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WEB TENSION CONTROL MEANS

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Fig-1

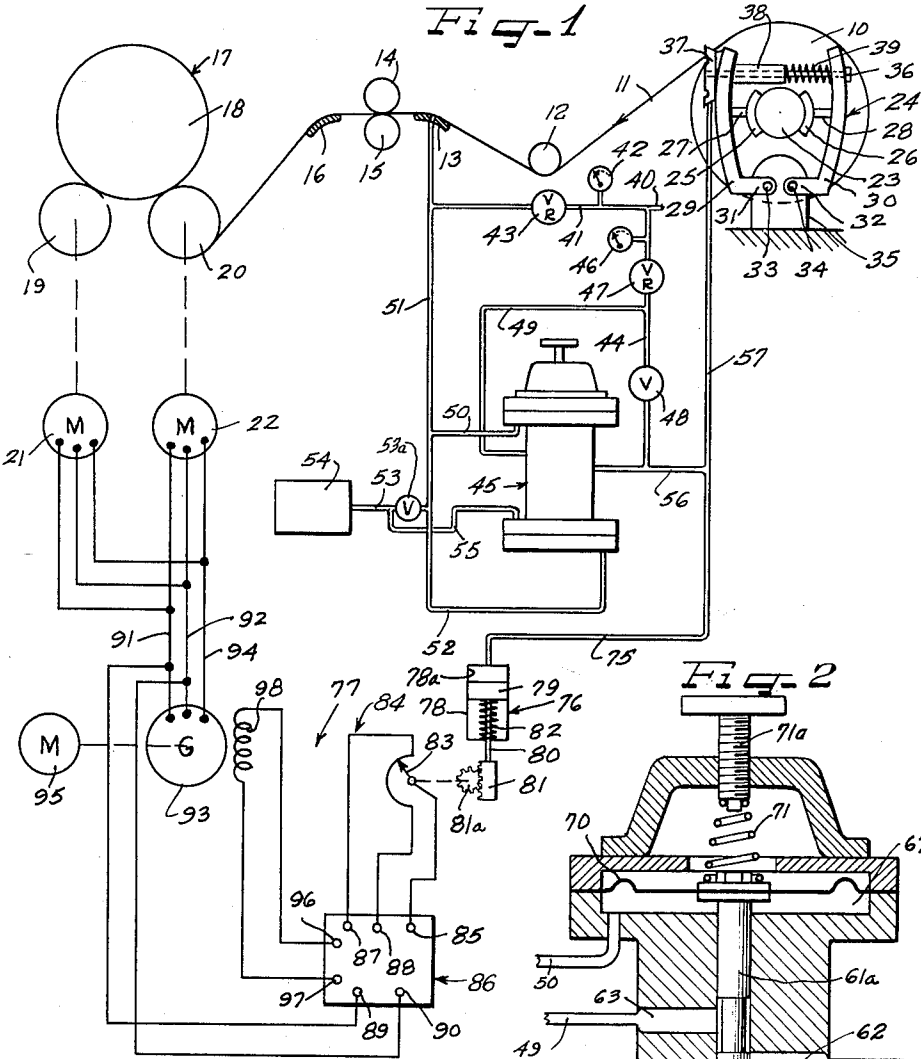
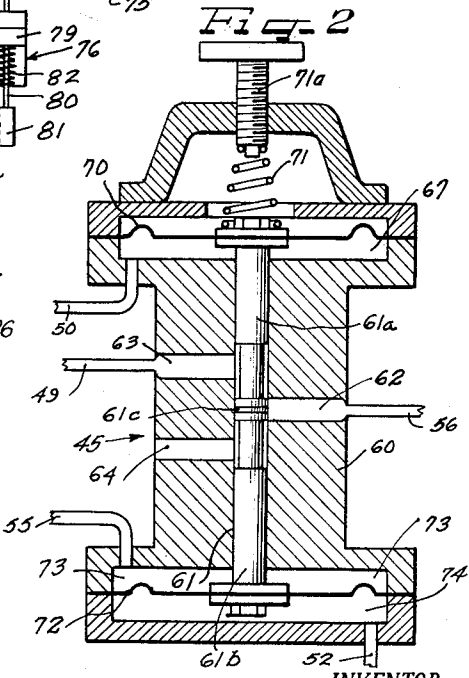


Fig-2



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WEB TENSION CONTROL MEANS

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The present invention relates broadly to the winding of sheet materials, and is more particularly concerned with means for controlling the tension in a web or strand being supplied to processing apparatus from a supply or unwind roll.

It is of course well known that the tension of a web or strand being unwound from a non-driven supply roll is limited by the strength of the web or by its strain properties, and that the web may be damaged and rendered unfit for its best intended use even when the strain is less than breaking strain. As is also known, the web strength properties or strain characteristics are essentially fixed or constant for a particular web or strand.

On the other hand, the force required to unwind the web from the non-driven supply roll and applied by means of tension is dependent upon a number of factors, an important one of which is the size of the roll. In addition, the dictates of efficiency and high production rates require a rapid acceleration of the supply roll from a rest condition to the desired operating speed of the unit being served thereby. It is further known that the inertia of the supply roll must be overcome by an acceleration torque, which is the product of web tension and roll radius, and accordingly limited by the stated necessity that the tension applied be less than that which could cause web damage. Further, since the roll inertia is a function of the square of the roll radius, it follows that larger rolls cannot be accelerated at the rates tolerable with rolls of lesser diameter.

It is a requirement of the art that a successful unwinding system provide for control of several sizes of supply rolls, as well as start and stop operations on a single roll. There is accordingly in use supply roll systems having friction brake arrangements in which the braking efforts are reduced or removed by a constant force, as exemplified by spring means. The same friction brake arrangement then increases or applies the braking effort by a modulated force, such as may be provided by a fluid diaphragm or cylinder. The two forces are in opposition, so that at zero braking effort there is required a positive output from the modulating control.

Now, in this arrangement the braking system is modulated as a direct function of the web tension. However, experience with this system has demonstrated inadequacy in coping with web tensions produced during acceleration, particularly when the tension results from inertia of the supply roll rather than from the braking effort. In other words, the modulated fluid pressure in such event is less than the zero or null mentioned and no braking effort is applied. In attempts to avoid web damage under the stated conditions, the operator must at least pay extremely close attention to his apparatus, as well as possess skill in control of the winder drive. As a further expedient in avoiding web damage the available power input to the drive unit has been limited to a value suited to the tolerable acceleration of the weakest web or strand which might be wound, thus being too slow for stronger webs. It is immediately apparent that such attempts at successful winder operation can never result in maximum production efficiencies.

It is accordingly an important aim of the instant invention to provide web tension control means effectively overcoming the named prior art problems.

Another object of this invention lies in the provision of a simple, automatic and highly reliable web tension con-

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trol system productive of constant sheet tension and permitting greater acceleration rates to be used with smaller diameter rolls than with larger diameter rolls, to thereby markedly increase the output of the apparatus.

Other objects and advantages of the invention will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals designate like parts throughout the same:

FIGURE 1 is a more or less diagrammatic view of web tension control means constructed in accordance with the principles of this invention; and

FIGURE 2 is a vertical sectional view of a fluid pressure responsive valve which may be employed in the system of FIGURE 1.

Referring now to FIGURE 1, there is shown a supply or unwind roll 10 from which a strand or web 11 of paper or like materials is unwound or pulled, the web 11 passing during its travel beneath a guide roll 12, over a tension sensing shoe or bleed valve means 13, between a pair of rolls 14 and 15, and over a guide shoe 16 to a rewinder assembly 17. The rewinder assembly 17 may be seen to comprise a rewind or delivery roll 18 supported upon and driven by a pair of rolls 19 and 20, diagrammatically shown as connected to motor means 21 and 22 to be rotatably driven thereby.

The supply roll 10 is non-driven, and is provided with shaft means 23 the rotative speed of which is under control of friction brake means, generally designated by the numeral 24. The exemplary form of brake means illustrated may comprise a pair of brake shoes 25 and 26 supported through shaft means 27 and 28 by lever arms 29 and 30, which are in turn connected to link members 31 and 32 pivotally mounted at 33 and 34 to stand structure 35, fixedly mounted as shown.

The upper ends of the lever arms 29 and 30 are apertured to receive therethrough bolt means 36 to support on the lever arm 29 air brake means 37. The air brake means or fluid pressure actuated motor may take the form of a brake diaphragm the construction of which is well known in the art, and accordingly need not be further described herein. It may be observed in FIGURE 1 that the bolt means 36 further has an enlarged portion 38 thereon, and bottoming at one end against the enlarged portion 38 is spring means 39, which encircles the bolt means 36 and bottoms at its opposite end against the lever arm 30.

In the manner known to the art, braking efforts are reduced or removed by the constant force provided by the spring means 39, while the braking efforts are increased or applied by the modulated force provided by the brake diaphragm 37. It is to be observed that the spring means 39 exerts forces in opposite directions against the lever arm 30 and enlarged portion 38, and the latter force is opposed by the force exerted by the lever arm 29 through the brake diaphragm 37. Accordingly, to obtain any braking effort a positive output is required from the modulating control, to be later described. Illustratively, the absorbing force of the spring means 39 may be ten pounds per square inch, and the braking effort by the brake diaphragm 37 may be in the range of ten to fifty p.s.i. Any braking effort would therefore require ten p.s.i. or more to be applied to the diaphragm 37.

In Patent 2,755,032, issued July 17, 1956, in the name of the instant applicant and assigned to the assignee of the present application, there is disclosed and claimed a web tension control system incorporating many of the elements thus far described in this application. Since the instant invention is particularly directed to novel means for controlling the acceleration of the supply roll 10 by controlling the power delivered by the motor means 21

and 22 in response to the braking effort, the modulation system in control of the braking effort in the noted Justus patent has been simplified to facilitate the instant description.

As appears in my patent in greater detail, a suitable air pressure source communicates with an air source line 40 connected to header 41 which has positioned therein an air pressure gauge 42 and air pressure regulator 43 in control of the pressure supply to the tension sensing shoe 13. The air source line 40 further leads to a header 44 supplying air pressure responsive valve means 45, the structure of which also appears in my noted patent, but which will be later reviewed herein when specific reference is made to FIGURE 2.

The header 44 has positioned therein an air pressure gauge 46 and an air pressure regulator 47, and also in this header is a by-pass gate valve 48, which as is described in Patent No. 2,755,032 is in an open position during manual operation of the system to by-pass the valve 45, and in a closed position during automatic operation.

The header 44 is tapped through a suitable T-connection to supply air pressures through conduit means 49 to the valve means 45 during automatic operation when the by-pass valve 48 is closed. As well, there leads to the upper portion of the valve means 45 a header 50 for actuating a diaphragm therein, to be later described, in response to signal air pressure from header 51 in fluid communication with the tension sensing shoe 13. The signal air pressure header 51 further connects with a signal header 52 leading to the lower portion of the valve means 45, and in control of a second diaphragm to provide a valve damping effect, which will be more fully understood when later reference is made to FIGURE 2.

The signal header 51 is tapped by a header 53 leading to a surge tank 54 and connected to the header 53 is a throttle valve 53a and a surge tank signal header 55 terminating in the lower portion of the valve means 45, and acting against the second diaphragm. Air pressures in control of the brake diaphragm 37, as well as the acceleration control means of this invention and to be later described, are supplied from the valve means 45 through an automatic control header 56. The header 56 has a first conduit means 57 connected thereto and leading to the brake diaphragm 37 as shown.

Referring briefly now to FIGURE 2, the valve 45 has a valve body 60 in which is mounted cooperatively a valve piston 61 provided with valve land portions 61a and 61b near its extremities for slidably engaging the body portion 60 so as to form fluid seals therebetween. Near the middle of the valve piston 61 is a third valve land portion 61c normally closing or lapping passageway 62 to which leads the header 56. It will be observed that the diameter of the piston 61 is substantially reduced between the land portions 61a and 61c (aligned with passageway 63) and between the land portions 61c and 61b (aligned with passageway 64).

Accordingly, it will be seen that if the piston 61 is moved downwardly, the movement of the land portion 61c will uncover the passageway 62, thereby affording fluid communication from the control supply header 49 through the passageway 63, the interior of the valve 45, the passageway 62, and the automatic control header 56 to the actuating air pressure header 57. Conversely, upward movement of the piston 61 results in upward movement of the land portion 61c, so as to permit venting of air pressure through the passageway 62, the interior of the valve 45, and the venting passageway 64 to atmosphere.

As appears in FIGURE 1, the signal air pressure header 51 communicates with a top diaphragm chamber 67 by means of the signal header 50. As can be appreciated, an increase in the signal air pressure thus being introduced into the top diaphragm chamber 67 acts against top diaphragm 70 so as to move the piston 61 upwardly and thereby to effectively vent some of the air pressure in the headers 56 and 57. It will thus be seen that an increase

in tension on the web 11 causes an increase in the signal air pressure, which in turn actuates the valve 45 so as to effect a decrease in the actuating air pressure communicating with the air brake 37, essentially as is described in my earlier patent.

Above and in contact with the top diaphragm 70 there is positioned an adjustable spring 71 so as to resist upward movement thereof in response to signal air pressure increases. The spring 71 may be adjustably set as by screw means 71a to resist movement of the diaphragm 70 to a predetermined extent.

A bottom diaphragm 72 is mounted at the bottom of the piston 61, and separates an upper diaphragm chamber 73 from a lower diaphragm chamber 74. The signal air pressure header 51 communicates through the header 52 with the lower diaphragm chamber 74, and also connected to the header 51 through the header 53 is the noted surge tank. Suitable throttle valving would of course normally be employed in the header 53, and as appears in FIGURE 2, the surge header 55 communicates with the upper diaphragm chamber 73.

In this manner and during automatic operation an increase in the signal air pressure in the header 51 effects an increase in the air pressure in the lower diaphragm chamber 74 by means of the signal header 52. At the same time, the increase in air pressure in the header 51 begins to increase the pressure in the surge tank 54 by bleeding through the mentioned throttle valve means 53a. In a comparatively short time the pressure in the surge tank 54 reaches a pressure that is the same as that in the header 51, and accordingly, the surge tank signal header 55 permits an equalizing pressure to be formed in the diaphragm chamber 73, thereby tending to return the piston 61 to its original position. In this manner, the piston 61 may be started back to its original position before it has a chance to produce a change in the actuating air pressure against the air brake member 37 that is greater than that necessary to correct the tension on the web 11.

While the arrangement thus far described possesses many advantages over earlier unwinding systems, it has been found that improvements can be made therein to prevent breakage of or damage to a relatively light sheet by acceleration forces, as well as to produce a constant tension on the sheet during acceleration. As was earlier explained, if tension in the traveling paper web 11 increases the signal air pressure in the header 51 increases to actuate the valve 45 and thereby decrease the actuating air pressure communicated by the header 57 to the air brake 37. Under these circumstances the modulation output provided by the control system just described would be less than the constant force output and the brake is released; however, the unwind roll 10 would have sufficient inertial resistance to rotation to cause at least damage to the web, if not breakage thereof. Particularly is this the case with relatively light sheets, webs or strands.

However, by this invention the acceleration rate of the rewind roll 18 is controlled by the same actuating air pressures which are in control of the air brake 37. Simply stated, in accordance with this invention when the modulating output to the air brake 37 is at or below the required positive output for zero braking effort, the current supply to generator means supplying the drive means 21 and 22 is modulated so that the power available to the drive rolls 19 and 20 is controlled to provide a constant sheet tension.

In this manner a smooth stepless transition of the tension control is made which matches the productive speed of the machine in accordance with either the inertia or drag of the supply means.

Referring now again to FIGURE 1, the control header 56 has a second connection 75 communicating therewith which terminates in a fluid pressure operated device 76 forming a part of the pressure responsive electrical con-

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trol means of this invention and generally designated by the numeral 77. The device 76 may be seen to comprise a cylinder 78 housing for reciprocal movement piston means 79 to which is connected rod means 80 carrying at its opposite end a rack gear 81. The cylinder 78 defines therewithin a piston chamber 78a, and resiliently urging the piston 79 to a return position is spring means 82 mounted in encircling relation to the rod member 80.

The rack gear 81 meshes with a pinion gear 81a mechanically connected to a moveable contact 83 of a potentiometer 84, as is indicated by the dotted line. The contact 83 is connected to terminal 85 of a control unit 86, while the end terminals of the potentiometer are connected to terminals 87 and 88 of the unit 86. The control unit 86 has power input terminals 89 and 90 connected to output conductors 91 and 92 of generator means 93. The output conductors 91 and 92 are connected to the motors 21 and 22, together with a third output conductor 94. The generator 93 is driven by a motor 95 or other motive power source, as diagrammatically illustrated.

The control unit 86 has output terminals 96 and 97 connected to a field winding 98 of the generator 93. The control unit 86 may comprise a suitable amplifier, the output of which is controlled by the position of the potentiometer contact 83. In the alternative, the potentiometer 84 may be connected as a rheostat directly between the input terminals 89 and 90 and output terminals 96 and 97, to directly control the generator excitation.

While the operation of the instant tension control system is believed quite apparent from the preceding description, a brief summary will now be given. Assuming first that the spring means 39 of the friction brake arrangement 24 absorbs 10 pounds per square inch and that the braking output of the air brake 37 is within the range of from 10 to 50 pounds per square inch, if the braking pressure supplied through the actuating air header 57 is at 10 pounds per square inch or more, a similar amount of pressure is supplied through the valve means 45 to the conduit 75 and fluid pressure operated device 76. This causes downward movement of the piston 79 to move the potentiometer contact 83 to a maximum or approaching maximum current setting, depending of course upon the particular pressure values applied. The generator 93 is thereby excited through its field winding 98 at a relatively high level, to provide through the generator conductors 91, 92 and 94 a relatively high output to the motor means 21 and 22, so that sufficient power is delivered by the motor means to the drive rolls 19 and 20, assuring sufficient acceleration of the rewind roll 18 to maintain constant tension in the traveling sheet or web 11.

On the other hand, and again assuming the same braking effort values, if the actuating air pressures supplied through the header 57 to the air brake 37 vary from 10 p.s.i. to 0 p.s.i., substantially the same air pressures are supplied to the device 76 to modulate the current setting and thereby assure that the power supplied by the motor means 21 and 22 is at a sufficiently low level to again prevent a mismatched acceleration and sheet damage or breakage.

As well, by provision of the disclosed system in control of the acceleration of the rewind roll 18, substantially greater acceleration rates can be employed with smaller unwind rolls than with larger unwind rolls, without encountering damage or breakage problems. As was stated in the early portions of this specification, the acceleration torque required to overcome inertia of the unwind roll is a product of web tension and roll radius. Since the permissible web tension is a known value as limited by the inherent strength of a particular web, it follows that as the radius of the unwind roll is reduced, an increase in acceleration is permitted. In this manner, various size rolls can be accommodated on the same apparatus, thereby increasing its versatility, or as the radius of a par-

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ticular unwind roll is reduced during the unwinding of web material therefrom, the acceleration forces applied to the rewind roll can be increased, to produce the important benefit of markedly increased production.

It is of course to be appreciated that a hydraulic system could be employed in substitution for the disclosed pneumatic system, and that the pressure responsive electrical control means 77 can be constituted in ways different from that specifically disclosed. It also will be evident that the system described is not limited in its application to winding machines but is of equal utility in control of web tension from any web supplying unit to any "web fed" unit such as coating or printing apparatus. These and other modifications can accordingly be effected without departing from the novel concepts of this invention.

I claim as my invention:

1. Means for controlling the tension on sheet material being unwound from a roll, comprising a fluid pressure responsive brake for the roll, a fluid pressure source, a fluid pressure responsive valve in control of communication between the brake and source applying a fluid pressure to the brake, valve means responsive to the tension on the sheet material for imparting fluid pressure to the fluid pressure responsive valve, and pressure responsive electrical control means operatively connected to the fluid pressure responsive valve for modulating the acceleration of the roll in accordance with the fluid pressure applied to the brake.
2. Tension control means for sheet material, comprising a supply roll, a delivery roll, driving means for the delivery roll, a fluid pressure responsive brake for the supply roll, means responsive to variations in the sheet tension for controlling the fluid pressure input to the brake, and means responsive to variations in the fluid pressure input to the brake and connected to said driving means for controlling the acceleration of the delivery roll.
3. Tension control means for sheet material, comprising a supply roll, a delivery roll, brake means for the supply roll, drive means for the delivery roll, means responsive to variations in the tension of the sheet material for varying the braking effort of the brake means, and rheostat means mechanically connected to the brake means and to the means for varying the braking effort thereof and electrically connected to the drive means for controlling the acceleration of the delivery roll in response to variations in the braking effort.
4. Tension control means for sheet material, comprising an unwind roll, a rewind roll, a fluid pressure responsive brake for the unwind roll, drive means for the rewind roll, a fluid pressure source, a fluid pressure responsive valve in control of communication between the brake and source, valve means responsive to the tension on the sheet material for imparting fluid pressure to the fluid pressure responsive valve, and fluid pressure operated rheostat means in fluid communication with the brake and with the fluid pressure responsive valve and electrically connected to the drive means for controlling the acceleration of the rewind roll in response to the fluid pressures applied to the brake.
5. Tension control means for sheet material, comprising an unwind roll, a rewind roll, a fluid pressure responsive brake for the unwind roll, drive means for the rewind roll, a fluid pressure source, a fluid pressure responsive valve in control of communication between the brake and source, valve means responsive to the tension on the sheet material for imparting fluid pressure to the fluid pressure responsive valve, fluid pressure responsive actuating means in fluid communication with the brake and with the fluid pressure responsive valve, and rheostat means mechanically connected to the actuating means and electrically connected to the drive means for controlling the acceleration of the rewind roll in response to the fluid pressures applied to the brake.

6. Tension control means for sheet material, comprising an unwind roll, a rewind roll, drive means for said rewind roll, a fluid pressure responsive brake for said unwind roll, a fluid pressure responsive valve in control of fluid communication between said brake and a source, bleed valve means presenting a leakage aperture adapted to engage the sheet material, conduit means connecting said bleed valve means to said pressure responsive valve and said latter valve to said brake, generator means electrically connected to said drive means, and pressure responsive electrical control means in fluid communication with said pressure responsive valve means controlling the current input to said generator means in accordance with the pressure applied to said unwind roll by said brake.

7. Tension control means for sheet material, comprising an unwind roll, a rewind roll, drive means for said rewind roll, a fluid pressure responsive brake for said unwind roll, a fluid pressure responsive valve in control of fluid communication between said brake and a source, bleed valve means presenting a leakage aperture adapted to engage the sheet material, conduit means connecting said bleed valve means to said pressure responsive valve and said latter valve to said brake, generator means electrically connected to said drive means, and fluid pressure operated rheostat means in fluid communication with the brake and with the fluid pressure responsive valve and electrically connected to the generator means for varying the current input to the generator means and the power delivered by the drive means to control the acceleration of the rewind roll in response to the fluid pressures applied to the brake.

8. Tension control means for sheet material, comprising an unwind roll, a rewind roll, drive means for said rewind roll, a fluid pressure responsive brake for said unwind roll, a fluid pressure responsive valve in control of fluid communication between said brake and a source,

bleed valve means presenting a leakage aperture adapted to engage the sheet material, conduit means connecting said bleed valve means to said pressure responsive valve and said latter valve to said brake, generator means electrically connected to said drive means and having a field winding therein, fluid pressure responsive actuating means in fluid communication with the brake and with the fluid pressure responsive valve, rheostat means mechanically connected to the actuating means, and amplifier means electrically connected to said rheostat means and to said field winding, said actuating means being actuated in response to the fluid pressures applied to the brake to vary the current setting of the rheostat means, thereby modulating the power supplied by the generator means to the drive means for controlling the acceleration of the rewind roll.

9. Means for controlling tension in a sheet travelling from a supply means to a takeup means, comprising drive means for said takeup means, a fluid pressure source, a pressure control header, a fluid pressure responsive valve in control of communication between the header and the source applying fluid pressure to the header, valve means responsive to the tension on the sheet for imparting actuating fluid pressure to said fluid pressure responsive valve, means for controlling said supply means in response to fluid pressure in said header, and means connected to said drive means for controlling said drive means in response to fluid pressure variation in said header.

References Cited in the file of this patent

UNITED STATES PATENTS

2,469,706	Winther	May 10, 1949
2,755,032	Justus	July 17, 1956
2,925,963	De Gelleke	Feb. 23, 1960
2,983,463	Aaron et al.	May 9, 1961