, Fullerton, Calif., and George Garnet McDonald Eastwood, Neenah, Wis., assignors to Kimberly-Clark Corporation, Neenah, Wis., a corporation of Delaware

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This invention relates to the making of paper and in particular to the control of the temperature of the web drying rollers used in conjunction with a paper making machine.

In the manufacture of paper the web is usually dried by passing it over several rollers which are generally heated by steam. It is necessary to maintain the temperature of the rollers within a predetermined range in order to obtain a good quality paper. If the temperature is too low, the paper will not be completely dried, so that a poor quality of paper is the result. On the other hand, if the temperature is too high, the paper will be dried too fast, possibly even to the extent of charring, so that again the paper will be of poor quality. Many times the web will break while being dried and therefore it will not be associated with the rollers until rethreaded thereon. During this period the temperature of the rollers will rapidly rise if the roller steam is not decreased because of the decrease in the rate of heat extraction. If this condition continues for any length of time, the temperature will rise above the maximum allowable for a good quality paper upon rethreading. On the other hand, if the steam is completely cut off, the temperature will fall below the required minimum. Thus, when the web is started again, it may be of poor quality due to insufficient drying or overdrying, depending upon the procedure followed.

In the prior art there are numerous means and methods for measuring the temperature of drying rolls. Most of these, while reasonably accurate, have certain deficiencies which are undesirable in the manufacture of paper. Moreover, many of the prior art methods are not adapted to control the temperature during a shutdown of the rollers.

Therefore, it is an object of the invention to provide a novel means for accurately controlling the temperature of the drier rollers of a paper making machine.

Another object is to provide means for accurately controlling the temperature of the rollers of a paper making machine during both normal operation and shutdown.

Another object of the invention is to provide means that will detect any break in the paper and will instantly compensate for any change in the condensate temperature.

Another object of the invention is to provide means that will automatically reduce the temperature of the rollers a predetermined amount during shutdown.

Another object is to provide means that will measure the surface temperature of the rollers during shutdown and will maintain the temperature at the surface at a predetermined level.

Another object of the invention is to provide means for controlling the temperature of the rollers as a function of the condensate temperature.

Other objects of the invention will be apparent upon development of the specification with reference to the drawings.

In the drawings:

FIGURE 1 is a diagrammatic illustration of the control system embodying the invention.

FIGURE 2 is a diagrammatic illustration of a control system, including a refinement over that shown in FIGURE 1.

Referring now to FIGURE 1, there is shown two series of rollers 8 designated as a dry end section 10 and a wet

end section 11 on which is threaded a paper web 9 from a paper making machine. These series of rollers constitute a part of a drier train which is usually divided for control purposes into several sections, including a dry end section 10, a wet end section 11, and possibly one or more intermediate sections.

Each section consists of one or more rollers and is usually fed by one steam header 12. A final state of dryness of a web 9 is accomplished on the dry end section. In the preferred embodiment the control system is used in conjunction with the dry end section, as will be seen later on. The other sections are controlled as a function of the condensate temperature of the dry end section control system which will be described later on.

Steam from any suitable source is supplied to the rollers 8 through the conduit 12 and in turn through the branch lines 13. After the steam is condensed in the rollers 10, it is exhausted through the condensate lines 14. A temperature sensing device 15 is located within the condensate line 14 so as to measure the temperature of the condensate flowing therethrough. It has been found if the temperature measuring device 15 is installed within the rollers that many times it will become enveloped by superheated steam or entrained air which will not reflect the true temperature of the steam and as a result is inaccurate. However, by installing the temperature measuring device 15 within the condensate line 14, these inaccuracies are substantially eliminated, as the temperature of the condensate is essentially equivalent to the steam from which it was condensed, and is the closest measurement to the inside surface temperature at the roller. Furthermore, the condensate temperature measuring device as located in the condensate line is easily accessible for maintenance purposes.

The temperature measuring device may be of any suitable type; one of which is particularly suited for this use is the gas expansion type. This type of temperature measuring device transforms increments of condensate temperature into directly proportional increments of pressure which constitute a signal. The pressure signal from the temperature measuring device 15 is directed to a temperature transmitter 16 which may be of any suitable type such as that sold by Minneapolis Honeywell Company as shown in their catalog C100–1, pages 24 and 26. The temperature transmitter 16 transforms the input signal into a proportionate pneumatic signal within the range of 3 to 15 p.s.i. The pneumatic signal is generated from air supplied by an air supply set 17 which is normally adjusted to 20 p.s.i. The pneumatic signal from the temperature transmitter 16 is directly proportional to the condensate temperature and is directed to the variable chamber 18 of a stack type controller 19. The stack type controller 19 may be of any suitable type such as that sold by Minneapolis Honeywell Company as shown in their catalog C100–1, pages 19, 20, and 21. The pneumatic signal is also communicated to a recorder 20 of any suitable type through the branch line 21. The recording devices by way of example may be any one of those commercially available, such as those sold by Foxboro Company as shown in their Bulletin 1325A and by the Minneapolis Honeywell Company as shown in their catalog C100–1 on pages 25 and 26.

As was mentioned previously, the controller 19 in the preferred embodiment is of the stack type. This type of controller consists of four chambers, i.e., the set chamber 22, the variable chamber 18, the valve chamber 23, and the supply chamber 24. The set chamber 22 receives a signal of predetermined magnitude from the set point section of the recorder 20 as will be seen later on. This signal is balanced against the signal received from the temperature transmitter 16 in the variable chamber 18. When the condensate temperature is at the desired level,

the signals received by these two chambers are substantially equal in magnitude. However, when the signals are not equal, the valve chamber **23** is caused to emit an increased or decreased pressure signal which is a function of the signals received in the set chamber **22** and the variable chamber **18**. The signal from the valve chamber **23** is generated from supply air received by the supply chamber **24** from an air supply set **25**. The signal is communicated through a conduit **26** to a steam control valve **27** to adjust the amount of steam flowing into the rollers in accordance with the temperature.

Referring now to the recorder **20**, it consists of two separate sections, i.e., a recording section, and an adjustable pneumatic set point section. The recording section receives the pneumatic output signal from the temperature transmitter **16** and by means of a Bourdon tube acting in conjunction with appropriate mechanical linkages, a recording pen is caused to continually record the condensate temperature. The adjustable pneumatic set point section may be conveniently located within the enclosure of the recorder but may be located elsewhere. This section continually provides a predetermined pneumatic set point signal to the set chamber **22** of the controller **19**. This section consists of an air supply set **28** which is adjusted to provide a constant pressure supply of 20 p.s.i. and an appropriate mechanical linkage which transforms the air supply into the desired pneumatic set point signal. The magnitude of the set point signal may be adjusted by means of a manual adjustment knob **29**. Any given set point corresponds with a given control temperature and the controller will tend to maintain the temperature of the condensate at the control temperature or the related set point selected.

The set point signal is normally communicated to the controller **19** through the conduit **31** in which is located the three way solenoid valve **32**. Under certain conditions the solenoid valve **32** is reversed so that the conduit **31** is blocked off. When the valve is in this latter position, the signal is communicated through the conduit **33** in which is located the biasing relay **34** which is operated by air from an air supply set **35**. The relay **34**, which is manually adjustable, is so constructed that it automatically reduces the set point signal from the recorder **20** a predetermined amount. As will be seen later, this reduction in magnitude of the set point signal causes a corresponding reduction in the temperature of the dry end section. The biasing relay **34** may be of any suitable type such as that sold by Minneapolis Honeywell Company as shown in their catalog C100–1, pages 36 and 38, and that sold by Taylor Instrument Company, as shown in their Bulletin 98097 AC.

The solenoid valve **32** is controlled by a photoelectric device generally denoted by the numeral **36**. The photoelectric device **36** senses a break in the web **9** and instantaneously sends a signal through the wires **37** to the solenoid valve **32**. In FIGURE 1 the photoelectric device **36** is shown as being located within the wet end section. However, it may be located in any one of the several drying sections. The photoelectric device **36** and solenoid are so related that as long as the web **9** interrupts a light beam, the three way solenoid valve **32** is open to the conduit **31**. If the beam should be completed by a break in the web, then the solenoid valve reverses itself so that the conduit **33** is open and the conduit **31** is closed.

The operation of the control system as previously disclosed will now be briefly described. During normal operation the temperature of the condensate in the lines **14** is sensed by the temperature measuring device **15**. The latter sends a signal to the temperature transmitter **16** which in turn generates a proportionate pneumatic signal in the range of 3 to 15 p.s.i. This signal is communicated to the controller **22** and a recorder **20**. At the same time a signal of predetermined magnitude is being sent by the set point section of the recorder **20** to the set chamber **22** of the controller **19**. As long as the signals of the set

chamber **22** and the variable chamber **18** are substantially the same, the system is in equilibrium. If the signal received in the variable chamber **18** varies either upwardly or downwardly, a decreased or increased signal respectively will be sent to the steam control valve **27** in order to decrease or increase the steam.

If during the operation, the web **9** should break, the photoelectric device **36** will cause the three way solenoid valve **32** to be reversed. At this point the set point signal is directed through the conduit **33** and the biasing relay **34**. As mentioned previously the relay **34** subtracts a predetermined amount from the set point signal. Thus the signal received in the set chamber **22** is reduced from that received during normal operation. The signal received in the variable chamber **18** is now greater than that received in the set chamber **22** indicating that the temperature of the dry end section **10** is too high. As a result, a signal is sent out from the variable chamber **18** to partially close the steam control valve **27** in order to reduce the steam input into the rollers.

During the shutdown due to the break in the web **9** the control device will act substantially the same in controlling the temperatures of the rollers as during the normal operation with the exception of the set point signal being directed through the biasing relay. It is apparent from the foregoing description that the control system instantaneously acts to reduce the amount of steam into the rollers after a break in the paper. During the remainder of the shutdown the control system maintains the roller temperature at some level below the normal operating temperature. In actual operation the reduced temperature is generally slightly below the operating temperature preferably within the satisfactory drying range. Thus when the web is threaded back onto the rollers, any delay ordinarily necessary to bring the rollers back up to temperature is substantially eliminated. At the same time any tendency for the rollers to increase in temperature due to the decrease in the heat extraction rate is also eliminated.

Referring now to FIGURE 2, there is shown a temperature control system including a refinement over that shown in FIGURE 1. This control system includes the system disclosed with regard to FIGURE 1 and several additional elements which comprise the refinement and will now be described. The basic part of the system is substantially the same as that described previously and will not be repeated at this time.

Adjacent to the surface of one of the rollers is a suitable device **40** for measuring the surface temperature of the roller. One type of temperature sensing device that is particularly adapted for this use is a surface pyrometer. This type of temperature sensing device has only to be accurate as to changes in temperature, and need not necessarily be accurate as to the absolute value, without detracting from the effectiveness of the control. Other types of temperature measuring devices may be used if desired.

The surface pyrometer **40** transmits a signal to a surface temperature transmitter **41** which may be of the same type as transmitter **16** and which is operated by **20** p.s.i. air from an air supply set **42**. The surface temperature transmitter **41** transforms the air from the air supply set **42** into a pneumatic signal proportional to the surface temperature and in the range of 3 to 15 p.s.i. This signal is communicated by the conduit **44** to a recorder **43** which provides a continuous written record of the surface temperature. The signal is also directed to a stack type controller **45** into the set chamber **46** and the variable chamber **47** by the conduits **51** and **56**, respectively. The controller **45** may be of the same type as controller **19** and in this instance is operated by 20 p.s.i. air received in the supply chamber **49** from an air supply set **48**. A normally open solenoid valve **50** is located within the conduit **51**. When the solenoid valve **50** is open, the signal received by the controller **45** is the same in both the set chamber **46** and the variable chamber **47**.

Connected to the valve chamber 52 by the conduit 53 is the relay 54 which receives pneumatic signals from the valve chamber 52. As long as the solenoid valve 50 is open so that the set chamber 46 and the variable chamber 47 are in balance, there is a constant signal from the valve chamber 52. The relay 54 may be of the same type as relay 34.

The relay 54 is somewhat different from that shown in FIGURE 1 in that it receives not only the signal from the recorder 20 but also the signal from the valve chamber 52. The relay is of such a construction that, the moment the set point signal from the set point section of recorder 20 is passed through it, it instantly reduces this signal a predetermined amount. The relay also acts to continually modify the reduced signal in conformance with the control signal emitted from the controller 45 which is proportional to changes in the drier surface temperature which occur after the web break.

The operation of the refinement will now be briefly described in conjunction with the basic system best shown in FIGURE 1. If the paper should break, the photoelectric device 36 will cause the solenoid valve 32 to be reversed so that the set point signal from the recorder 20 is now communicated through the conduit 33 into the relay 54. At the same time the solenoid valve 50 will be closed so that the pneumatic signal received in the set chamber 46 is locked in. Assuming that the system is in equilibrium at the time of the break, the locked in signal will be the reference signal for surface temperature during the break. During the time the solenoid valve is closed, the pressure within the set chamber 46 will remain substantially the same.

As soon as the break occurs, the relay 54 reduces the set point signal a predetermined amount, so that the signal received by the set chamber 22 of the controller 19 is reduced. As was explained previously, this will cause an unbalance between the said chamber 22 and the variable chamber 18 of the controller 19 so that a signal is communicated through the conduit 26 to partially close steam control valve 27. As a result, the steam control valve is partially closed so that the amount of steam fed into the rollers 10 is reduced.

At the same time, if the temperature at the surface of the rollers should vary, the corresponding variance in signal is received in the variable chamber 47 of the controller 45 from the surface temperature transmitter 41. This variance will cause an unbalance between the said chamber 46 and the variable chamber 47, so that a signal proportional to surface temperature is emitted from the valve chamber 52 of the controller 45. This signal is received by the relay 54. If the signal is the result of a decrease in the roller surface temperature, the relay output signal will correspondingly increase in magnitude. Thus the reduced set point signal to the set chamber 22 will be increased, so that the steam control valve 27 is opened to a greater extent. Conversely, if the signal is the result of an increase in roller surface temperature, the signal from the valve chamber 52 will cause the relay to decrease the reduced set point signal so that the valve is closed to a greater extent. In this way the surface temperature of the rollers is maintained at a predetermined level during the shutdown.

As soon as the paper is threaded on the rollers, the solenoid valve 50 is opened so that the signal received from the surface transmitter 18 is substantially the same in both the set chamber 46 and the variable chamber 47. At the same time the three way solenoid valve 32 is reversed to its normally open position so that the set point signal generated by the recorder 20 is communicated directly to the set chamber 22 of the controller 19. Thus it is apparent that the refinement operates only during the shutdown due to a break in the paper and that during normal operation the temperature is controlled by the basic portion of the system.

In the preferred embodiment a steam control valve 27 of the air to open type has been selected so that in the event of a control air failure, the steam would automatically be shut off. However, other types of valves that may be automatically controlled by a pneumatic signal may be used in the practice of the invention.

As was mentioned previously, the dry end section of the driers is controlled as described and other sections are normally controlled as a function of the dry end section. This may be accomplished by means of a relation controller (not shown) which is a device that continually provides a signal on the steam control valve of the next section of a predetermined amount less than the instantaneous signal on the control valve of the dry end section. The difference in actual operation between adjacent steam control valves is usually 3 p.s.i. This corresponds to a reduction of a typical dry end condensate temperature of 238° F. to about 236° F. for the condensate temperature of the adjacent section. In this manner the various sections of the drier train can be controlled as a function of the condensate temperature of the dry end section.

The controller used in the preferred embodiment of this invention is a stack type controller with proportional plus reset response. This type of controller provides excellent control even with load changes because of the use of quick response high precision instrumentation with a reset feature. Thus, if the load should change, the controller will make a corresponding correction so that there is no interruption in the operation. However, in certain operations a proportional type controller without the reset feature may be adequate for this use. This is particularly so when the paper making machine is used for making one type of paper.

Although certain elements, uses, and values have been specified, it is to be understood that these may be varied wherever possible and that they are merely by way of example rather than limitation. It is apparent that certain modifications of the invention as disclosed herein may be made within the scope of the claims without departing from the spirit of the invention.

We claim:

1. A system for maintaining steam heated rollers for drying the web from a paper making machine at a predetermined temperature comprising a temperature sensing device adapted to measure the temperature of the steam condensate from said rollers, a controller for receiving a signal from said temperature sensing device, means for establishing a predetermined reference signal in said controller, said reference signal and said first signal being substantially equal when said rollers are at said predetermined temperature, a valve for controlling the amount of steam flowing into said rollers, said valve being operated by a signal from said controller which is a function of said first signal and said reference signal, a photoelectric device for detecting a break in the web, means for reducing the magnitude of said reference signal actuated by said photoelectric device, a temperature sensing device for measuring the surface temperature of said rollers, and a controller actuated by a break in the web and adapted to receive signals from said temperature sensing device, said last named controller varying the amount of the reduction of said reference signal by said last named means in accordance with the signals from the temperature sensing device.

2. A system for maintaining the steam heated rollers for drying the web from a paper making machine at a predetermined temperature, comprising a temperature sensing device adapted to measure the temperature of the steam condensate from said rollers, a controller for receiving a signal from said temperature sensing device, a recorder actuated by said temperature sensing device, means for establishing a predetermined reference signal in said controller, said reference signal and said first signal normally being in balance, a valve for controlling the amount of steam flowing into said rollers, said valve being operated by a signal from said controller which is a func-

tion of said first signal and said reference signal, a photoelectric device for detecting a break in the web, a pyrometric device for measuring the surface temperature of said rollers, a second controller for receiving signals from said pyrometric device, a solenoid valve actuated by said photoelectric device, said solenoid valve causing a reference signal to be established in said second controller during a break in the web, and a relay means for reducing the magnitude of said first reference signal in accordance with said surface temperature.

3. A system for maintaining the steam heated rollers for drying the web from a paper making machine at a predetermined temperature comprising a temperature sensing device adapted to measure the temperature of the steam condensate from said rollers, a controller for receiving a signal from said temperature sensing device, means for establishing a predetermined reference signal in said controller, said reference signal and said first signal being substantially equal when said system is in equilibrium, a valve for controlling the amount of steam flowing into said rollers, said valve being operated by a signal from said controller which is a function of said first signal and said reference signal, a photoelectric device for detecting a break in the web, relay means for reducing the magnitude of said reference signal actuated by said photoelectric device, a pyrometric device for measuring the surface temperature of said rollers, a second controller for receiving signals from said pyrometric device, and a solenoid valve actuated by said photoelectric device, said solenoid valve causing a reference signal to be locked in said second controller during a break in the web, said second controller causing the reduction of the reference signal to be varied in accordance with the surface temperature of said rollers.

4. A system for maintaining the steam heated rollers for drying the web from a paper making machine at a predetermined temperature comprising a temperature sensing device adapted to measure the temperature of the steam condensate from said rollers, a controller for receiving a signal from said temperature sensing device, means for establishing a predetermined reference signal in said controller, said reference signal and said first signal being substantially equal when said rollers are at said predetermined temperature, a valve for controlling the amount of steam flowing into said rollers, said valve being operated by a signal from said controller which is a function of said first signal and said reference signal in accordance with the variation from said predetermined temperature, a photoelectric device for detecting a break

in the web, relay means for reducing the magnitude of said reference signal actuated by said photoelectric device, a pyrometric device for measuring the surface temperature of said rollers, a second controller for receiving signals from said pyrometric device, and a solenoid valve actuated by said photoelectric device, said solenoid valve causing a reference signal to be locked in said second controller during a break in the web, said second controller communicating a signal to said relay means so that the amount of reduction in said first reference signal is varied in accordance with the surface temperature of said rollers.

5. A system for maintaining the steam heated rollers for drying the web from a paper making machine at a fixed temperature comprising a temperature sensing device adapted to measure the temperature of the steam condensate from said rollers, a controller for receiving a signal from said temperature sensing device, means for establishing a predetermined reference signal in said controller, said reference signal and said first signal normally being in balance, a valve for controlling the amount of steam flowing into said rollers, said valve being operated by a signal from said controller which is a function of said first signal and said reference signal, a photoelectric device for detecting a break in said web, relay means for reducing the magnitude of said reference signal actuated by said photoelectric device, a pyrometric device for measuring the surface temperature of said rollers, second a controller for receiving a surface temperature signal from said pyrometric device, a solenoid valve actuated by said photoelectric device, said solenoid valve causing a reference signal to be locked in said second controller during a break in the web, said second controller being actuated by the differential between said second reference signal and said surface temperature signal to cause the reduction of said first reference signal to be varied in accordance with the surface temperature of said rollers.

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