

**Dec. 13, 1927.**

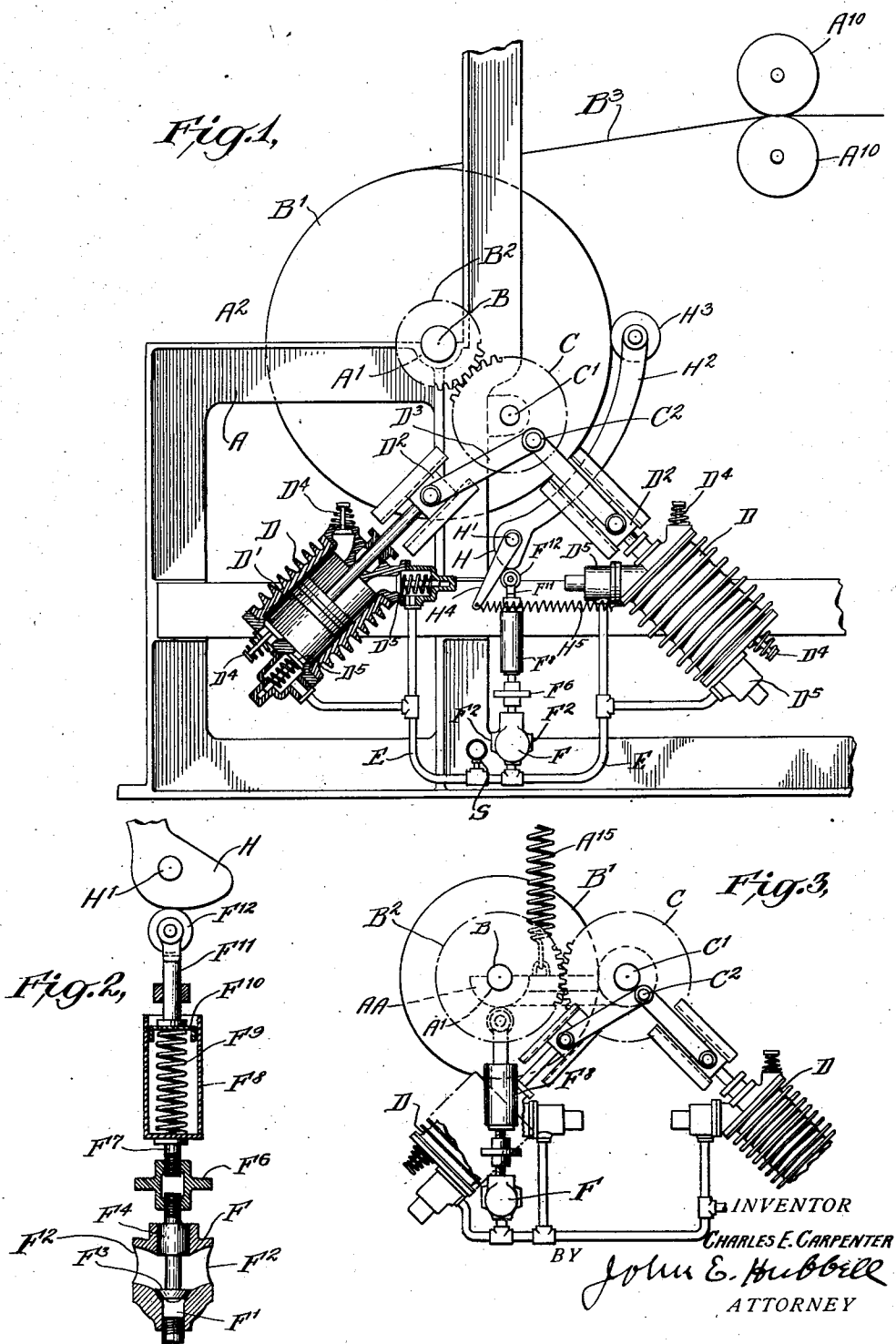
**C. E. CARPENTER**

**1,652,299**

## METHOD AND APPARATUS FOR TENSION CONTROL

Filed Oct. 18, 1921

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METHOD AND APPARATUS FOR TENSION CONTROL

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Fig. 4,

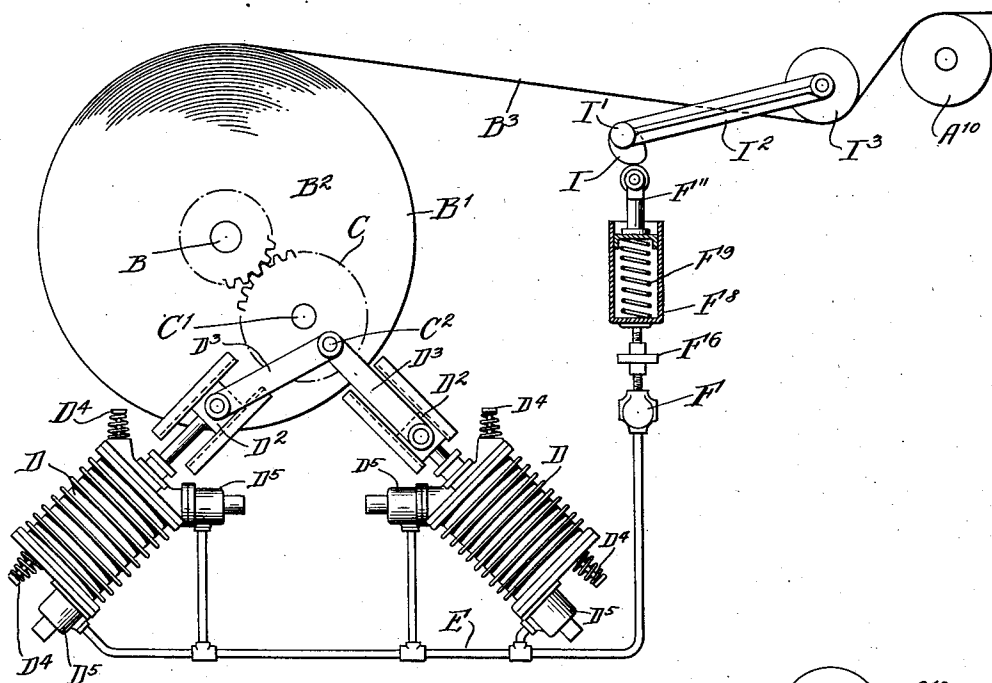
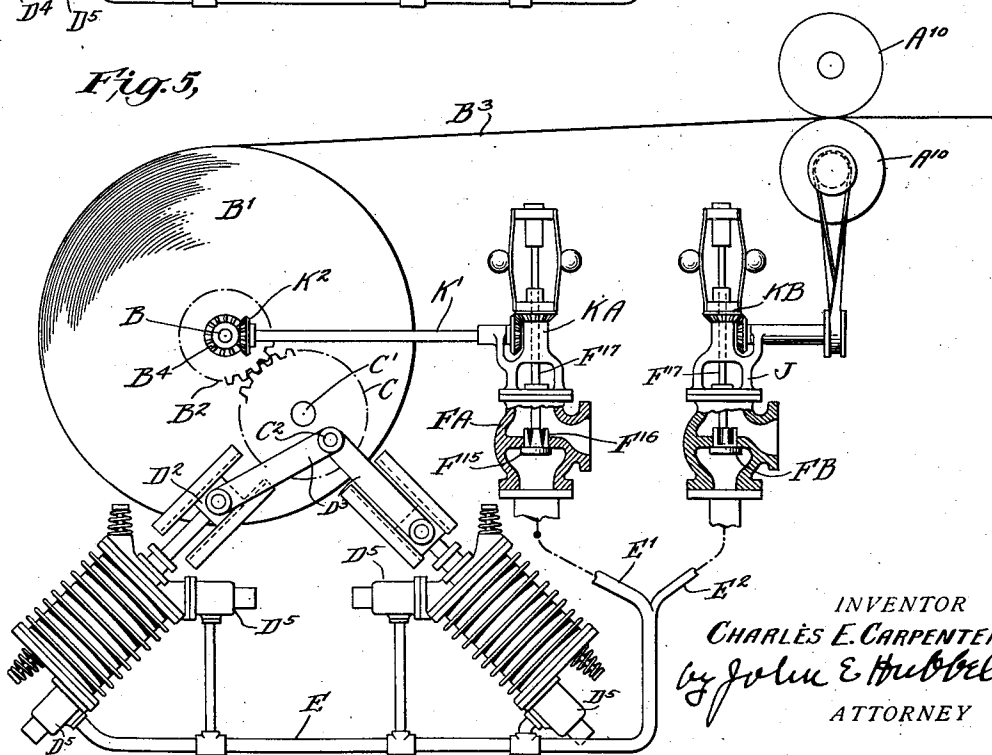


Fig. 5,



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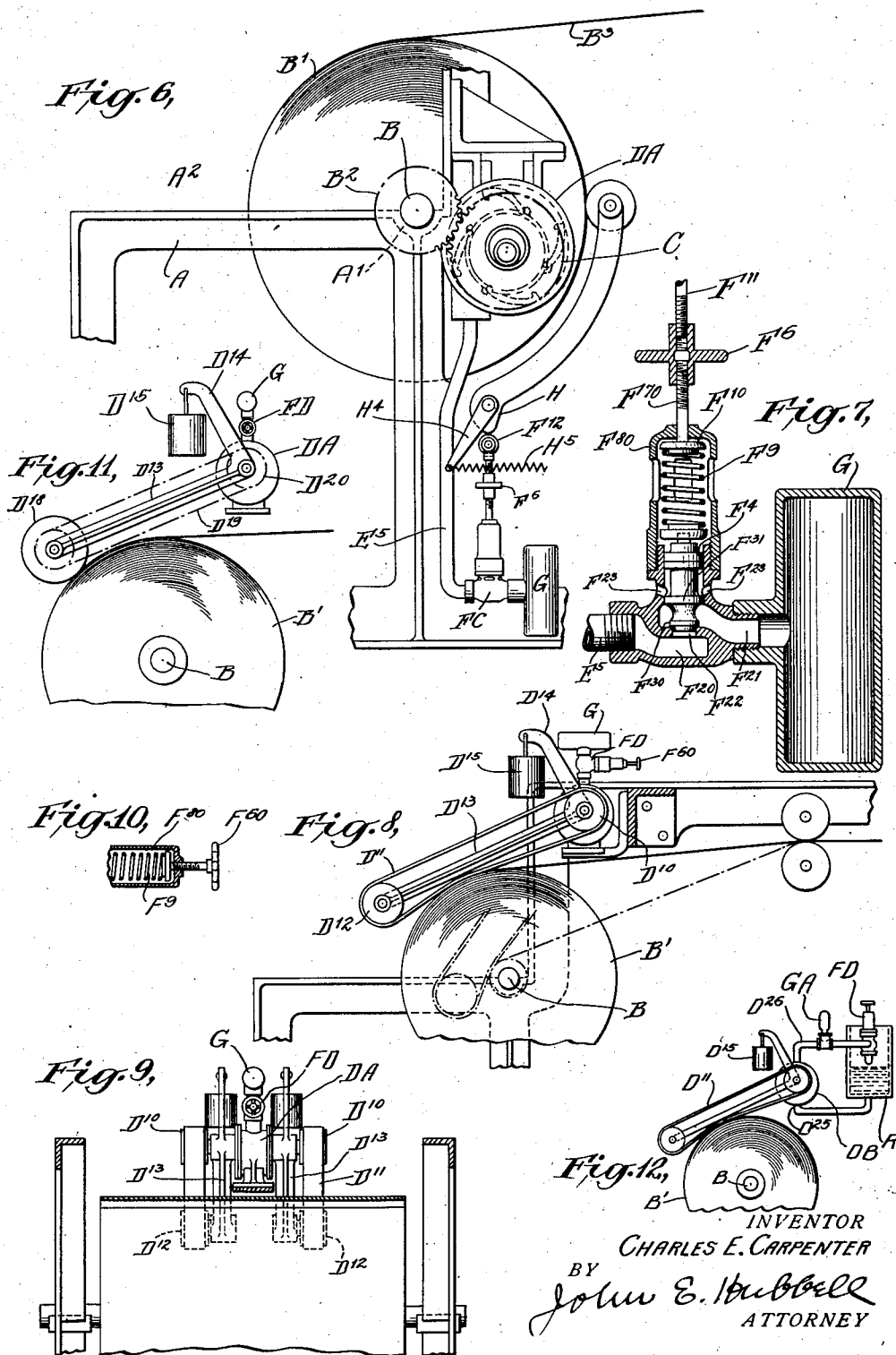
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## METHOD AND APPARATUS FOR TENSION CONTROL

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3 Sheets-Sheet 3



## UNITED STATES PATENT OFFICE.

CHARLES E. CARPENTER, OF NEW YORK, N. Y.

METHOD AND APPARATUS FOR TENSION CONTROL.

Application filed October 18, 1921. Serial No. 508,547.

The general object of my present invention is to provide an improved method of, and apparatus for controlling the tension of a travelling web of material. The invention was particularly devised, and is especially adapted for use in controlling the tension of a web of paper as it is fed into a newspaper printing press, a waxing machine, slitting rolls, or other apparatus to which paper is supplied. The invention, however, is not necessarily limited to use with paper but is generally useful where it is desirable to maintain tension on moving web or strand-like material.

In maintaining material under tension in accordance with the present invention I utilize the tension impressed on the material as the driving force for a pump, and regulate the condition under which the pump operates so as to make the power required to drive the pump that which will put the proper tension on the material. The fluid pumped may be either a liquid or a gas, but preferably is the latter, and in practice I ordinarily prefer to use an air pump or compressor of the positive displacement type, and I regulate the pump driving force required by throttling the outlet, or the inlet, or both outlet and inlet of the pump. In the case of web material drawn from a supply roll, the pump may be driven either at a speed proportional to the speed of rotation of the supply roll, or proportional to the linear speed of the web. In general when the pump is driven at a speed proportional to the speed of the web or strand, the controlling mechanism should operate to maintain a constant driving load on the supply roll or other tension controlling element under the normal operating conditions. When the pump is driven at a speed proportional to the speed of rotation of a supply roll or reel from which the web or strand is drawn, the braking load exerted by the pump should diminish as the roll or reel is unwound and decreases in diameter and my invention comprises provisions for this purpose.

Heretofore various schemes have been proposed and some of them used, for automatically controlling web or strand tension by exerting a braking force on a tension controlling element, but the present invention is distinguished by the comparative

simplicity and low cost of the apparatus required, the ease with which it can be controlled and regulated in normal operation at full web or strand speed, in starting, and in making certain adjustments such as the "inching" adjustments necessary in the operation of printing presses and other apparatus with which the invention may be used.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, and the advantages possessed by it, and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described preferred methods of and apparatus for carrying out my invention.

Of the drawings:

Fig. 1 is an elevation partly in section of apparatus comprising one embodiment of my invention;

Fig. 2 is a sectional elevation on a larger scale than Fig. 1 showing a portion of the apparatus of Fig. 1;

Figs. 3, 4, 5, and 6 are diagrammatic elevations each of which represents a different form of the invention;

Fig. 7 is a sectional elevation of a valve mechanism employed in Fig. 6;

Figs. 8 and 9 are elevations taken at right angles to one another illustrating another modification of the invention;

Fig. 10 is a sectional elevation of a portion of the control valve employed in Figs. 8 and 9;

Fig. 11 is a diagrammatic elevation of a slight modification of the apparatus shown in Figs. 8 and 9; and

Fig. 12 is a diagrammatic representation of still another form of my invention.

In the drawings and referring first to the apparatus shown in Figs. 1 and 2, A represents the framework of a printing press or the like, provided with bearings A' for the spindle B of a supply roll B'. The spindle B carries a spur gear B<sup>2</sup> in mesh with a spur gear C journaled in the framework A at C'. Preferably the parts are so arranged that the roll spindle B may be rolled along the framework guides A<sup>2</sup> into the bearings A', and so that as the spindle seats it-

self, the gear B<sup>2</sup> will come into mesh with the gear C. The gear C forms the driving element of the tension regulating pump which, in the construction shown, is a reciprocating air compressor comprising two cylinders D set at right angles to one another. The stems of the pistons D' working in the cylinders D, are connected to crossheads D<sup>2</sup> working in suitable guideways and connected by rods D<sup>3</sup> to the same crank pin C<sup>2</sup> carried by the gear C'. The cylinders D are each provided at each end with an inlet valve D<sup>4</sup> and an outlet valve D<sup>5</sup>. The outlet valves D<sup>5</sup> all discharge into a piping system E, preferably of small volumetric capacity, which opens to the inlet port F' of the controlling valve F. The latter, as shown, is provided with outlet ports F<sup>2</sup> opening to the atmosphere. The port F' is controlled by a poppet valve member F<sup>3</sup>. The stem of the valve member F<sup>3</sup> comprises a cylindrical portion F<sup>4</sup> which works in a guideway or opening formed in the top of the valve casing. The upper end of the valve stem is threaded into one end of a turn-buckle adjusting device F<sup>6</sup>. Into the opposite end of the turn-buckle is screwed a threaded projection F<sup>7</sup> from a spring housing F<sup>8</sup>. Within the spring housing F<sup>8</sup> is a helical spring F<sup>9</sup> acting between the lower end of the spring housing and a piston-like follower F<sup>10</sup> working in the housing F<sup>8</sup> and secured to the lower end of the rod F<sup>11</sup>, which, as shown, is provided at its upper end with an anti-friction roll F<sup>12</sup> engaged by a cam H. The latter is pivoted to the framework of the machine at H' and is provided with an operating arm H<sup>2</sup> carrying at its free end a roll H<sup>3</sup> which bears against the periphery of the supply roll B'. The cam is provided with a second arm H<sup>4</sup> connected by a spring H<sup>5</sup> to the framework so as to lightly hold the roll H<sup>3</sup> at all times in contact with the roll B'.

In the normal contemplated mode of operation of the apparatus shown in Figs. 1 and 2, the web B<sup>3</sup> of the paper or the like is drawn from the supply roll B' at a relatively high and more or less uniform speed by the feeding mechanism, conventionally illustrated as rolls A<sup>10</sup>, of the machine fed from the roll B'. The pull thus exerted on the web B<sup>3</sup> keeps the roll B' in rotation and thereby operates the compressor at a speed proportional to the speed of the rotation of the roll spindle B. The force required to drive the compressor, and the resultant braking or retarding force with which the compressor opposes the rotation of the supply roll, depends primarily upon the differences between the fluid pressures at the inlet and outlet of the compressor, and with the apparatus shown in Figs. 1 and 2 this depends upon the tension of the valve spring F<sup>9</sup>. If the latter is of sufficient length to make its tension substantially independent of the ex-

tent to which the valve member F<sup>3</sup> is open, the outlet pressure will be practically constant at all speeds and will be that sufficient to hold the valve F<sup>3</sup> off its seat. On an increase or decrease in web speed, the valve F<sup>3</sup> opens or closes as required to accommodate the resultant increase or decrease in fluid delivery by the compressor without appreciable change in the compressor delivery pressure or in the web tension. A certain amount of power is required, of course, to overcome the friction losses in the compressor, but this power is comparatively constant and may be relatively small with suitably designed apparatus.

With a given linear speed of the web B<sup>3</sup>, the angular velocity of the roll B' depends upon the amount of paper on the roll B', and increases as the amount of paper decreases. In consequence the pressure against which the compressor discharges should decrease as the roll diameter decreases, if a constant tension is to be maintained. This result is obtained with the apparatus shown in Figs. 1 and 2 by giving a suitable contour to the cam H, so that as the roll decreases in diameter, the spring follower F<sup>10</sup> is permitted to rise and thereby decrease the tension with which the spring F<sup>9</sup> acts on the valve disc F<sup>3</sup>. While in general the tension on the web should remain constant as the roll diminishes in diameter, it is sometimes found desirable to decrease the web tension when the supply roll is nearly all used up because irregularities then developing in the contour of the supply roll tends to make the feed somewhat irregular, and makes a reduced average tension desirable to avoid momentary increases in the web tension sufficient to break the web. This decrease in web tension when the roll becomes very small, can be readily obtained by suitable shaping the cam H.

Among the advantages of regulating the tension by means of a pump as described, is the simplicity and comparatively small cost of the apparatus required, the ease with which this apparatus may be installed in connection with existing as well as new printing presses, paper waxing machines or other machines where a web or strand tension control is desirable; the reliability of operation of the apparatus; and the ease with which it may be adjusted to meet changes in conditions of operation. For example, in handling paper, the tension of the web may advantageously be varied in some cases in response to changes in the humidity of the atmosphere which affects both the flexibility and strength of the paper web. Similarly different kinds of paper stock or variations in the normal web speeds may make changes in web tension desirable. These changes in web tension are readily obtainable with the apparatus shown, while the

apparatus is in operation at full speed, by a simple adjustment of the turn-buckle  $F^6$  to correspondingly increase or decrease the tension of the spring  $F^9$ .

5 An advantageous characteristic of the invention arises from the fact that at the instant of starting the apparatus into operation from a condition of rest, the pump imposes no initial retarding force on the web except that due to friction. When the compressor stops operation, the pressure at the outlet falls almost instantly into an equality with the pressure of the atmosphere as a result of the inevitable leakage in the system. 15 When the compressor is again started into operation there is of course no resistance to its operation due to the excess of pressure at its outlet over that at its inlet. The fact that the compressor thus exerts no resistance, aside from that due to frictional resistance, to the initial movement of the apparatus in starting is advantageous because the inertia of the supply roll and the frictional resistance of the apparatus puts ample tension on the web in starting. It will be understood, of course, that the frictional resistance to the rotation of the supply roll  $B'$  and to the operation of the compressor is greater in starting from rest than in running. 30

If the capacity of the piping  $E$  is small, as should ordinarily be the case, only a small fraction of a turn of the roll  $B'$  is required, however, to develop a pressure in the piping  $E$  which will put a substantial tension on the web. This is largely desirable to avoid over travel of the roll and consequent festooning of the web in the so called "inching" operation, which, in the case of a printing press, for example, requires the web to be advanced a few inches at intervals in certain adjustments of the press. 40

With my improved tension regulating means, the tension maintained is a definite function of the outlet pressure, and may be measured by means of the pressure gauge  $S$  shown in Fig. 1 since my improved tension regulator does not subject the web to undue tension in starting from a condition at rest and once started maintains practically constant tension at all speeds. The tension regulating means ordinarily does not require any adjustment in starting, running up to and at full speed and in slowing down and stopping. This fact, coupled with the fact that the tension maintained is a definite and easily determined thing makes it readily possible to run the web with less tension than is ordinarily employed with heretofore used tension devices with which the actual tension maintained is not readily known and which require adjustment in starting up or slowing down. With such tension devices the tension actually employed is usually 65 more than in really necessary to insure suffi-

cient tension. Excess tension is objectionable because it involves extra driving power unnecessarily large wear due to friction, as well as increased frequency of web rupture.

In the modification illustrated in Fig. 3, 70 the reduction in the compressor outlet pressure to compensate for the decrease in diameter of the roll  $B'$  as the latter is unwound, is made directly dependent on the weight of the roll  $B'$ . For this purpose the roll  $B'$  is mounted in arms  $AA$  pivoted to turn about an axis coaxial with the shaft  $C'$  of the compressor driving gear  $C$ , and the weight of the roll  $B'$  and of the arms  $AA$  is carried by helical springs  $A^{15}$  so that the roll spindle  $B$  rises and falls with the changes of weight of the web material wound about it. As shown one of the arms  $AA$  directly engages the anti-friction roller  $F^{12}$  of a control valve  $F$ , which may be identical with that shown in Figs. 1 and 2. The valve  $F$  thus tends to decrease the compressor outlet pressure as the weight of the roll  $B'$  diminishes. The same variation in throttling effect may be obtained by differences in shape and disposition of the portion of the arm  $AA$  engaging the roll  $F^{12}$  as is obtainable in the construction shown in Figs. 1 and 2 by varying the contour of the cam  $H$ . 80 85 90

In Fig. 4 I have illustrated a modification 95 of the invention which differs from that shown in Figs. 1 and 2 only in that the throttling valve  $F$  is adjusted in direct response to the tension on the web  $B^3$ . For this purpose I replace the cam  $H$  of Figs. 1 and 2 by a cam  $I$  journaled at  $I'$ , and connected to an arm  $I^2$  carrying an idler roll  $I^3$  which rests on the portion of the web  $B^3$  running from the roll  $B'$  to an adjacent guide or feed roll  $A^{10}$ . With this arrangement the tension on the portion of the web engaged by the roll  $I^3$  will be a function of, and will be measured by the elevation at which the roll  $I^3$  is held. On a decrease or increase in the tension of the portion of the web engaged by the roll  $I^3$ , the latter will fall or raise and thus increase or decrease the tension of the spring  $F^9$  of the regulating valve  $F$ . 100 105 110

In Fig. 5 I have illustrated a modification 115 of the apparatus shown in Fig. 1 in which the compressor outlet pressure is automatically regulated in direct response to the speed of operation of the apparatus. As shown in Fig. 5 the throttling effect on the compressor outlet is varied in response to changes in the speed of rotation of the roll spindle  $B$  by means of a valve  $FA$  controlling the discharge into the atmosphere from the piping  $E$  through a branch discharge pipe  $E'$ . The movable valve member  $F^{15}$  of the valve  $FA$  has its stem  $F^{17}$  connected to the axially movable element of a ball governor  $KA$  which is driven from the roll spindle  $B$  and carried by the spindle  $B$  by means of a 120 125 130

shaft K', a bevel gear B<sup>4</sup>, and a meshing bevel gear K<sup>2</sup> carried by the shaft K'. As shown the valve member F<sup>15</sup> is provided with a cylindrical skirt having notches F<sup>16</sup> the shape of which determines the effective free port area in different positions of the valve members. By suitably shaping the notches F<sup>16</sup> the braking effect of the compressor can be varied to compensate for changes in the diameter of the roll B' as is done with the apparatus of Figs. 1 and 2 by varying the contour of the cam H. To provide for a further adjustment of the braking effect of the compressor in direct response to the speed of the web B<sup>3</sup>, I employ in Fig. 5 a supplemental regulating valve FB which may be generally similar to the valve FA, which may well be rectangular in the valve FB and V-shaped in the valve FA. The stem F<sup>17</sup> of the valve FB is connected to the axially movable member of a ball governor KB which is driven at a speed proportional to the speed of the web, this result being obtained in the arrangement shown in Fig. 5 by gearing the governor KB to one of the feed rolls A<sup>10</sup>. The valve FB discharges air into the atmosphere from the piping E through the branch outlet pipe E<sup>2</sup>.

While in the forms of my invention heretofore described I have employed a braking compressor of the reciprocating type, it will be understood, of course, that other types of compressors may be employed, and indeed I prefer ordinarily to employ a rotary compressor of the well known positive displacement type such as the well known compressor illustrated in Fig. 6 in which the compressor driving gear C is mounted on the shaft of the rotary compressor DA. The control valve mechanism employed with the apparatus shown in Fig. 6 may be identical with that shown in Fig. 2 but the valve mechanism FC shown in Fig. 6 and in Fig. 7 is of a modified form.

The valve FC comprises an inlet chamber F<sup>20</sup> and an outlet chamber F<sup>21</sup>. The inlet chamber F<sup>20</sup> is connected to the outlet port of the compressor by piping E<sup>5</sup>, which is preferably short and of small volumetric capacity. The chambers F<sup>20</sup> and F<sup>21</sup> are connected by a port F<sup>22</sup> directly controlled by a movable valve member F<sup>30</sup>. The outlet chamber F<sup>21</sup> is connected to a small pressure equalizing reservoir G and opens to the atmosphere in operation, through ports F<sup>23</sup> controlled by a cylindrical valve member F<sup>31</sup> secured to the valve member F<sup>30</sup> and preferably of larger diameter than the latter. The valve members F<sup>30</sup> and F<sup>41</sup> are rigidly connected to a guide member F<sup>4</sup> and are urged toward their closed positions by a spring F<sup>9</sup> working in a housing F<sup>80</sup> and interposed between the guide F<sup>4</sup> and a follower F<sup>10</sup> connected by the turn-buckle F<sup>6</sup>, and adjustable extension F<sup>11</sup> carrying an anti-friction roll

F<sup>12</sup> engaged by a cam H as in Fig. 1. The valve members F<sup>30</sup> and F<sup>31</sup> are so shaped that the ports F<sup>23</sup> are fully covered until after the initial upward movement of the valve members. The small volumetric capacity preferably provided between the compressor outlet proper and the port F<sup>22</sup> facilitates a quick building up of the tension creating drag of the compressor as the latter starts into operation. This quick building up of a substantial tension in starting may be augmented, as shown, by making the portion of the valve member F<sup>30</sup> exposed to the pressure in the compressor outlet before the valve member moves to open port F<sup>22</sup> smaller than the portion exposed after the port F<sup>22</sup> is opened.

The reservoir G serves to equalize the compressor discharge pressure, and substantially eliminate all tendency of the valve to chatter. At the same time its location prevents it from retarding the rate at which the compressor outlet pressure builds up in starting.

Instead of driving the braking compressor by positive gearing between the supply roll spindle and the compressor as shown in the forms in Figs. 1, 3, 4, 5 and 6, I may, advantageously, in some cases, drive the compressor through a belt or pulley bearing against the periphery of the paper roll. Thus in the arrangement shown in Figs. 8 and 9, the rotary compressor DA has driving pulleys D<sup>10</sup> secured to the ends of the compressor shaft. Each of the pulleys D<sup>10</sup> is connected by a belt D<sup>11</sup> to an idler pulley D<sup>12</sup> journalled at the end of a corresponding arm D<sup>13</sup>, shown as pivotally connected to the housing of the compressor DA, and normally urged by its own weight and by an adjustable loading weight D<sup>15</sup> against the periphery of the roll B'. As shown each weight D<sup>15</sup> is carried by a projection D<sup>14</sup> from the corresponding arm D<sup>13</sup> and the parts are so shaped and disposed that as the arm D<sup>13</sup> turns about its pivotal support to maintain the belt D<sup>11</sup> in contact with the roll B' as the latter is unwound and decreases in diameter the contact pressure between the belt D<sup>11</sup> and the roll B' will remain approximately constant and prevent slippage as the roll B' decreases in diameter and the arm A<sup>13</sup> swings downward from its initial position. Since with the type of apparatus shown in Figs. 8 and 9 the speed of the compressor is proportional to the speed of the web regardless of the diameter of the roll B', the controlling valve mechanism FD need not include provisions for automatic adjustment in response to the change in the ratio between the web speed and the angular velocity of the roll. The valve FD may be and is shown as being similar to the valve FC except that the follower F<sup>10</sup> (see Fig. 10) is carried by a screw spindle which is threaded through the end of the spring

housing  $F^{80}$  and provided at its outer end with a hand wheel  $F^{60}$ . By rotating the hand wheel  $F^{60}$  adjustments of the tension of the spring  $F^0$  may be obtained analogous to those obtained with the valves  $F$  and  $FC$  by adjustments of the turn-buckles  $F^0$ . The purpose of providing two driving belts  $D^{11}$  with the compressor  $DA$  shown in Figs. 8 and 9 is to obtain the necessary amount of driving effort in handling webs of full width, without requiring unnecessary friction when a half length roll is used as is sometimes the case in printing presses. In such case one of the belts  $D^{11}$  may be removed or permitted to run idle.

In Fig. 11 I have illustrated a modification of the apparatus shown in Figs. 8 and 9 in which the arms  $D^{13}$  each has journaled at its free end a friction roll  $D^{18}$  which bears against the periphery of the supply roll and is connected by a driving chain or belt  $D^{19}$  to a pulley  $D^{20}$  replacing the corresponding pulley  $D^{10}$  of the apparatus shown in Figs. 8 and 9.

While I prefer that the fluid pumped by my tension regulating pump should be an elastic fluid such as air, this fluid may be a liquid such as water or oil in which case the pump should be connected to a circulating system into which the pump discharges and from which the controlling liquid is returned to the pump inlet. In Fig. 12 I have diagrammatically illustrated a system of this sort in which  $DB$  represents the regulating pump which may be either a reciprocating pump or a rotating pump and if the latter as is shown in Fig. 12, the pump is preferably of the positive displacement type, though a centrifugal pump may be employed. In the particular arrangement shown in Fig. 12, the pump  $DB$  is driven from the roll  $B'$  by power transmitting means similar to those shown in Figs. 8 and 9, and the pressure at the pump outlet regulated by a valve  $FD$  which may be like the valve  $FD$  employed in Figs. 8 and 9 except that the connection to the pressure equalizing chamber  $G$  of the valve mechanism shown in Figs. 8 and 9 is omitted. As shown an air containing pressure equalizing chamber  $GA$  is connected to outlet pipe between the pump outlet  $F^{26}$  and the valve  $FD$ . The liquid discharged from the pump outlet  $F^{26}$  passes into a tank or reservoir  $R$  from which liquid passes by gravity to the pump inlet  $D^{25}$ .

Special features of construction and arrangement differentiating the forms of my invention illustrated in Figs. 8, 9, 11 and 12 from other forms of my invention herein illustrated are claimed in my co-pending application, Serial No. 508548, Pat. No. 1,538,887, filed of even date herewith.

While in accordance with the provisions of the statutes I have illustrated and de-

scribed the best forms of my invention now known to me, it will be understood that changes in the form of the apparatus and methods of operation specifically disclosed herein may be made without departing from the spirit of my invention as set forth in the appended claims, and that some of the features of my invention may sometimes be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of subjecting web or strand-like material to tension while said material is travelling at varying speeds which consists in operating a pump by a driving force transmitted to the pump through the material and variably throttling the pump outlet as required to maintain an approximately constant tension with varying pump speeds by opposing the outflow through said outlet with a resilient force of regulable intensity.

2. The method of regulating the tension on a web being unwound from a supply roll which consists in gearing the supply roll spindle to a pump and varying the pressure differential between the pump inlet and the pump outlet in automatic response to the amount of material on the supply roll to compensate for the reduction in diameter of the roll as the latter is unwound by opposing the outflow through said outlet with a resilient force, the intensity of which is automatically diminished as the diameter of the roll increases.

3. The combination with means for advancing web or strand-like material, of means for regulating the tension to which the material is subjected comprising a pump and means for driving the pump by force transmitted through the material from the means for advancing the material and means for maintaining an approximately constant pump delivery pressure notwithstanding variations in the pump speed comprising a valve member subjected to the opposing action of the outlet pressure and of a regulable tension controlling force.

4. The combination with means for advancing web or strand-like material, of a pump driven by the web at a speed which is a function of the speed at which the web is advanced, and a valve regulating the pressure at the outlet of the pump comprising a valve member subjected to the opposing action of the outlet pressure and of a regulable tension controlling force.

5. The combination with a supply roll comprising a spindle about which material is wound, of means for drawing the material from the supply roll and means for regulating the tension of the material comprising a pump connected to and driven by said

spindle, a valve regulating the pump discharge and subjected to the opposing action of the pump delivery pressure tending to open the valve and a regulable tension controlling force tending to close the valve and means for diminishing said force as the roll decreases in diameter.

6. The combination with a supply roll comprising a spindle about which material is wound of means for drawing the material from the supply roll and a pump connected to and driven by said spindle, a valve regulating the pump delivery pressure compris-

ing a valve member acted on by the pump delivery pressure in a direction tending to open the valve and thereby decrease the pump delivery pressure and subjected to the action of a tension spring tending to close the valve and means for adjusting the tension of said spring in automatic response to changes in the diameter of the supply roll.

Signed at New York, in the county of New York and State of New York, this 17th day of October, A. D. 1921.

CHARLES E. CARPENTER.