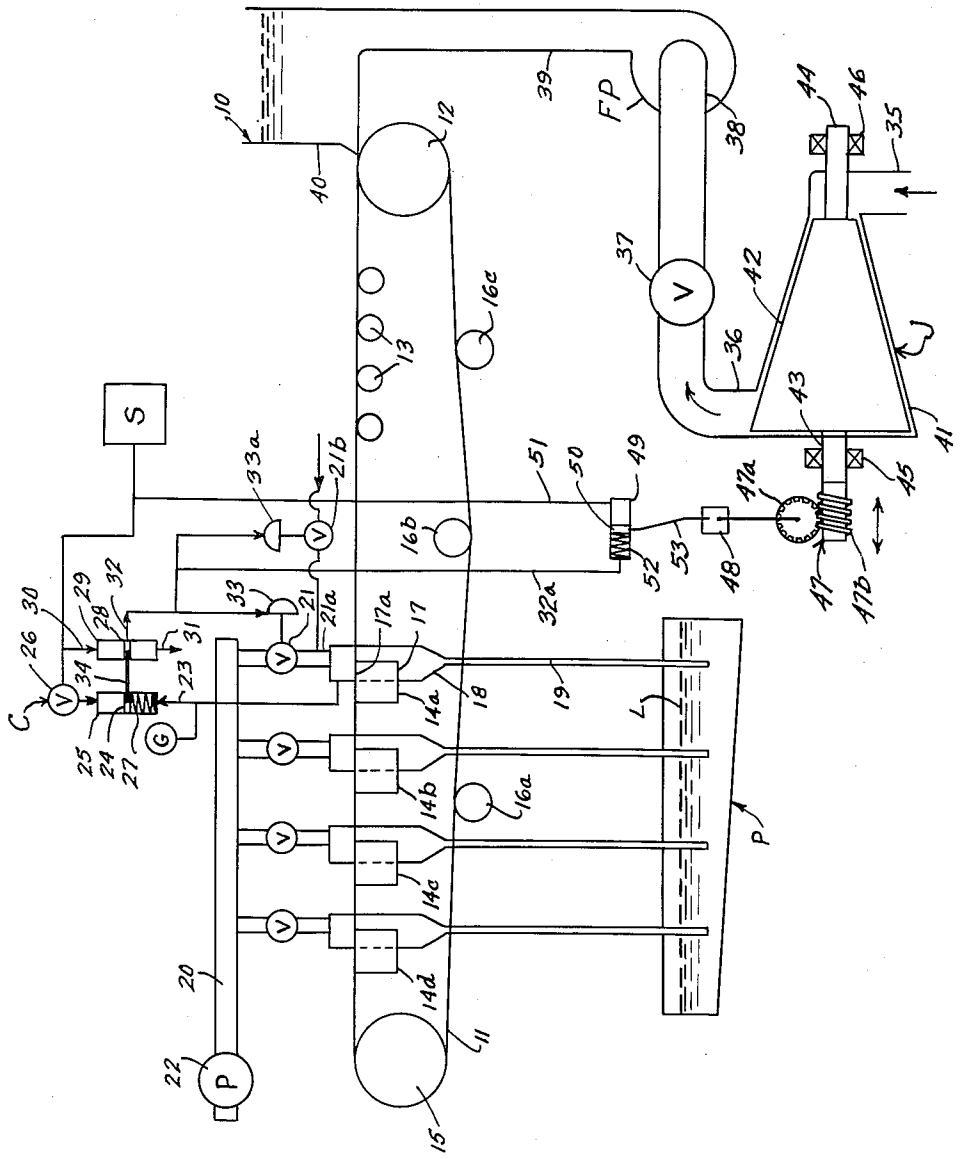
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INSTRUMENT CONTROL OF FREENESS ON THE FOURDRINIER WIRE

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INSTRUMENT CONTROL OF FREENESS ON THE FOURDRINIER WIRE

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The instant invention relates to improved control in the operation of paper machines, and more particularly, to improved control in the stock refining process and in the resulting character of the paper web formed on the wire.

In the Fourdrinier type paper machine, stock is fed onto the traveling forming wire at one end of the top run of the looped wire and the stock is dewatered to form a web on the wire. The wire travels initially over table rolls which support the same and permit the free flow of water through the wire. Next, the wire passes over suction boxes or the so-called "flat boxes" which present a foraminous top surface that engages the bottom side of the wire. A vacuum is maintained within the suction box so that it withdraws water from the web through the forming wire and the top of the box. There are a substantial number of suction boxes thus mounted in succession and after the last suction box the wire passes on over a couch roll and the web is then removed from the wire and taken on through the press section and dryers. Heretofore, the general idea was to maintain maximum vacuum on the suction boxes so as to obtain the maximum dewatering of the web as it passes thereover. This is done mainly by manual control of the vacuum applying means. Usually each suction box would be connected to a main vacuum header through a manually controlled valve, which valve was used to control the vacuum in the suction box.

Unfortunately, however, the manual control of such suction boxes left something to be desired in that it was often inadequate to take care of variations in the stock so that pressures across the wire varied randomly. The stock, or more particularly the web formed on the wire, tends to vary in its ability to release water. The ability of a web to permit release or permeation of water from the stock is referred to in the art as its "freeness." If the web releases water readily to the suction boxes it is said to have high "freeness" and the pressure differential across the web required to withdraw water therefrom at a given rate may be relatively low; whereas a much higher pressure differential would be required to withdraw the same amount of water in the case of a web of much less "freeness." Since the pressure on the top of the wet web is substantially atmospheric pressure, the pressure differential is controlled by variations in the vacuum maintained in the suction box. The water withdrawn from the web by the suction boxes flows through a drop leg to the seal pit and the measurement thereof is relatively difficult, so that variations in the rate of dewatering are not readily detectable to the operator, even though such variations may make a material difference in the final properties of the paper web as well as in operating conditions throughout the entire paper machine.

It has been found that variations in the freeness of the web or stock may be obtained through variations in the refinement of the stock before it is conducted onto the forming wire. For some time, the most commonly

used stock refining device has been the Jordan engine. The Jordan engine consists essentially of a conical cast iron shell, the inside of which is fitted with long narrow steel bars, and a relatively rotatable conical shell member (known as the "plug") fitting within the shell and mounting on its outside surface long narrow steel bars or knives which rotate in close running relation to the bars carried on the inside of the shell or housing member. The plug is journalled for rotation about the axis of the cone and it is axially movable for adjustment in the close running relation between the rotary knives on the plug and the stationary knives on the shell. The closer together the knives are the more shearing action is obtained on the fibers and the greater the refinement of the stock. It has been found that the more greatly the stock is refined, the less freeness is exhibited on the wire.

Other refining devices are known and may be used in the practice of the instant invention, such as the Marshal engine, the Claflin continuous beater, and the like and these devices resemble the Jordan engine in that they mount an axially movable rotating conical plug member carrying knives for close running relation with the knives on the conical housing member and the degree of refinement obtained in these devices can be altered by axial movement of the plug.

The instant invention is based on the discovery that greatly improved control in the operation of a paper machine is obtained if a sensing device for the freeness of the web on the wire is employed to actuate the means in control of axial movement of the plug in the refiner. More specifically, it has been found that an automatic control for vacuum control valve means for a suction box, operated in response to variations in the vacuum in the suction box, may be used for obtaining a controlled vacuum in the suction box and the means for controlling the valve means may also be used to actuate the means for controlling the axial position of the plug in the refiner. In a particular embodiment, automatic control valve means interconnect a suction box with the vacuum header or ambient atmosphere to control the vacuum in the suction box. The water flowing down the drop leg creates some vacuum; and the valve means may open to ambient atmosphere to reduce this vacuum or open to the vacuum header to increase such vacuum. This valve means is pneumatically actuated. A signal for actuating the valve means is given through a vacuum sensing means which senses the actual vacuum in the suction box. This sensing device creates an amplified pneumatic signal which actuates the control valve means; and it has been found that this pneumatic signal is closely related to the property of the stock on the wire, with respect to freeness. Accordingly, this signal is used through appropriate power multiplying means to maintain the axial position of the plug in the refiner (or expressed in other terms, to control the degree of refining carried out by the refiner). Stated otherwise, the sensing device or means derives a signal which is a measure of the output of a control device functioning in turn to maintain a constant pre-selected subatmospheric pressure in the suction box, and the signal is fed to the power multiplying means or regulating means to adjust the degree of refining.

It is, therefore, an important object of the instant invention to provide an improved control for the operation of paper machines, and more particularly, an improved control for the freeness of the stock flowing onto the wire to form the web.

Another object of the instant invention is to provide a paper machine comprising a stock refiner formed of a conical housing member and a relatively rotatable conical plug member received thereby, said members carry-

ing knives in close running relation for shearing fibers in the stock passing through said refiner and said plug being movable axially of said housing to control the degree of refinement of the fibers in stock passing therethrough, a travelling forming wire, means conveying stock from the refiner to said wire to form a wet web on the wire, a suction box mounted beneath the wire withdrawing water from the web, means maintaining a vacuum in said suction box, and means actuated by the vacuum in the suction box in control of axial movement of said plug.

Other and further objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed d'sclosure thereof and the drawing attached hereto and made a part hereof.

In the drawing the figure shown is essentially a diagrammatic view in elevation of the forming end of a paper machine showing the control embodying the instant invention.

In the drawing, the reference numeral **10** indicates generally a wet end of a paper machine. In the instant machine **10**, a looped forming wire **11** is trained over a breast roll **12**, a plurality of table rolls **13, 13**, a plurality of suction boxes **14***a*, **14***b*, **14***c*, **14***d*, a couch roll **15**, and return rolls **16***a*, **16***b*, **16***c*. As will be appreciated, substantially more suction boxes than the four here shown may be used and usually are, but for the purposes of simplicity additional suction boxes have been eliminated. Also, it will be noted later that the control arrangement is shown in connection with the first suction box **14***a* for purposes of simplifying the instant drawing, although the control arrangement can and preferably is connected to a suction box located at the "dry line" for better control (where free water on the web on the wire disappears).

Referring to suction box **14***a*, this device comprises a long narrow box **17** provided with a foraminous top cover **17***a* engaging the bottom of the wire **11**. The box **17** and cover **17***a* extend the full width of the wire **11** and, as here shown on the back side of the wire **11**, an air-water separator **18** is connected to the interior of the box **17** and is equipped with a drop leg **19** which extends downwardly below the level L of water in a seal pit P maintained below the level of the wire **11**. The action of water in the drop leg **19** creates some vacuum in the separator **18**. The separator **18** is connected to a vacuum header **20** through a control valve **21** (mounted in a conduit **21***a* interconnecting the separator **18** and the header **20**) for increasing the separator vacuum. In addition, valve **21***b* may admit atmospheric air into the conduit **21***a* to reduce vacuum therein. A suitable vacuum source such as a pump **22** maintains a substantially constant vacuum in the header **20** and the control valve means **21, 21***b* control the vacuum in the separator **18** and, therefore, the vacuum in the suction box **17**. As is indicated, substantially identical structures are shown for the other suction boxes **14***b*, **14***c* and **14***d* and further description of the details relating thereto is not necessary herein.

Referring again to the initial suction box assembly **14***a*, it will be noted that a vacuum sensing line **23** (equipped with a suitable gauge G) is connected to the separator **18** and continuously senses the vacuum therein. A control device indicated generally at C operates in response to signals from the sensing line **23** to control the valve means **21, 21***b* and thus control the vacuum in the suction box assembly **14***a*.

The control C here shown comprises a piston **24** mounted in the cylinder **25**. A fluid under pressure, such as air from the compressed air source S is fed through a pressure regulating valve **26** into the top of the cylinder **25** to urge the piston **24** downwardly. A spring **27** tends to counteract the downward force applied to the piston **24** by the compressed air and the vacuum sensing line **23** communicates with the cylinder **25** at the bottom, on the spring side of the piston **24**. Variations in the vacuum thus cause relative movement between the piston **24** and the cylinder **25**, as sensed through the line **23**. If the vacuum in the line **23** increases the piston **24** is moved downwardly, and vice versa.

A second piston **28** is mounted for relative movement in a second cylinder **29**, as another part of the control device C. Compressed air enters the top of the cylinder **29** through the line **30** and an air bleed **31** to the atmosphere is mounted at the bottom of the cylinder **29**. At the middle of the cylinder **29** there is positioned an air supply line **32** which supplies actuating air to the control mechanism **33, 33***a* for the valve means **21, 21***b*. As an example, the control device **33** may operate to open and close the valve **21** over a control pressure range of 0 to 10 p.s.i. in the line **32** (to decrease the opening of the valve **21** in response to pressure and close the same at 10 p.s.i.) and the control device **33***a* may operate to open and close the valve **21***b* over a control pressure range of 10–15 (to close the valve **21***b* at 10 p.s.i. and open it wide at 15 p.s.i.).

The control device C is shown here in the neutral position with the second piston **28** closing off the air supply line **32** so that constant air pressure (of, for example, 8 p.s.i.) is maintained on the devices **33, 33***a* and the valve means **21, 21***b* are maintained in the fixed position as a result (with valve **21***b* closed and valve **21** partially open). If the freeness of the stock on the wire **11** should increase under these initial operating conditions, the vacuum in the separator **18** will decrease. This results in an increase in the pressure in the vacuum sensing line **23** and a raising of the piston **24** in the cylinder **25**. The piston **24** and the second piston **28** are connected by a tie rod **34** so that they will move together, and the movement upward of the piston **24** results in a corresponding upward movement of the piston **28**. This opens the air supply line **32** to the ambient atmosphere through the bleed line **31** and the compressed air pressure fed to the valve control mechanism **33, 33***a* is lowered correspondingly (to, for example, 5 p.s.i.) to cause additional opening of the valve **21**. As the valve **21** moves toward open position, the vacuum in the separator **18** will increase and the corresponding decrease in pressure in the vacuum sensing line **23** results in downward movement of both pistons **24** and **28**, until the piston **28** closes off the air supply line **32**. Then the desired vacuum in the separator **18** has been reached and is being maintained by an altered setting of the valve **21**, such alteration being necessary because of the original alteration in the freeness of the stock.

Referring now to the refining section shown in the drawing, it will be seen that the stock flows initially into an intake **35** at the conical apex of the Jordan engine J and then out a discharge **36** at the conical base of the Jordan engine J, as indicated by the arrows. The stock then flows through a control valve **37** into the suction end **38** of a fan pump FP and then out the discharge **39** of the fan pump FP and upwardly into a head box **40**, from which the stock flows out onto the wire **11** over the breast roll **12**.

The Jordan engine J comprises a conical housing **41** and a conical plug **42** rotatably mounted therein in close running relation. The details of the housing **41** and the plug **42** have already been described herein and the general operation of the Jordan engine J is so well understood in the art that a detailed description thereof is unnecessary herein. It is sufficient to note that the plug **42** is mounted on journals **43, 44** (received by bearings **45, 46**, respectively) for limited axial movement (in the direction indicated by the double headed arrow) relative to the housing **41**. As the plug **42** is moved to the right in the drawing closer running relation with the housing **41** is established and greater refinement of stock is accomplished. As the plug **42** is moved to the left

less refinement of the stock is accomplished and the freeness of the stock increases correspondingly. Although it will be appreciated that in actual practice, the movement of the plug 42 is very slight in order to obtain the changes desired, and relatively delicately controlled moving means are employed, moving means 47 are here shown as a worm gear driven by a suitable motor 48 (shown diagrammatically) in the form of means which accomplish controlled slow rotation of a gear 47*a* in either direction so as to obtain limited axial movement of a worm 47*b* which is mounted for coaxial movement with the journal 43 (and the plug 42). The motor 48 may be any of a number of well known driving means including a geared down electric motor or even a piston and cylinder actuated by compressed air, since the actual rotation of the gear 47*a* would be very slight in either direction in order to accomplish the desired axial movement of the plug 42.

The motor 48 is provided with actuating means which comprise a cylinder 49 and a relatively movable piston 50 mounted therein. At the right hand side of the cylinder 49 compressed air from the compressed air source S enters through a line 51 to urge the piston 50 to the left; and a spring 52 in the cylinder 49 urges the piston 50 to the right. Also, a compressed air line 32*a* connected to the air supply line 32 for the actuation of the vacuum control valve 21 is connected to the left side of the cylinder 49 to urge the piston 50 to the right. As used in the claims, regulating means makes reference to the air lines 32*a* and 51 and the piston, motor and cylinder structure 48—50, representative of one form of regulating or power multiplying means which can be used to adjust the degree of refining in accordance with an output produced by the control means C to maintain the constant pre-selected subatmospheric pressure within the suction box 14*a*.

As previously indicated an increase in the freeness of the stock results also in an increase in the pressure in the vacuum sensing line and this, in turn, results in upward movement of the piston 28 to cause a reduction in air pressure in the air supply line 32. The valve 21, which closes in response to increased air pressure applied to the mechanism 33 will thus move toward open position to permit more air to be drawn into the vacuum header 20 and effect a corresponding decrease in the separator air pressure. The air pressure in the compressed air line 32*a*, which is connected to the air supply line 32, will also decrease and such decrease serves to move the piston 50 to the left in the cylinder 49. The piston 50 is connected through a switch 53 to the motor 48 and movement of the piston 50 actuates the motor 48. The instant movement of the piston 50 to the left actuates the motor 48 to drive the worm gear 47 so as to move the plug 42 to the right slightly. This will cause increased refinement of the stock and a consequent decrease in the freeness on the wire 11. As will be appreciated the general features of the control C as well as the motor 48 and actuating piston and cylinder 49, 50 are here shown in greatly simplified form, so that the operation of the overall device may be understood, but it will also be understood that compensating devices to prevent "hunting" and to more accurately and effectively accomplish the desired control may be used. For example, there will be a time lag before a change in the operation of the Jordan engine J will actually result in a change of the freeness in the stock on the wire 11; and to prevent continuous hunting the motor 48 and piston and cylinder 49, 50 control means will be set to "over" or "under" compensate for signals received through the compressed air line 32. These features represent, however, details of operation which are readily understood by those skilled in the art and need not be described in further detail herein.

An important feature to note in the instant device is that a freeness sensing device associated with the stock on the wire is used to actuate refinement of the stock in the Jordan engine and to control such refinement. The variations in vacuum in a suction box are a measure of variations in freeness in the stock and such variations in vacuum (actually being one of the first observable indications of variations in freeness in the stock) are used to produce actuating signals for the operation of the Jordan engine and also for the operation of vacuum control means for the suction box.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. In a paper machine, a stock refiner formed of a conical housing member and a relatively rotatable conical plug member received thereby, said members carrying knives in close running relation for shearing fibers in the stock passing through said refiner and said plug being movable axially of said housing to control the degree of refinement of the fibers in stock passing therethrough, a travelling forming wire, means conveying stock from the refiner to said wire to form a wet web on the wire, a suction box mounted beneath the wire withdrawing water from the web, means maintaining a constant predetermined vacuum in said suction box, and means actuated by the last-named means in control of axial movement of said plug and the degree of refining accomplished thereby.

2. In a paper machine, a refining engine having a member therein that is movable to control the degree of refinement of the fibers in stock passing therethrough, a support means for supporting a wet web of stock, means conveying stock from the refining engine to said support means, a suction box positioned for drawing water through said wet web on said support means, a suction header connected to said suction box, a valve means between the suction header and suction box and controlling the flow of air from the suction box to the suction header to maintain the suction pressure substantially constant, sensing means operating as a function of the flow of air through said suction box, control means actuated by said sensing means and actuating said valve means, and means actuated by said control means and maintaining an essentially constant vacuum in the box controlling movement of said member.

3. In a paper machine, a refining engine having a member therein that is movable to control the degree of refinement of the fibers in stock passing therethrough, a travelling forming wire, means conveying stock from the refining engine to said wire to form a wet web on the wire, a suction box mounted beneath the wire withdrawing water from the web, sensing means responsive to a change in the vacuum in said suction box, control means actuated by said sensing means, means connecting with said control means to control the vacuum in said suction box at a constant predetermined pressure, and means actuated by said connecting means controlling movement of said member.

4. In a paper machine, a refining engine having a member therein that is movable to control the degree of refinement of the fibers in stock passing therethrough, a travelling forming wire, means conveying stock from the refining engine to said wire to form a wet web on the wire, a suction box mounted beneath the wire withdrawing water from the web, a suction header, valve means interconnecting the suction header, ambient atmosphere and the suction box and controlling vacuum in the suction box at a constant predetermined pressure, sensing means responsive to the flow of air into the suction box from atmosphere as a result of the constant vacuum maintained in said suction box, control means actuated by said sensing means and connecting with the valve means to actuate the valve means bleeding air from the atmosphere whereby the vacuum in the suction box is maintained at said constant predetermined pressure, and means actuated by the control means controlling movement of said member in the refining engine to adjust the degree of refining.

5. In a paper machine, a refining engine having a member therein that is movable to control the degree of refinement of the fibers in stock passing therethrough, a traveling forming wire, means conveying stock from the refining engine to said wire to form a wet web on the wire, a suction box mounted beneath the wire withdrawing water from the web, a suction header, a variable valve means connected between the suction header and suction box and controlling vacuum in the suction box at a constant predetermined pressure, sensing means measuring the freeness of a web on the wire over said suction box, and control means actuated by said sensing means controlling the opening of said valve means and flowing bleed air thereto and simultaneously controlling the movement of said member.

6. In apparatus for the manufacture of paper from paper making stock, a refining engine having adjusting means for the regulation of the degree of refining accomplished therein, means for conveying the refined stock from the refining engine to a forming wire, a forming wire adapted to receive said stock from the

conveying means, a suction box mounted beneath said forming wire withdrawing water from the stock thereon, a control device for maintaining a constant preselected sub-atmospheric pressure in said suction box, sensing means deriving a signal which is a measure of the output of said control device, and regulating means adjusting the degree of refining in accordance with said signal.

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