

Sept. 15, 1970

B. COWAN

3,528,281

PULP STOCK CONSISTENCY REGULATOR

Filed April 19, 1968

2 Sheets-Sheet 1

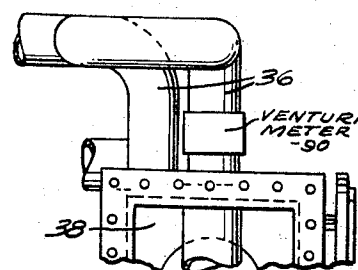
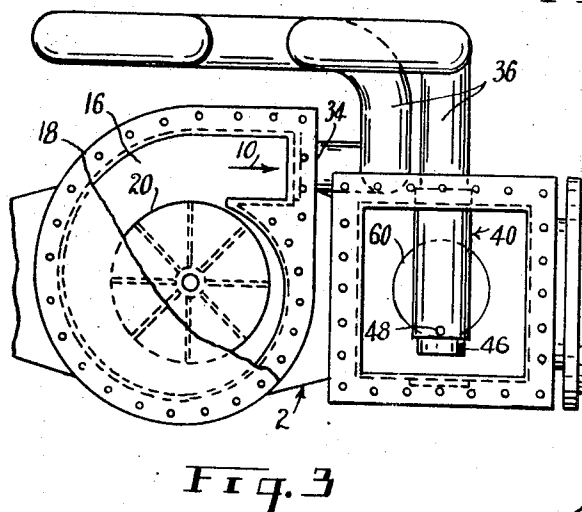
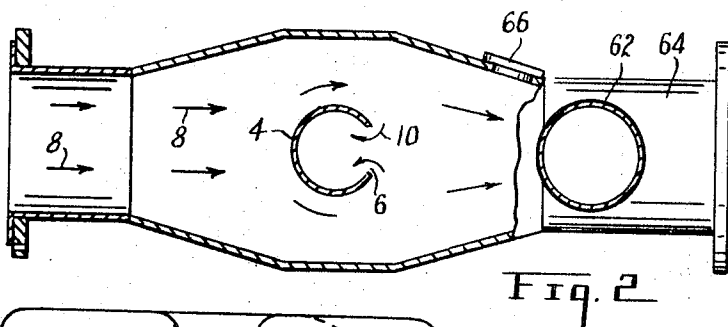
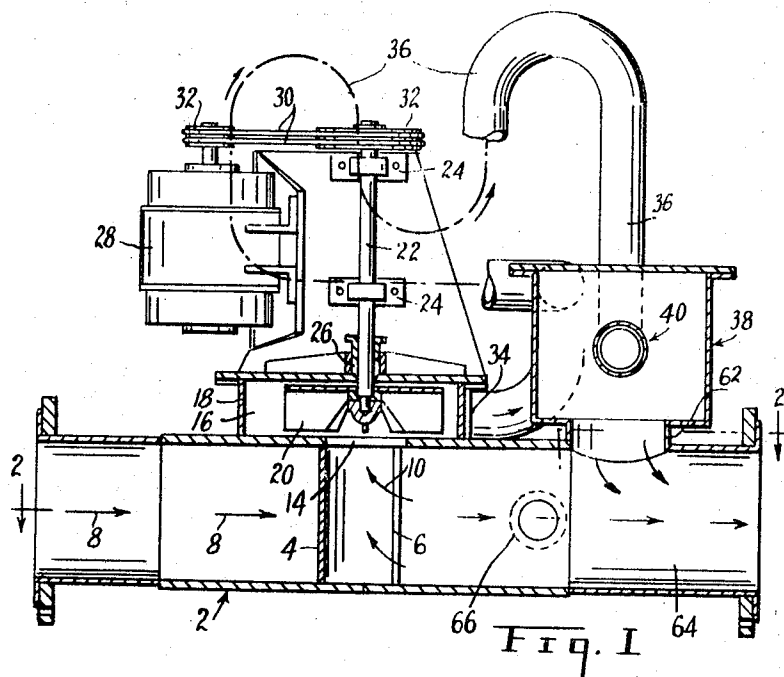


Fig. 3A

INVENTOR

B. COWAN

Fetters & Co.
ATTORNEYS

Sept. 15, 1970

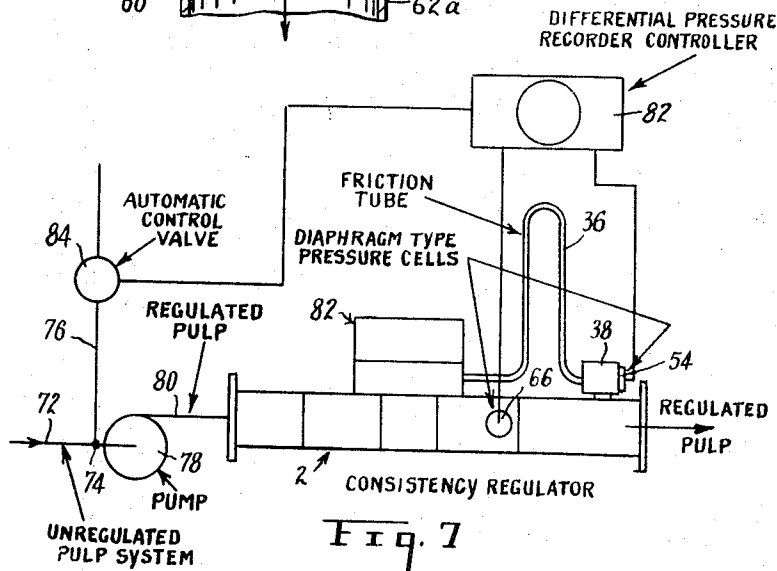
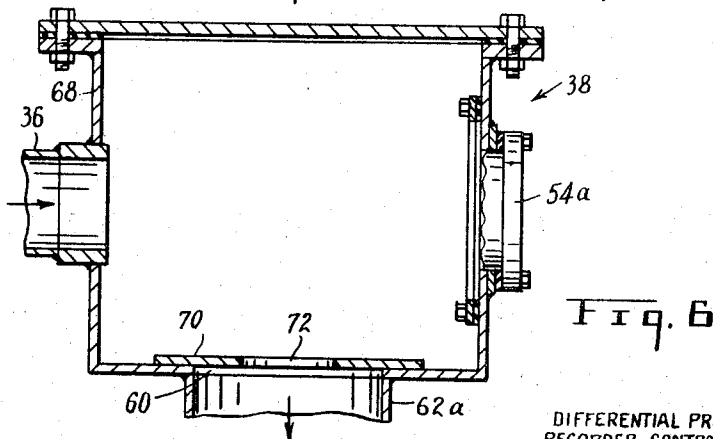
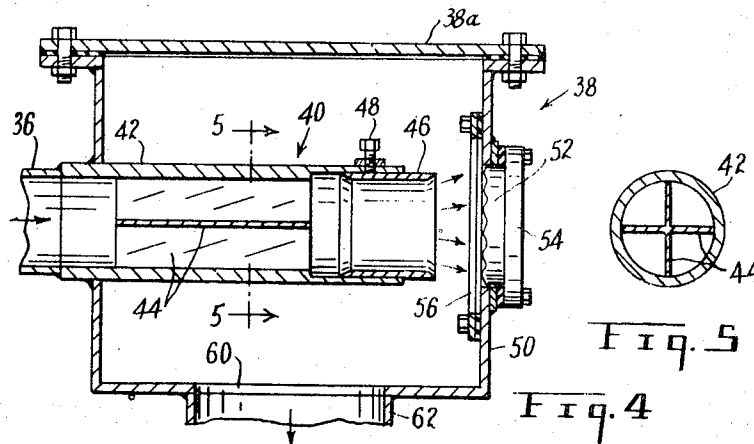
B. COWAN

3,528,281

PULP STOCK CONSISTENCY REGULATOR

Filed April 19, 1968

2 Sheets-Sheet 2



INVENTOR
B. COWAN

Fetthustonhaugh & Co.
ATTORNEYS

1

3,528,281
PULP STOCK CONSISTENCY REGULATOR
Ben Cowan, 5460 Patricia Ave., Montreal 29,
Quebec, Canada

Filed Apr. 19, 1968, Ser. No. 730,673
Int. Cl. G01n 11/04

U.S. Cl. 73—61

14 Claims

ABSTRACT OF THE DISCLOSURE

A stock consistency regulator consisting of a housing inserted in the stock feed line, the housing having a stock sampling pipe located vertically therein and having an opening throughout its length on the downstream side, a pump drawing the stock from the stock sampling pipe and passing it through a friction tube terminating in a diffuser and a nozzle in a discharge box, an outlet from the discharge box leading back into the housing downstream of the sampling pipe. A pair of diaphragm type pressure cells are located in the discharge box opposite the discharge end of the nozzle and the other located in the wall of the housing downstream of the sampling pipe, and a differential pressure controller connected to said diaphragm pressure cells and actuating a control valve to regulate the feed water into the stock upstream of the housing.

The present invention relates to a method and apparatus for measuring and regulating the consistency of a flowing fluid medium. Particularly, the invention relates to an automatic consistency regulator to maintain a constant consistency, i.e., constant ratio of solids to water by weight, in a flowing solids/fluid stream.

The apparatus of the invention has particular application to the paper making industry to provide the desired solid-liquid consistency to the paper making stock.

In the making of paper, water is added to ground wood pulp, sulphite pulp or whatever other material from which the paper is to be made and these materials thoroughly mixed in a mixer or pump and from there transferred to the stock storage boxes and the Fourdrinier end of a paper machine. It is essential that the stock be of a proper and constant consistency since measurements of the quantity of pulp throughout the system is based on volume of flow.

Many attempts have been made to provide apparatus for determining and regulating the consistency of the pulp stock. These usually involve the principle of changes in friction or shear value with changes in consistency of the stock, with a more liquid consistency stock offering less friction resistance to flow. The changes in friction or shear value of the stock flow are measured and used to control a water dilution valve which regulates the ratio of water to pulp solids.

One of the conventional consistency regulators consists of a spinning disc or paddle positioned in the pulp stock and driven by an electric motor at a constant speed, with the current flow necessary to drive the motor at the constant speed being used as a measure of the friction or consistency of the stock.

Another type of regulator consists of positioning a probe in a flowing stream of pulp, with the friction on the probe being a measure of the consistency of the stock.

These two types of regulators are the units normally in use, as they can be mounted directly in a pipe line and close to the source pump. One disadvantage however is that pipe line units having a driven disc or paddle must be fitted with a stuffing box where the drive shaft passes through the pipe wall. The frictional load at this point is much greater than the fluid friction, and any changes in stuffing box characteristics will upset the consistency regulation and require recalibration. Moreover, it is gen-

2

erally necessary to provide sealing water to the stuffing box and this water must be regulated in pressure to correspond with the pipe line pressure. The latter will vary and cause sealing difficulties. Another disadvantage is that the measuring unit is located at one point, and this can result in misleading effects if there is stratification in the pipe line.

In the case of probes depending on velocity of flow to develop friction, the unit is accurate only in a limited range of velocities and the results are inaccurate if velocity of flow varies widely.

Another type of conventional regulator used and which is possibly the most accurate, involves extracting a sample of pulp from the stock flow and permitting it to flow through a passage under a gravity head, the friction and consistency being measured by the head required to maintain a constant flow. Such apparatus however has the defect that a sample only is measured which may be misleading if there is stratification of flow at the source. Moreover a portion of the system is open and requires showers and regular cleaning to avoid pulp build-up. Also the regulator must be located to suit the sampling arrangement and can rarely be located close to the pumping unit. This causes a slow response to changes of consistency in the system. In addition such an installation is complicated due to sampling lines, water lines, overflows, etc.

The consistency regulator of the present invention provides all of the advantages of sampling type regulators and avoids the disadvantages inherent in such types.

The apparatus of the invention consists of a section of pipe which is positioned directly in and forms part of the stock flow pipe line. The pipe section is provided with a central or sampling tube positioned therein and normal to the axes of the pipe and stock flow, and having a slotted opening on the downstream side. One end of the sampling tube is open through the wall of the pipe section and is provided with a pump to draw a fixed volume of stock sample through the slotted opening and out the open end of the sampling tube. The slotted opening in the sampling tube extends the full length of the tube and completely across the interior diameter or width of the pipe thereby avoiding stratification and turbulence complications when sampling. Moreover as the slotted opening is on the downstream side of the sampling tube the velocity of the stock flow through the pipe line does not affect the sample flow to the pump.

The pump which may be a straight bladed impeller is driven by an electric motor, and the speed of the impeller is designed to generate a constant hydraulic head. The flow through the friction tube is a function of the hydraulic head which is constant, and the friction which varies with consistency. Thus it can be calculated that, if the consistency varies from 3 to 3½% the flow through the tube will vary from 200 U.S. g.p.m. to 40 U.S. g.p.m. Measurement of the flow rate will thus give a measurement of consistency. This can be measured by a magnetic flow meter, venturimeter orifice, or impact plate.

Method A.—The end of the friction tube, remote from the pump, projects into a discharge box and the jet from the discharge pipe nozzle is directed against a diaphragm pressure measuring element protected by a flexible rubber cover. This measuring element measures the static pressure of the system plus the impact pressure from the nozzle. A second diaphragm pressure measuring element is mounted on the pipe line to measure the static pressure in the system only. The two pressure measuring elements are connected to a differential pressure cell, which produces a net measurement of impact pressure from the nozzle which is connected in turn to a con-

3

troller actuating the addition of dilution water to control the consistency of the pulp stock.

Method B.—In this case the friction tube discharges freely into the discharge box. The return opening between the discharge box and the main stock pipe is fitted with an orifice. The two pressure measuring cells are connected as before, one on the discharge box and the second on the main stock pipe and measure the volume of flow (and consistency) by the pressure drop across the orifice.

The length of the friction tube can be varied and the tube can be coiled to suit the particular installation, types of stock to be measured or to vary the sensitivity of the unit.

The present apparatus utilizes the most accurate principle of the open sampling consistency regulator but is, in fact, a closed type regulator mounted directly in a pipe line. Moreover, it measures friction loss directly, with a controlled flow, and gland friction has no effect on the measurement. It is thus more accurate than other pipe line types of regulator.

The unit of the invention can be installed in any position, horizontal or vertical, and at any point in the pipe line, as near the source pump as desired, and it cannot be damaged by solids passing through the pipe. The unit requires no sealing water at controlled pressures, and has simple mechanical parts for easy maintenance.

It is the principle object of the present invention to provide apparatus for automatically measuring the consistency of a fluid medium flowing through a pipe line, and which measurements are not affected by changes in velocity of the fluid flow or by stratification or turbulence in the pipe line.

It is a further object to provide a regulator for accurately and automatically regulating the consistency of a flowing fluid medium in a pipe line, which can be installed in any horizontal or vertical position at any point in the pipe line and which is constructed of simple mechanical and electrical components for ease of maintenance and replacement.

It is another object to provide apparatus for measuring the consistency of a solids/liquid material flowing in a pipe line, comprising a pipe section positioned in and forming part of the pipe line, and a sampling tube positioned within and extending completely across the pipe section and normal to the axis thereof, and a slot in the sampling tube on the downstream side thereof, and an opening through the pipe section at one end of the sampling tube, and a casing positioned adjacent the opening and exterior of the pipe section and a friction tube having a first end connected to the casing and a second end connected to the pipe section down-stream of the sampling tube, and a pump impeller rotatably mounted in the casing and means to rotate the impeller to draw a sampling stream of the material through the opening and force a variable volume of flow through the friction tube, and pressure sensing means are provided to measure the variation in flow.

It is still another object to provide a method of measuring the consistency of a solids/liquid flow in a pipe line comprising withdrawing a sample stream representative of the material flow across the pipe line from the pipe line and forcing the sample stream through a friction tube having ingress and egress ends, and measuring the pressure of the sampling stream at the egress end of the friction tube, as a measurement of the consistency of the material.

These and other objects will become apparent from the following description and accompanying drawings wherein:

FIG. 1 is a side elevation partially in section of the sampling and measuring apparatus of the invention;

FIG. 2 is a plan sectional view taken along line 2—2 of FIG. 1;

4

FIG. 3 is a plan view partially in section taken along line 3—3 of FIG. 1;

FIG. 3A is a fragmentary view showing a portion of FIG. 3 in a slightly modified embodiment of the invention;

FIG. 4 is a vertical sectional view of the discharge box shown in FIGS. 1 and 3 showing Method A.

FIG. 5 is a transverse section of the discharge pipe within the pressure box taken on the line 5—5 of FIG. 4.

FIG. 6 is a vertical sectional view of the discharge box but showing Method B.

FIG. 7 is a control diagram showing the stock flow and sampling flow and regulation of the stock consistency.

Referring now particularly to the drawings numeral 2 represents a pipe section which forms part of the apparatus of the invention and which is positioned in and forms a section of the paper stock pipe line. The pipe section 2 may be placed at any desired point along the stock pipe line, and as close to the source pump as desired.

In the drawings the pipe section 2 is shown as being generally rectangular in cross-section, but it can equally be round or of other configuration. Positioned centrally within the pipe section 2 is a sampling tube 4 which extends completely across the interior of the pipe section 2, and is provided with a slot or opening 6 on the downstream side. See particularly FIG. 2. The sampling tube 4 which is used to withdraw, by means elaborated below, a sample stream flow from the main pipe line. The sampling tube is preferably positioned vertically and as the slot 6 extends the complete length of the tube 4 the sample withdrawn is representative of material flow vertically across the pipe thereby avoiding incorrect consistency measurements due to stratification or turbulence of the material in the pipe. Also as the sample stream is withdrawn on the downstream side of the sampling tube the passage of damaging solids through the regulator is avoided, and the sampling stream is unaffected by velocity change in the main pipe flow.

In the drawings arrows 8 indicate the direction of flow of the paper stock through the pipe line, and arrows 10 the direction of flow of the sampling portion.

It will be noted that the central section 12 of the pipe section 2 broadens adjacent the sampling tube 4 in order to maintain the normal cross section of the pipe line so that the presence of tube 4 does not affect the flow of paper stock therepast.

One end of the sampling tube 4 opens at 14 through the pipe section 2 into a pump chamber 16 formed by pump casing 18. Positioned in the pump chamber 16 adjacent the opening 14 is a pump impeller 20 which is supported by shaft 22 mounted on bearings at 24 and sealed at 26. The pump impeller blades are rotated by an electric motor 28 through belts 30 and sheaves or pulleys 32. This latter equipment is mounted on frame 33.

The casing 18 opens at 34 into a first or ingress end of a friction tube 36 which empties at a second or egress end 38 back into the main paper stock flow downstream of the sampling tube 4. In the drawings the friction tube 36 is shown as being generally curved and coiled and with bends and straight sections but it can be of any configuration, and of any length to suit the types of stock to be measured or to vary the sensitivity of the unit.

As discussed above the slotted sampling tube 4 extends completely across the main pipe line thus enabling the sampling stream to be representative of the complete material flow through the pipe line irrespective of any stratification that may be present. Moreover the presence of the sampling tube will act to de-stratify any stratification in the main pipe flow and the return of the blended sampling stream at 38 will further act to blend the material in the main pipe line.

The speed of the impeller pump 20 is designed to generate a hydraulic head sufficient to force a variable volume of sampling stock flow through the friction tube 36 which is coiled or curved or otherwise designed to

provide sufficient friction to dissipate the hydraulic head generated by the pump.

The friction tube 36 discharges into a discharge box 38 through a nozzle 40, see FIGS. 4 and 5. This nozzle 40 consists of a diffuser section 42 having diffuser plates 44, and an adjustable nozzle tube 46 secured in its axially adjusted position by the screw 48.

The wall 50 of the box 38 has an aperture 52 axially in alignment with the nozzle 40 and a diaphragm pressure measuring element 54 is secured to the outer surface of the wall 50 over the aperture 52. The measuring element 54 is protected by a flexible rubber cover 56 mounted on the inner surface of the wall 50.

The bottom wall 58 of the box 38 has a discharge opening 60 and a short length of pipe 62 connects the box 38 with the downstream end 64 of the pipe 2.

A second diaphragm pressure measuring element 66 is located in the pipe 2 at a position preferably downstream from the sampling tube 4 as seen in FIGS. 1 and 2. A suitable cover plate 38a permits ready access to the pressure chamber for maintenance purposes.

FIG. 3A shows a slightly modified embodiment wherein a venturi meter 90 is provided in the friction tube 36, upstream from the discharge box 38. Such a venturi meter may also be used in the further modified embodiment of FIG. 6, hereinafter described.

In an alternative arrangement shown particularly in FIG. 6 the friction tube 36 terminates in an opening in the wall 68 of the pressure box 38. A diaphragm pressure measuring element 54a is mounted on the wall 50 as above described and illustrated in FIG. 4 and is located preferably directly opposite from the discharge of the pipe 36 into the box. However, in this case the element 54a could be mounted on any wall of the box and give satisfactory pressure indication.

The discharge opening 60 from the box is partially blocked by an orifice plate 70 having an orifice 72 controlling the discharge outflow from the box 38 to the downstream end 64 of the pipe 2.

In the arrangement shown in FIG. 4 the flow velocity is measured by impact and in the alternative arrangement shown in FIG. 6 measurement of flow velocity is by the pressure drop across the orifice 72.

By comparing the differential pressure between the two diaphragms a measurement of the consistency of the sample flow and hence the main stock flow can be determined and the necessary regulation made to either increase or decrease the liquid content of the paper stock as the occasion demands to obtain the desired consistency.

This may be better understood by reference to the accompanying FIG. 7 which is a flow and control diagram. In this figure consistency unregulated pulp is forced through pipe 72 where at point 74 liquid (water) is introduced via water pipe 76 to give the pulp stock the desired consistency. The stock and water are thoroughly mixed and blended at mixer and pump 78 and forced through pipe 80 to the system.

The consistency regulator of the invention shown generally at 82 in FIG. 7, is positioned in pipe line 80 and sampling is taken and measured in friction tube 36 as discussed above. The pressure differential measured by the first and second pressure diaphragms 54 and 66 is recorded by the differential pressure recorder controller 82 which controls the automatic water control valve 84 to increase or decrease the water supply to stock pipe 72 to maintain the consistency of the stock mixture flowing in pipe 80 at a desired and constant level.

In the operation of this invention, the head generated by the impeller 20 will be constant, and the friction loss through the tube will vary with the consistency of the stock. Using published friction factors for pulp stock flowing in pipe lines, the following table shows the measure of variation of flow with consistency.

TABLE I

Consistency A.D., percent	Flow U.S. g.p.m.	Flow velocity, f.p.s.	Velocity head, ft.
3½-----	40	1	0.03
3-----	200	5	0.77
2½-----	430	11	3.70
2-----	625	16	8.00

Thus the measure of velocity in the tube 36 or velocity head can be used to control the consistency of the pulp stock to a set point.

The velocity may be measured in the manner above described or by the use of a venturi meter, magnetic flow meter, etc.

The above described apparatus ensures that, so long as the impeller pump 20 is in operation a continuous sampling of the pulp stock flow is withdrawn, its consistency sensed, and a controlled feed of water to the pulp stock is made automatically so that the pulp stock downstream of the regulator is of uniform consistency. Furthermore, as the sample of pulp stock withdrawn from the main pipe line is taken from across the full depth of the pipe and is mixed in the pump 20 before the pressure differential is recorded, the accuracy of the pressure differential recording is much greater and hence the control of the water feed into the pipe 72 will ensure that the consistency of the pulp will be as desired. This being so, once the system is in operation, only minor regulation will be required and this will be accomplished automatically.

What I claim is:

1. Apparatus for measuring the consistency of a solid/liquid material flowing in a pipe line, comprising a pipe section positioned in and forming part of the pipe line, a sampling tube positioned within and extending completely across the pipe section and normal to the axis thereof, the said sampling tube having a slot on the downstream side thereof, an opening through the pipe section at one end of the sampling tube, and a casing positioned adjacent the opening and exterior of the pipe section, a friction tube having a first end connected to the casing and a second end connected to the pipe section downstream of the sampling tube, a pump impeller rotatably mounted in the casing, means to rotate the impeller to draw a sampling stream of the material through the opening and force a variable volume of flow through the friction tube, and sensing means to determine the variation in flow with consistency.

2. Apparatus according to claim 1 in which the downstream end of the friction tube terminates in a chamber and a discharge opening connects the said chamber with the pipe section downstream from the sampling tube.

3. Apparatus according to claim 2 in which said sensing means comprise a pressure responsive venturi meter provided in said friction tube.

4. Apparatus according to claim 2 in which the said sensing means consists of two elements, one sensing the pressure in said chamber and the other sensing the pressure in the said pipe section.

5. Apparatus according to claim 4 further comprising means for comparing the pressure differential between the first and second of said sensing elements as a measurement of the consistency of the liquid material flowing in the pipe line.

6. Apparatus according to claim 4 further comprising a differential pressure controller and a water control valve controlled by said differential pressure controller to increase or decrease water supply to the material in the pipe line upstream of the sampling tube to maintain a selected material consistency.

7. Apparatus according to claim 6 comprising the further step of utilizing the pressure differential measurement to control water input into the solids/fluid flow.

8. Apparatus according to claim 2 in which the said friction tube terminates in a nozzle within the said chamber and one pressure sensing means is of the diaphragm

7

impact type and is located in a wall of the said chamber axially opposite from the discharge end of said nozzle.

9. Apparatus according to claim 8 wherein the opening through the pipe section is at the upper end of the sampling tube.

10. Apparatus according to claim 1 in which the downstream end of the friction tube terminates in a chamber and a discharge opening connects the chamber with the pipe section downstream from the sampling tube, the said discharge opening including a restricted orifice and the said pressure sensing means consists of two elements, one sensing the pressure in said chamber and the other sensing the pressure in the said pipe section.

11. Apparatus according to claim 1 wherein the friction tube is generally coiled or curved consisting of bends and straight sections.

12. Apparatus according to claim 1 wherein the sampling tube is positioned vertically within the pipe section, and the slot in the sampling tube extends the full length thereof.

13. Apparatus according to claim 1 wherein the pipe section broadens in the area of the sampling tube.

14. In a system for measuring and regulating the consistency of solids/liquid material flowing in a pipe line having a water control valve for controlling the amount of water added to the material to alter its consistency, comprising a pipe section positioned in and forming part of the pipe line, and a sampling tube positioned within and extending completely across the pipe section and normal to the axis thereof, and a slot in the sampling tube on

8

the downstream side thereof, and an opening through the pipe section at one end of the sampling tube, and a casing positioned adjacent the opening and exterior of the pipe section and a friction tube having a first end connected to the casing and a second end connected to a pressure chamber, the said pressure chamber having an opening connected to the pipe section downstream of the sampling tube, and a pump impeller rotatably mounted in the casing and means to rotate the impeller to draw a sampling stream of the material through the opening and force a variable volume of flow through the friction tube, and pressure sensing means located at said pressure chamber and said pipe section downstream from said sampling tube to obtain a measurement of the consistency of the material, and means to regulate the water control valve to regulate the consistency of the material flow.

References Cited

UNITED STATES PATENTS

3,017,767	1/1962	Mossberg	73—54
3,027,756	4/1962	Head	73—54 X
3,057,187	10/1962	Read et al.	73—61
3,163,172	12/1964	Buzzard	73—54 X

S. CLEMENT SWISHER, Primary Examiner

J. W. ROSKOS, Assistant Examiner

U.S. Cl. X.R.

137—92; 162—258