Feb. 26, 1963 W. F. HUCK 3,078,587

COORDINATED HEATER AND SPEED CONTROL FOR WEB DRYING MACHINES

Filed Jan. 29, 1959 4 Sheets-Sheet 1

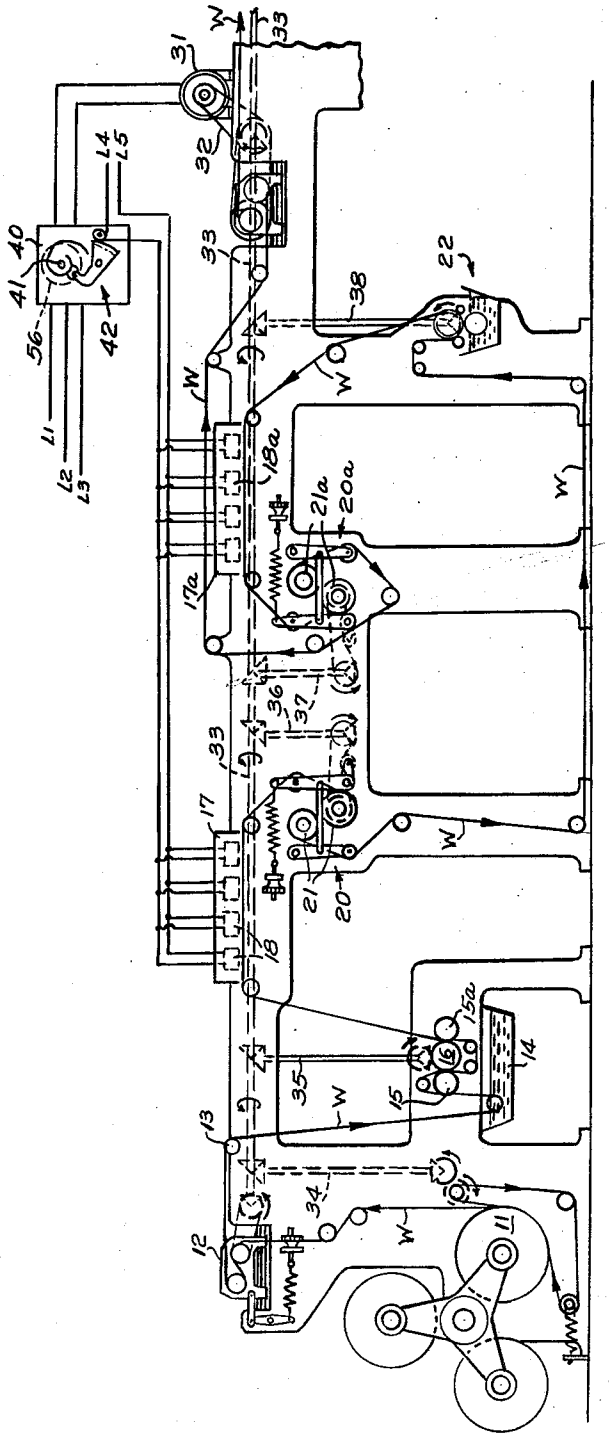


Fig. 1

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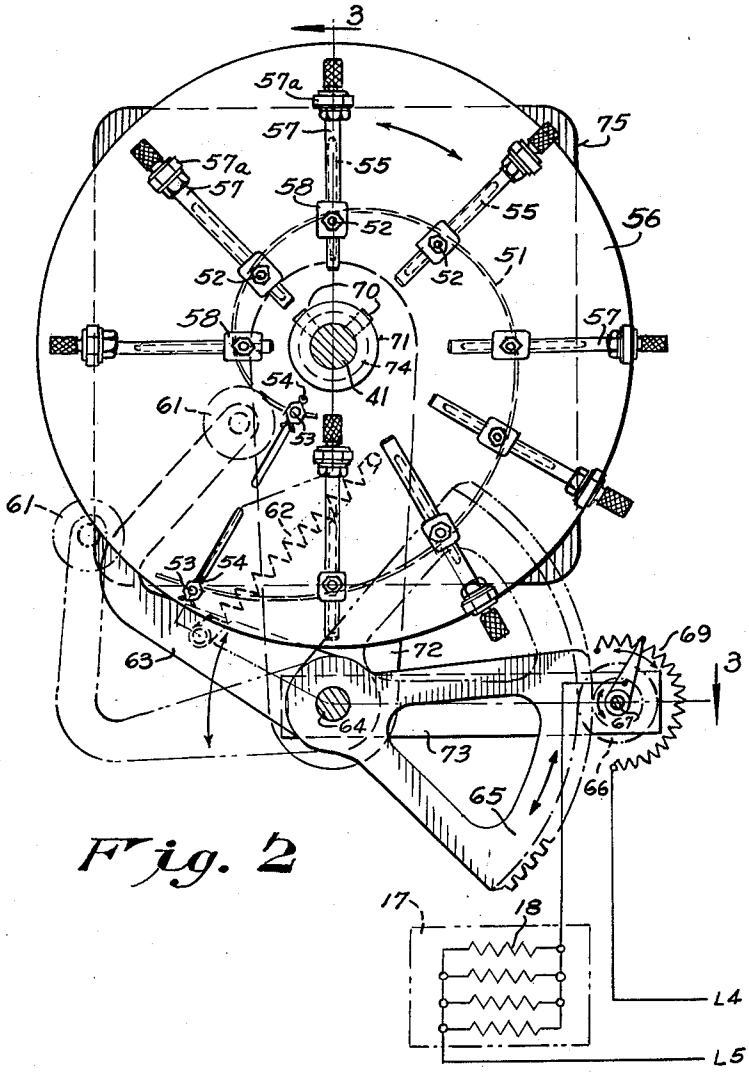


Fig. 2

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COORDINATED HEATER AND SPEED CONTROL FOR WEB DRYING MACHINES

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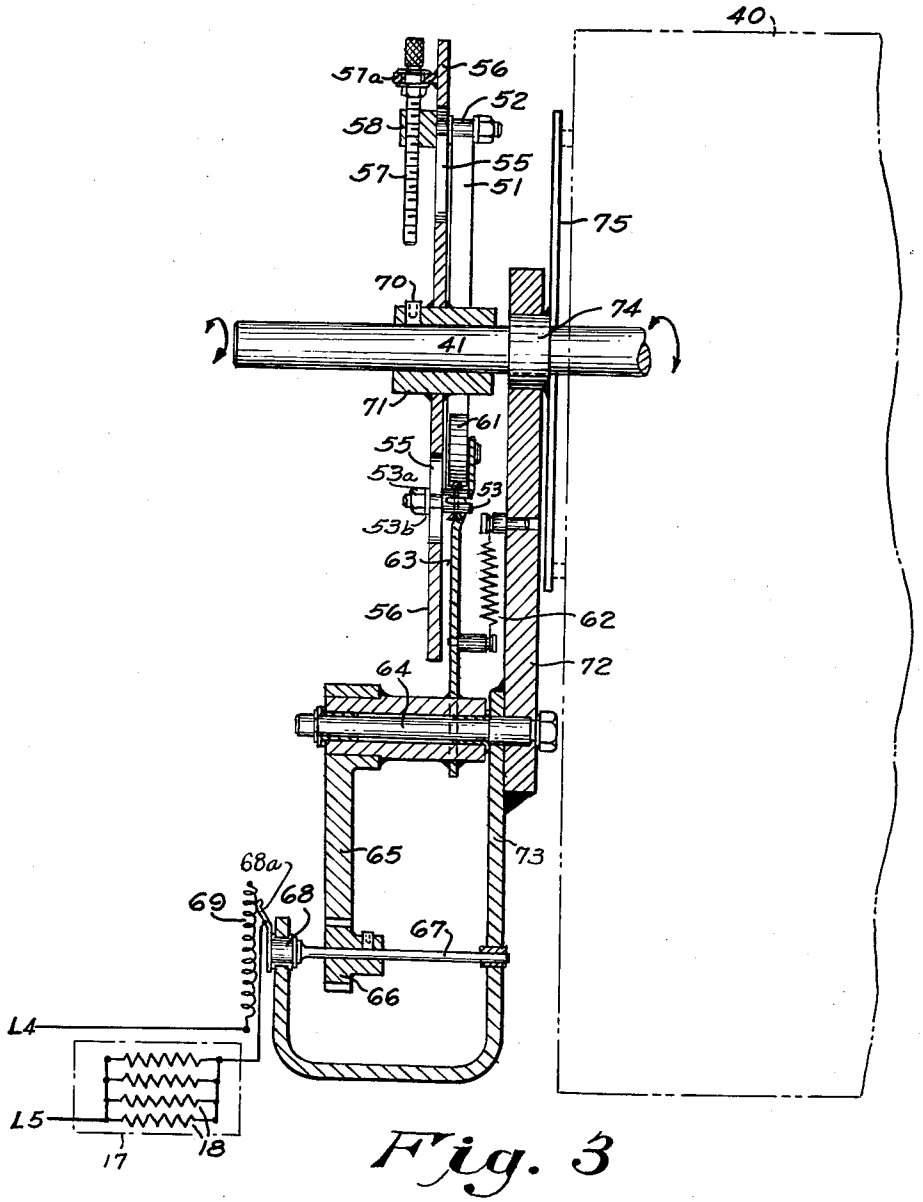


Fig. 3

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COORDINATED HEATER AND SPEED CONTROL FOR WEB DRYING MACHINES

Filed Jan. 29, 1959 4 Sheets-Sheet 4

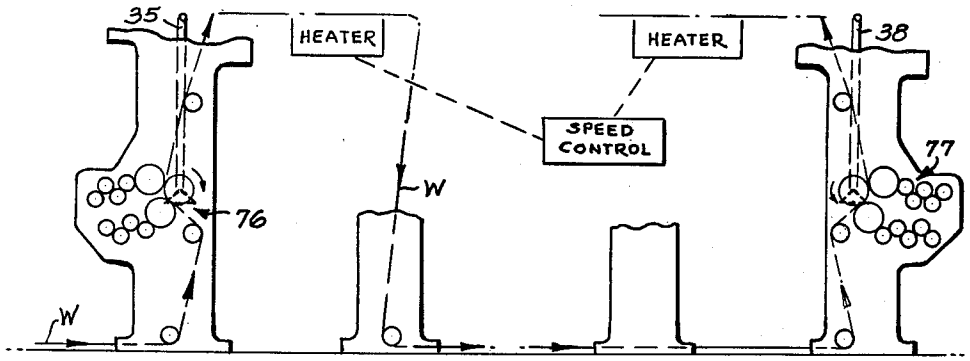


Fig. 4

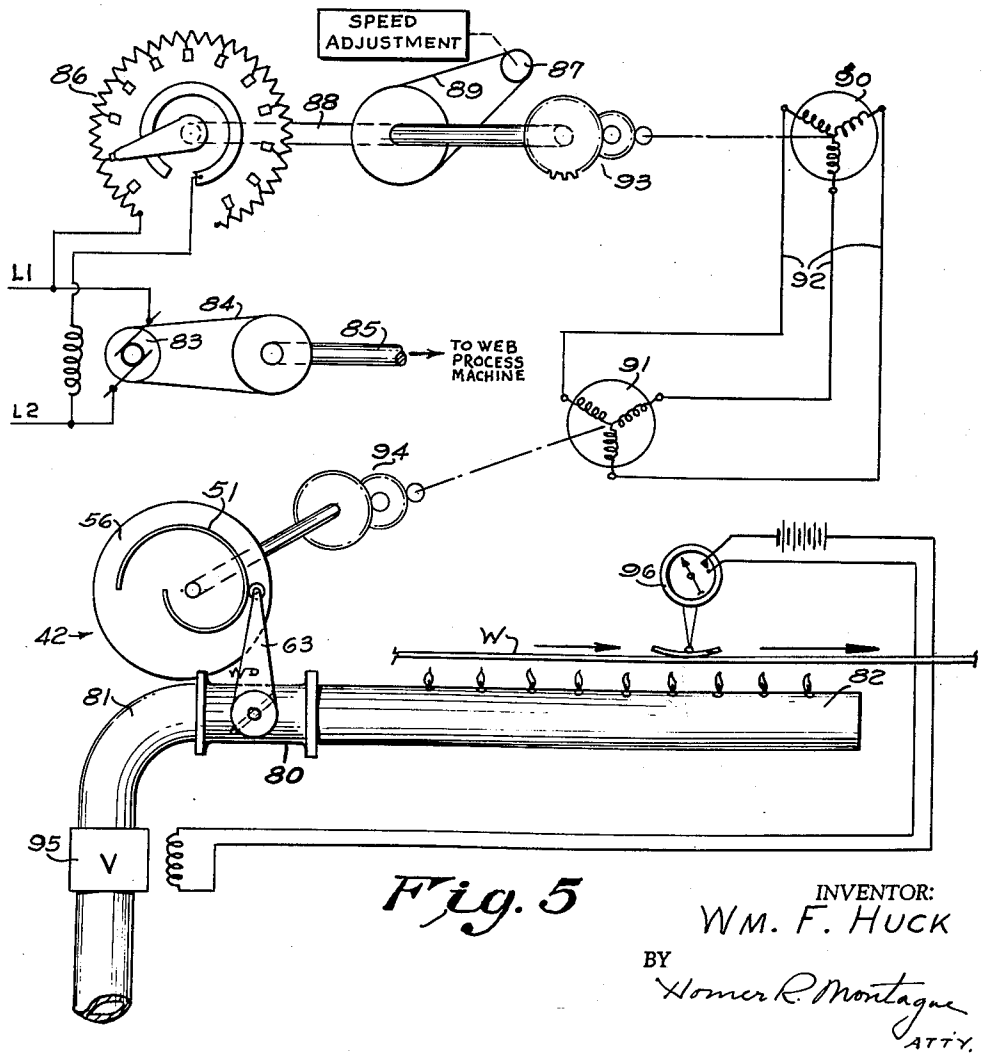


Fig. 5

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3,078,587

COORDINATED HEATER AND SPEED CONTROL FOR WEB DRYING MACHINES

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Filed Jan. 29, 1959, Ser. No. 789,970
5 Claims. (Cl. 34—48)

The present invention provides improvements in the automatic and coordinated control of the relationship between the heating effect and the rate of web travel, in web processing machines such as printing presses or the like, or similar machines involving any kind of moistening and drying stages where heat is employed as the drying agent.

The invention is particularly applicable to machines and processes employed in the graphic arts industries, where the web material is usually paper or analogous foils which are susceptible to differential shrinkage or extension as a result of moistening and drying operations. For this reason, the following specification will be directed specifically to such typical examples but without any intention thereby to limit the applicability of the principles of the invention to such installations.

Presently known automatic heating control devices, which are used to regulate electrical heating effects, or heating and drying by hot air, oil or gas flames, or steam or hot water drums and the like, operate on the principle of attempting to maintain a constant temperature, either directly on the web or in ovens surrounding the web. These controls invariably require continuous small fluctuations of the heat input about a certain median value, in an attempt to maintain constant net heating effect on the web, even when the latter is moving at a constant speed. This "hunting" action is due to the inherent time delay in such controls, between the sensing of errors and their correction. The effect of the time delay is less serious when the web speed is constant, but becomes more so during periods of web speed change. Also, while such systems may work well enough at slow processing speeds because the delay effects average out over the relatively lengthy exposure time of a web region to the heating effect, they introduce intolerable errors at high processing speeds.

For example, that section of a web length subjected to more heat will shrink more than another section subjected to less heat, producing a corresponding variation in register accuracy. Tests have shown that two hundred inches of moist paper web subjected to a temperature variation of 35° Fahrenheit will vary in length approximately 0.01 inch (due to the combined effects of thermal expansion and desiccation), whereas, in high quality printing work, a variation of 0.005 inch in web register is considered excessive.

It is accordingly a principal object of this invention to provide a simple and reliable heat input control that will automatically assure the predetermined heating effect required for a selected web speed, and will thereafter maintain this heating effect in a proper functional relation to the web speed, without fluctuations of any sort. The invention achieves this aim by providing an arrangement such that the magnitude of heat input can be established for two or more values of web speed within the range desired, as by experiment at these speeds, to establish a correct functional relation which should be maintained. These values are set manually into an adjustable cam device having a preferably flexible surface, which therefore conforms to interpolated values between the successive control values as already established. Where the cam is a rotary element, its angular position will be controlled by the speed adjusting means of the web process machine, and a suitable follower riding on the cam surface will

set the heat input control, be it electrical or of other type, to the desired correct position for optimum heating effect at the particular speed of the web. Thus, the invention will provide correct heat control for each given web speed, even when the latter varies rather widely, as during start-up and shut-down operations, and without the usual fluctuations which are inherently involved in the technique of sensing a temperature change in the web, and only after such a change occurs, initiating a heating variation. Also, of course, since the invention provides a normally constant heating effect for a given web speed, the hunting variations of conventional controls, which occur even at constant speed, will not be introduced.

Briefly, then, the invention provides a control system for machines processing webs and including the heating or drying thereof, such that the magnitude of the heat input effect is instantaneously varied under direct control of the machine speed, or web travel speed, according to a predetermined arbitrary, empirical, or even calculated schedule defining a functional relationship which has been established as satisfactory; and this, apart from any direct control of the heating effect by temperature sensing. Preferably, the control is exercised through the medium of a settable cam including a flexible cam surface, to provide smooth interpolation for values between those established directly by measurement or observation. A web temperature sensing safety or limit control can, of course, be used as an auxiliary device to prevent excessive heating by shutting off the fuel or heat supply entirely.

Certain preferred embodiments of the invention will now be disclosed in detail, by way of example, and with reference to the appended drawings, in which:

FIGURE 1 is a schematic side elevational view of a typical web process machine incorporating the invention, shown with the near side machine frame removed for clarity.

FIGURE 2 is a plan view of a preferred form of heat-control cam device suitable for control in accordance with the machine speed.

FIGURE 3 is a vertical sectional view, taken along the broken line 3—3 of FIGURE 2.

FIGURE 4 is a fragmentary schematic view, similar to FIGURE 1, but showing the invention applied to a different specific web process machine.

FIGURE 5 is a schematic view showing the invention as applied to a web process machine utilizing fuel-fired web heating or drying.

Referring first to FIGURE 1 of the drawings, there is shown a typical web processing machine in which a web W, of paper, for example, unwinds from a supply roll 11 and then travels vertically upward into a web tension control device 12 which may be of the type shown in Huck Patent 2,787,463 of April 2, 1957. Web W thereafter travels to the right over idler roller 13 and subsequently downward into the tinting bath 14 which saturates the web material with a tinting liquid. The excess moisture is removed from the web by the action of squeegee rollers 15, 15a against the impression cylinder 16, after which the damp web travels upward into the drying oven 17 where it is dried by radiant electric heaters 18. Web W, after emerging from oven 17, next comes into contact with cooling rollers 21 which are part of the web tension control mechanism 20, the operation of which is fully described in the pending patent application, Serial No. 677,143, filed August 8, 1958, now Patent No. 2,949,295. The said application, filed in the name of the present inventor, is assigned to the owner of the present application, and provides a system for equalizing the web tension in web W before and after heating and cooling of the web.

The operations described above are then repeated by passing the tinted, dried and cooled web horizontally to

the right along the bottom of the machine and then upward into a gumming unit, generally indicated by reference numeral 22, which applies an adhesive gum coating of uniform thickness to the web. The web then travels upward to a second drying oven 17*a* and thereafter is brought into contact with cooling rollers 21*a* of tension control mechanism 20*a*, these parts being identical with those already described and having similar but unlettered reference numbers. Finally, the web exits to the right where it may undergo additional processing, or be coiled for shipment.

The processing machine is driven by a motor 31 through belt drive 32 and a horizontal driveshaft 33 which runs along the top of the processing machine as shown in FIGURE 1. Each unit of this machine is driven individually by vertical transmission shafts 34, 35, 36, 37 and 38. The speed of drive motor 31 is controlled by speed variator unit 40, a well known commercially available speed control device. Control unit 40 has a shaft extension 41 which changes its position as the variator calls for web speed variations. The heating control mechanism, generally indicated by numeral 42, is carried on this shaft extension.

In a typical constructed embodiment of the invention, the power input to control unit 40 was of the three-wire, 230 volt, 60 cycle, three-phase alternating current type. Control unit 40 also contains a rectifier device which converts this input power to direct current to drive motor 31, in a typical variable speed press drive. However, the principles of the invention are applicable to any other form of electrical power supply, as will be understood by those skilled in the art.

Heating control unit 42 is indicated only schematically in FIGURE 1, and for a detailed description thereof, reference will now be made to FIGURES 2 and 3 of the drawings. As there shown, the device consists essentially of a variable contour cam whose contour is formed by flexible strip 51, preferably of polished metal or the like, which wraps about pins 52 and is secured at its ends to pins 53 by means of cotter pins 54. Pins 53, as best shown in FIGURE 3, may be secured in proper radial position within their range by means of a clamping nut 53*a* and washer 53*b*. Each of the other pins 52 is precisely adjustable, in the radial direction, by means of a threaded screw 57 journalled in a block 57*a* secured as by welding to the disc 56, and engaging the threads of a corresponding pin-carrying head 58. The arrangement permits the operator to select one or more of the cam points at will, as dictated by knowledge or experiment, and then to establish the other cam-defining points to obtain satisfactory operation for other values of web speed.

A cam roller 61 is held in continuous contact against flexible strip 51 by spring 62. Follower arm 63 pivots about shaft 64 and has a gear sector 65 attached to its opposite end. The gear sector meshes with pinion 66 on the output shaft element 67 which has an extension 68 carrying the wiper arm 68*a* of a heating control rheostat 69. Shaft extension 41 constitutes the input element of the over-all heating control mechanism, and thus controls the position of the output shaft element 67 to modify or alter (and thus act as a regulator for) the application of heat to the web as the web speed changes.

The slotted disc 56 is positioned on input shaft extension 41 as by means of set screws 70 in hub 71, so that the disc rotates identically with the input shaft 41, which, as has been stated, operates like a speedometer spindle; that is, the angle through which the shaft moves is proportional to the change in the operating speed of its associated device. Frame pieces 72 and 73, located at right angles to the shaft 41, are supported by hub 74 fixedly secured to a stationary plate 75, in turn secured to speed variator control unit 40 as seen in FIGURE 3.

In operation with a web processing machine in which flexible materials such as paper, cloth, felt and the like are moistened by tinting, water-marking, gumming, printing and so on, and subsequently dried by heating, the input shaft 41 is actually an extension of the drive motor control rheostat which is set, usually manually, to establish the desired speed of the traveling web. Rheostat 69, on the extension 68 of output shaft 67, is located in the heating circuit, or heating control circuit, of the drying unit. Since the variable cam unit is driven by shaft 41, it follows that rheostat 69 will be varied in accordance with any change in the web travel speed, to an extent regulated by the shape of the cam. Hence, a change in web speed is immediately reflected as a modulation in the heat input to the web, without any delay of the kind involved in systems which vary the heat control only in response to an actual change in the temperature of the web.

FIGURE 4 of the drawings is similar to FIGURE 1, but illustrates the control as applied to a multiple impression printing press, the tinting unit 14, 15, 16 having been replaced by an imprinting unit 76 which places printed patterns on one side of web W, and gumming unit 22 has been replaced by a second imprinting unit 77, which prints patterns on the other side of the web. Similar arrangements can be used with other forms of perfecting or multi-color presses and analogous machines requiring heating or drying facilities.

From what has been said, it will be obvious to those skilled in the art that the invention does not depend upon the particular type of speed regulator which is employed, so long as it provides an output shaft, or other movable element, whose position is uniquely related to the web travel speed. Thus, the control shaft may be a manual speed control, or it may be a mere speed indicating shaft, or it may be a part of an automatic speed regulating system. In any case, accurate control of the web heating power input will depend only upon the accuracy with which the operator in charge of the machine adjusts the variable cam, which can best be done by trial and error with a given machine set-up, material, process and like parameters.

FIGURE 5 of the drawings illustrates in schematic form a variation of the invention which is particularly applicable to machines which employ other than electrical heating power, and in which, therefore, the controls for the heat input are likely to be near the point of heat application and hence remote from the motor speed control. Also, the controls for such systems may well be multiple valves or other multiple controls.

FIGURE 5 therefore illustrates a servo or follow-up control system between the speed variator shaft and the controlled device or devices, here exemplified as a fuel valve 80 in a gas line 81 supplying a flame drying unit 82 arranged to dry a web again denoted W. The web drive motor is indicated at 83, connected by chain or like drive means 84 to the main shaft 85 of the web processing machine. A speed control for motor 83 is indicated as a rheostat 86 electrically in series with the field winding of the motor, but it will be understood that equivalent different systems can be employed. In any case, the actual speed adjustment is made by a shaft 87 under suitable manual or automatic control, said shaft being connected to the shaft 88 of rheostat 86 in any convenient manner, herein by a chain 89. Remote control of the heat control unit 42, which is the same as in FIGURES 1, 2 and 3, is accomplished by a remote control system here exemplified as a servometer 90 acting as a transmitter, and a similar unit 91 acting as a receiver. As well known, such devices are capable of reproducing mechanical motions to good accuracy over wire lines, here shown as three conductors 92.

For good accuracy and sensitivity, I have shown shaft 88 as connected to transmitter 90 through step-up gearing 93, and receiver 91 connected to unit 42 by equivalent step-down gearing 94; the servo system may if desired

be of the alternating current "Selsyn" type, but many equivalent remote control systems can also be utilized. Where more than one valve or like fuel control device must be adjusted, a single transmitter **90** may transmit control signals to several receivers, each connected to a valve.

It sometimes happens that a particular control cam unit setting can be used for several different processes, with a change in the effect thereof which is proportional throughout the control range; for example, where the only process change is a change in the basic weight of the web material. In such cases, it is unnecessary to readjust the entire cam strip **51**, because the necessary correction may be made merely by proper phasing of the output shaft of the control unit. As shown in FIGURE 5, such may be accomplished by altering the positions of two adjacent gears as at **93** or **94**, or by changing the position of follower arm **63** relative to the damper shaft of the valve **80**.

FIGURE 5 also illustrates a completely independent safety shut-off for the fuel line, in case of dangerously excessive temperatures or fire. This includes a shutoff valve **95** operated under control of a thermocouple-type thermometer **96** of known kind arranged to sense the temperature of web W and to complete a control circuit, shown only diagrammatically, when the web temperature rises too high, or beyond the range of the heat control.

The foregoing description has been given in considerable detail to enable those skilled in the art to make and practice the invention, but it is to be understood that the basic concept of the invention can be carried out by other arrangements. Basically, the invention depends upon the discovery that drying by heating, of webs, and especially at high production speeds, cannot satisfactorily be controlled merely by maintaining constant the temperature of the web, as is done with known control systems. As a rule, a given web temperature does not result in the same drying effects at different speeds, in cases where drying time is a factor. When these previous systems are employed, a manual readjustment of the set temperature is necessary whenever web speed is being changed. The invention also depends upon the realization that proper drying and improved operation can be attained by controlling the net heating effect (not the web temperature) immedimately in response to a change in web speed, and to a defined degree, not by oscillating the heating effect about a desired constant level. These concepts can, of course, be implemented in various ways, and all such are intended to be included within the spirit of my invention, if they fall within the scope of the appended claims.

What is claimed is:

1. In a web processing machine of the type including, in combination, web conveying means, speed control means for adjusting the speed of said conveying means and thereby the speed of web travel, means for subjecting the web to a treatment increasing the fluid carried thereby, and drying means and a regulator therefor for applying heat to the treated web whereby to decrease its fluid content subsequent to said treatment, the improvement which comprises means controlled solely in response to the adjustment of said speed control means for modifying the application of heat to the web in accordance with a predetermined direct functional relationship to said adjustment; said modifying means including a variable contour cam type motion-transmitting mechanism having an input element connected to said speed control means and an output element to said regulator for the drying means to control the application of heat to said web.

2. The combination according to claim 1, in which said drying means comprises electrical heating elements, and in which the modifying means comprises a rheostat in circuit with said electrical heating elements, said rheostat being connected for control by the output element of said motion-transmitting mechanism.

3. The combination according to claim 1, in which said drying means comprises gas-fired heating means, and in which said modifying means comprises a gas-flow control valve connected for control by the output element of said motion-transmitting mechanism.

4. The combination of claim 1, in which said mechanism comprises a flexible cam strip and means for holding said strip in any desired configuration at a selected number of points along its length.

5. The combination of claim 4, in which said cam unit also comprises a support plate mounted to rotate in response to changes in the adjustment of said speed control means, and in which said cam strip is secured to said plate for rotation therewith; and a cam follower biased against said strip and connected to said drying means.

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