

Nov. 19, 1940.

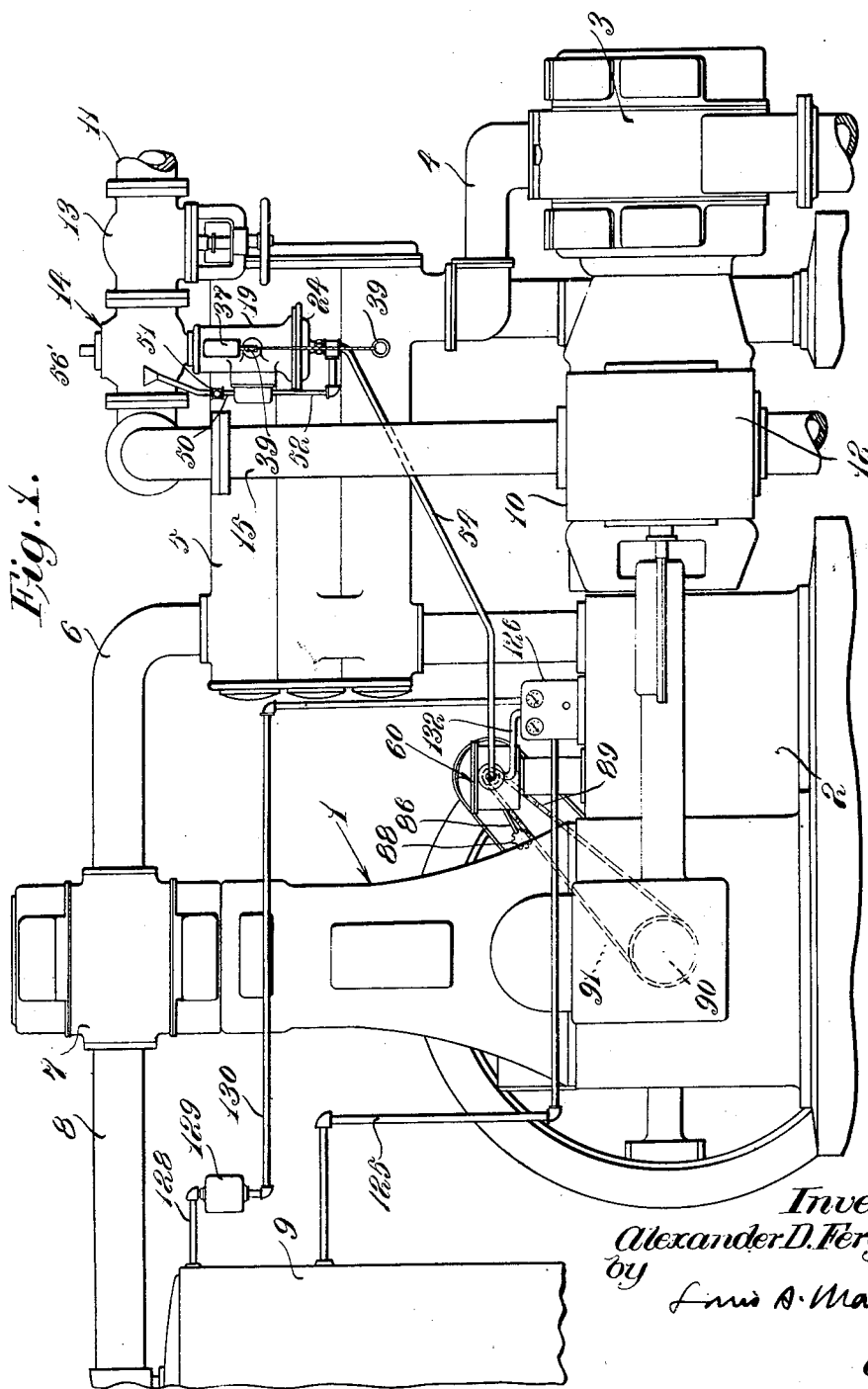
A. D. FERGUSON

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Filed April 18, 1938

5 Sheets-Sheet 1



Nov. 19, 1940.

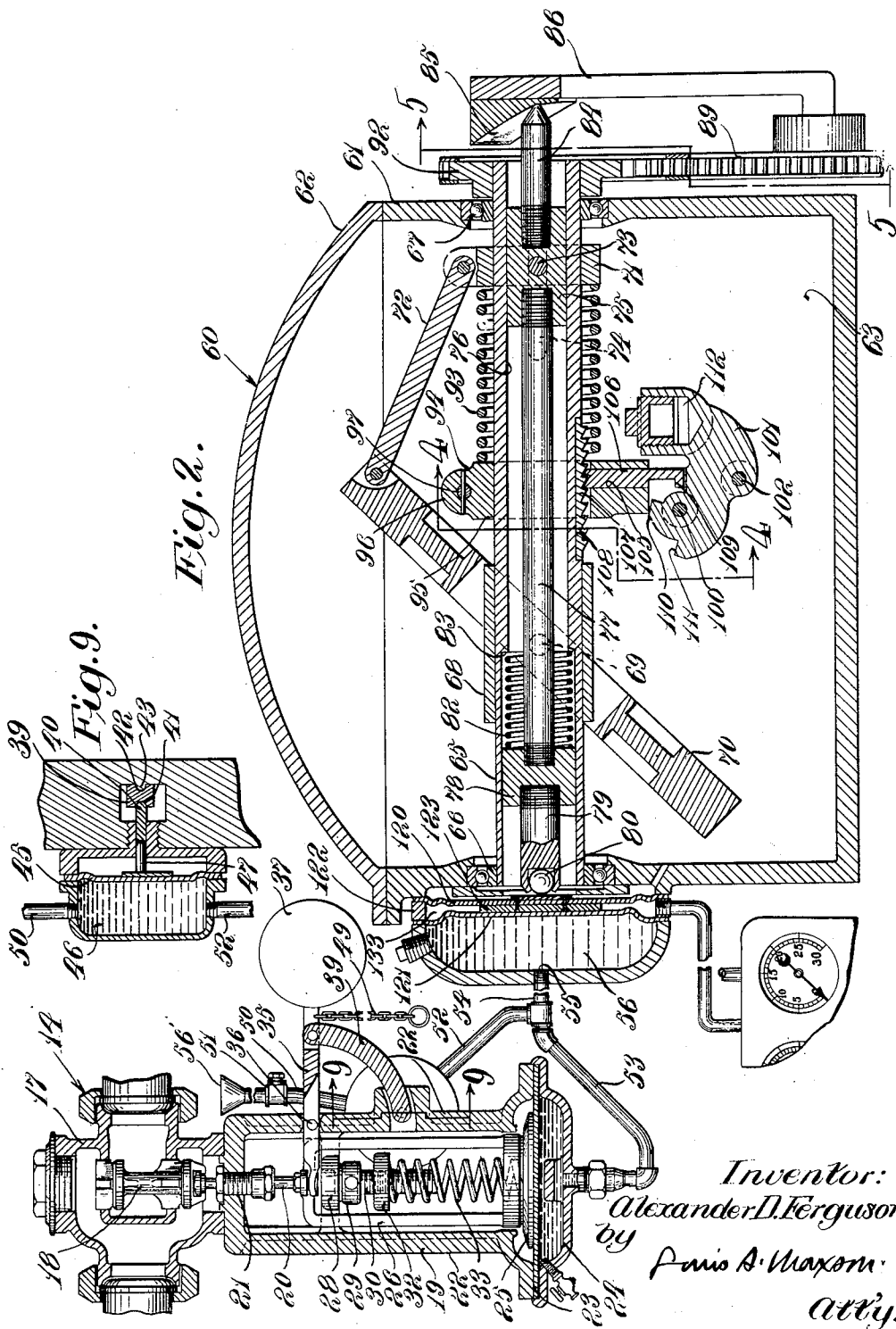
A. D. FERGUSON

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Filed April 18, 1938

5 Sheets-Sheet 2



Inventor:
Alexander D. Ferguson
by
Paris A. Maxon
Atty.

Nov. 19, 1940.

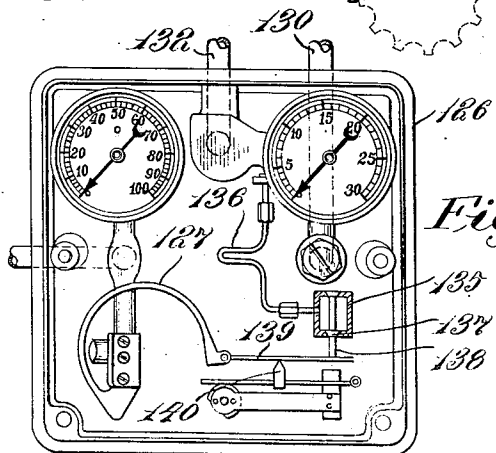
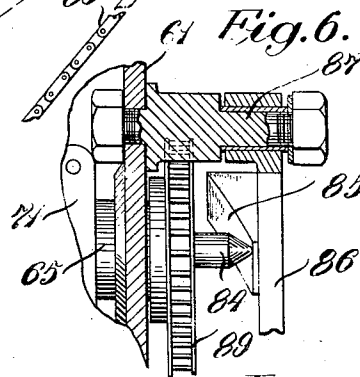
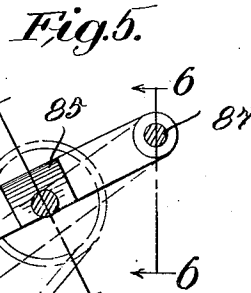
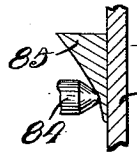
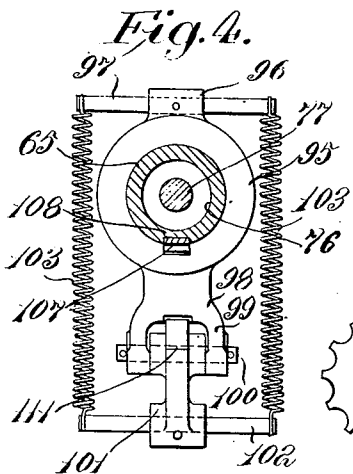
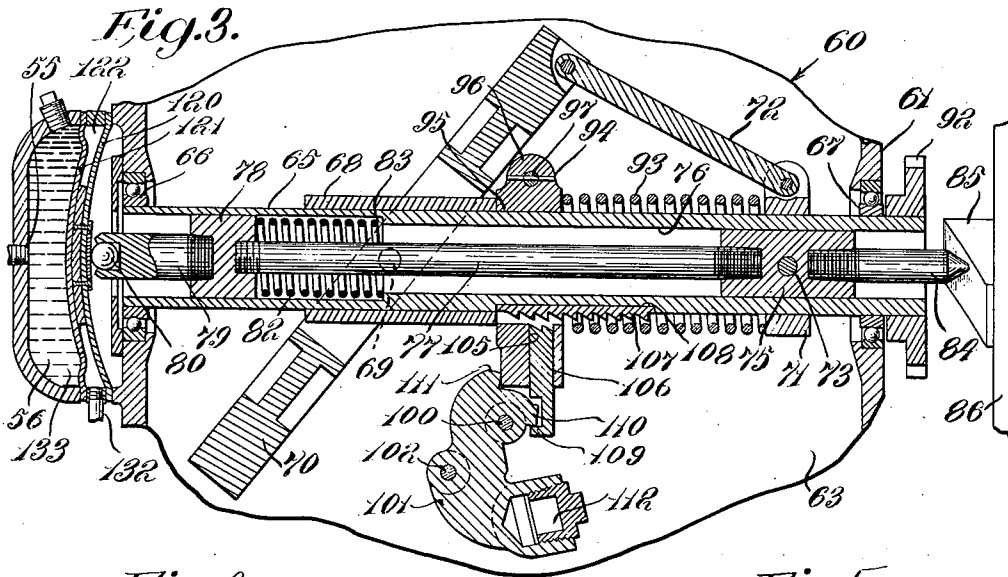
A. D. FERGUSON

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Filed April 18, 1938

5 Sheets-Sheet 3



Inventor:
Alexander D. Ferguson.
by
J. A. Maxson.
Atty.

Nov. 19, 1940.

A. D. FERGUSON

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Filed April 18, 1938

5 Sheets-Sheet 4

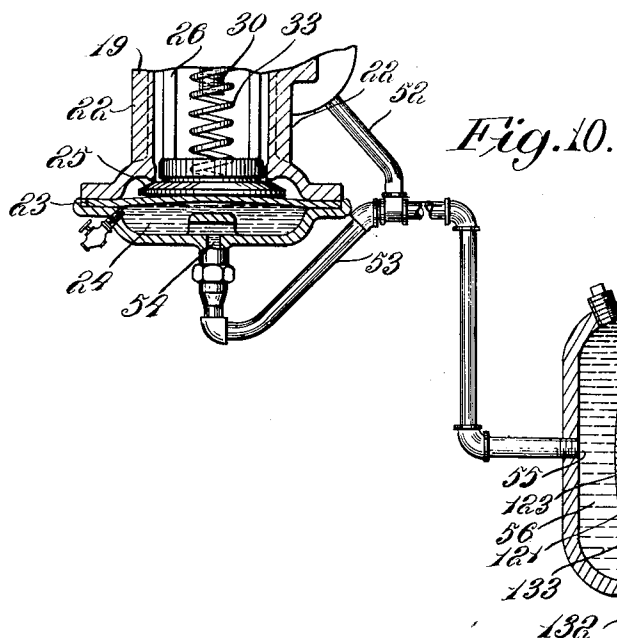


Fig. 10.

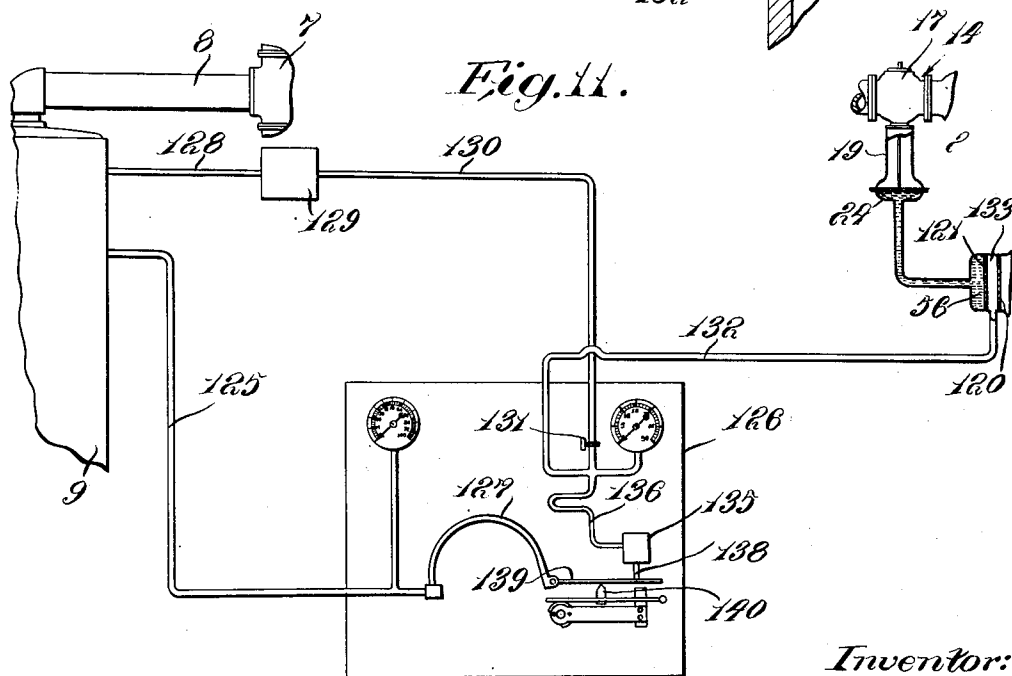


Fig. 11.

Inventor:
Alexander D. Ferguson.
by Annis A. Maxson.
Atty.

Nov. 19, 1940.

A. D. FERGUSON

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Filed April 18, 1938

5 Sheets-Sheet 5

Fig. 16.

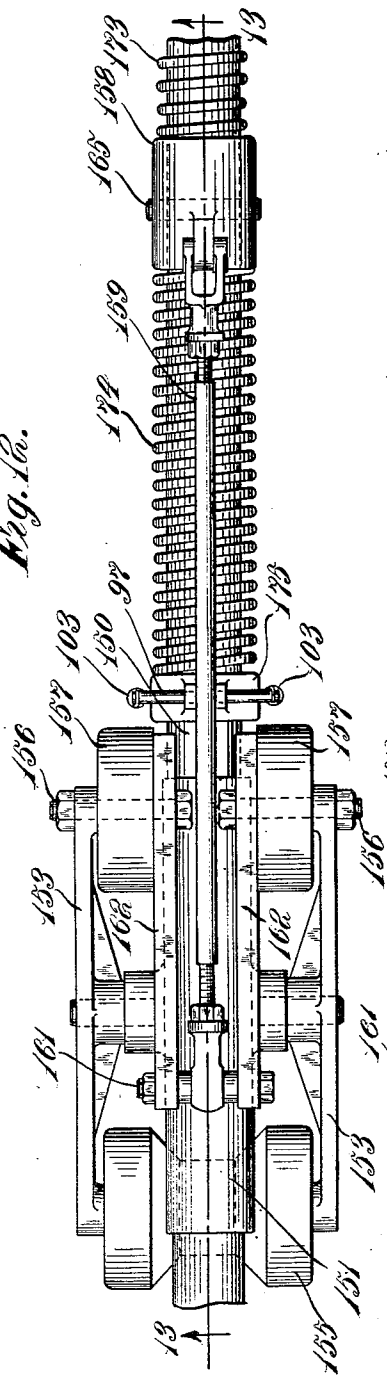
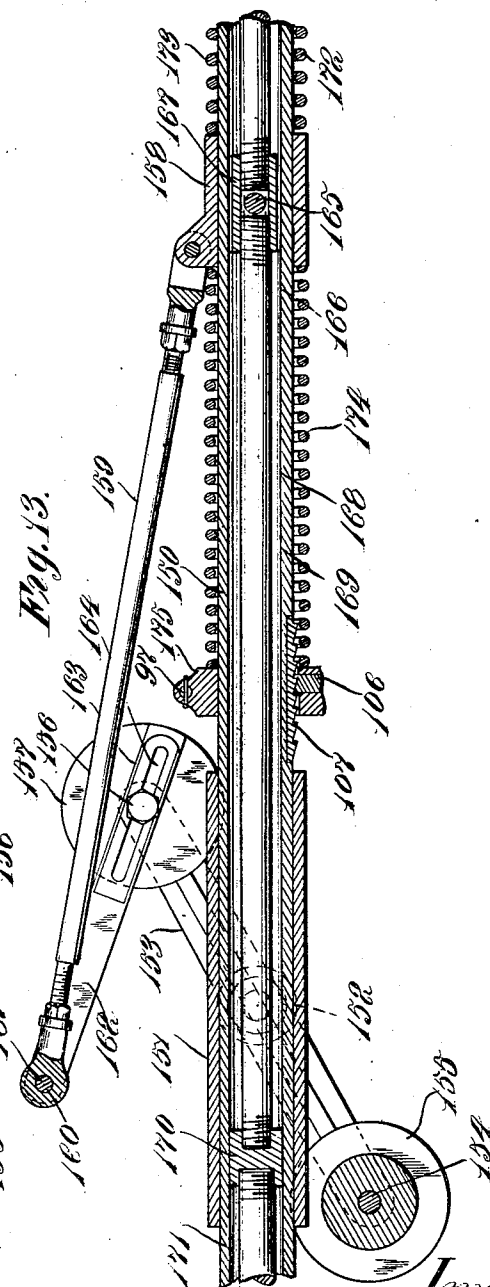


Fig. 13.



Inventor:
Alexander D. Ferguson.

By
Finn A. Maxam.

Att'y.

UNITED STATES PATENT OFFICE

2,221,791

CONTROLLING MEANS FOR PRIME MOVERS

Alexander D. Ferguson, Michigan City, Ind., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application April 18, 1938, Serial No. 202,680

27 Claims. (Cl. 230—4)

My invention relates to controlling means for prime movers, and more particularly to controlling means for the steam engines. It has other aspects which will appear in the course of the following specification and the appended claims, including the one of steam-driven compressors.

It is desirable, in connection with pressure fluid driven engines, to effect the regulation thereof in accordance with the load, to provide for a less-throttled supply of operating fluid when the load increases and vice versa, to provide for automatic regulation of operating fluid supply by speed-responsive means, also, to insure against the engine's running away in the event of the derangement of any of its control devices, and to permit immediate stopping thereof when the engineer considers this imperative. It is an object of my invention, in one of its more specific aspects, to provide an improved control system for an engine which shall by improved means accomplish these several desirable ends. It is, more generally, an object of my invention to provide an improved control apparatus for a prime mover. It is a further object of my invention to provide, for a compressor driving engine, an improved control governed by compressor discharge pressure. It is another object of the invention to provide an improved speed-responsive governor having improved means for slowing down or stopping the engine if the speed becomes too high. It is yet another object to provide an improved safety stop for an engine associated with the speed-responsive governor thereof for stopping the engine if the drive for said speed-responsive governor is broken. It is still a further object of the invention to provide an improved control mechanism embodying a combination of speed and load control of novel form. It is a still further object of the invention to provide for hydraulic governing of a throttle valve controlling a compressor-driving engine under speed and compressor discharge pressure control, and again, to provide an improved means whereby separate or cumulative control is possible. Yet another object of the invention is to provide an improved steam-driven compressor. Other objects and advantages will hereinafter more fully appear.

In the accompanying drawings, in which, for purposes of illustration, an illustrative embodiment of the invention is disclosed—

Fig. 1 is a side elevation of a steam-driven compressor embodying an illustrative form of the invention.

Fig. 2 is a view mainly in section, with parts shown on different scales, and more or less in the nature of a diagrammatic view, showing major elements of the control system.

Fig. 3 is a view of a portion of the mechanism of Fig. 2, showing parts in a different relative position.

Fig. 4 is a detail sectional view on the planes of the section line 4—4 of Fig. 2.

Fig. 5 is a fragmentary view showing a governor drive.

Fig. 6 is a section on the plane of the line 6—6 of Fig. 5, showing details of construction.

Fig. 7 is a detail section on the line 7—7 of Fig. 5, showing a control cam.

Fig. 8 is an elevational view of an automatic pressure responsive device which may be used in my improved control system.

Fig. 9 is another detail sectional view, this one on the plane of the line 9—9 of Fig. 2.

Fig. 10 is a fragmentary sectional view showing a portion of the mechanism of Fig. 2 with parts in different relative positions.

Fig. 11 is a diagrammatic view showing portions of the system, particularly the pressure-responsive portions thereof.

Figs. 12 and 13 are, respectively, an elevation and a section on the plane of the line 13—13 of Fig. 12, disclosing a modified form of speed-responsive governor providing for a wider range of speed control.

Referring to the drawings, it will be observed that my invention in its illustrative embodiment is incorporated in a steam-driven compressor system which includes a multi-stage steam-driven compressor generally designated 1 and comprising a base frame 2 on which there is mounted a low pressure cylinder 3 discharging through a low pressure discharge line 4 to an intercooler 5, and from the latter an intake line 6 of a high pressure cylinder 7, also mounted on the base frame, receives air, while a discharge line 8 conducts the compressed air from the high pressure cylinder 7 herein to a receiver 9. The compressor is provided with a steam engine 10 of any suitable construction, and this supplies the power for the compression of air in the low and high pressure cylinders. A main steam line 11 supplies steam to the usual valve chest of a steam cylinder 12 of the engine and a manually operable throttle 13 may be closed to stop the steam engine 10. An automatic governor mechanism, including an automatic controlling device generally designated 14, is arranged between the manual throttle 13 and a steam delivery line 15.

As shown most clearly in Fig. 2, the automatic controlling device 14 includes a casing 17 in which a balanced steam-flow-regulating valve 18 is reciprocable. The casing 17 is supported upon a frame 19, and the regulating valve 18 has a stem 20 which extends through a suitable gland 21 into the space between legs 22, 22 of the frame 19. A suitable fluid actuated diaphragm 23 is mounted between the bottom of the frame 19 and an element forming a diaphragm chamber 24. A circular plate 25 rests upon the diaphragm and is connected by a suitable yoke 26 to the lower end

of the valve stem 20. The frame 19 provides an abutment 28 against which the head 29 of an adjusting screw 30 rests. This adjusting screw may be moved to alter the position of an abutment 32 for a spring 33 which presses upon the upper surface of the circular plate 25 and normally tends to depress the latter against the pressure exerted upon the diaphragm 23 and to effect an increased opening of the steam-flow-regulating valve 18.

In addition to the diaphragm 23, means for controlling the position of the steam-flow-regulating valve 18 is provided, including means for effecting closure of the regulating valve in the event of loss of the operating fluid from beneath the diaphragm 23 and means for permitting quick stopping of the steam engine 10, if desired, manually. For these purposes there is pivotally supported a lever 35 at 36 upon the frame 19. This lever carries a substantial weight 37 at its outer end, a weight sufficient, when permitted to fall, to shove the steam-flow-regulating valve 18 into closed position. A curved link 39 is provided with a releasable latch 40 (see Fig. 9) extending into a suitably-formed notch 41 in the lower end of the link 39, the other side of the link 39 also having a notch 42 which cooperates with a stationary projection 43 to hold the link in the position of Fig. 2 of the drawings. A diaphragm 45 bounding a liquid-receiving or diaphragm chamber 46 in communication with the system, of which the space beneath the diaphragm 23 forms a part normally presses a pin 47 carrying the latch 40 into the recess 41 and holds the link 39 in the position relative to the stop 43 such that the weight 37 is prevented from dropping. A chain 49 led to any convenient place where it may be quickly seized and pulled, is arranged to enable the holding effect of the latch mechanism just described to be overcome and to permit substantial instantaneous manual closing of the steam-flow-regulating valve 18, if desired.

It will be noted that a fluid conduit 50 having a suitable stop valve 51 therein leads to the chamber 46, and a conduit 52 leads downwardly to communicate with a conduit 53, one of whose ends opens at 54 through the member forming the diaphragm chamber 24 and whose other end opens at 55 into a diaphragm chamber 56 shortly to be described in more detail. The diaphragm chambers and the conduits contain a liquid such as glycerine, and the liquid system may be replenished with liquid, when the valve 51 is open, through a filler cup 56' located at a high point in the system, as shown in Fig. 2. Filling, of course, takes place when the compressor and steam engine are shut down. It will be noted that the structure so far described contemplates the automatic regulation of the amount of steam supplied to the valve chest of the steam cylinder 12, the position of the steam-flow-regulating valve 18 to be controlled automatically by the position of a diaphragm 23, and the position of that diaphragm to be controlled by liquid pressure in the conduit 52.

For the purpose of controlling automatically the position of the steam-flow-regulating valve 18 and for protecting the steam engine 10 against running away in the event of certain possible derangements, I have provided mechanism which is generally indicated by the reference character 60. This includes speed-responsive mechanism governed by the speed of the steam engine and compressor; compressor discharge pressure responsive mechanism; an automatic stop

effective in the event of over-speeding; and a further automatic stop effective in the event of breakage of the drive for the speed-responsive mechanism. A casing 61 having a detachable top 62, provides a lubricant reservoir 63 into which certain rotating portions of the mechanism within the chamber are adapted to dip for the purpose of throwing the oil and effecting a very efficient splash lubrication of such mechanism. It will be noted that a hollow tubular shaft 65 is mounted within the casing in anti-friction bearings 66, 67 supported by the end casing walls. On the outside of this hollow shaft there is mounted a sleeve 68 pivotally supporting at 69 a speed responsive member, herein a wobble plate 70. In the form of mechanism illustrated in Figs. 2 and 3, the hollow shaft supports a sliding collar 71 which is connected by a link 72 with the wobble plate 70 and is connected by a transverse pin 73 extending through longitudinal slots 74 in the shaft 65, to a cylindrical slide member 75 movable within the bore 76 of the hollow shaft. A rod 77 connects the slide member 75 with another cylindrical slide member 78 which has fixed thereto a short projecting mounting element 79 carrying a thrust ball 80 at its outer end. A comparatively light spring 82 extends between a shoulder 83 within and on the tubular shaft 65 and the right-hand end surface of the slide member 78 in Fig. 2, and normally tends to move the slide members 78 and 75 and the collar 71 to the left in Fig. 2, and to cause the wobble plate 70 to move towards perpendicularity to its axis of rotation. The slide member 75 has fixed thereto a projecting spindle-like element 84 which projects beyond the right-hand end of the tubular shaft 65 in Fig. 2 and having a conical or pointed end which is engaged by the cam surface of a cam 85 mounted on an arm 86 (Figs. 2, 3 and 5) which is pivoted at 87 (Fig. 6) on the casing 61 and this arm carries an idler sprocket 88 engaging with a roller drive chain 89 driven from the crank shaft 90 of the compressor by a sprocket 91 fixed to the crank shaft and connected by the chain to a sprocket 92 fixed to the tubular shaft 65. It will be evident that in the event that this drive chain 89 should break the support provided for the idler sprocket 88 would be lost, and accordingly the arm 86 would swing downwardly and the cam 85 would thrust the spindle 84 and collar 71 to the left in Fig. 2 of the drawings. This motion will, as will later appear, operate to slow down, or, if carrier far enough, to stop the steam engine 10. A spring 93, more powerful than the spring 82, engages at its right-hand end in Fig. 2 the collar 71, while its left-hand end is engaged by an adjustable stop member 94, which is mounted on and movable along the tubular shaft 65. This adjustable stop member plays two important functions in the operation of this apparatus. It enables adjustment of the compression of the spring 93 and so a variation in the responsiveness to speed variations of the wobble plate 70. It also provides a very efficient and inexpensive safety stop mechanism. It will be noted that the member 94 is in the form of an annulus 95 surrounding the tubular shaft 65 and having diametrically opposite bosses thereon (see Fig. 4). One of these bosses 96 is comparatively short and provides a mounting for a transverse pin 97. The other of these bosses 98 is longer and provides a fork 99 in which a transverse pin 100 is mounted, this pin pivotally supporting a swingable

speed-responsive member 101. The swingable member 101 likewise carries a transverse pin 102, herein parallel to the pins 97 and 100, and the opposite ends of this pin are connected by side springs 103 with the opposite ends of the transverse pin 97. These transverse pins are so related to each other and to the pivot pin 100 that the springs 103 normally hold the member 100 in the position shown in Fig. 2. A guideway 105 in the member 94 is provided for a toothed latch element 106 which is adapted to engage with a rack 107 carried in a longitudinal slot 108 in the periphery of the tubular shaft 65. The teeth upon the latch 106 and rack 107 are beveled teeth, so that the member 94 may be slid freely to the right in Fig. 2, but not to the left unless the latch 106 is released. The latch is cut away to provide a shoulder 109 adjacent its lower end, and a striking element or hammer portion 110 is formed upon the end of the swingable member 101 at its end nearer the pivot pin 100. A stop shoulder 111 engageable with the side surface of the member 94 is provided to limit the movement of the member 101 about the pivot pin 100. A chamber 112 is provided in the free end of the swingable member 101 to receive mercury, shot or slugs, or other suitable material in the desired quantity to provide for response to the desired maximum speed. This automatic stop mechanism as so far described may have its mode of operation briefly summarized at this point.

It will be appreciated that as the tubular shaft 65 is driven through the chain and sprocket connections 89, 91 and 92 the swingable member 101 which is pivoted on the pin 100 at a point considerably offset from its center of mass, will be subjected to centrifugal force tending to swing the free end of the member 101 outwardly. This tendency will be resisted by the springs 103 until the line of action of these springs, due to the movement of the pin 102 about the axis of the pin 100, falls to the left of the plane including the axes of the pivot pin 100 and the transverse pin 97. Thereafter, the action of the springs 103 will be in the same direction with the action of centrifugal force upon the member 101, and the latter will snap sharply around to the position shown in Fig. 3, will cause the hammer portion 110 to strike against the latch-shoulder 109 sharply to withdraw the teeth of the latch 106 from the teeth of the rack 107, to release the stop member 94 from the tubular shaft 65 and will thus allow the spring 93 to force the stop member 94 over to the left as viewed in Fig. 3, against the adjacent end of the sleeve 68, thereby reducing the force exerted by the spring 93 and allowing the wobble plate 70 to swing outwardly at a much lower speed, thereby slowing down the steam engine 10 through the mechanism which will now be described.

It will be noted that the diaphragm chamber 56 shown in Fig. 2, is bounded at its side next to the casing 61 by a diaphragm 120 and that in back relation with the diaphragm 120 is another diaphragm 121 spaced at its periphery from the diaphragm 120 by a comparatively narrow spacer element 122. The diaphragm 121 carries a central re-inforcement and thrust-transmitting mechanism generally designated 123. The thrust ball 80 contacts one side of this thrust transmitting and re-enforcement mechanism. The other side provides a spacer between the diaphragms 120 and 121 when these are in their most proximate positions. Having in mind the

fact that the fluid system including the chamber 56, the conduits 52, 53, the diaphragm chambers 46 and 24 and the sealed portion of the conduit 50 is full of liquid as explained above, it will be appreciated that any movement toward the left in Fig. 2 by the diaphragm 120 will exercise a closing influence upon the steam-flow regulating valve 18. Movement of the diaphragm 120 to the left may be effected with the construction disclosed either by the exertion of mechanical thrusts thereon through the reinforcement and thrust transmitting mechanism 123 under the action of the thrust ball 80 or by pneumatic means which will also be described. The pneumatic means comprises apparatus for multiplying the effect of compressor discharge pressure variations and transmitting amplified pressure variations to the diaphragm 121. It will be noted that the receiver pressure in the receiver 9 (Figs. 1 and 11) is transmitted through a conduit 125 to a mechanism 126 to act within a pressure-responsive device, herein a Bourdon tube 127. Receiver pressure is also transmitted to this mechanism through a conduit 128, a pressure reducing valve 129 and a further conduit 130, and this low pressure air is delivered past a throttling device 131 and through a conduit 132 to a space 133 between the diaphragms 120 and 121. Means for effecting substantial variations in the pressure within the space 133 in response to comparatively small variations of the pressure within the receiver includes a vent valve mechanism 135 (see Fig. 8) which is connected through a conduit 136 to the conduit 130 so that the pressure at the discharge side of the throttling device 131 may be bled down rapidly when the vent device 135 is opened. The vent device includes herein a double-beat vent valve apparatus 137 having a stem 138 which rests upon a pivoted lever 139. The fulcrum 140 of this lever is adjustable both longitudinally of the lever and up and down by well-known means, and this structure is not per se my invention, but a well-known device of commerce. It will be understood by reference to Figs. 8 and 11 that when the pressure within the receiver 9 rises, the Bourdon tube 127 will tend to straighten out and to raise the left-hand end of the lever 139. This will allow seating of the double-beat valve mechanism 137, and since the pressure will not be permitted to escape from the space 133, it will rise to that value which is permitted by the pressure reducing valve 129. Accordingly, the diaphragm 121 will be forced to the left and will displace liquid beneath the diaphragm 23 and move the steam-flow-regulating valve 18 in a closing direction. This will cause the steam engine 10 to slow down, and accordingly, the rate of air discharged by the compressor will be reduced, and if the air consumption rate is not also reduced the pressure in the receiver 9 will gradually be lowered until such time as the reduction in pressure within the Bourdon tube 127 will cause the latter to move from a position permitting the valve 137 to be closed to a position opening that valve. Then, since the bleeding capacity of the double-beat valve device 137 exceeds the air supply rate past the throttling device 131, the pressure in the space 133 will be rapidly reduced, and the spring 33 will be enabled then to force the steam-flow-regulating valve 18 in an opening direction.

It may now be noted that if the compressor runs at too high a speed, this increased speed will be effective through action of pressure applied through the thrust ball 80 upon the diaphragm 120 and the pressure transmitted by the

diaphragm 120 against the diaphragm 121 also to effect a raising of the diaphragm 23 in a controlling valve closing direction. It will still further be noted that if the compressor should overspeed for any reason, the automatic safety stop 5 through releasing the compression of the spring 93 would allow the speed-responsive wobble plate 70 to move in such a manner as will cause the thrust ball 80 to exert the necessary pressure on the diaphragm 120 to effect stopping of the steam engine 10. If the drive for the governor breaks, the cam 85 will also act to reduce or interrupt the supply of fluid past the steam-flow regulating valve 18. Thus it may be noted that the compressor driving engine has its speed automatically controlled by pressures transmitted through a single diaphragm both in response to compressor discharge pressure variations and to variations in engine speed, these latter variations being transmitted to the first diaphragm through a second one. It will further be noted that the engine is under substantial instantaneous manual control; is guarded against overspeed; is guarded against breakage in the governor drive, and is guarded 25 against the springing of a leak in the hydraulic control system for the diaphragm 23.

In Figs. 12 and 13 there is disclosed a modified form of speed-responsive means whereby different settings of the speed-responsive, weighted control means may be obtained to meet varying operating conditions. In this construction, which is similar to that shown in Figs. 2 and 3, the tubular shaft, driven through the chain and sprocket connections 89, 91 and 92 from the compressor crank shaft 90, is designated by the reference character 150, and the sleeve corresponding to the sleeve 68 is designated 151. Both the shaft and sleeve are of substantially greater length than those described above in regard to the other form of the invention. The tubular shaft 150 is journaled in bearings supported within the casing of the mechanism, as in the form of the invention above described. The sleeve 151 has pivotally mounted thereon at 152 at opposit sides thereof, a pair of arms 153 connected at one end by a bolt 154 carrying a weight 155. The other ends of the arms 153 have mounted thereon by bolts 156, weights 157, 157 respectively. The tubular shaft 150 supports a sliding collar 158 which is pivotally 50 connected to one end of a link 159. The opposite end of the link 159 is pivotally connected at 160, as by a bolt 161, to a pair of arms 162, 162. These arms are slidably guided in guideways 163 formed on the inner adjacent sides of the weights 157 and are slotted at 164 to permit adjustment thereof in the weight guideways. The bolts 156 also serve as securing means for holding the arms 162 in their adjusted position in the weight guideways. The sliding collar 158 is connected by a transverse pin 165 extending through longitudinal slots 166 in the tubular shaft 150, to a cylindric slide member 167 movable within the bore 168 of the shaft. A rod 169 connects the slide member 167 with another slide member 170 also movable 65 within the shaft bore and which has fixed thereto a projecting rod element 171 for actuating, through the thrust ball 80, the diaphragms 120, 121 of the liquid control system, in the manner described above. The slide member 167 has fixed thereto a projecting spindle-like element 172 corresponding to the element 84 and similarly engaging the cam surface of the cam 85 on the arm 86 which carries the drive-chain-engaging idler sprocket 88. A spring 173 acting on the sliding collar 158 urges the latter toward the left in Fig.

13. A spring 174, more powerful than the spring 173, engages at its right-hand end in Fig. 13 the collar 158, while its left-hand end is engaged by an adjustable stop member 175 corresponding to the stop member 94 in the form of the invention above described. The member 175 has associated therewith the elements 97, 100, 101, 102 and 103 and is provided with the same form of latch means 106, 107, as in the other form of the invention. When the tubular shaft is driven through the chain and sprocket connections 89, 91 and 92, the weighted arms 153 provide a speed-responsive means for controlling the position of the projecting element 171, thereby to control, through the liquid control system, the position of the steam-flow-regulating-valve 118. When the speed for any reason becomes excessive, the latch means 106, 107 is operated to release the stop member 175 from the shaft 150, permitting this stop member to move toward the left in Fig. 13, thereby to reduce the pressure exerted by the spring 174; and as a result, the spring 173 effects movement of the sliding collar 158 relative to the shaft, thereby to actuate the projecting element 171 into a position to effect, through the liquid-control system, closure of the steam-flow-regulating-valve 118. By the provision of the adjustable arms 162, the setting of the angle of the weighted arms 153 of the control means may be varied so that the range of control of the speed-responsive means may be correspondingly varied, thereby to meet different operating conditions, in an obvious manner. Otherwise, this form of the invention is the same as that above described.

While there are in this application specifically described one form and a modification which the invention may assume in practice, it will be understood that this form and modification of the same are shown for purposes of illustration and that the invention may be further modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a controlling mechanism, in combination, a prime mover, means for supplying motive medium thereto, a fluid control system including means responsive to the pressure of the fluid in said system for controlling said supply means, and means responsive to the speed of said prime mover for automatically regulating the pressure in said fluid control system.

2. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive medium to said prime mover, a fluid control system including means responsive to the pressure of the fluid in said system for controlling said supply means, means responsive to the speed of said prime mover for automatically regulating the pressure in said fluid control system, and means automatically responsive to the pressure of the pump discharge for regulating the pressure in said fluid control system.

3. In a controlling mechanism, in combination, a prime mover, means for supplying motive medium thereto, a pump driven by said prime mover, a fluid control system including means responsive to the pressure of the fluid in said system for controlling said supply means, and means responsive to the pump discharge pressure for automatically regulating the pressure in said fluid control system.

4. In a controlling mechanism, in combination,

a prime mover, a pump driven thereby, means for supplying motive medium to said prime mover, means responsive to the speed of said prime mover for automatically controlling said supply means, and associated means automatically operative in the event of failure of a part of the mechanism for automatically controlling said supply means.

5. In a controlling mechanism, in combination, a prime mover, means for supplying a motive medium thereto, means responsive to the speed of said prime mover for automatically controlling said supply means, means driven by said prime mover for driving said speed responsive means, and means automatically operative in the event of failure of a part of said driving means for automatically cutting off the supply of motive medium to said prime mover.

6. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying a motive medium to said prime mover, means responsive to the speed of said prime mover for controlling said supply means, means responsive to the pump discharge pressure for controlling said supply means, said two last mentioned means including a common supply-means-control element through which supply control is effected, and means operative in the event of failure of said supply-means-control element for automatically cutting off the supply of motive medium to said prime mover.

7. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive medium to said prime mover, hydraulic control means responsive to the speed of said prime mover for controlling said supply means, and hydraulic control means responsive to the pump discharge pressure for controlling said supply means, said hydraulic control means including a common hydraulic fluid system.

8. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive medium to said prime mover, hydraulic control means responsive to the speed of said prime mover for controlling said supply means, and hydraulic control means responsive to the pump discharge pressure for controlling said supply means, said hydraulic control means including a common hydraulic fluid system and said fluid system including a fluid chamber adapted to contain an actuating fluid and having a movable wall actuated by said speed responsive means and said pump-discharge-pressure responsive means.

9. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said air compressor, means for supplying steam to said steam engine, a valve for controlling the flow of steam through said supply means, a fluid control system for controlling said valve, means responsive to the speed of said steam engine for controlling the pressure in said fluid control system, and means responsive to the compressor discharge pressure for controlling the pressure in said fluid control system.

10. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said compressor, means for supplying steam to said engine, a valve for controlling the flow of steam through said supply means, a fluid control system for said valve including a diaphragm containing chamber, means responsive to the speed of said steam engine for actuating said diaphragm to control the pressure in said fluid control system, and means responsive to the compressor discharge pressure for actuating said diaphragm to control the pressure in said fluid control system.

11. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said air compressor, means for supplying steam to said steam engine, a valve for controlling the flow of steam through said supply means, a fluid control system for controlling said valve, means responsive to the speed of said steam engine for controlling the pressure in said fluid control system, means responsive to the compressor discharge pressure for controlling the pressure in said fluid control system, and means automatically operative in the event of failure of a part of said speed responsive means for automatically controlling the pressure in said fluid control system.

12. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said compressor, means for supplying steam to said engine, a valve for controlling the flow of steam through said supply means, a fluid control system for said valve including a diaphragm containing chamber, means responsive to the speed of said steam engine for actuating said diaphragm to control the pressure in said fluid control system, means responsive to the compressor discharge pressure for actuating said diaphragm to control the pressure in said fluid control system, and means automatically operative in the event of failure of a part of said speed responsive means for automatically controlling the pressure in said fluid control system.

13. In a controlling mechanism, in combination, a control element, speed responsive means for controlling said control element, and means automatically operative in the event of an excessive speed for automatically varying the normal controlling action of said speed responsive means.

14. In a controlling mechanism, in combination, a control element, speed responsive means for controlling said control element, and means automatically operative in the event of an excessive speed for automatically varying the normal controlling action of said speed responsive means, said automatically operative means including a separate speed responsive controlling means.

15. In a controlling mechanism, in combination, a control element, speed responsive means for controlling said control element, and means automatically operative in the event of an excessive speed for automatically varying the normal controlling action of said speed responsive means, said automatically operative means including a latch means for rendering a part of said speed responsive means less effective and a separate speed responsive means for controlling said latch means.

16. In combination, in a speed-responsive controlling device, a movable controlling element, speed-responsive means for moving said element in a direction to reduce the speed of the device controlled thereby, yielding means tending to oppose the movement of said speed-responsive means, an adjustable abutment against which said yielding means reacts, and speed responsive means for automatically releasing said abutment to reduce the opposition of said yielding means to said speed responsive means automatically upon excess speed.

17. In a controlling mechanism, in combination,

tion, an element movable in one direction to reduce the speed of a device controlled by said controlling mechanism, speed-responsive means operative on increasing speeds to move said element in said direction, driving means for said speed-responsive means, and means for moving said element in said speed-reducing direction automatically upon release normally held inoperative by said driving means.

18. In combination, a prime mover, a pump driven thereby, a device for varying the operating medium supply to said prime mover, an actuating means for said device including an enclosed hydraulic system having elements respectively movable to control the position of said device and movable to move the liquid in said hydraulic system to move said first mentioned element, means controlled by the speed of said prime mover for moving said second-mentioned element, and means controlled by the discharge pressure of said pump for also moving said second mentioned element.

19. In combination, in a controlling mechanism for a prime mover, a device for regulating the operating medium supply to said prime mover, a hydraulic system for adjusting the position of said device, a device operative when released to move said first mentioned device automatically completely to interrupt the supply of operating medium to said prime mover, and means for automatically releasing said last mentioned device upon loss of liquid from said hydraulic system.

20. In combination, in a pumping system, a pump, a prime mover driving said pump, operating medium supply means for said prime mover, and automatic controlling means for said operating medium supply means including cumulatively acting mechanism for regulating the operating medium supply automatically in accordance with the speed of said prime mover and the pump discharge pressure.

21. In a controlling mechanism, in combination, an element to be controlled, a controlled hydraulic operating system for said element including a chamber having a movable wall changes in whose position effect control, means cooperating with said wall to form a second chamber and including another movable wall spaced from said first wall, means for transmitting movement to said second wall and through the latter to said first mentioned wall to effect control, and means for alternatively supplying fluid to and venting fluid from the space between said walls for exercising a different control.

22. In a controlling mechanism, in combination, a prime mover, means for supplying a motive medium thereto, a fluid control system including means responsive to the pressure of the fluid in said system for controlling said supply means, means responsive to the speed of said prime mover for automatically regulating the pressure in said fluid control system, and associated means automatically operative in the event of failure of a part of the controlling mechanism for effecting an increase in pressure in said fluid control system.

23. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive fluid to said prime mover, a valve for controlling the flow of motive fluid through said supply means, means for con-

trolling said valve including a movable member, means responsive to the speed of said prime mover for actuating said movable member, means responsive to the pump discharge pressure for actuating said movable member, and means automatically operative in the event of failure of a part of said speed responsive means for actuating said movable member to effect closure of said valve.

24. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive fluid to said prime mover, a valve for controlling the flow of motive fluid through said supply means, a controlled hydraulic operating system for said valve including a chamber having a movable wall, changes in whose position effect control, means cooperating with said wall to form a second chamber and including another movable wall spaced from said first wall, means responsive to the speed of said prime mover for transmitting movement to said second wall and through the latter to said first mentioned wall to effect control, and means for alternatively supplying pump discharge pressure to and venting pressure from the space between said walls for exercising a different control.

25. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said air compressor, means for supplying steam to said steam engine, a valve for controlling the flow of steam through said supply means, a fluid control system including means responsive to the pressure of the fluid in said system for controlling said valve, means responsive to the speed of said steam engine for controlling the pressure in said fluid control system, and means automatically operative in the event of an excessive speed of said steam engine for controlling the pressure in said fluid control system.

26. In a controlling mechanism, in combination, an air compressor, a steam engine for driving said compressor, means for supplying steam to said engine, a valve for controlling the flow of steam through said supply means, a fluid control system for said valve including a diaphragm containing chamber, means responsive to the speed of said steam engine for actuating said diaphragm to control the pressure in said fluid control system, means responsive to the compressor discharge pressure for actuating said diaphragm to control the pressure in said fluid control system, and means automatically operative in the event of an excessive speed of said steam engine for rendering said speed responsive means more effective to control the pressure in said fluid control system.

27. In a controlling mechanism, in combination, a prime mover, a pump driven thereby, means for supplying motive fluid to said prime mover, a valve for controlling the flow of motive fluid through said supply means, means for controlling said valve including a movable member, means responsive to the speed of said prime mover for actuating said movable member, means responsive to the pump discharge pressure for actuating said movable member, and means automatically operative in the event of an excessive speed of said prime mover for effecting actuation of said movable member in a valve closing direction.

ALEXANDER D. FERGUSON.