June 29, 1971 S. M. SALOMON 3,589,980

CONTROL OF HEADBOX STOCK CHACTERISTICS

Filed Jan. 2, 1968 2 Sheets-Sheet 1

Fig. 1

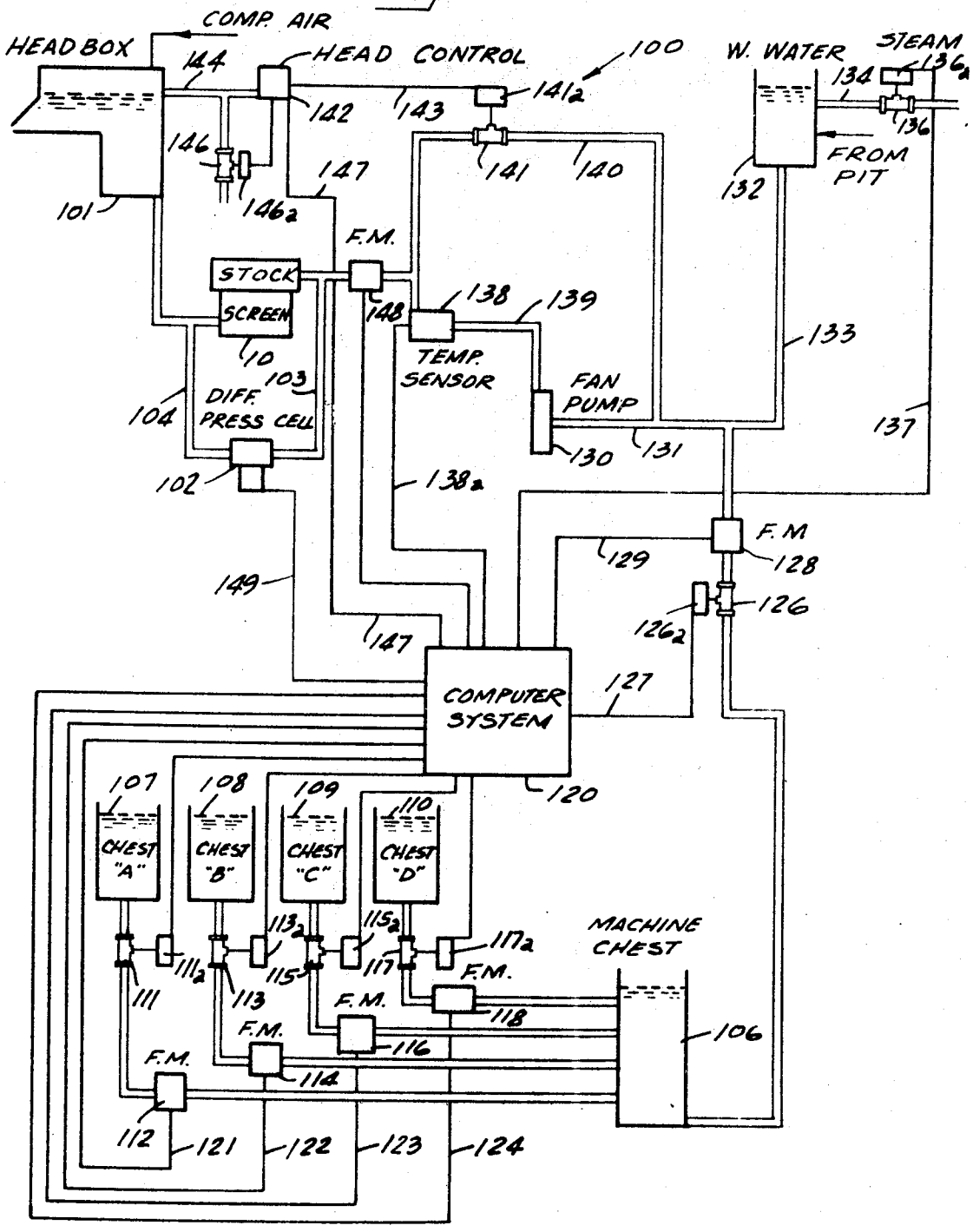

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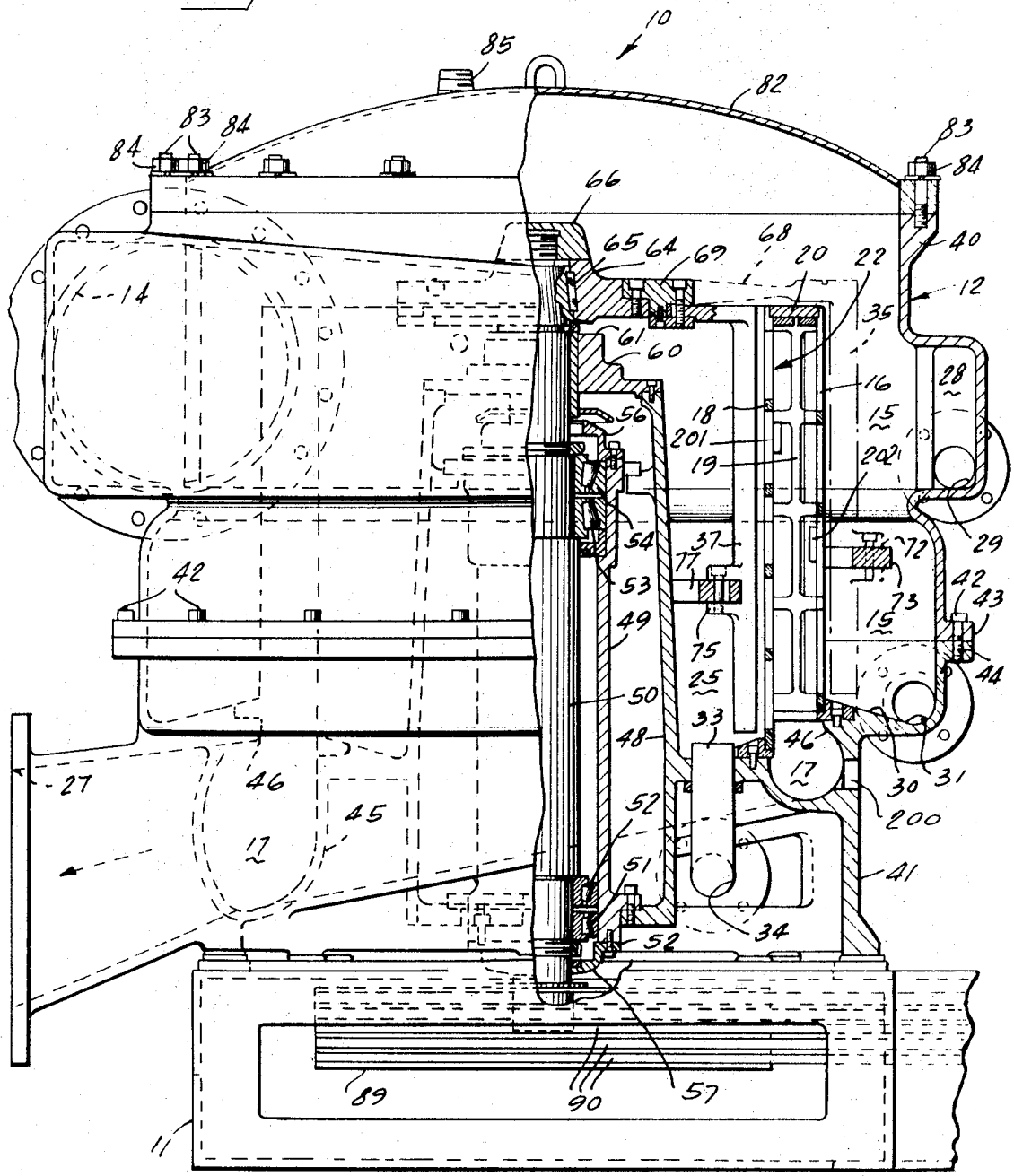
Fig. 2



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CONTROL OF HEADBOX STOCK CHARACTERISTICS

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ABSTRACT OF THE DISCLOSURE

This invention is directed to apparatus for controlling the characteristics of stock delivered to a headbox of a papermaking machine. The stock of different consistencies are contained in a plurality of stock reservoirs and the stock from each of the reservoirs is delivered to a main stock chamber where the stock is mixed together to form a stock of a desired consistency. The stock from the main stock chamber is then delivered via a flow control valve to a stock screening apparatus where the stock is finally screened before being delivered to a headbox of a papermaking machine. The temperature of the stock is measured prior to the stock entering the screening apparatus, and the pressure drop of the stock passing through the apparatus is measured. The measured pressure drop and temperature of the stock is then computed to develop control signals to control the flow of stock to the screening apparatus thereby maintaining the stock delivered to the headbox at a desired characteristic.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to an apparatus for screening fibrous materials suspended in liquid such as papermaking stock and the like.

The invention has special relation to stock delivery systems incorporating screening apparatus for screening the stock before the stock is finally delivered to the headbox of the papermaking machine. In the embodiment disclosed herein the screening apparatus includes a vertically extending cylindrical screen having respective inner and outer screen members spaced radially apart to form a chamber therebetween for receiving material of desired consistency and delivering the material to the output of the screening apparatus. Means are provided within the screening apparatus to measure the pressure drop either between the input and output of the apparatus or to measure the pressure drop across the screening area of the apparatus.

Description of the prior art

Heretofore, controlling of the characteristic of stock delivered to a headbox of a papermaking machine was accomplished by periodic manual samplings of various conditions of the stock delivered to the headbox. The information obtained by such periodic samplings was then used to determine which controls of the stock delivery system should be altered to obtain the desired stock characteristic delivered to the headbox. This manual periodic sampling would ultimately result in obtaining the desired stock characteristic issuing from the headbox onto the forming wire. However, the time delay between manual sampling and manual adjustment of the stock delivery system would cause substantial variation of the stock issuing from the headbox.

SUMMARY OF THE INVENTION

Accordingly, one of the objects of the present invention is to provide a stock delivery system which automatically measures several important characteristics of the stock to develop sampling signals which are automatically computed to develop control signals to quickly and automatically vary the necessary apparatus of the control system to maintain a uniform stock characteristic issuing from the headbox.

Another object of the present invention is to provide a stock delivery system which is relatively simple in construction and easy to maintain while being highly efficient and reliable in operation.

Another object of the present invention is to provide apparatus for continuous analysis of various changes of characteristic of the stock which flows from the fan pump of the stock delivery system to the headbox, and accurately measuring the pressure drop across a screening apparatus located in fluid communication prior to the headbox.

The measurement of the pressure drop of the stock passing through the screening apparatus can be accomplished in several ways. One method is to measure the upstream and downstream pressure at the inlet and outlet of the screening apparatus or in the immediate vicinity thereof and compare the pressure readings to obtain the accurate pressure drop between the inlet and outlet. Another method is to place pressure measuring devices in the upstream and downstream side inside the screening apparatus in the immediate vicinity of the screen plates therein.

The output information obtained from the pressure measuring devices is preferably calibrated to read in inches of water (H_2O) or fractions thereof, thereby representing the pressure difference existing across the screening apparatus or across the screen plates therein. Once the flow to the screening plates is established for a given mechanical adjustment, the only changing condition in the system which will create varying pressure drops in the screening apparatus is the consistency or quantity and quality of the stock being supplied to the screening apparatus.

It has been found by experimentation that for a fixed mechanical condition of the screening apparatus, that is a given stock flow, the consistency of the recirculating stock could be brought to the desired level with the addition of heavy stock to the system. This is accomplished by watching the changes in pressure drop across the screening apparatus.

According to the present invention these variations are used to produce continuous sampling signals which are then delivered to a computer with other important available data. The computer then develops several control signals to automatically control the operation of various components of the stock delivery system to maintain the output of the system at a desired stock characteristic.

Accordingly, other objects, features and advantages will be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings in which like reference numerals throughout the various views of the drawings are intended to designate similar elements or components.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a stock delivery system constructed in accordance with the principles of this invention; and

FIG. 2 is an elevational view which is partly broken away in vertical section to show the screening apparatus constructed in accordance with the principles of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Seen in FIG. 1 is a stock flow control system constructed in accordance with the principles of this inven-

tion, and is designated generally by reference numeral **100**. The control system **100** includes a stock screening apparatus **10** for delivering stock of desired consistency to a headbox **101**. The pressure drop between the stock entering the screening apparatus **10** and the stock leaving the screening apparatus is measured by a pressure cell **102** which, in turn, is connected to the input and output of the apparatus **10** via lines **103** and **104** respectively. According to the present invention, the continuous sampling of the pressure drop of stock passing through the screening apparatus **10** provides important information which can be used to control the characteristics of the stock delivered to the headbox **101**. Although the pressure cell **102** is shown as receiving pressure from the input and output of the screening device **10** it will be understood that independent pressure cells may be located within the screening device to measure pressure drops at the desired locations within the device.

A stock slurry having the desired characteristics is accumulated in a main stock receiving chamber **106**. A plurality of stock reservoirs **107**, **108**, **109** and **110** supply the main receiving chamber **106** with stock of different characteristics thereby mixing the stock and forming a stock slurry of the desired characteristic in the chamber **106**. The reservoir **107** is connected to the chamber **106** via a flow control valve **111** and a flow meter **112**. Similarly, the reservoir **108** is connected to the chamber **106** via a flow control valve **113** and a flow meter **114**, and reservoir **109** is connected to the chamber **106** via a flow control valve **115** and a flow meter **116**. Similarily, reservoir **110** is connected to the chamber **106** via a flow control valve **117** and a flow meter **118**.

Each of the flow control valves **111**, **113**, **115** and **117** are provided with controller devices **111***a*, **113***a*, **115***a* and **117***a* respectively for controlling the quantity of stock flowing through the valve. Each of the controllers **111***a*, **113***a*, **115***a* and **117***a* is connected to a computer control system **120**.

The computer control system **120** continuously evaluates various parameters of the control system and provides control signals to the controllers within the control system to continuously maintain the stock delivered to the headbox **101** at a desired characteristic. Therefore, each of the flow meters **112**, **114**, **116** and **118** is provided with a readout line **121**, **122**, **123** and **124** respectively which are connected to the computer control system **120** to provide continuous sampling information as to the gallonage of stock delivered to the main chamber **106** from each of the reservoirs **107–110**.

The stock of a predetermined consistency is then delivered from the output of the chamber **106** to a flow control valve **126** which has a controller **126***a* thereof connected to the computer **120** via a line **127**. The output of the control valve **126** is connected to a flow meter **128** which, in turn, is connected to the computer **120** via a line **129**. Connected in fluid communication with the flow meter **128** is a fan pump **130** via a conduit **131**. Also connected to the fan pump **130** is a white water reservoir **132** from the wire pit of the paper making machine. The reservoir **132** is connected to the fan pump via a conduit **133**. Steam is introduced into the reservoir **132** via a conduit **134** and a flow control valve **136** which, in turn, has a controller **136**a connected to the computer control system **120** via a line **137**. By controlling the amount of steam introduced into the white water within the reservoir **132** the temperature of the stock may be maintained within a predetermined range of temperatures.

The output of fan pump **130** is connected to a temperature sensing device **138** through a conduit **139**. The temperature sensing device **138** measures the temperature of the stock and produces a continuous sampling signal of the temperature at that point in the stock delivery system. The electrical output of the temperature sensing

device is connected to the computer control system **120** via a line **138***a*, and the stock output of the temperature sensing device is delivered to a flow meter **148** and a flow control valve **141**. The flow control valve **141** is connected in fluid communication with a conduit **140** which, in turn, is connected to the input of the fan pump **130**. Therefore, the conduit **140** together with the flow control valve **141** provide a recirculating path for excess stock leaving the fan pump **130**. The flow control valve **141** includes a controller **141***a*, which is electrically connected to a head control **142** via a line **143**. The head control is connected to the headbox **101** by means of a conduit **144** for sensing a predetermined stock level or pressure within the headbox to maintain the stock level within the headbox at a given predetermined value. The conduit **144** is in fluid communication with a flow control valve **146** which controls the overflow from the headbox **101**. A controller **146***a* associated with the valve **146** is electrically connected to the header control **142**. The electrical output of the header control **142** is connected to the computer control system **120** via a line **147**.

The stock passing through the flow meter **148** is then delivered to the stock screen apparatus **10** and therefrom to the headbox **101**.

In operation, flow meters **112**, **114**, **116**, **118**, **128** and **148** together with the head control **142** and temperature sensor **138** and differential pressure cell **102** provide continuous sampling signals which are applied to the computer control system **120**. Therefore, the computer control system continuously produces control signals to operate the various controllers associated with each of the flow control valves within the system.

The preferred embodiment of the screening apparatus **10** incorporated in the control system of the present invention is shown in FIG. 2. The screening apparatus **10** includes a base **11** supporting a main body **12** of substantially cylindrical configuration. An inlet **14** is provided near the upper portion of the body **12** for receiving a supply of fibrous materials suspended in liquid such as paper stock. The material is delivered to a chamber **15** within the housing **12** whereupon the desired constituent of the material passes through a screen member **16** and is collected by an outlet receiving chamber **17**. The annular screen member **16**, an annular screen member **18**, a support member **19** disposed between the screen members **16** and **18** and a ring assembly **20** are constructed to form a cylindrical screen assembly **22**. The cylindrical screen assembly **22** has the form of a tube having a hollow space between the inner and outer walls of the tube. That is, the cylindrical screen member **16** is placed concentrically about the cylindrical screen member **18** and spaced radially therefrom by the ring **20**.

The support member **19** serves to support the screen members **16** and **18** against the pressure exerted thereon by the incoming material. Material will fill the chamber **15** and flow over the cylindrical screen assembly **22** to fill a chamber **25** located radially inwardly of the screen assembly **22**. Therefore, the desired constituent of material, which is carried over into chamber **25**, will pass through the screen **18** and is collected in the receiving chamber **17**. The desired constituent of material collected in the receiving chamber **17** is then delivered to a main outlet **27**.

The heaviest undesired constituent of the material is separated by a plurality of actions but chiefly by centrifugal force and is collected in a receiving chamber **28** whereupon this undesired constituent of the material is delivered to an outlet **29**. Still a further undesired constituent of the material, which is heavier than the desired constituent of material, is separated by gravitational means and falls to the bottom of chamber **15**. The bottom of chamber **15** forms a trough **30**. An outlet **31** communicates with the trough **30** for receiving the undesired material collected thereby. Another trough **33** is located at the bottom of chamber **25** for collecting the constituent

of material unacceptable to the process and which is carried over the top of the screen assembly **22**. An outlet **34** communicates with the trough **33** for receiving the undesired constituent of material collected thereby.

One or more rotatable foils **35** extend axially of the screen assembly **22** and radially outwardly thereof and immediately adjacent thereto as indicated by the dotted lines shown in FIG. 2. In the preferred embodiment of the present invention a plurality of foils **35** are spaced equally apart around the periphery of the screen assembly **22**. The foils **35** are rotated to clean the surface of the screen member **16** of materials which would otherwise clog the screen. Some of the undesired constituents of the material which are removed from the screen members **16** will fall to the bottom of the chamber **15** into trough **30** and be removed by outlet **31**, and some of the undesired material will be carried in suspension over the top of the screen assembly **22** and ultimately collected within the trough **33** and removed by outlet **34**.

In a similar fashion a plurality of equally spaced foils **37** extend axially and radially inwardly of the screen **18** and immediately adjacent thereto. The foils **37** are also rotated to remove undesired constituents of the material from the surface of the screen member **18** which would otherwise clog the screen. This undesired constitutent of material is ultimately collected within the trough **33** and removed via outlet **34**.

A better understanding of the detailed construction of the screening apparatus shown in FIGS. 1 and 2 can be had by reference to the following description.

The housing **12** consists of an upper portion **40** and a lower portion **41** which are fastened together by a plurality of screws **42** engaging flanges **43** and **44** of the upper and lower portions **40** and **41** respectively. The receiving chamber **17**, which communicates with the main outlet **27**, is formed by an involute **45** which has the major diameter thereof at an outlet **27**, as seen in FIG. 2. An opening **46** is provided in one side of the involute **45** in a plane perpendicular to the axis thereof and concentric therewith. The opening **46** is in direct communication with the space between the screen members **16** and **18** of the screen assembly **22**.

A support member **48** is formed concentrically and integrally within the lower portion **41** and extends upwardly within the upper portion **40**. Located concentrically within the support member **48** is a sleeve **49**. A shaft **50** is journalled by bearings **51**, **52**, **53** and **54** which are carried within the sleeve **49**. Retainer caps **56** and **57** are secured respectively to the upper and lower ends of the sleeve **49** for retaining the bearings **51**, **52**, **53** and **54** and the shaft **50** therein. A cover **60** is secured to the upper end of the support member **48**, and a seal **61** is carried between the shaft **50** and the cover **60**.

A hub **64** is removably connected to the upper end of the shaft **50** and is prevented from rotating relative thereto by a key **65**. A contoured nut **66** threadably engages the shaft **50** to retain the hub **64**. One or more arms **68**, indicates by dotted lines in FIG. 2, extend outwardly from a ring **69** which is secured to the hub **64**. Each of the arms **68** serves to carry one of the foils **35**, as seen in FIG. 2. Also connected to the ring **69** are one or more arms **70**, and each of the arms **70** serves to carry one of the foils **37**. It will be understood that each of the foils **35** or **37** may be fixedly connected to their associated arm or may be removably connected thereto.

The foils **35** have bosses **72** which engage a stiffener ring **73** located radially outwardly of the foils. The ring **73** is connected to all of the foils **35** and serves to prevent the foils **35** from flexing axially thereby causing a gap between the foil **35** and the bottom portion of the screen member **16**. The foils **37** have bosses **75** which are connected to a stiffener ring **76** radially inwardly of the foils **37**. The ring **77** has substantially the same function as the ring **73**.

The top portion **40** of the housing **12** is provided with an inlet passage **80** which is formed as an involute as best seen in FIG. 2. The involute **80** has an opening on the inside arcuate portion thereof communicating with the interior of the housing **12** for delivering the material to be screened to the interior of the housing **12**.

A cover **82** is secured to the upper portion **40** of the housing **12** by a plurality of studs **83** and nuts **84**. A threaded fitting **85** is provided on the cover **82** and may be connected to suitable piping means.

The lower end of the shaft **50** extends into a space within the base **11** and is connected to a multiple V-belt pulley **89**. The pulley **89** is rotated by a plurality of belts **90** which are connected to a suitable power source.

Although the specific embodiment of the present invention shows single outlets **29**, **31** and **34**, it is not to be construed in the limiting sense. The housing **12** may have a plurality of outlets for receiving undesired constituents of material that is delivered to the outlet **29**. Furthermore, the housing **12** may have a plurality of outlets around the housing to receive the undesired constituent of material which is received by the outlet **31**. Similarly, the housing **12** may have a plurality of outlets in communication with the chamber **25** for receiving the undesired constituents of material therefrom.

According to the present invention the screening apparatus **10** includes a pressure sensing cell **200** positioned within the involute chamber **17** for sensing the stock pressure at the output of the apparatus **10**. A pair of pressure sensing cells **201** and **202** are positioned adjacent the inner and outer screening members respectively. The pressure cells **201** and **202** may be connected in parallel so as to produce an average pressure indicative of the input pressure to the screening apparatus, or may be independent one from the other to monitor the pressure drop across the inner screen as well as the pressure drop across the outer screen.

The accuracy of measuring the pressure drop across the screening apparatus **10** is preferably kept within 0.5 inch of water in order to operate the delivery system at the best possible efficiency. Therefore, the pressure sensing devices are preferably air loaded diaphragms 2 inches in diameter positioned either at the inlet and outlet of the screening apparatus or across the screening mechanism therein. The pressure drop across the screening apparatus as sensed by the cells are then delivered to a differential pressure cell, which is commerically available. By using a zero suppression feature of this type of differential pressure cell, a compensation for the major part of the pressure drop can be made, and a further pressure drop can be recorded or further process the signal which will now only show the top portion of the varying fraction but greatly amplified. This top portion can be expressed in mathematical terms as being a function of variations in fiber quantity, in fiber character and composition and variations in temperature when the flow is constant.

In so recording and displaying this pressure differential and using the primary signal for the further control of the process in a method whereby the main stock valve (stuffgate) supplying the raw furnish to the machine can be controlled through a loop system if the machine is controlled by continuous sampling of various aspects of the system.

In mathematical terms;

$$F(p)dt = K_1 \frac{\partial W}{\partial t} \cdot \Delta W + K_2 \frac{\partial S}{\partial t} \cdot \Delta S + K_3 \frac{\partial T}{\partial t} \cdot \Delta T$$

Where:

Q=flow of fiber slurry (constant)

ΔW=variation of fiber quantity (consistency)

ΔS=variation of fiber character composition (geometrical shape and surface character as well as fiber type)

ΔT=variation in temperature

t=time

K_1, K_2, K_3=constants

Accordingly, the method and apparatus disclosed herein is based on the premise that the flow of stock to the headbox is constant and that it can be so maintained or if not corrections made to maintain the flow constant since the pressure drop across the screening apparatus for any given flow can be experimentally obtained. Also, the variables that effect the pressure drop across the screen for a given hydraulic and mechanical setup have been experimentally determined. For example, the temperature is kept constant within one degree range during the process, and the stock characteristics, comprising shape of the fiber (slenderness, length, surface, characteristic, etc.) are normally kept within a certain range during the normal paper making process. Additionally, the stock quantity within the slurry (consistency) can be controlled to maintain a predetermined stock characteristic.

The present invention provides a method and apparatus for detecting consistency changes for fiber quantity in the range that was heretofore considered extremely difficult. It will be understood that variations and modifications may be effected without departing from the spiirt and scope of the novel concepts of this invention.

I claim as my invention:

1. A control system for controlling the consistency and quantity of stock delivered to a headbox of a paper making machine comprising:

a plurality of stock supply means for containing stock of different consistencies;

a main stock receiving chamber;

a plurality of flow control means connected between each of said stock supply means and said main receiving chamber for controlling the quantity of each of the different stock consistencies to said main stock chamber;

a flow control device connected in fluid communication with the output of said main stock receiving chamber;

a temperature sensing device for sensing the temperature of stock passing through said flow control device;

a screening apparatus for receiving the stock from said flow control device;

first and second pressure measuring devices positioned within said screening apparatus upstream and downstream of the stock passing therethrough for measuring the pressure drop across said screening apparatus;

means for adding hot dilutant to said stock between said main stock receiving chamber and said temperature sensing device; and

computer means responsive to said pressure drop and said temperature of the stock to control the flow control means at the output of each of said stock supply means thereby varying the consistency of the stock delivered to said main stock receiving chamber and further controlling said means for adding hot dilutant to said stock to control the temperature of the stock.

2. A screening apparatus for screening fibrous material in liquid suspension to deliver the desired constituent of the material at an outlet of the apparatus to the input of a headbox, said apparatus comprising:

a housing having a plurality of openings defining a a single inlet and a multiplicity of outlets;

a cylindrical screen having respective inner and outer screen members spaced radially apart to form a chamber between;

an involute shaped space within said housing substantially concentric therewith having an opening on one side thereof in a plane perpendicular to its axis for communication with said screen chamber, said involute space having a portion extending outwardly from said housing to form the outlet for passing the desired constituent of material;

first and second foil means concentrically rotatably carried within said housing adjacent said inner and outer screen members respectively for preventing clogging of said screen members;

drive means for rotatably driving said first and second foil means within said housing;

first and second pressure sensing devices positioned within said housing so as to indicate a pressure drop of stock passing through said housing between said single inlet and the outlet passing the desired constituent of material,

said first pressure sensing device positioned within the wall surface of said involute;

said second pressure sensing device positioned adjacent said inner screen member for sensing the pressure drop of the stock passing therethrough; and

a third pressure sensing device positioned adjacent said outer screen member for sensing the pressure drop of the stock passing therethrough.

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