

Oct. 31, 1944.

R. D. RHOADS ET AL

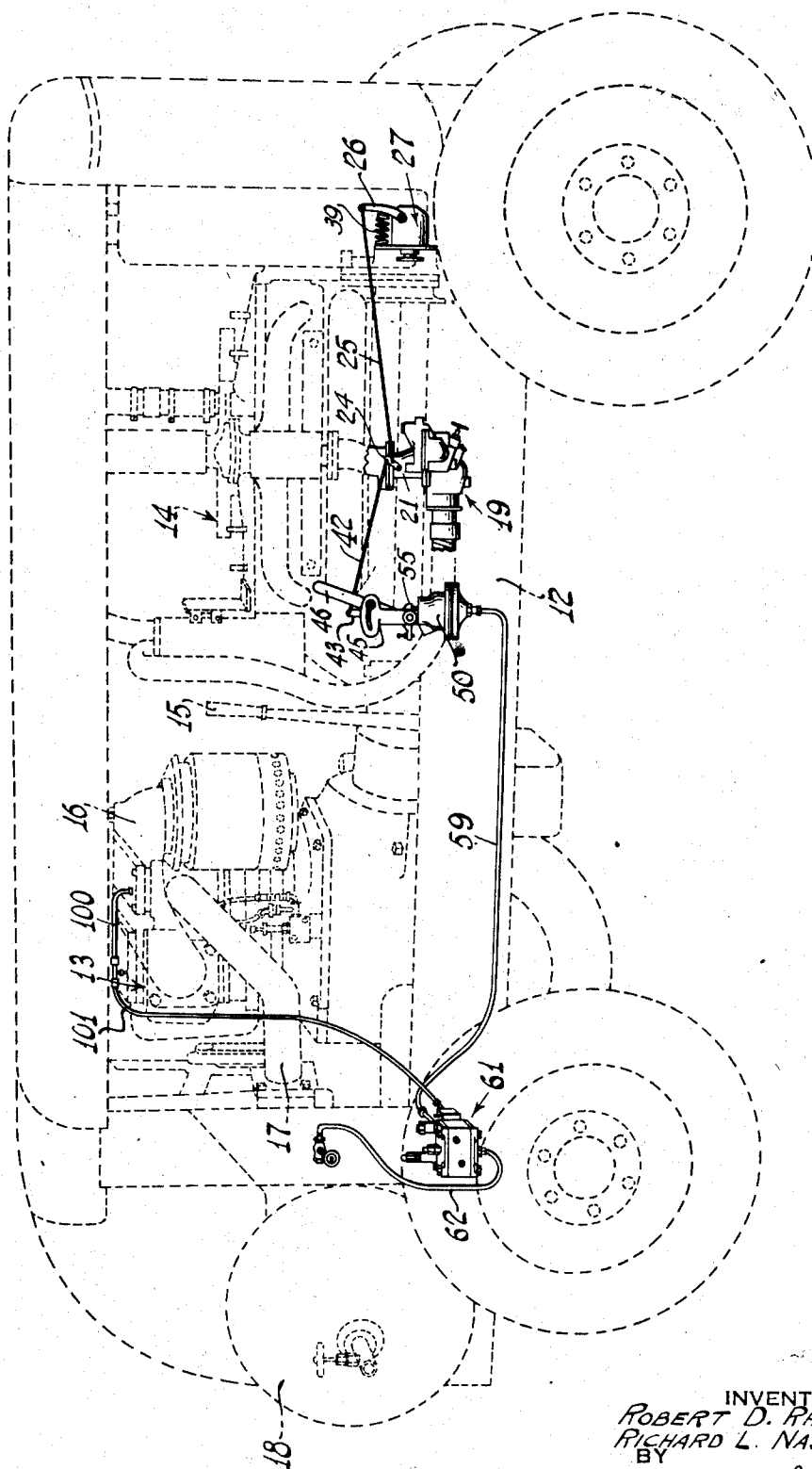
2,361,870

COMPRESSOR REGULATOR

Filed July 11, 1942

5 Sheets-Sheet 1

Fig. 1.



INVENTORS
ROBERT D. RHOADS.
RICHARD L. NASH.

BY

Raymond G. Muller
ATTORNEY

Oct. 31, 1944.

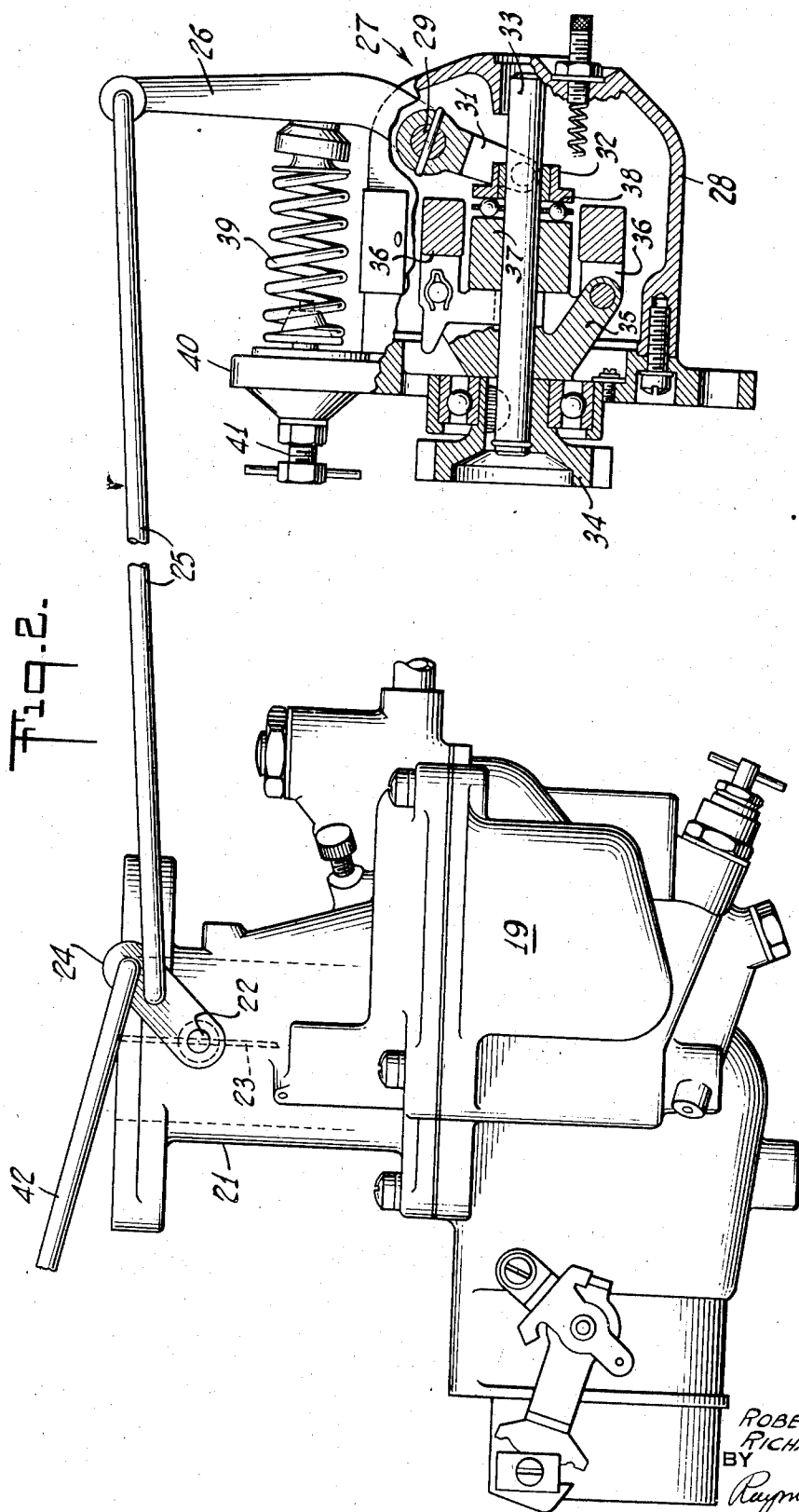
R. D. RHOADS ET AL

2,361,870

COMPRESSOR REGULATOR

Filed July 11, 1942

5 Sheets-Sheet 2



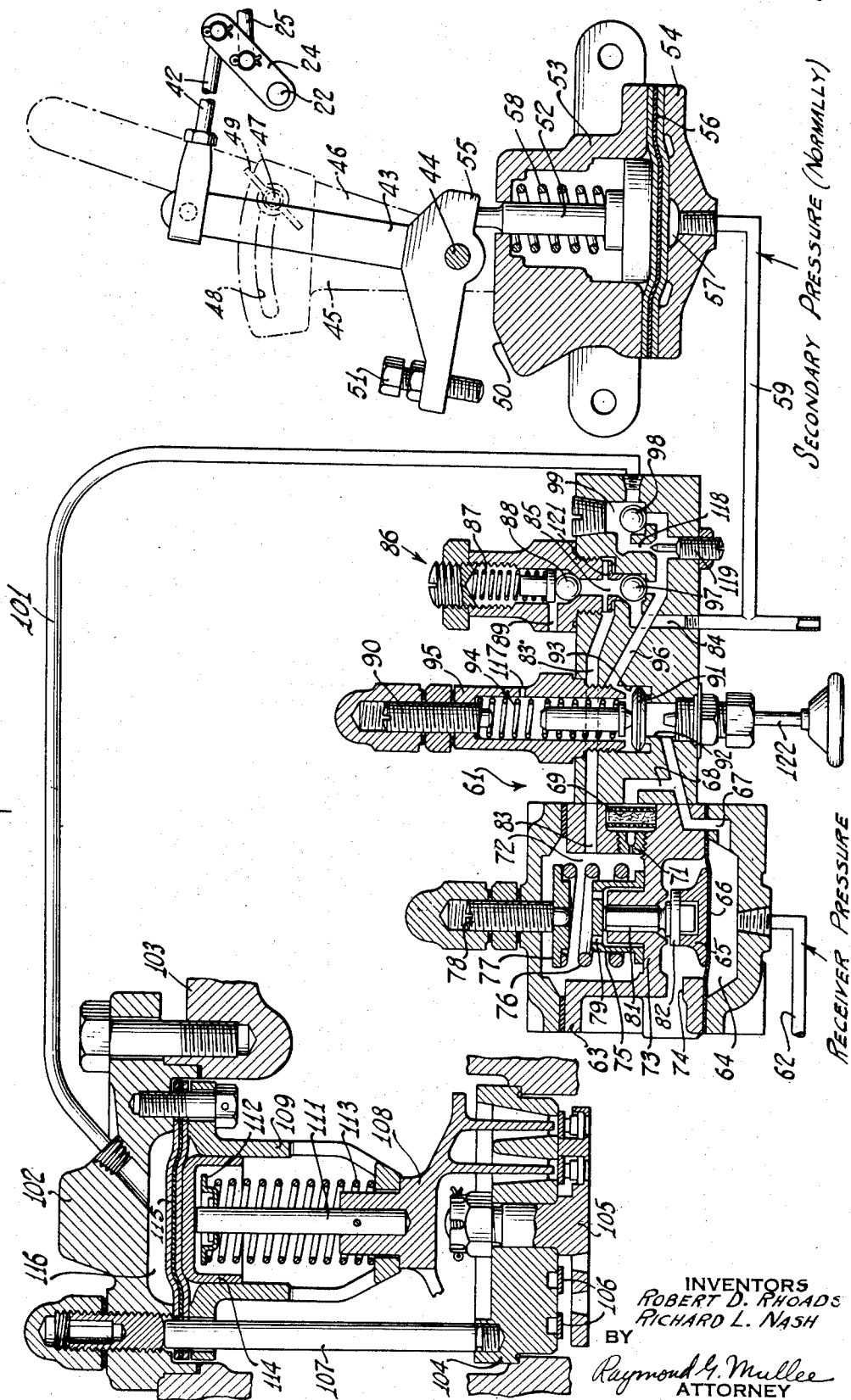
Oct. 31, 1944.

R. D. RHOADS ET AL
COMPRESSOR REGULATOR

2,361,870

Filed July 11, 1942

5 Sheets-Sheet 3



Oct. 31, 1944.

R. D. RHOADS ET AL

2,361,870

COMPRESSOR REGULATOR

Filed July 11, 1942

5 Sheets-Sheet 4

Fig. 5.

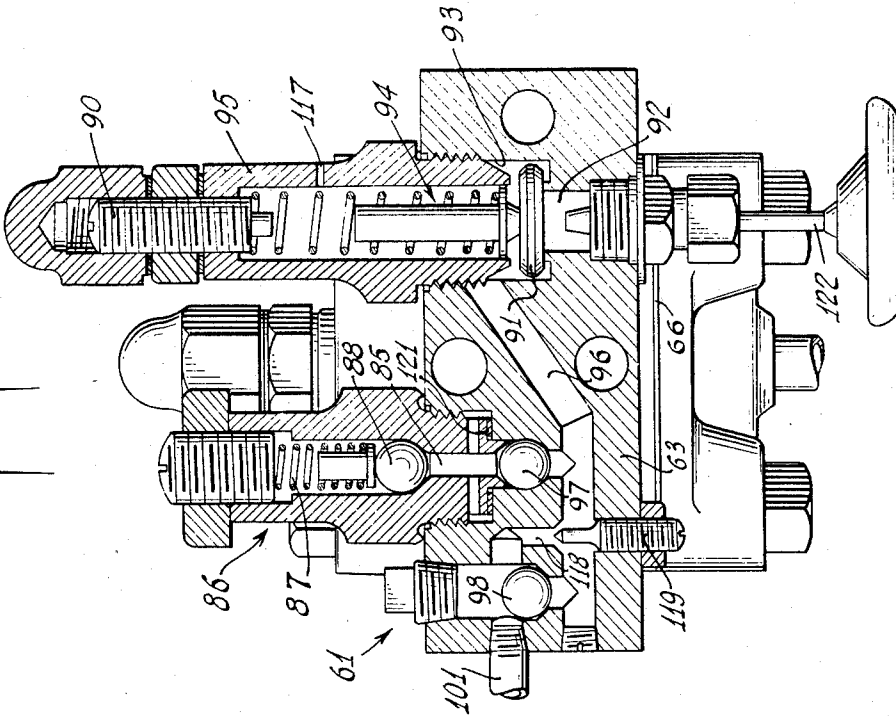
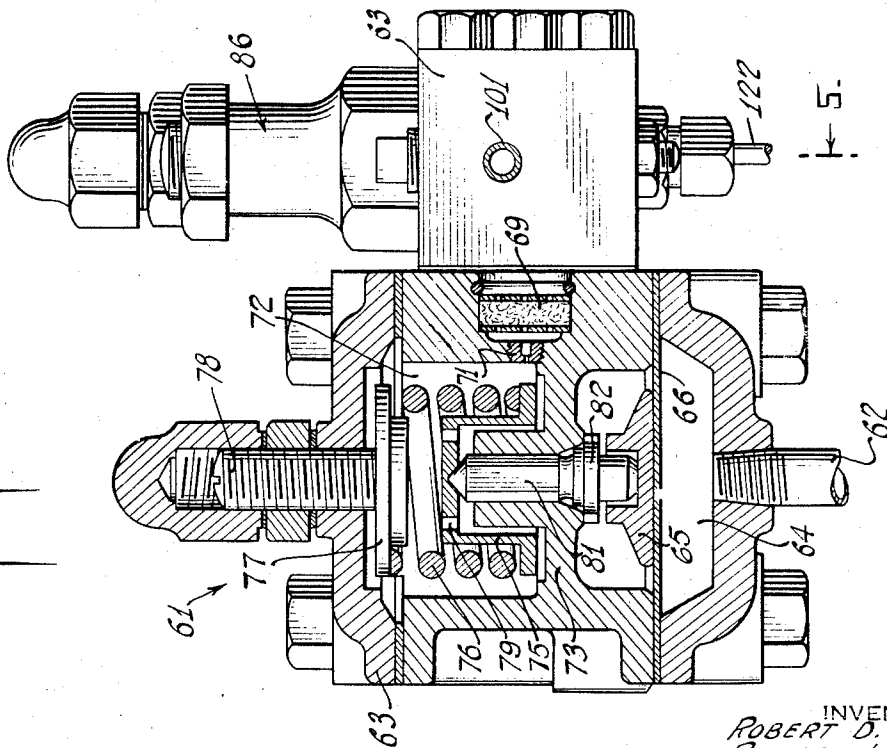


Fig. 4.



INVENTORS
ROBERT D. RHOADS
RICHARD L. NASH.
BY
Raymond S. Muller
ATTORNEY

Oct. 31, 1944.

R. D. RHOADS ET AL

2,361,870

COMPRESSOR REGULATOR

Filed July 11, 1942

5 Sheets-Sheet 5

Fig. 6.

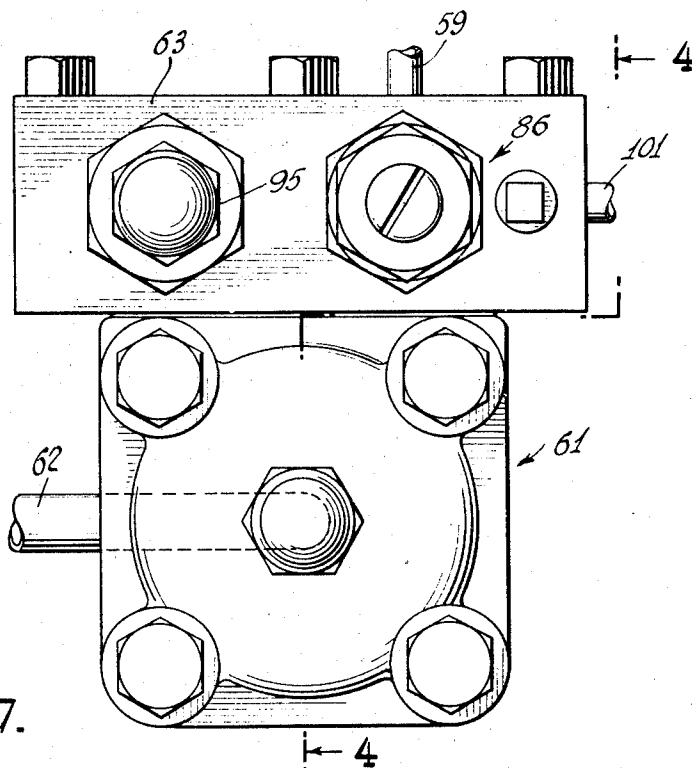
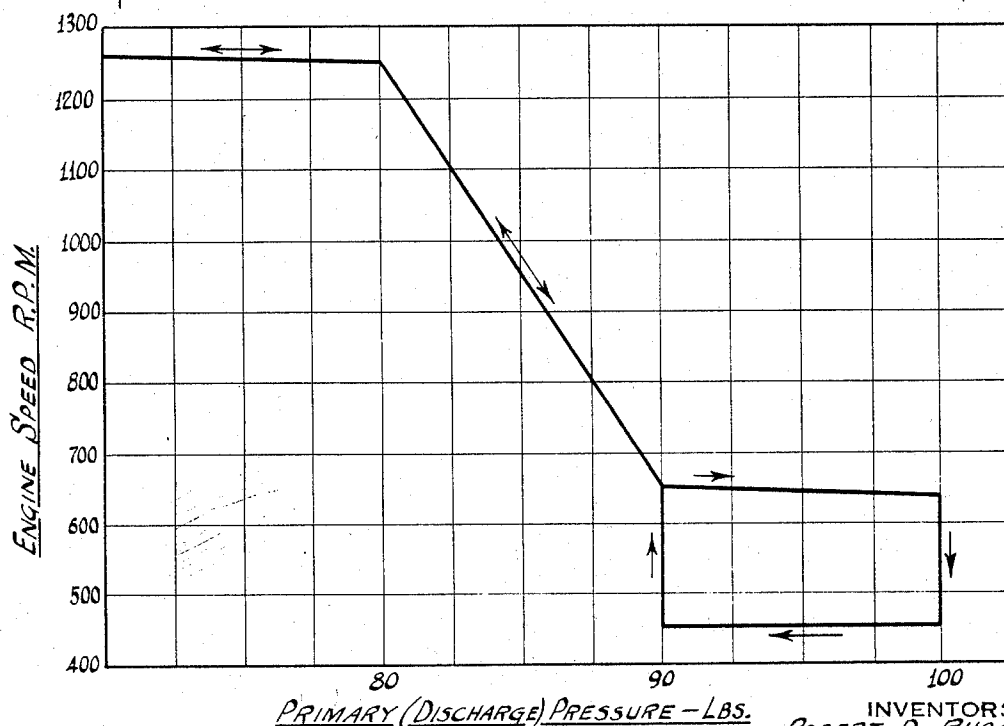


Fig. 7.



PRIMARY (DISCHARGE) PRESSURE - LBS.

INVENTORS
ROBERT D. RHOADS
RICHARD L. NASH
BY

Raymond L. Muller
ATTORNEY

UNITED STATES PATENT OFFICE

2,361,870

COMPRESSOR REGULATOR

Robert D. Rhoads and Richard L. Nash, Franklin, Pa., assignors to Chicago Pneumatic Tool Company, New York, N. Y., a corporation of New Jersey

Application July 11, 1942, Serial No. 450,566

10 Claims. (Cl. 230—5)

This invention relates to regulating apparatus for engine driven fluid compressors and more particularly to means for changing the speed of operation of the engine in correspondence with changes in the compressor discharge pressure within a predetermined range.

One class of fluid compressor to which the invention has application is the portable air compressor used especially in street and railway maintenance to supply motive fluid to pneumatic tools. In such a machine the compressor is mounted on a vehicle together with an internal combustion engine operating to drive the compressor at a speed determined by the setting of a throttle controller governing the engine fuel intake. As the compressor piston reciprocates, air is admitted to the cylinder, compressed and discharged into a receiver tank also carried on the vehicle. From the receiver the air flows, upon demand, through hose lines leading to the hammer drills, tie tampers or other tools engaged in the work at hand. As the tools alternately are started and stopped the demand for pressure fluid varies. With the compressor operating at a constant speed the supply of fluid to the receiver is substantially constant so that variations in the demand normally cause a corresponding rise or fall of the air pressure within the receiver. Hereinafter, for the sake of convenience, such pressure variations are termed changes in the discharge pressure.

Usually, a predetermined maximum is set for the discharge pressure at which regulating devices operate to render the compressor ineffective and to reduce the speed of the motor to idling. It has long been recognized, however, that this degree of regulation will not alone produce a high compressor efficiency since the engine has only two speeds—idling and maximum. When the demand is light the engine shifts repeatedly from one extreme of operation to the other, never finding the right speed to meet the demand. Under any heavier demand not exactly equal to nor exceeding the capacity of the compressor the engine operates at a higher speed than is required to maintain a working pressure within the receiver and hence is wasteful of fuel.

In view of the limitations of elementary compressor regulation additional control devices have been proposed having a general object similar to that of this invention, that is, to meet the changing demand for pressure fluid with a gradual acceleration and deceleration of the engine speed. More specifically, it is intended to operate the engine at the lowest possible speed which will

maintain a working pressure in the receiver and constantly to make fine adjustments in the speed as the discharge pressure varies within a working range. Preferably this is accomplished by fluid pressure operation of the throttle controller. Heretofore, this object has been attained only in a general way because known regulators of the prior art lacked the sensitivity of response necessary for smooth throttle control. Thus, a rise or fall in the discharge pressure of only a few pounds was not accompanied by a corresponding adjustment of the engine speed since the pressure variation was insufficient to initiate operation of the throttle controller. As a result the engine speed fluctuated between extremes as before, except that the opposed limits now represented points between the maximum and idling speeds.

According to a feature of the present invention this defect of prior art regulators is overcome by operating the throttle controller through a pressure transformer acting to effect wide variations in the fluid pressure supplied to the controller in response to relatively small changes in the discharge pressure. The throttle controller, therefore, makes immediate response to even slight variations in the pressure fluid demand. It may be said that the regulating devices of this invention effect movement of the throttle controller in an infinite number of steps as contrasted with the few discrete steps to which throttle controllers of the prior art have been limited.

Other objects of the invention are to set a range for the transformer pressure corresponding to an intermediate range of discharge pressure; to discontinue communication of the pressure transformer with the throttle controller at a predetermined high discharge pressure; and to embody the pressure transformer in a pressure regulator containing also control means operable at said predetermined high discharge pressure to unload the compressor and to adjust the throttle controller to minimum speed setting position.

In the drawings:

Fig. 1 is a view of the regulating apparatus of the invention as it is mounted on a portable engine driven fluid compressor.

Fig. 2 is a view of the engine carburetor and main speed governor connected thereto, the governor being shown in longitudinal section.

Fig. 3 is a diagrammatic view of the regulating apparatus, showing the throttle controller, the pressure regulator and the unloading inlet valve assembly in longitudinal section.

Figs. 4, 5 and 6 are detail views of the pressure regulator. Fig. 6 is a plan view thereof, while

Fig. 4 is a longitudinal section taken along the line 4—4 of Fig. 6 and Fig. 5 is a longitudinal section taken along the line 5—5 of Fig. 4.

Fig. 7 is a chart showing the relation between engine speed and discharge pressure during a typical cycle of operation in which the discharge pressure rises to and returns from a predetermined maximum pressure.

The portable compressor unit of Fig. 1 comprises a wheel mounted frame 12 supporting fluid compressing means 13, a gasoline engine 14 and a driving connection between the engine and compressor controlled by a clutch lever 15. In operation the compressor 13 receives air through a conduit 16, compresses the air so admitted and discharges it through a conduit 17 to a receiver tank 18 on the rear of frame 12.

The compressor 13 supplies compressed air to the receiver 18 at a rate normally determined by the speed of the engine 14. In order to regulate the engine speed, control devices of a pressure responsive and speed responsive nature are provided for throttling the engine fuel intake. Referring also to Fig. 2, the engine assembly includes a carburetor 19 in which the combustible vapors are formed and directed through a tubular outlet 21 to the engine cylinders. A shaft 22 extends transversely through the outlet 21 and there is secured to the shaft, inside the outlet, a butterfly valve 23. By oscillation of the shaft 22 the valve 23 is moved toward and from a position blocking the outlet 21 and thereby is caused to exercise a variable restriction upon the flow of fuel to the engine. The speed of the engine increases in response to an increased flow of fuel and decreases as the rate of flow is reduced. The valve 23 thus functions as a throttle valve settable to control the speed of operation of the engine and of the compressor driven by the engine. At one end of the shaft 22, outside the outlet 21, is an arm 24 to which one end of a link 25 is pivotally connected. The link 25 extends forwardly in the machine and is similarly connected at its opposite end to a lever 26 which is part of a governor 27. The lever 26 extends into a housing 28 where it is pinned to a transverse shaft 29. Beyond the shaft 29 the lever has a bifurcated extension 31 engaging a collar 32 slidably mounted on a shaft 33. The shaft 33 extends longitudinally through the housing 28 and has a gear 34 keyed to its outer end, the gear 34 being directly connected, in a manner not fully shown herein, to the main drive shaft of the engine. During the operation of the engine, therefore, the shaft 33 has a continuous rotary motion varying in speed with changes in the speed of the engine. Also secured to the shaft 33, inside the housing 28, is a plate 35 carrying pivoted weights 36. Inwardly turned arms on the weights 36 engage a sleeve 37 on the shaft 33 abutting collar 32 through a ball thrust friction bearing 38. As the speed of rotation of the shaft 33 increases the weights 36 swing outward under centrifugal force and press the assembly comprising sleeve 37, bearing 38 and collar 32 toward the right (as viewed in Fig. 2), thereby rocking the lever 26 in a counter-clockwise direction about the pivot represented by shaft 29. Outside the housing 28 this motion of the lever 26 is transmitted through link 25 and arm 24 to the shaft 22 which moves the throttle valve 23 in a direction increasing the degree of restriction placed upon the flow of fuel to the engine. Actuation of the governor parts is opposed by a spring 39 having an adjustable base on a lateral-

ly projecting portion 40 of the housing 28 and pressing against the lever 26 intermediate its fulcrum on shaft 29 and the point of connection to link 25. Through the cooperation of the spring 39 and the pivoted weights 36 a maximum speed is set for the engine, which speed may be varied by changing the initial compression of the spring 39. This may be accomplished by a threaded adjusting rod 41. Upon tightening the rod 41, the spring 39 offers increased opposition to centrifugal force and accordingly a higher engine speed is required to throttle the fuel supply to the same extent as previously.

Control of the engine speed thus is effected through adjustment of the throttle valve 23, and it will be observed that anything rocking the arms 24 and shaft 22 will vary the setting of the valve while at the same time biasing the governor spring 39. Upon release of centrifugal force and any other pressure tending to close the throttle valve the parts are returned to normal by the governor spring.

A second means for rocking the throttle shaft 22 comprises a rearwardly extending link 42 connecting the arm 24 to the vertical arm of a bell-crank lever 43 (see Fig. 3) pivotally mounted on a transverse stub shaft 44. The shaft 44 is supported between uprights 45 (one shown) and provides also a pivotal mounting for a hand lever 46. The lever 46 carries a laterally projecting pin 47 lying forward of the lever 43 and adapted to impart thereto motion of the hand lever in one direction. The pin 47 extends through the lever 46 and on the side opposite lever 43 is engaged in a slot 48 in an upright 45 and has a threaded connection with a wing nut 49. The pin 47 and nut 49 in cooperation with the slotted upright 45 constitute a clamp whereby the lever 46 may be locked in a selected position of adjustment. The lever 46 and pin 47 are arranged to rock the lever 43 positively in a counter-clockwise direction, as viewed in Fig. 3, this motion serving to pull the link 42 rearward and thereby rock the shaft 22 also in a counter-clockwise direction to move the throttle valve toward closed position. Motion of the lever 43 in a direction to close the throttle valve is adjustably limited by a set screw 51 disposed in the horizontal arm of the lever and engageable with a housing 50. Lever 46 is used principally during the starting and warming up periods for hand setting the throttle to reduce speed.

The lever 43 in addition to its manual control by lever 46 forms part of a pressure fluid operated throttle controller automatically responsive in its action to variations in the discharge pressure. The throttle controller further includes a plunger 52 within the housing 50 which is made up of complementary flanged sections 53 and 54. The plunger 52 extends through the housing section 53 into contact with a nose 55 on a horizontal arm of lever 43, forwardly of the pivot 44. The inner end of the plunger 52 rests on a diaphragm 56 clamped between the housing sections 53 and 54 and acting in the usual manner to seal the interiors of the respective sections from each other and to transmit motion through pressure applied to the upper or lower surfaces thereof. The lower surface of the diaphragm 56 forms one wall of a chamber 57 within housing section 54 and expansible under the force of pressure fluid. The plunger 52 is maintained by a spring 58 in constant contact with the upper surface of the diaphragm 56. As a result an increase in pressure within the chamber 57 above that neces-

sary to overcome the initial compression of spring 88 will deflect the diaphragm 86 and press the plunger 82 outward to actuate the lever 48 and its associated linkage leading to the throttle valve.

Pressure fluid is admitted to the chamber 57 of the throttle controller through a conduit 59 leading from a pressure regulating device 61 in turn connected through a conduit 62 with the receiver 18. The pressure regulator 61 is embodied in a housing 63 (see also Figs. 4, 5 and 6), and comprises means for controlling the supply of pressure fluid to the throttle controller 57, means for controlling operation of compressor unloading devices (hereinafter described) and a pressure transformer insuring a ready response of the regulator to changes in the discharge pressure. Through the conduit 62 the pressure of the air within the receiver, here described as discharge pressure, is established also within a chamber 64 in the regulator housing 63 where it presses upon a plunger 65 through a diaphragm 66. From the chamber 64 the air may flow also through a passage 67, a branch 68 thereof and through an air filter 69 and an opening in choke plug 71 to a chamber 72 above chamber 64 and diaphragm 66. An internal wall 73 separates the chamber 72 from the area immediately above diaphragm 66, the latter area being open to the atmosphere by way of a port 74. The stem of plunger 65 extends upward through an aperture in the wall 73 into the chamber 72 and into a cup 75 within the chamber. The cup 75 serves as a mount for one end of a coil spring 76 the other end of which is seated on a plate 77 at the end of an adjustment screw 78. By the pressure of the spring 76 the cup 75 is urged downward, this pressure being transmitted to the plunger 65 through contact of the closed inner end of the cup with the stem of the plunger.

Provision is made for connecting the chamber 72 to the atmosphere through port 74. A series of apertures 79 is formed in the closed end of the cup 75 while longitudinal grooves 81 are cut in the stem of plunger 65. From the chamber 72 fluid may pass through the ports 79 and along the grooves 81 into the area above diaphragm 66 and out the port 74 to exhaust. Controlling the rate of flow of pressure fluid from the chamber 72 is a valve 82 movable toward and from a seat on the internal wall 73 variably to restrict the escape of fluid from the grooves 81 into the exhaust area. Normally, the valve 82 is held sufficiently far from its seat that the rate of flow of the escaping fluid balances the rate at which the fluid is admitted to the chamber 72 through choke plug 71. However, should the discharge pressure, as reflected in chamber 64, increase and thereby move the plunger 65 upward against the tension of spring 76 the degree of restriction exercised by the valve 82 is increased and the rate of flow from chamber 72 thereby decreases. When the flow of fluids passing to exhaust no longer balances the continuous flow entering through choke plug 71, the pressure in chamber 72 begins to rise, the rate of increase being directly responsive to the climbing discharge pressure but out of proportion thereto. Within its range of variance, one limit of which is defined by the point at which the plunger 65 starts to move upward and the other by the maximum pressure attainable in the chamber 72, the pressure in the chamber 72 will rise and fall in response to variations in the discharge pressure as the valve 82 moves toward and from seated posi-

tion. Further, the control of the exhaust fluids is caused to bear such a relation to the discharge pressure that a change of one unit of pressure within the chamber 64, inside the range of variance, will be magnified within the chamber 72 to a pressure change of a plurality of units. Thus, within a predetermined range of discharge or primary pressures there is established in the chamber 72 a secondary pressure which is related to primary pressure but which varies widely in response to relatively slight variations in the primary pressure.

The chamber 72 of the pressure transformer normally is in constant communication with chamber 57 of the throttle controller through passages 83 and 84 connected through a bore 85 and leading to the supply conduit 59. Accordingly, the actuating plunger 52 of the throttle controller is subject to the same pressures established in chamber 72 and changes the setting of the throttle valve in conformity with changes in such pressure. The spring 58 resists operation of the plunger 52, holding it against movement from the position shown in Fig. 3 by the normal secondary pressure which is held to a low point prior to the attainment of a working range of discharge pressures. A limit is placed on the secondary or transformer pressure by a relief valve assembly 86 positioned in the bore 85 and including a spring 87 of variable pressure interposing a ball valve 88 between the bore and an exhaust port 89. When the transformer pressure reaches a height sufficient to force the valve 88 from its seat the bore 85 is opened to atmosphere and any further rise in transformer pressure is prevented.

Should the discharge pressure continue to increase, even with the throttle valve in the lowest speed setting position to which it can be set by transformer pressure, it is desirable at a predetermined high discharge pressure to unload the compressor and to set the throttle valve to minimum speed setting position. To this end the pressure regulator 61 contains a valve disc 91 controlling the flow of pressure fluid through a bore 92 and movable within a counterbore 93 toward and from a lower seated position closing the bore 92 from the counterbore 93. A spring assembly 94 is confined within a tubular housing 95 and presses the valve 91 downward with a force variable according to the adjustment of a screw 90. Pressure fluid at the discharge pressure is introduced into the bore 92, beneath the valve 91, through the passage 67 leading from chamber 64 of the transformer. The force of the spring assembly 94 is such as to hold the valve 91 in seated position until the discharge pressure reaches a predetermined peak, this peak being higher than the discharge pressure necessary to create maximum transformer pressure. That is, if the maximum transformer pressure, say 50 pounds per square inch, corresponds to discharge pressures of 90 pounds or more, the valve 91 will permit the discharge pressure to continue rising after increase in secondary pressure has been checked by ball valve 88. Valve 91 will not open the bore 92 until the discharge pressure has risen further, for example to 100 pounds. As the discharge pressure passes said predetermined peak the valve 91 is forced upward by pressure fluid within the bore 92, which fluid then passes around the valve into the counterbore 93 and out a passage 96. Pressure fluid entering passage 96 is directed past a ball valve 97 to the passage 84 and past another ball valve 98 to a bore 99. From

passage 84 the primary pressure fluid is directed through conduit 59 to the throttle controller where it effects immediate movement of the plunger 52 and of the parts operated thereby through the maximum travel permitted by set screw 51. The position of adjustment selected for set screw 51 determines the minimum speed setting position of the throttle valve, which position the throttle valve assumes immediately following opening of the pressure responsive valve 91.

The fluid admitted to bore 99 around valve 98 flows through an outlet to a conduit 101 leading to unloader devices associated with the compressor cylinder (see also Fig. 1). The conduit 101 extends into the cylinder through a plate 102 closing an opening in the outer cylinder wall 103 provided to accommodate the inlet valve assembly by which air is taken into the cylinder for compression. In the present instance the inlet valve assembly comprises a circular valve seat 104, a valve keeper 105 spaced from and secured to the valve seat, and spring pressed annular valves 106 controlling the passage of fluid through arcuate openings in the valve seat. The valve seat 104 is held by posts 107 (one shown) within an opening in the inner cylinder wall. Air entering the compression chamber is constrained to do so by passing the valves 106 which open and close the arcuate ported areas of the valve seat in response to pressure variations of a determined degree on opposite sides of the valve assembly. Unloading here is accomplished by holding the valves 106 open mechanically, allowing air to pass freely and without compression into and out of the compressor in response to reciprocation of the compressor piston. The apparatus for effecting unloading includes a plate 108 overlying the valve seat 104 and formed with fingers extending through the seat into contact with the valves 106. The plate 108 and fingers thereof function as a lifter adapted when actuated to move the valves 106 from closed positions. The valve lifter 108 is guided by a cylindrical bracket 109 secured to the lower face of the closure plate 102. A rod 111 is secured to the lifter plate 108 and extends upwardly within the bracket 109. Interposed between a collar 112, surrounding the rod 111, and the lower end of the bracket is a compression spring 113 which urges the valve lifter upward into ineffective position with respect to the valves 106. Supported on the upper end of the rod 111 is a piston 114 which is pressed upward into engagement with the lower surface of a diaphragm 115 the outer edge of which is clamped between the upper end of the bracket 109 and the closure plate 102. The lower surface of the plate 102 is recessed to form above the diaphragm 115 a chamber 116 to which the pressure fluid from conduit 101 is directed. Upon the introduction of pressure fluid at the predetermined peak discharge pressure inside the chamber 116 the diaphragm 115 and piston 114 will be forced downward against the pressure of spring 113 to actuate the valve lifter 108 and thereby unseat the valves 106. As shown in Fig. 1 the compressor here disclosed has a second inlet valve assembly controlled through a branch 100 of the conduit 101. Preferably, the unloader devices are arranged to effect complete unloading, rather than partial or step-by-step unloading upon operation of valve 91.

The compressor will remain unloaded and the engine will continue to operate at minimum speed at least as long as the pressure of the air within the receiver is high enough to retain the valve 91

unseated. It will be observed that, because in the open position of the valve 91 a greater area thereof is exposed to pressure fluid than when the valve is closed, less pressure is required to maintain the valve in open position than is required initially to move it to such position. Fluttering of the valve 91 and attendant disadvantages thereby are avoided. The counterbore 93, passage 96 and communicating areas normally are open to exhaust through a series of radial ports 117 in the tubular spring housing 95. However, when the valve 91 shifts from closed position with respect to the bore 92 it moves to an oppositely disposed seat defined by the inner end of the housing 95 and so closes the interior of the housing from communication with the counterbore 93. Upon return of the valve 91 to a position closing the bore 92 pressure fluid previously admitted to the throttle controller, and to the inlet valve unloader, is vented through the ports 117, permitting the compressor to reload and permitting the engine speed to increase until it is again under the control of the transformer pressure.

It is undesirable that the compressor should reload while the engine is operated at minimum speed. Therefore, a means is provided for delaying reloading until the speed of the engine has increased sufficiently to carry the greater load without the likelihood of stalling.

The pressure fluid flowing back to bore 99 from conduit 101 and chamber 116 of the unloading device by-passes valve 98 which is permitted to return to its seat when passage 96 is connected to exhaust. The by-pass, indicated at 118, is controlled by an adjustable choke valve 119 restricting the passage of fluid therethrough. Thus the drop in pressure within chamber 116 is accomplished gradually and the valve lifter 108 reaches ineffective position only after withdrawal of discharge pressure from the throttle controller and the resultant speed-up of the engine. The ball valve 97 also drops to seated position in response to closure of the valve 91 but the bore 85 remains open to exhaust because the ball valve 88 is, at this time, held off its seat by the peak transformer pressure. The drop in pressure within throttle controller chamber 57 from maximum discharge pressure to maximum transformer pressure thus is substantially instantaneous. The escape of fluid at primary pressure past the valve 88 is prevented by providing an upper seating member 121 for the valve 97, engaged thereby during the unloaded-idling period of machine operation.

In the event that it is found desirable to maintain the compressor unloaded and operating at minimum speed irrespective of a drop in discharge pressure below the normal reloading pressure, the control valve 91 may be held unseated by positive means. The present structure provides for this purpose a screw threaded actuator 122 adapted to be turned manually into engagement with the lower surface of valve 91.

The compressor regulator is adjustable by changing the resistance imparted to the pressure responsive control elements thereby to vary at will the relation between engine speed and discharge pressure. Preferably the regulating apparatus functions to permit a maximum engine speed while the pressure in the receiver builds up from zero to about 80 pounds per square inch, which marks the beginning of the range of pressures best suited for operation of the pneumatic tools. At this point the secondary pressure in chamber 57 overcomes the initial force of oppos-

ing pressure elements and starts to lift the plunger 52. A continued rise through the range of working pressures is accompanied by a gradual slowing down of the engine until a discharge pressure of about 90 pounds is attained, at which point the pressure transformer reaches the limit of its effectiveness, the control lever 43 then being held stationary in a position intermediate its maximum or high speed adjustment and the minimum or idling speed adjustment. The mentioned intermediate position of the lever is stabilized upon the attainment of the stabilized maximum secondary transformer pressure of 50 pounds and determines the definite low working speed of the engine and compressor. Any increase in discharge pressure above 90 pounds is accomplished without effect on the engine speed until the valve 91 is forced open whereupon the speed is reduced to its minimum degree by the abrupt shifting of control lever 43 to its minimum idling speed adjustment, and the compressor is simultaneously unloaded.

The mode of operation of the compressor through a typical complete pressure cycle will be best understood by reference to the chart of Fig. 7 where a curve illustrates the speed variations of the engine as the discharge pressure attains and declines from a predetermined maximum height. As indicated in Fig. 7 the engine operates under the control of the main speed governor while the discharge pressure remains under 80 pounds per square inch. As the discharge pressure approaches 80 pounds the secondary or transformer pressure within chamber 72 rises gradually and then steeply as the valve 82 comes closer to its seat in the wall 73. The rising transformer pressure acts through the throttle controller upon the throttle valve to cause a smooth and regular reduction in the engine speed as the discharge pressure increases to 90 pounds. The transformer pressure during this period rises from 25 pounds to 50 pounds, at which point it is stabilized as the relief valve 88 is unseated. Between 90 and 100 pounds the discharge pressure increases without substantial effect on the engine speed, the throttle controller remaining subject only to the peak secondary pressure of approximately 50 pounds. When a 100 pound discharge pressure is reached, however, the valve 91 is lifted to its upper seat and air at the full discharge pressure flows to the throttle controller and the unloader chamber 116. Concomitantly with the action of the valve 91, therefore, the engine speed drops abruptly and the compressor is unloaded, discontinuing the supply of pressure fluid to the receiver. Any subsequent demand on the receiver causes the pressure therein to fall from the peak of 100 pounds, while the compressor continues to idle under no load. This condition of operation is maintained until the pressure in the receiver drops sufficiently to permit the valve 91 to return to its lower seat, which action takes place at about a 90 pound pressure. In response to the closing of the valve 91 the engine speed increases to the degree permitted by the 50 pound transformer pressure and shortly thereafter the compressor reloads. The time lag separating the operations of increasing the engine speed and of reloading the compressor is caused by the choke valve 119 and is only of about two seconds duration. Should the discharge pressure fall below 90 pounds each step of its descent causes a proportionately greater drop in secondary pressure and a consequent increase in the engine speed.

Normally the discharge pressure ranges between pressures of 80 to 90 pounds and varies a few pounds at a time as the tools are independently started and stopped. Pressure changes within this range are frequent and the value of a compressor regulator is largely determined by the sensitivity of its response to these changes. In the present regulator each pressure change between 80 and 90 pounds, however slight, is magnified by means of the pressure transformer and a prompt response of the throttle controller thereby assured. A better, more dependable regulator is obtained in this manner. Another advantage is gained through elimination of the necessity for finely machined parts by which it was endeavored in prior art devices to add to the sensitivity of response of the throttle controller.

For the sake of convenience, in the appended claims the throttle controller is described as acting itself to move the throttle valve toward minimum speed setting position. It will be understood, however, that this is literally true only when primary pressure is admitted to the throttle controller by the opening of valve 91. While under the control of secondary pressure the throttle controller operates by increasing the pressure on the governor spring 39 to permit a greater closure of the throttle valve by the governor. Within the range of secondary pressures the throttle valve is urged toward and from closed position by separate forces, these being: actuation by the governor weights, the resistance of the governor spring, and the pressure of the throttle controller, the latter being modified by the spring 58. The oppositely disposed forces of the governor weights and the governor spring attain a balance defining a normal running speed for the engine. As the secondary pressure rises above the degree necessary to overcome spring 58, a force is exerted on the throttle valve aiding the governor weights so that a new balance and a lower engine speed are attained. In effect the secondary pressures bias or reset the governor to different speed control positions.

What is claimed is:

1. In an engine driven fluid compressor having a throttle valve controlling the engine fuel intake and movable toward and from a position setting a minimum speed for said engine, the combination of pressure fluid operated means for moving said throttle valve toward minimum speed setting position, said means operating with an effect varying directly with the intensity of the fluid pressure supplied thereto; means for supplying to said pressure fluid operated means fluid at a primary pressure which is the same as the discharge pressure; means for supplying to said pressure fluid operated means fluid at a secondary pressure which is subject to variations corresponding in amplified degree to relatively smaller variations in the discharge pressure by being transformed with respect to said discharge pressure; means rendering said secondary pressure unresponsive to variations in the discharge pressure above a predetermined limited pressure range and above said range causing primary discharge pressure to supersede the secondary pressure; and means preventing the supply of primary pressure to said pressure fluid operated means until a discharge pressure is reached above said predetermined limited pressure range.

2. In an engine driven fluid compressor having a throttle valve controlling the engine fuel intake and movable toward and from a position setting

a minimum speed for said engine, the combination of a pressure fluid operated throttle controller acting to press said throttle valve toward minimum speed setting position with an effect varying directly with the intensity of the fluid pressure supplied thereto; a pressure regulator supplying fluid to said throttle controller at secondary pressures varying in correspondence with variations in the discharge pressure, the pressure regulator having means for varying the secondary fluid pressures in amplified degree in response to relatively smaller variations in said discharge pressure; means for independently supplying to said throttle controller fluid at primary pressures corresponding to the discharge pressure; means for controlling said pressure regulator to limit the secondary pressure to a range having a predetermined relation to an intermediate limited range of discharge pressures; and means for controlling the supply of fluid at primary pressure to said throttle controller to prevent such supply until a discharge pressure is reached above said predetermined intermediate limited range but allowing the secondary pressure to be effective in the latter pressure range and above the same causing the fluid supplied to the throttle controller at full discharge pressure to supersede the fluid supplied to said throttle controller at secondary pressure.

3. In an engine driven fluid compressor having an unloading element adapted when operated to render the compressor ineffective, and a throttle valve controlling the engine fuel intake and movable toward and from a position setting a minimum speed for the engine, the combination of first fluid pressure means for operating said unloading element; second fluid pressure means for moving said throttle valve to minimum speed setting position; loaded pressure responsive means preventing operation of said first and second fluid pressure means until a predetermined high discharge pressure is attained; third fluid pressure means controlling movement of said throttle valve through a predetermined limited range of discharge pressures below said predetermined high pressure; means for at least initially controlling the rate of release of said unloading element to inactive conditions; and further fluid operated means for effecting wide variations in the force of said third fluid pressure means in response to relatively small variations in the discharge pressure within said predetermined limited range.

4. In an engine driven fluid compressor having a throttle valve controlling the engine fuel intake and movable toward and from a position setting a minimum speed for the engine, the combination of a pressure fluid operated throttle controller varying the speed setting of said throttle valve in response to variations in the discharge pressure, said throttle controller having an expansible chamber supplied with fluid of variable pressure; a pressure chamber in communication with said expansible chamber; means admitting pressure fluid to said pressure chamber at a substantially constant rate; variable fluid control means allowing the pressure fluid to escape from said pressure chamber at a rate inversely variable in amplified degree with respect to and in response to changes in the discharge pressure; fluid pressure operated means defining one limit of pressure range within said pressure chamber by maintaining the rate of flow of pressure fluid from said pressure chamber substantially constant until a predetermined discharge

pressure is reached; and independent pressure responsive means for opening said pressure chamber to atmosphere thereby to define the other limit of the pressure range within said pressure chamber.

5. In an engine driven fluid compressor having a pressure fluid operated unloading element adapted when operated to render the compressor ineffective, and a pressure fluid operated throttle controller for increasing and reducing the engine fuel intake to vary the speed of the engine; the combination of regulating apparatus controlling the supply of pressure fluid to said unloading element and said throttle controller and comprising a fluid operated pressure transformer for effecting wide variations in the pressure of the fluid supplied to said throttle controller in response to relatively small changes in the discharge pressure; means for limiting said transformer pressure to a peak corresponding by transformation to a discharge pressure which is less than the maximum discharge pressure; a loaded control valve for preventing the supply of pressure fluid to said unloading element until a predetermined maximum discharge pressure is reached; and means operable in response to the opening of said control valve for cutting off the supply of transformer pressure to said throttle controller and instead admitting to said throttle controller fluid at a pressure higher than the peak transformer pressure.

6. In an engine driven fluid compressor having a throttle valve controlling the engine fuel intake and movable toward and from a position setting a minimum speed for said engine, the combination of a pressure fluid operated throttle controller acting to press said throttle valve toward minimum speed setting position with an effect varying directly with the intensity of the fluid pressure supplied thereto, a fluid operated pressure regulator supplying fluid to said throttle controller at secondary pressures varying in correspondence with variations in the discharge pressure but to a greater degree, pressure means for moving the throttle valve to minimum speed setting position automatically upon the attainment of a predetermined high discharge pressure, an unloader device for said compressor, means for automatically operating said unloader device upon the attainment of a predetermined maximum discharge pressure, releasing means for disabling said pressure means upon a predetermined reduction of discharge pressure below said maximum pressure to permit the engine to change from idling to minimum working speed, and reloading means for disabling said unloader device, said reloading means being responsive to the operation of said releasing means automatically after a lapse of a predetermined time interval, whereby the compressor is prevented from reloading at or near the idling speed.

7. In an engine driven fluid compressor system having a compressor, compressor unloading means, a speed governor for the engine, a throttle valve controlling the engine fuel intake and movable reversibly through a range of minimum to maximum speed setting positions for said engine, and pressure fluid responsive means operable in response to changes in the discharge pressure in order to control the settings of said speed governor and of said throttle valve within a range of settings from maximum speed setting to minimum speed setting, the combination of limiting means including a fluid operated valve normally effective to limit the pressure fluid responsive

means to operation in response to a predetermined limited range of fluid operating pressures, a shiftable member moved in one direction by said pressure fluid responsive means and connected to said speed governor and throttle valve and cooperating with said fluid operated valve to cause said pressure fluid responsive means to operably control the settings of the speed governor and of the throttle valve through a range of settings extending from a point disposed a limited distance from maximum speed setting toward minimum speed setting to establish a maximum working speed and a low working speed above a minimum idling speed with a variable range of working speeds therebetween, an additional fluid operated valve capable upon operation of throwing the first mentioned fluid operated valve out of action, a loaded pressure fluid operated valve operative exclusively at a fluid discharging pressure considerably above said limited range of operating pressures to cause simultaneous operation of said unloading means and of said additional fluid operated valve and also further operation of said pressure fluid responsive means to bring both said speed governor and throttle valve beyond said limited range of speed settings to a minimum speed setting and reduce the speed of said engine and compressor to a minimum idling speed below said low working speed, said last mentioned pressure fluid operated means being capable of being restored to normal idle condition so as to release said unloading means preparatory to reloading of said compressor when the fluid discharging pressure drops approximately to said predetermined limited range and of allowing said fluid operated valve to resume control of the speed governor and the throttle valve and effect restoration thereof to the low working speed setting and to the limited range extending up from the latter speed setting to maximum speed setting thereof, and delaying means for temporarily delaying the effective closure or restoration of the released unloading means beyond the moment of actual resumption of control of said speed governor and throttle valve by said fluid operated valve, the last mentioned delaying means thereby allowing the engine to speed up from minimum idling speed to the low operating speed for reloading said compressor.

8. An engine driven fluid compressor system according to claim 7, in which the delaying means include a further pressure fluid responsive means associated with the unloading means for operating the latter, a pressure fluid connection from the pressure fluid operated means to said further pressure fluid responsive means, a one way valve capable when open, of allowing passage of pressure fluid through said pressure fluid connection in one direction from the pressure fluid operated means to said further pressure fluid responsive means but blocking return passage of fluid in the opposite direction from said further pressure fluid responsive means during release of said unloading means, and a small bypass means including a restricted fluid passage for allowing a limited return flow of pressure fluid from said further pressure fluid responsive means past said one way valve toward an escape orifice so as to allow gradual escape of said return flow of pressure fluid from the system.

9. In an engine driven fluid compressor system having a compressor, fluid pressure operated compressor unloading means, a speed governor for the engine, a throttle valve controlling the engine

fuel intake and movable reversibly through a range of minimum to maximum speed setting positions for said engine, and pressure fluid responsive means operable in response to changes in the discharge pressure in order to control the settings of said speed governor and of said throttle valve within a range of settings from maximum speed setting to minimum speed setting, the combination of a pressure fluid regulator capable of transforming relatively small changes in the original discharge pressure into wide secondary changes in the pressure of the pressure fluid supplied to the pressure fluid responsive means, limiting means including a fluid operated valve normally effective to limit the pressure fluid responsive means to operation in response to a predetermined limited range of fluid operating pressures, a shiftable member moved in one direction by said pressure fluid responsive means and connected to said speed governor and throttle valve and cooperating with said fluid operated valve to cause said pressure fluid responsive means to operably control the settings of the speed governor and of the throttle valve through a range of settings extending from a point disposed a limited distance from maximum speed setting toward minimum speed setting to establish a maximum working speed and a low working speed above a minimum idling speed with a variable range of working speeds therebetween, an additional fluid operated valve capable upon operation of throwing the first mentioned fluid operated valve out of action, a loaded pressure fluid operated valve operative exclusively at a fluid discharging pressure considerably above said limited range of operating pressures to cause simultaneous operation of said unloading means and of said additional fluid operated valve and also further operation of said pressure fluid responsive means to bring both said speed governor and throttle valve beyond said limited range of speed settings to a minimum speed setting and reduce the speed of said engine and compressor to a minimum idling speed below said low working speed, said last mentioned loaded pressure fluid operated valve being capable of being restored to normal idle condition so as to initiate the release of said unloading means preparatory to reloading of said compressor when the fluid discharging pressure drops to approximately said predetermined limited range and of allowing said fluid operated valve to resume control of the speed governor and of the throttle valve and effect restoration thereof to the low working speed setting and to the limited range extending up from the latter speed setting to maximum speed setting thereof, and delaying means including fluid restricting means for impeding release of operating pressure fluid from the unloading means and thereby temporarily delaying the effective closure or restoration of the released unloading means beyond the moment of actual resumption of control of said speed governor and throttle valve by said fluid operated valve, the last mentioned delaying means thereby allowing the engine to speed up from minimum idling speed to the low operating speed for reloading said compressor.

10. In an engine driven fluid compressor system having a compressor, compressor unloading means, a speed governor for the engine, a throttle valve controlling the engine fuel intake and movable reversibly through a range of minimum to maximum speed setting positions for said engine, and pressure fluid responsive means operable in

response to changes in the discharge pressure in order to control the settings of said speed governor and of said throttle valve within a range of settings from maximum speed setting to minimum speed setting, the combination of limiting means including a fluid operated valve normally effective to limit the pressure fluid responsive means to operation in response to a predetermined limited range of fluid operating pressures, a shiftable member moved in one direction by said pressure fluid responsive means and connected to said speed governor and throttle valve and co-operating with said fluid operated valve to cause said pressure fluid responsive means to operably control the settings of the speed governor and of the throttle valve through a range of settings extending from a point disposed a limited distance from maximum speed setting toward minimum speed setting to establish a maximum working speed and a low working speed above a predetermined minimum idling speed with a variable range of working speeds therebetween, said limiting means including escape valve means loaded to open at a pressure above said predetermined limited range of fluid operating pressures in which said pressure fluid responsive means is intended to operate, said escape valve means being effective at fluid pressures above said predetermined limited range, of allowing excess pressure fluid to escape from the system, auxiliary fluid operated valve means capable upon opera-

tion of shunting said escape valve means out of action, pressure fluid operated means comprising further valve means loaded to resist pressures ranging up to the maximum pressure range intended for the fluid discharging pressure and capable above said maximum pressure range of causing operation of said unloading means and of said auxiliary fluid operated valve means to shunt said limiting means out of action and also of bringing said speed governor and throttle valve beyond said limited range of speed settings to a minimum speed setting and thereby reduce the speed of said engine and compressor to a minimum idling speed below said low working speed, said last mentioned pressure fluid operated means comprising the further valve means being capable of being restored to normal idle condition so as to initiate the release of said unloading means preparatory to reloading of said compressor when the fluid discharging pressure drops to approximately said predetermined limited range of operating pressures and thereby allowing aforesaid fluid operated valve to resume control of the speed governor and of the throttle valve and effect restoration thereof to the low operating speed setting and the limited range extending up from the latter setting to maximum speed setting thereof.

ROBT. D. RHOADS.
RICHARD L. NASH.