United States Patent [19]

Shimizu et al.

[11] **3,774,971**

[45] **Nov. 27, 1973**

[54] **SAFETY DEVICE FOR A SYSTEM OF HYDRAULICALLY TRANSPORTING SOLID MATTERS**

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[22] Filed: **Nov. 16, 1971**

[21] Appl. No.: **199,107**

[52] **U.S. Cl.** **302/15,** 417/40

[51] **Int. Cl.** **B65g 53/30**

[58] **Field of Search** 302/14, 15, 66; 137/206, 207, 207.5; 417/40

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[57] **ABSTRACT**

In a system of hydraulically conveying solid matters adapted to hydraulically transport a mixture of the solid such as wood chip or wood bark through a pipeline to a destination, a safety device which comprises a pressure liquid tank containing a pressure water or liquid and a pressure air or gas therein, and a pressure liquid supply line communicating said pressure liquid tank with the pipeline. Said safety device permits the liquid contained in said pressure liquid tank to be delivered through said pressure liquid supply line to the pipeline in case of emergency with the help of the expanding pressure of the air or gas in said pressure liquid tank.

2 Claims, 3 Drawing Figures

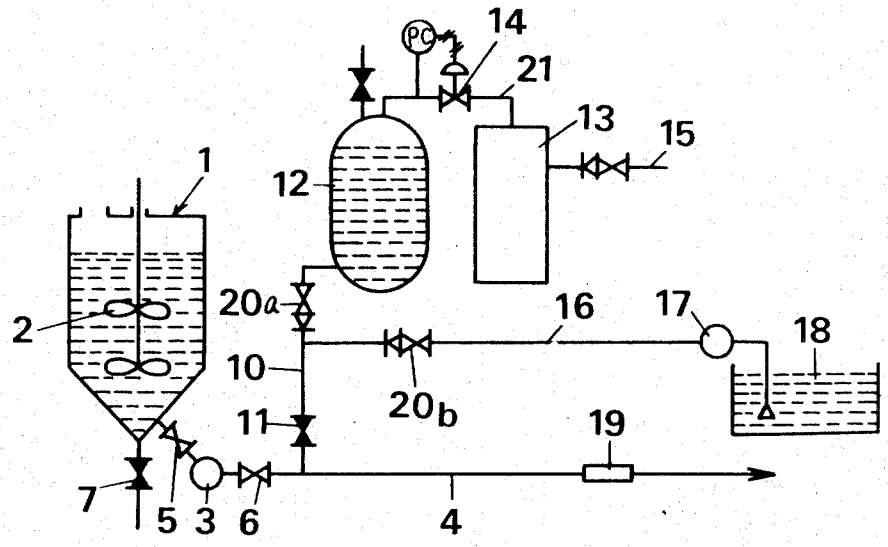


Fig.1

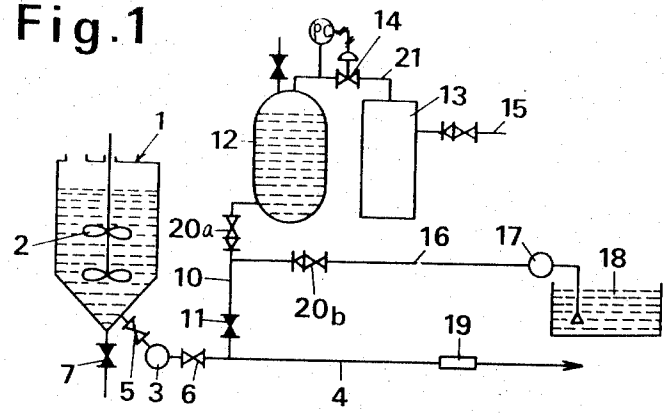


Fig.2

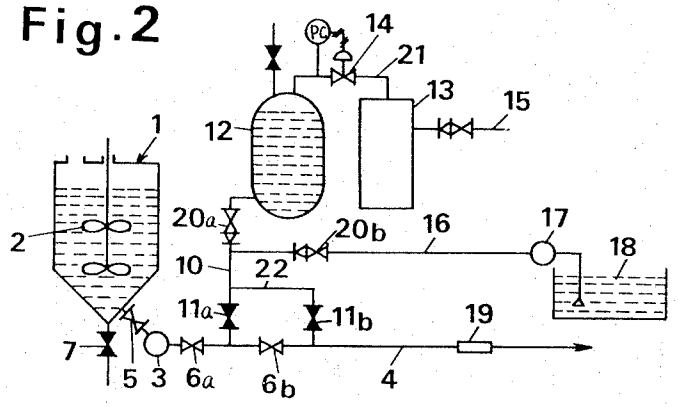
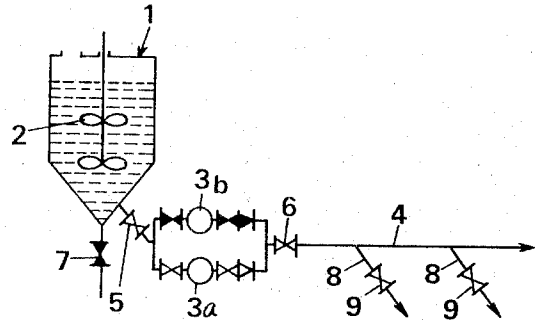


Fig.3



SAFETY DEVICE FOR A SYSTEM OF HYDRAULICALLY TRANSPORTING SOLID MATTERS

This invention relates to safety devices for a system of hydraulically transporting solid matters such as wood chip or wood bark, and more particularly it deals with a safety device of the type described which permits to hydraulically transport a large quantity of solid matters safely and positively ever a long distance while permitting to minimize the volume of the pressure water tank used to attain the end.

The hydraulic transportation system as means of transportation has a long history. In recent years, the demand for rationalization of transportation has expanded the scope of use of hydraulic transportation, with a result that there is now a demand for a new method of carrying the system into practice. Besides, the use of this system for transporting goods over an extraordinarily long distance is desired, and the goods transported by this system have been greatly increased in type and number. Hydraulic transportation of wood chips, masses, capsulated materials and the like which have not hitherto been handled by this transportation system has made a remarkable progress.

Also, a method has been developed which is intended not only to hydraulically transport solid matters but also to extract useful constituentes from solid matters and release the same into the fluid while hydraulically transporting the solid matters, to cause a reaction to take place between the solid matters and the fluid used as means of transportation while the former are being transported by the latter, and to subject the solid matters to a physical or chemical treatment while being transported. Thus, the hydraulic transportation system has made great strides in recent years and it is now used not only as means for transporting solids or slurries but also as new means of material treatment born of technical innovation.

The present invention will now be explained with reference to the accompanying drawing, in which:

FIG. 1 is a systematic view of a piping of the safety device according to this invention;

FIG. 2 is a systematic view of a modified form of piping of the safety device according to this invention; and

FIG. 3 is a systematic view of a piping of the prior art.

In the embodiments described herein, the safety device according to this invention is described as being used with a hydraulic conveying system which involves water and solid matters. It is to be understood, however, that the invention is not to be construed to be limited to the system which uses water alone as a transportation medium, and that the invention is applicable to such system of transportation which uses other liquids than water.

FIG. 3 shows a piping of a hydraulic conveying system of the prior art. In the figure, 1 is a mixing tank, 2 an agitator, 3*a* a hydraulic transportation pump, 3*b* a reserve pump, 4 a pipeline for hydraulic transportation, 5 a main supply valve of solid-water mixture, 6 a main shut-off valve, 7 a blow-out valve for the mixing tank, 8 discharge branch lines, and 9 emergency discharge valves provided in the branch lines 8.

In FIG. 3, solid matters to be transported are mixed with water or other fluid and agitated in the mixing tank 1 in order that the mixture of solid matters and water has uniform density. The mixture prepared in this way is fed to the transportation pump 3*a* which pumps out the mixture into the transportation pipeline 4 for hydraulically transporting the solid matters to the destination. There are other systems of hydraulic transportation. One of them uses a fresh water pump and solid matters are supplied to the delivery side of such pump through rock-hopper feed system for transporting the solid matters hydraulically as is generally done. Other system uses a reciprocating pump, in place of a centrifugal pump, as the transportation pump. Essentially, these systems are nothing more than modifications of the basic system shown in FIG. 3.

Safety devices for such hydraulic transportation systems must have as their primary aim the prevention of clogging of the transportation line by sedimentation of the solids as a result of reduction in the rate of flow of the mixture of water and solid matters. To this end, the following measures have higherto been taken.

A. First of all, a high reliability is imparted to a power source for operating the pump so that there may be no failure of power at all times. For example, two power sources may be used or a power source voltage may be introduced directly from more reliable high-tension lines;

B. In case the measure described above is not considered satisfactory in securing a high degree of reliability of power supply, an emergency power source installation is provided to switch to non-utility generation for power supply in case of emergency;

C. Means is provided for switching quickly and readily to the reserve pump 3*b* from the transportation pump 3*a* so as to cope with the hitch or trouble of pump 3*a* or its drive motor;

D. In case the measures described above in A, B and C are not considered satisfactory in securing a high degree of reliability of power supply, the reserve pump 3*b* or both the transportation pump 3*a* and reserve pump 3*b* are made independent of the electric power source by driving them with diesel engines, gasoline engines or steam turbines etc.; and

E. In case the measures described above in A, B, C and D are not considered satisfactory in securing a high degree of reliability of the transportation system, a plurality of branch lines 8 are provided in suitable positions in the pipeline as shown in FIG. 3 and the emergency discharge valves 9 are opened in case of emergency by remote control to discharge the flow of mixture to sewage or nearby rivers for preventing the clogging of the pipeline.

The aforementioned safety devices will all have effect if the mixture of solid matters and water has a relatively low volumetric concentration (the ratio in volume of the solid matters to the mixture of solid matters and water) and the flow of such mixture is substantially like a flow of liquid or slurry as is the case when the mixture handled consists of materials in the form of pulverized materials or slurries and water. However, such safety devices are unable to produce satisfactory results when the hydraulically transported solid matters are complex in shape, relatively large in size and the mixture of such solid matters and water has a high volumetric concentration and cannot be regarded as a fluid as it is the case with hydraulic transportation of pulpwood chips or wood barks.

More specifically, when solid matters complex in shape and large in size and having a high volumetric concentration is transported hydraulically, the pump is

liable to be jammed in its inner parts (in gaps between the blades of pump runner, for example) with the solid matters even if the pump-drive-means or pump itself is in operation. In such case, the safety devices described in paragraphs A, B, C and D are of no avail.

Also, when hydraulic transportation of such solid matters of high volumetric concentration is carried out, cessation of flow of the mixture of solid matters and water even for a very short time interval of several to ten-odd seconds results in clogging of the pipeline, so that it is not desirable to permit the rate of flow to be reduced below a predetermined level (which is referred to as a critical flow rate) even for an instant, This makes it substantially impossible to smoothly switch from the pump that has troubled to a reserve pump in case of emergency.

Furthermore, when such solid matters of high volumetric concentration is transported hydraulically, it is not possible to discharge the mixture of solid matters and water in uniform flow even if the facilities (branch lines **8** and discharge valves **9** of FIG. **3**) described in paragraph E are provided. In such case, a dehydration phenomenon is liable to occur. When any of the discharge branch lines is opened in case of emergency, the mixture of solid matters and water may be discharged through such branch line for some time after the branch line is opened. However, as the rate of flow of the mixture in the pipeline is reduced, movement of the solid matters is retarded while the rate of flow of water is not considerably reduced, with a result that the concentration of the mixture discharged through the branch line is rapidly reduced till finally only the water is discharged. Thus, only the solid matters remain stationary in the pipeline, thereby making it impossible to restart flow of the mixture. Besides, draining of the hydraulically transported solid matters into sewage or rivers is not only undesirable because of solid matters losses but also liable to cause a public nuisance. Thus, discharging of the mixture of solid matters and water through discharge branch lines involves various problems difficult to obviate,

The present invention obviates the aforementioned disadvantages. The invention has as its object the provision of a safety device which permits to carry out hydraulic transportation of various types of solid matters without any trouble.

According to this invention, there is provided a safety device for a system of hydraulically transporting solid matters which represent a departure in concept from the safety devices of the prior art described above. The safety device provided by this invention permits to maintain the flow rate of the mixture of solid matters and water above a predetermined safety level at all times by detecting beforehand an occurrence of emergency and supplying automatically fresh water or other liquid in place of the mixture, so that the flow rate of the mixture can be dept at a constant level by purging with pressure water and clogging of the pipeline can be prevented by replacing the mixture in the pipeline by the fresh water or other liquid.

More specifically, the safety device according to this invention is such that it can detect all the abnormalities in the hydraulic transportation system, such as disabling of the power source for operating the pump, deviation from the normal pressure differential between the inlet and the outlet of the pump, a reduction in the flow rate of the mixture in the pipeline and the like, and the pressure water main valve provided at the inlet of the pipeline is opened when any of such abnormalities is detected so as to ensure that the mixture in the pipeline is transported and purged by means of the pressure water and the flow rate of the mixture is not reduced below a critical level at all times.

FIG. **1** shows one embodiment of this invention, and reserve pumps of this embodiment are omitted in the interest of brevity. Like reference characters designate similar parts in all the drawings.

The hydraulic transportation system shown in FIG. **1** is similar to the conventional hydraulic transportation system shown in FIG. **3** except that in the former a pressure water supply line **10** is connected to the pipeline **4** in a position which is delivery side of the pump **3** and the main shut-off valve **6** for maintaining communication between the pipeline **4** and a pressure liquid tank **12** containing water or other liquid under pressure, and a fresh water or other liquid supply line **16** is connected to the line **10.** A pressure water stop valve **11** and an adjusting valve **20*a*** are provided in the pressure water line **10,** and the pressure water tank **12** is maintained in communication, through a pipe **21** mounting a pressure reducing valve **14,** with a compressed air receiver tank **13** which in turn is maintained in communication with a compressed air source through a pipe **15.**

The fresh water supply line **16** is connected to a fresh water reservoir **18** through an adjusting valve **20*b*** and an emergency fresh water pump **17.** Provided in the pipeline **4** is a flowmeter **19** which is connected to a suitable servomechanism for controlling the valves and pumps of the lines connected to the pressure tank and fresh water tank respectively in accordance with the read-out values of the flowmeter.

In operation, water or other liquid and solid matters to be transported are fed into the mixing tank **1** and agitated therein so that they may be made into a uniform mixture of any concentration which is delivered to the pipeline **4** by the pump **3** and transported hydraulically to its destination. The flow rate of the mixture in the pipeline **4** is measured by the flowmeter **19** at all times so that the system may be operated normally except when the flow rate is reduced below a critical rate.

In case of emergency or when a reduction in the flow rate is detected by the flowmeter **19,** the pressure water main valve **11** is immediately opened and at the same time th pipeline shut-off main valve **6** is closed so as provisionally to fill the pipeline **4** with a supply of water from the pressure water tank **12** and maintain the flow rate of mixture therein at a predetermined level. While this is in progress, the emergency fresh water pump **17** is actuated at once so that a supply of fresh water is delivered under pressure by the fresh water pump **17** to the pipeline **4** and then the mixtures in the pipeline are purged and replaced gradually with the fresh water from the fresh water reservoir **18.** Thereafter, the pipeline **4,** pump **3** and other parts can be inspected or the machines used can be switched to reserve machines.

Now we assume that a mixture of wood chips and water having a volumetric concentration of about 25 to 30 percent is hydraulically transported through a pipeline made of steel and having a diameter of 8 inches at an average flow velocity of 2 meters per second with an average flow rate of 4 cubic meters per minute and a critical flow velocity is 0.7 meter per second, and in case of emergency the flow rate in the pipeline must be

maintained at the predetermined average level by a supply of pressure water from the pressure water tank for about 2 minutes and thereafter a supply of fresh water may be delivered under pressure to the pipeline from the fresh water reservoir by means of the emergency fresh water pump **17.** In such case, a tank of small capacity or about 10 cubic meters may be used as the pressure water tank **12.** If the emergency fresh water pump **17** is driven by a diesel engine or gasoline engine, it can be started within 30 seconds, making it possible to quickly switch from one source of supply of pressure water to another source.

If the delivery pressure of the pump is 6 kg/cm² by assuming that the transportation distance of the mixture is about 3 kilometers, only one compressed air receiver **13** havig a capacity of 20 cubmic meters may be provided by using a compressed air of 19 kg/cm².

If no emergency fresh water pump **17** were provided and the mixture were to be transported and purged through the pipeline **4** over the entire distance of 3 kilometers only by a supply of pressure water from the pressure water tank, the pressure water tank **12** would have to have a capacity of no less than 100 cubic meters. If the pipeline for hydraulic transportation covered a longer distance or had a larger diameter, it would be almost impossible because of large capacity of the pressure water tank **12** to carry out hydraulic transportation and purge of the mixture referred to hereinabove only by a supply of pressure water from the pressure tank. It is to be understood that, if the distance to be covered were short or the pipeline had a smaller diameter and the mixture to be transported has a small volume, the pressure tank **12** of suitable capacity could be used and the emergency fresh water pump and associated mechanisms **16, 17** and **18** might be done without.

FIG. **2** shows another embodiment of this invention which provides particularly against the solid matters being bitten by the main shut-off valve **6** when it is closed in case of emergency.

When wood chips or wood barks are transported hydraulically, no difficulty is faced with in quickly opening the pressure water main valve **11** shown in FIG. **1,** but the closing of the pipeline shut-off main valve **6** is often closed incompletely because there is the danger of wood chips being bitten by the valve body, thereby making it impossible to fully shut-off the pipeline.

In order to obviate this disadvantage, the safety device according to this invention comprises, in another aspect, two shut-off main valves **6*a*** and **6*b*** shown in FIG. **2,** in place of one main valve **6,** which are arranged in series and spaced apart from each other a proper distance; the pressure water main line **10** is connected to the pipeline **4** in a position interposed between the two shut-off main valves **6*a*** and **6*b;*** a branch line **22** of the pressure water main line **10** is connected to the pipeline **4** in a position which is disposed opposite the main line **10** connected with the pipeline **4** with respect to the second shut-off main valve **6*b;*** and pressure water stop valves **11*a*** and **11*b*** are mounted in parallel with each other in the pressure water main line **10** and branch line **22** respectively.

In case of emergency, the pressure water stop valve **11*a*** is quickly opened and shut-off main valve **6*a*** is closed so as to permit a supply of pressure water to be delivered through the main line **10** to the pipeline **4** to a degree such that the mixture of solid matters and water in a portion of the pipeline **4** near the shut-off main valve **6*b*** is replaced by the fresh water under pressure. When this is accomplished, the pressure water stop valve **11*b*** is opened and at the same time the valve **11*a*** and the main valve **6*b*** are closed. This permits to deliver a supply of pressure water from the pressure water tank **12** to the pipeline **4** through the pressure water branch line **22,** while a portion of the pipeline **4** from its connection to the tank **1** to the pump **3** is completely isolated by the stop valve **6*b*** from the remainder of the pipeline **4,** so as to thereby prevent the clogging of the pipeline **4.** Thus, the provision of the two shut-off main valves **6*a*** and **6*b*** is effective to fully cut off the pipeline **4** from the tank **1** and the pump **3** by closing the second main valve **6*b*** in case the first main valve **6*a*** is incompletely closed due to wood chips being bitten by the valve **6*a*.**

In the embodiments described hereinabove, the pressure water tank **12** is connected to a compressed air receiver or an air compressor. It is to be understood that the pressure water tank **12** could alternatively be connected to a high pressure gas holder or gas pressure producing device of considerable capacity so as to use the gas pressure for producing pressure water for transporting and purging the mixture in the pipeline.

The pressure water tank **12** may be supported at a great height to increase the natural water head more than the necessary pressure of the pressure water which is supplied from the tank **12.** If this is the case, the compressed air receiver, compressor and the like can be eliminated.

From the foregoing description, it will be appreciated that the safety device according to this invention comprises features which offer many advantages. The feature of maintaining the pipeline in communication with the pressure water or pressure liquid tank through the pressure water or pressure liquid supply line which is connected at its intermediate portion to the fresh water or liquid supply system is effective to carry out safety hydraulic transportation of a mixture of solid matters and water without any trouble at all times, because this feature permits to first deliver a supply of pressure water or liquid to the pipeline and then switch from the supply of pressure water or liquid to a supply of fresh water or liquid and transport and purge the mixture in the pipeline in case of emergency so as to prevent the clogging of the pipeline. Since the pressure water or liquid tank is rendered operative only in initial stages of emergency case and switched immediately to the fresh water or liquid supply system, a tank of a small capacity can be used as the pressure water or pressure liquid tank.

The feature of installing the two shut-off main valves in series with each other in the pipeline and providing the two pressure liquid stop valves in parallel with each other in respective pressure liquid supply lines connected to the pipeline immediately posteriorly to the shut-off main valves permits to completely cut off the pipeline from the mixing tank and the pump in case of emergency in spite of the fact that wood chips, wood barks or other solid matters of relatively large size mixed with water or liquid are liable to be bitten by the valve body. This is effective to transport and purge the mixture of body matters and liquid in the pipeline in case of emergency, and permits to carry out safely hydraulic transportation of a mixture of solid matters and

liquid having a high volumetric concentration in a great volume over a long distance without any trouble.

We claim:

1. In a system of hydraulically conveying solid matters such as wood chip or wood bark through a pipeline to a destination, a safety device which comprises a pressure liquid tank containing a pressure water or liquid and a pressure air or gas therein, two main shut-off valves installed in series with each other in the pipeline, a pressure liquid supply line communicating said pressure liquid tank with the pipeline between said two main shut-off valves, a pressure liquid supply branch line from an intermediate portion of said pressure liquid supply line connecting a portion of the pipeline which is disposed opposite the connection of said pressure liquid supply line to the pipeline with respect to one of said two main shut-off valves, and two pressure liquid stop valves installed in parallel to each other in the pressure liquid supply line and the pressure liquid supply branch line respectively, which permits one of said main shut-off valves to be closed completely and the liquid contained in said pressure liquid tank to be injected through said pressure liquid supply line to the pipeline in case of emergency with the help of the expanding pressure of the air or gas in said pressure liquid tank whereby the flow rate of the mixture in the pipeline can be maintained at a predetermined level.

2. In a system of hydraulically conveying solid matters such as wood chip or wood bark through a pipeline to a destination, a safety device which comprises a pressure liquid tank containing a pressure water or liquid and a pressure air or gas therein, two main shut-off valves installed in series with each other in the pipeline, a pressure liquid supply line communicating said pressure liquid tank with the pipeline between said two main shut-off valves, a liquid feed system connected to said pressure liquid supply line at an intermediate portion thereof, a pressure liquid supply branch line from an intermediate portion of said pressure liquid supply line connecting to a portion of the pipeline which is disposed opposite the connection of said pressure liquid supply line to the pipeline with respect to one of said two main shut-off valves, and two pressure liquid stop valves installed in parallel to each other in the pressure liquid supply line and the pressure liquid supply branch line respectively, which permits one of said main shut-off valves to be closed completely and the liquid contained in said pressure liquid tank be first injected through said pressure liquid supply line to the pipeline in case of emergency and then a liquid to be fed to the pipline through said liquid feed system, whereby the flow rate of the mixture in the pipeline can be maintained at a predetermined level.

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