Sept. 29, 1953 P. H. DAVEY 2,653,753

COMPRESSOR REGULATOR

Filed Dec. 19, 1946 3 Sheets-Sheet 1

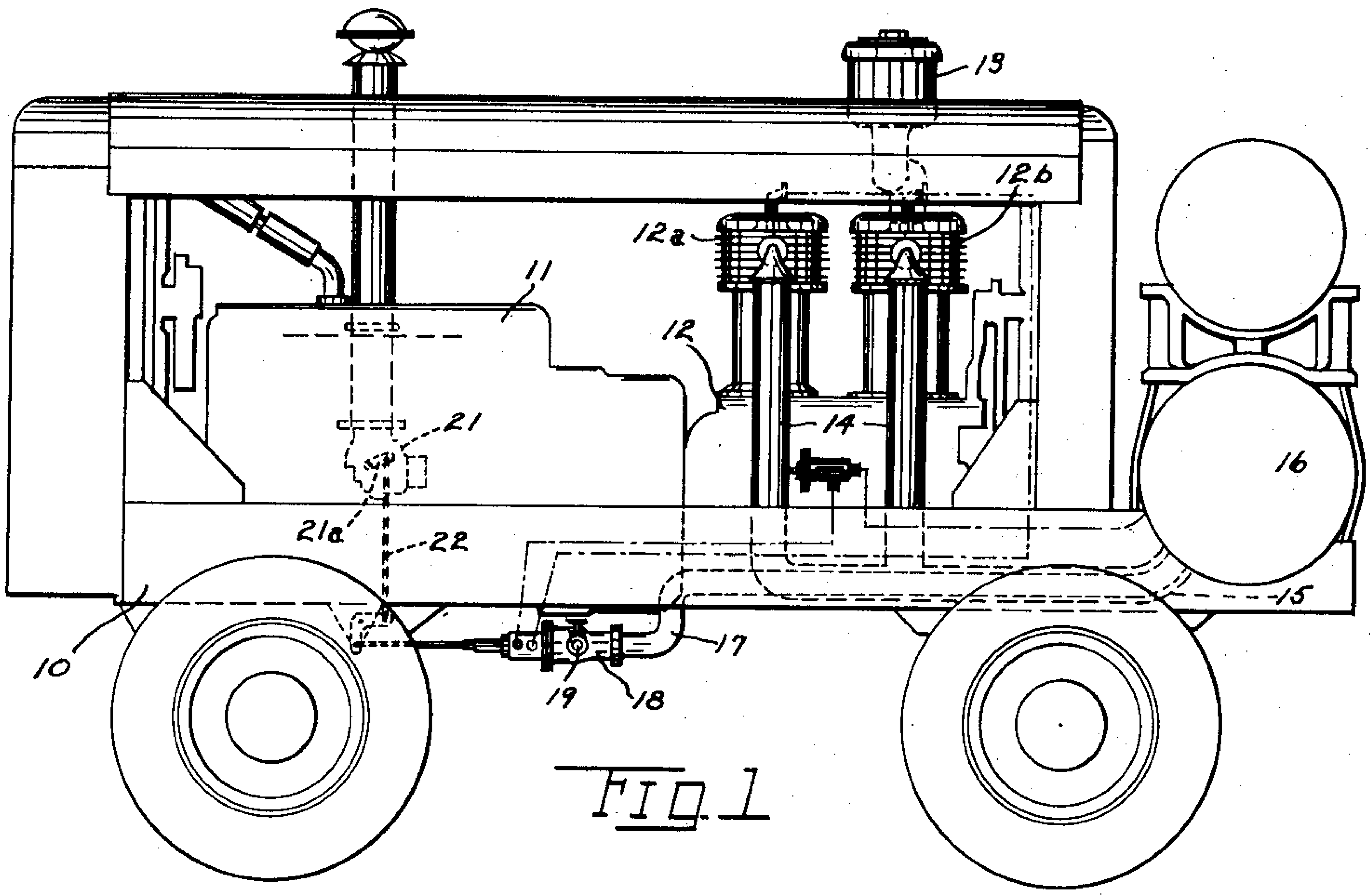

FIG. 1

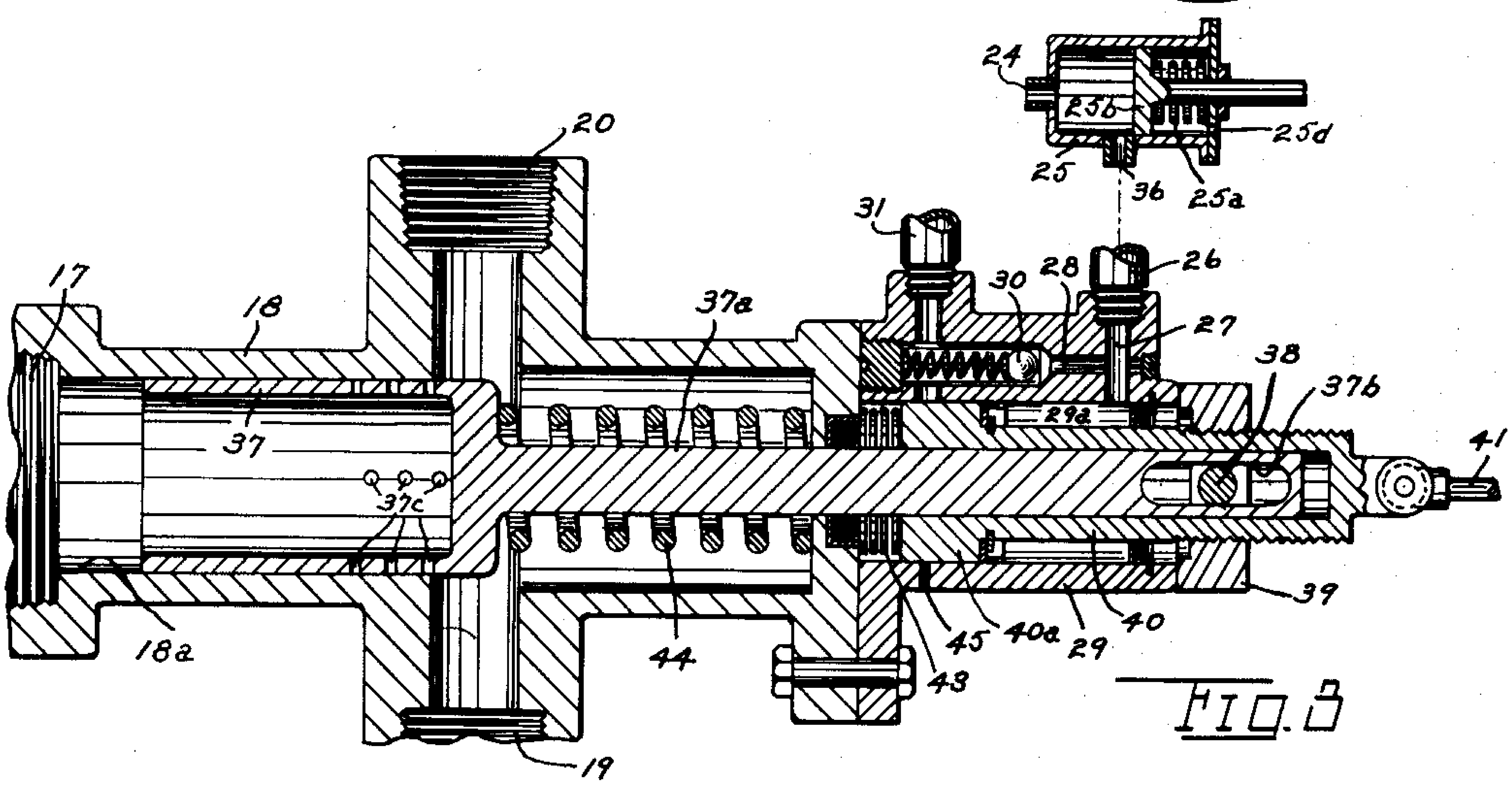

FIG. 3

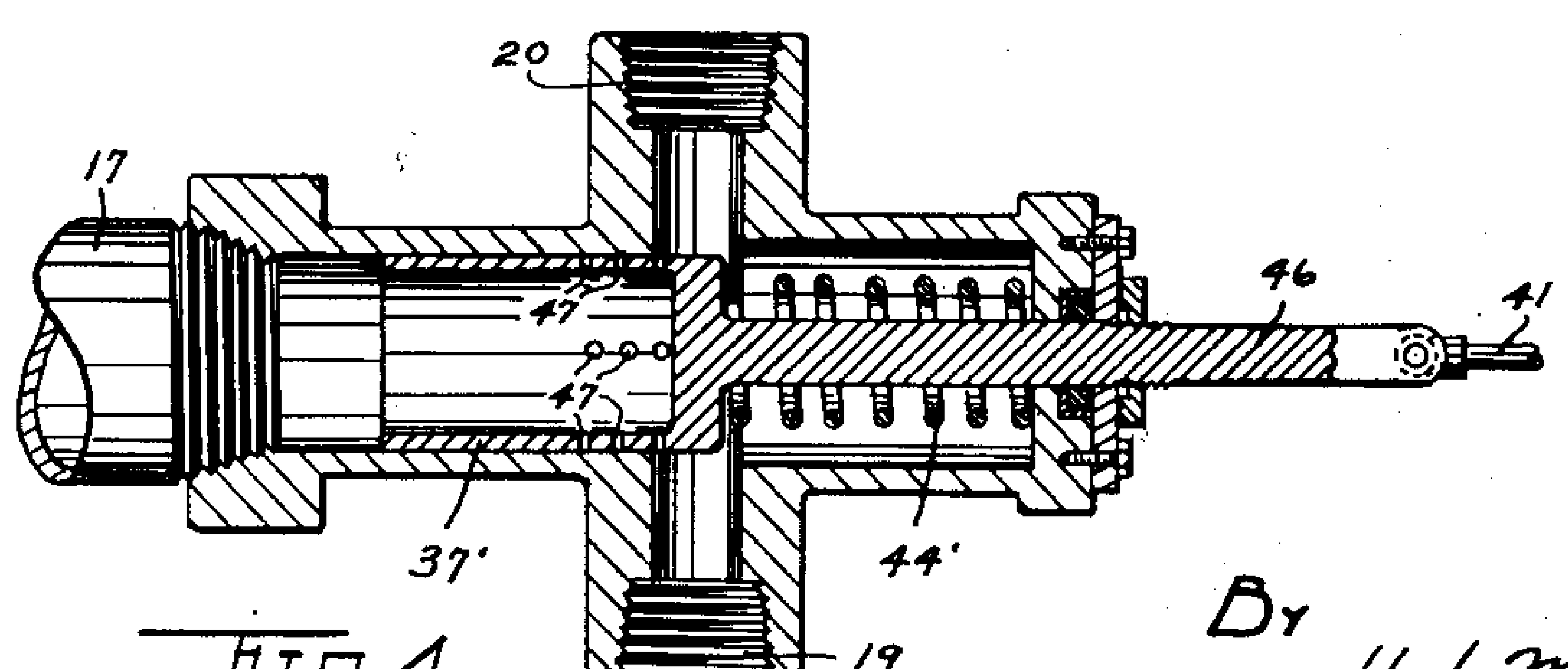

FIG. 4

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Sept. 29, 1953 — P. H. DAVEY — 2,653,753

COMPRESSOR REGULATOR

Filed Dec. 19, 1946 — 3 Sheets-Sheet 2

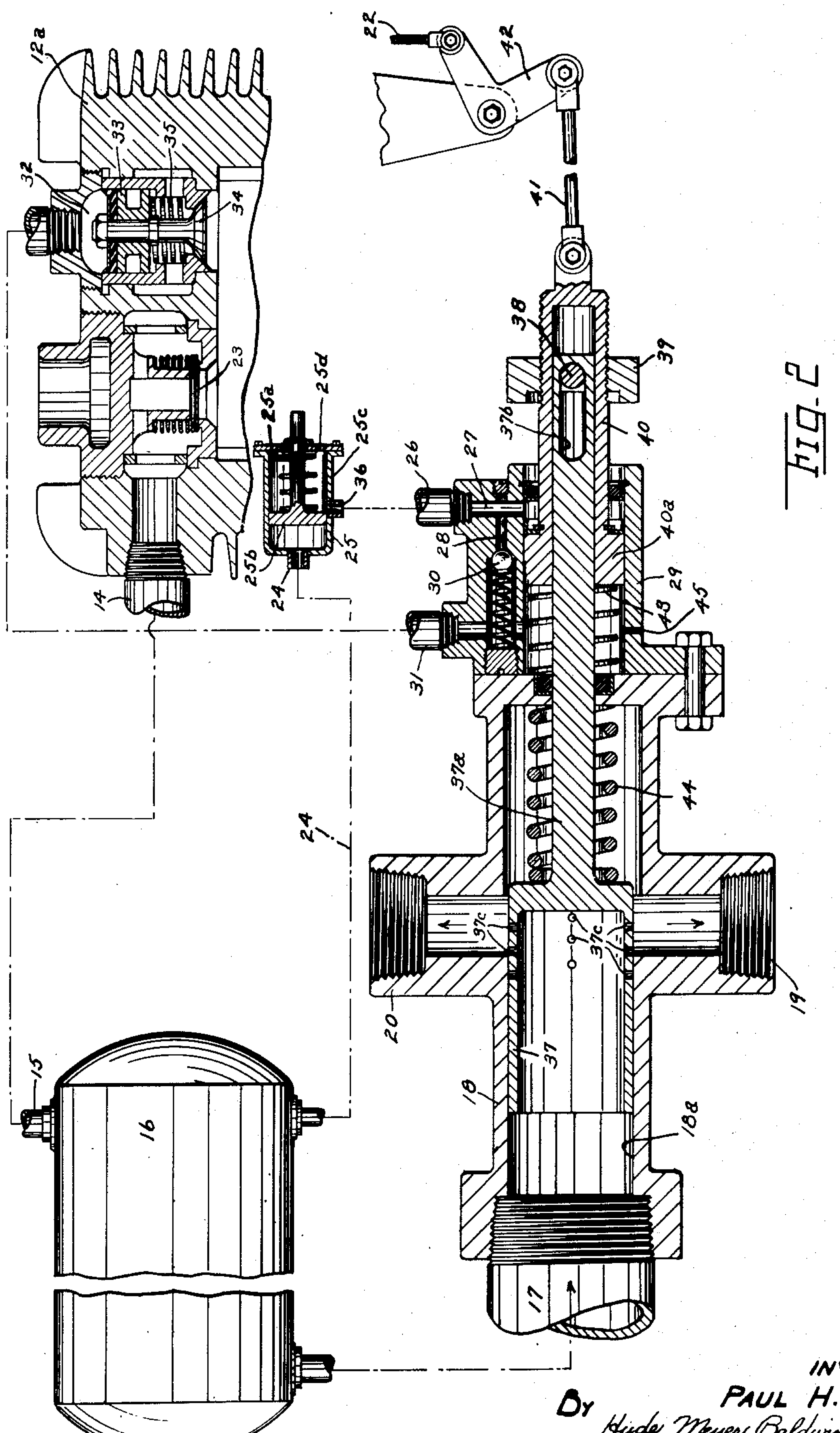

Fig. 2

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Sept. 29, 1953 P. H. DAVEY 2,653,753

COMPRESSOR REGULATOR

Filed Dec. 19, 1946 3 Sheets-Sheet 3

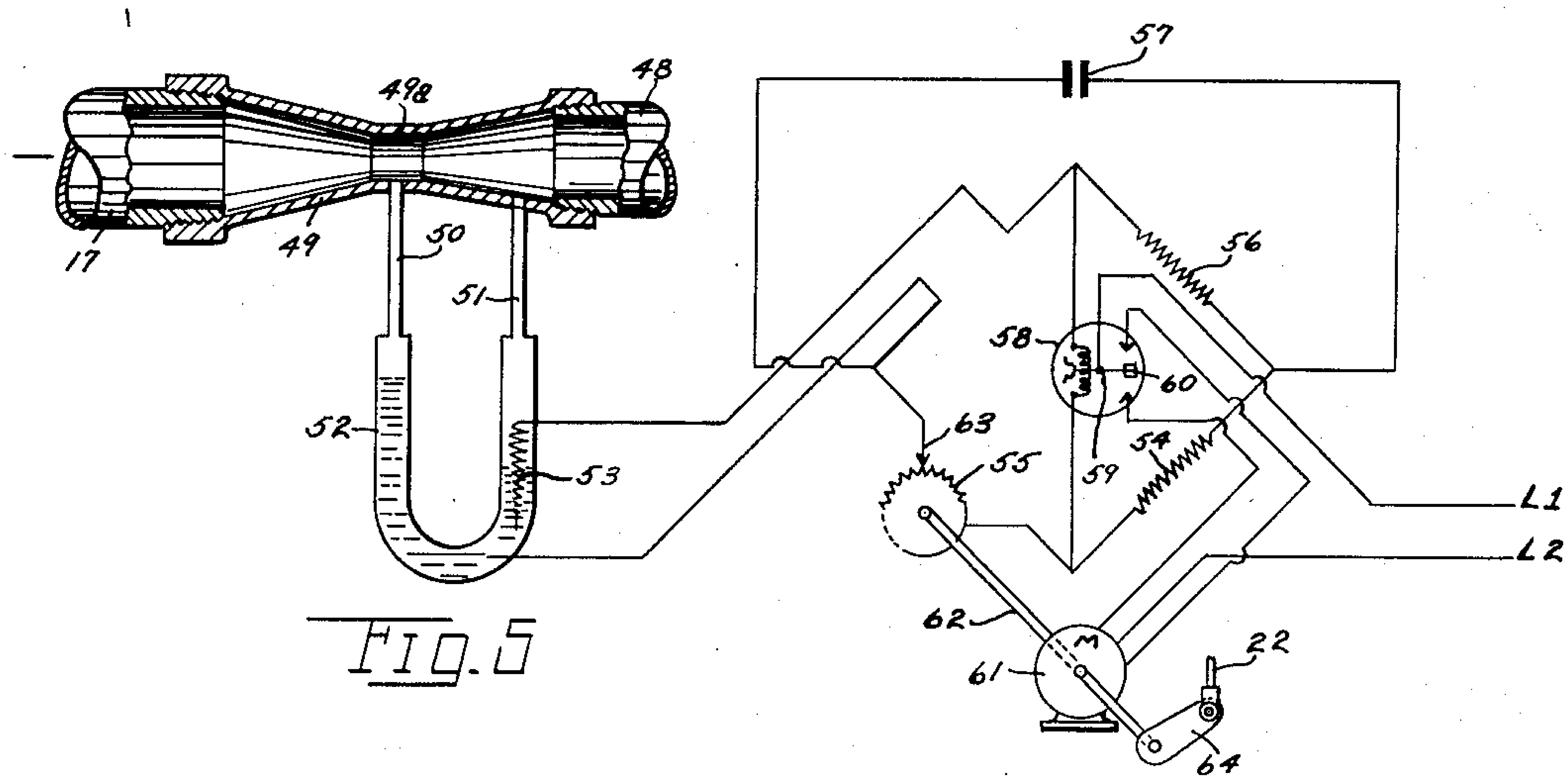

FIG. 5

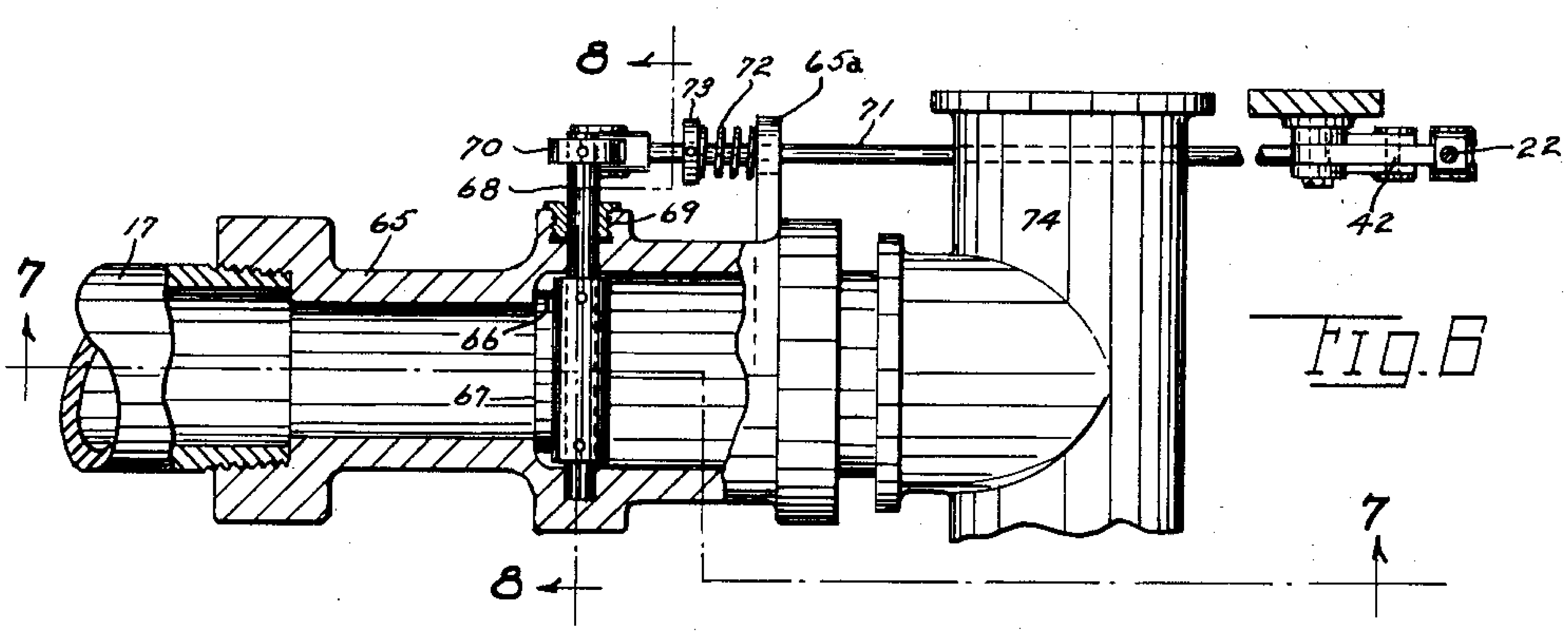

FIG. 6

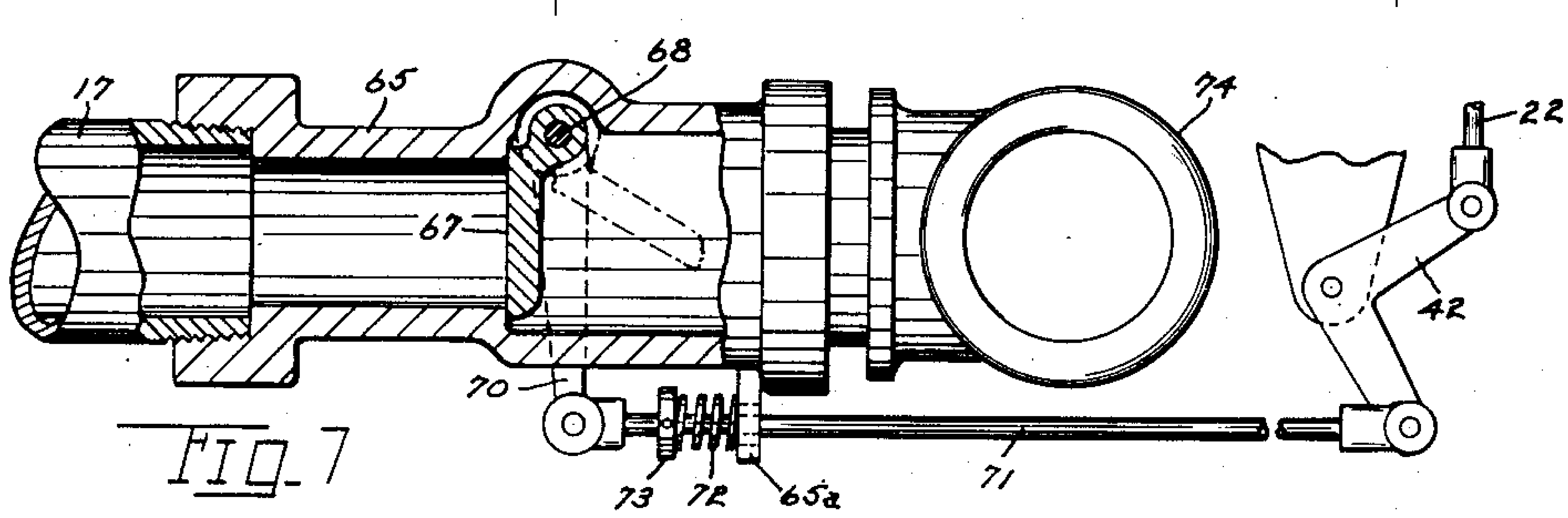

FIG. 7

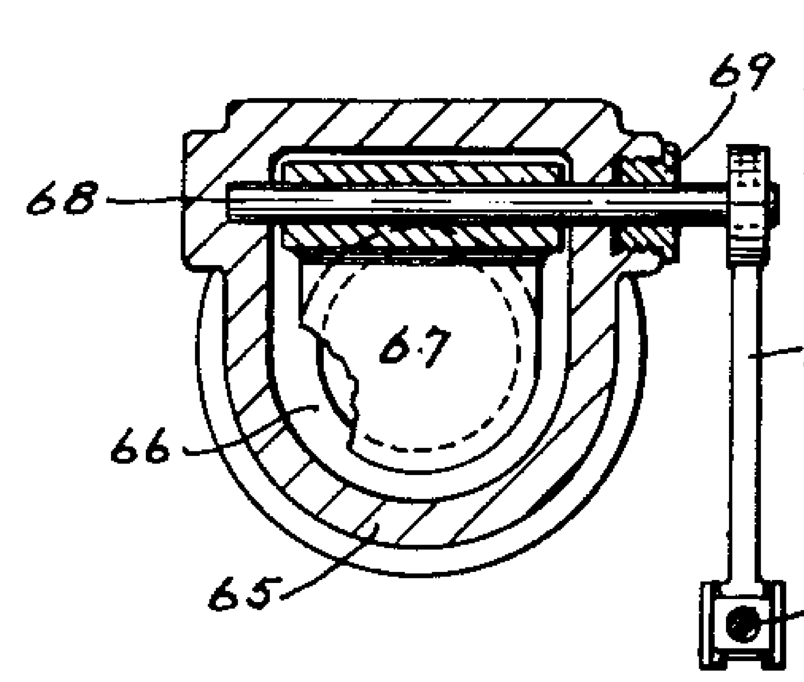

FIG. 8

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Patented Sept. 29, 1953

2,653,753

UNITED STATES PATENT OFFICE

2,653,753

COMPRESSOR REGULATOR

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Application December 19, 1946, Serial No. 717,103

2 Claims. (Cl. 230—10)

1

This invention relates to improvements in compressor regulators and more particularly, to improvements in control means for the prime mover driving a compressor and responsive to the requirements for compressed fluid.

An object of the present invention is to provide a device for controlling the speed of a compressor responsive to the demand for gaseous fluid as it is being used.

Another object of the present invention is to provide a device responsive to flow in a stream of compressed gas or air, and an operative connection between such a device and a prime mover for operating the compressor so that as the device is affected by greater or less flow of fluid in the line of the prime mover is speeded up or slowed down respectively.

Another object of the present invention is to provide, in combination with the above mentioned control device, a lost motion arrangement whereby the compressor may be slowed down independently of the position of said control device when such slowing down is desirable for some other reason such as, for instance, if the container for compressed fluid reaches a predetermined pressure.

Other objects and advantages of the present invention include novel arrangements of the parts and control connections for carrying out the above mentioned purposes as will appear from the accompanying drawings and description, and the essential features of which will be set forth in the appended claims.

In the drawings,

Fig. 1 is a side elevational view of a known type of air compressor equipped to utilize my invention;

Fig. 2 is a diagrammatic view showing the essential operating parts of Fig. 1 arranged so as to show their operative relationship with each other. The control device, responsive to flow of compressed air, is greatly enlarged relative to the other parts;

Fig. 3 is another view of a portion of Fig. 2 showing a different position of the parts;

Fig. 4 is a modified form of device for carrying out a portion of the functions described in connection with Figs. 2 and 3 and omitting the arrangement for slowing down the compressor upon the reservoir reaching a predetermined pressure;

Fig. 5 shows a further modification including a different arrangement responsive to flow in the compressed air line and an operative connection between the same and the prime mover control member including electrical connections;

2

Fig. 6 is a sectional view through a still further modification of my invention;

Fig. 7 is a sectional view of the same taken along the line 7—7 of Fig. 6; while

Fig. 8 is a transverse sectional view taken along the line 8—8 of Fig. 6.

I have chosen to disclose and describe my device as applied to a known type of air compressor driven by an internal combustion engine, but it should be understood that my control apparatus is equally adapted for use with any gaseous compressor and with other types of prime movers, as will be readily understood by those skilled in this art.

In Fig. 1 I have shown one form of compressor apparatus adapted to utilize my invention. On a wheeled chassis **10** there is mounted an internal combustion engine **11** which drives a compressor **12**, two cylinders of which are shown at **12***a* and **12***b*. The air to be compressed enters through an air cleaner **13** and after compression, passes through the lines **14** to line **15**, and then to a reservoir **16**. The air to be used is drawn from reservoir **16** through line **17** which passes through the housing **18** of the control device to outlets **19** and **20** for use at opposite sides of the vehicle. The fuel supply for the engine **11** passes through a carburetor indicated at **21** and the supply of fuel is controlled by the position of arm **21***a* which is connected by a rod **22** with my improved control apparatus.

Most of the prior devices known to me, controlling the prime mover driving a compressor of this type, operate in response to the pressure in a reservoir such as that shown at **16**. In a simple form of device the compressor is unloaded, or the prime mover driving the same is caused to slow down (or both) when the pressure in the reservoir reaches a predetermined value. In another well-known control the compressor is progressively slowed down in several steps as the pressure in the reservoir approaches a predetermined value. One of the difficulties with these devices is that they never supply the full volume of compressed air at the full pressure for which the apparatus is designed. In other words, the compressor is driven at full speed only when the pressure in the receiver is something less than the full pressure for which the apparatus is designed. One of the advantages of my invention is that it supplies a full volume of fully compressed air when full volume is demanded, and supplies at all times a substantially steady volume at the same rate as demanded.

As indicated in Fig. 2, I have illustrated a compressor cylinder, say 12a, of the free air unloading type. The compressed air normally passes out of the cylinder through valve 23 to the line 14 on its way to the reservoir 16. A line 24 leads from the reservoir through a pressure responsive valve 25 to line 26 and thence through passageways 27 and 28 in the housing 29, and through a spring pressed check valve to line 31 which leads to chamber 32 above piston 33 which controls the unloading valve 34 which in turn is normally held closed by the spring 35. The spring 25a of valve 25 is set for a predetermined value so that when reservoir 16 has reached a predetermined pressure it will drive the piston 25b backward or toward the right, as viewed in Fig. 2, so as to uncover port 36 leading to line 26. There will now be a flow of compressed air through valve 30 and line 31 to the chamber 32. This drives piston 33 downwardly opening valve 34 so that the compressor is unloaded and the pistons move up and down without compressing any air. The operation of this unloading valve is tied in with my novel control, as will later appear.

Means is provided within the housing 18, responsive to the demand for compressed air, to speed up the engine 11 when more air is being used, or to slow down the engine when less air is being used. This device is placed in line 17 which leads out of the reservoir 16, but it should be understood, that the principle of my invention permits its use in any line, subject to the flow of air required by the tools or other apparatus for its utilization.

To accomplish the above purpose, I have formed the passageway 18a, of the housing 18, into a cylinder which is fitted with a reciprocating piston 37. This piston is connected with the rod 22 which controls the carburetor 21 in a novel fashion. The piston rod 37a has a slot 37b in its outer end in which rides a pin 38 which is integral with a stop collar 39 which in turn is threaded on a sleeve 40, the outer end of which is pivotally connected with a link 41 which in turn operates a bell crank 42 which is pivotally connected with the rod 22. The sleeve 40 carries a piston 40a which is mounted for reciprocation in the hollow portion of the housing 29. The piston 40a is urged toward the right as viewed in Figs. 2 and 3 at all times by a light spring 43. The piston 37 is urged toward the left at all times by a strong spring 44. There are provided a plurality of openings 37c through the walls of piston 37 and adapted to be uncovered progressively as piston 37 moves toward the right, as viewed in Figs. 2 and 3. Here, the cylinder wall 18a is imperforate and the piston 37 is perforated. Obviously, this construction could be reversed so that the piston 37 was imperforate and uncovered flow openings in the cylinder wall 18a as the piston moved toward the right. In either case, when air is used out of either of the branches 19 or 20 the pressure becomes less on the right-hand face of piston 37 so that the greater pressure on the left-hand face forces piston 37 toward the right against the action of spring 44 until sufficient of the openings at 37c are uncovered to permit the flow of air required The greater the demand for air, the farther piston 37 will move toward the right and then more of the openings 37c will be uncovered. With the spring 43 maintaining pin 38 in the right-hand end of slot 37b, obviously the sleeve 40 will move back and forth responsive to the movements of piston 37 and the connection with the carburetor is such that it speeds up the engine 11 as rod 22 moves upwardly. Thus, as piston 37 moves toward the right it increases the speed of engine 11 and as piston 37 moves toward the left it causes a slowing down of engine 11. Thus, in normal operation, the greater the requirement of compressed air, the faster the engine 11 will drive the compressor. In practice, the parts are so constructed that the engine drives the compressor at a rate that about equals the demands for air. This is in contrast with the usual custom of alternately driving the compressor at full speed and then causing it to idle.

The operation of the unloading valve will now be apparent from a study of Fig. 3. Here the pertinent parts of Fig. 2 have been reproduced, it being understood that the other connections are like those already described. Whenever the pressure in reservoir 16 reaches a predetermined value so that it is transmitted through line 24 to the piston valve 25 at a great enough pressure to overcome spring 25a, piston 25b will be moved to the position shown in Fig. 3 and compressed air will flow through port 36 and line 26 to the housing 29. Flowing through passageway 27 it will fill the chamber 29a driving piston 40a toward the left, as shown in Fig. 3 against the tension of spring 43. Regardless of the position of piston 37, piston rod 37a and the slot 37b, the sleeve 40 will move toward the left impelled by piston 40a until stop collar 39 strikes the housing 29, as shown in Fig. 3. The lost motion of pin 38 in slot 37b permits this action to take place. This movement of sleeve 40 carries link 41 toward the left so as to move bell crank 42 in a clockwise direction which pulls down on rod 22 so as to operate the carburetor 21 to slow down the engine 11. Thus, at the same time that air flows through check valve 30 and line 31 to unload the compressor it moves piston 40a to cause a slowing down of the engine 11.

Regardless of the position of piston 37, if the pressure in receiver 16 falls below a predetermined point when the parts are in the position of Fig. 3, the spring 25a will overcome the air pressure acting upon piston 25b so as to return it to the position shown in Fig. 2 so that line 26 then communicates through port 36 with the chamber 25c and exhaust port 25d. Immediately, the air pressure is relieved in passageways 27 and 28 and the ball check valve 30 will close. The air is momentarily trapped in line 31 and chamber 32 so that valve 34 will remain open for a short period of time. Air is immediately evacuated from the chamber 29a as spring 43 returns piston 40a from the position of Fig. 3 to that of Fig. 2. Regardless of the position of piston 37 this will speed up the engine by again moving rod 22 upwardly as previously described. As piston 40a moves toward the right it uncovers a small port 45. This permits the escape of trapped air from line 31 and chamber 32 so as to permit spring 35 to close valve 34 and the compressor will again compress air. This arrangement causes the engine to speed up slightly before the load is placed on the compressor.

In Fig. 4 I have shown a modification wherein the control device is arranged to speed up the compressor when more air is used and to slow down the compressor when less air is used but without the features described in connection with the unloading valve 34. In other words, the piston 37′ moves toward the right as more air is required at the outlets 19 and 20 so as to cause the piston rod 46 to move toward the right. Here the piston rod is connected with link 41 which leads through bell crank **42** to the carburetor control rod **22** as previously described. The greater the requirement of air, the more holes **47** will be uncovered and the farther piston **37′** will move toward the right to speed up the compressor. Obviously, when less air is used, spring **44′** will move piston **37′** toward the left, a viewed in Fig. 4, until the number of openings **47** uncovered is just sufficient to take care of the air required in use. This will slow down the compressor to that speed necessary to supply the demand for air.

In Fig. 5, I have shown a modification wherein a different sort of device is provided in the line **17** subject to the quantity of air flowing through line **48** to a point of use. I have shown a Venturi tube **49** having a throat **49***a*. Pressure lines **50** and **51** lead respectively from the throat and mouth of the Venturi tube to a differential pressure manometer **52** filled with mercury or other electrically conductive liquid. In one leg of the manometer I have mounted resistance **53** so that the greater the flow through the Venturi tube **49** the more of resistance **53** will be exposed, in other words, its electrical resistance value will be increased. This resistance is in one leg of a Wheatstone bridge arranged so that the product of **53** times **54** is equal to the product of variable resistance **55** times **56**. The current for the bridge is supplied through battery **57**. A galvanometer armature is pivotally connected at **59** and carries contacts **60** adapted to close an electric circuit from source L1 through motor **61** to the source L2. The motor is reversible so that it is driven in opposite directions depending on the direction of movement of the contacts **60**. This is a well known form of device for causing motor **61** to follow the variations of resistance **53**. The motor is connected through shaft **62** with arm **63** so as to vary the resistance **55** to bring the bridge into balance after each variation of resistance **53**. Motor **61** through shaft **62** also oscillates the lever arm **64** which is connected to the carburetor control rod **22** previously described.

The operation of the modification of Fig. 5 should now be apparent. As flow increases in the Venturi tube **49** the electrical value of resistance **53** is increased causing motor **61** to operate in a direction to increase the value of resistance **55** in the bridge circuit. This causes lever arm **64** to move in a counterclockwise direction which raises rod **22** and speeds up the engine **11**. Conversely, when the flow is decreased in the Venturi tube the motor **61** will move in the opposite direction so as to pull down on rod **22** and cause a slowing down of the compressor.

It will be noticed in Fig. 5 that line **51** leading to the manometer is subject substantially to the static head in the line **17** connected with the compressor receiver. It is a well known fact that in a Venturi tube the static head at the outlet side of the Venturi tube is substantially the same as at the inlet side thereof. The line **50** connected to the throat of the Venturi tube is a rough measure of the velocity head developed at the throat **49***a* corresponding to the flow of fluid through the throat of the tube. Thus, the manometer of Fig. 5 is a differential device having two sides, one side being substantially responsive to a pressure the same as the receiver pressure and the other side being responsive to a pressure which is generally in step with the velocity of the compressed fluid flowing to the using device connected to the pipe **48**.

The modification shown in Figs. 6, 7 and 8 shows still another manner in which my invention may be utilized. The line **17** previously described is connected to a valve body **65** which provides a valve seat **66** which is adapted to be closed by a butterfly valve **67** which is rigidly secured to a shaft **68** rotatably mounted in the valve body. Suitable packing is provided at **69** where the shaft emerges from the valve body. A lever arm **70** is mounted to move with the shaft **68** responsive to the movement of valve **67**. A link **71** connects the arm **70** with the bell crank **42** previously described. A spring **72** held between a bracket **65***a* on the valve body and a collar **73** on the link **71** normally urges the valve **67** toward closed position.

The operation of this last described modification should now be apparent. When air is called for by a tool connected to one of the outlets **74**, valve **67** is opened by the greater pressure on the left-hand side thereof as viewed in Figs. 6 and 7, so that it moves to the dot-dash position indicated in Fig. 7. The amount of opening of the valve **67** will be roughly proportional to the volume of air demanded by the working tool. Therefore, the greater the demand for air the more valve **67** will be moved in a counterclockwise direction, as viewed in Fig. 7, and the more the link **22** will be raised in the direction to speed up the engine driving the compressor. Thus, at any given demand for air, the engine will be speeded up to approximately the point to fulfill that air demand without the repeated sudden acceleration and deceleration generally encountered in compressors using presently known types of controls.

What I claim is:

1. In apparatus comprising a gaseous fluid compressor and a prime mover for operating the same and a line for the flow of compressed gaseous fluid for use, the combination of a control member controlling the speed of said prime mover, a Venturi tube in series in said flow line, a differential pressure manometer having its legs in communication respectively with the throat and mouth of said tube, an electrically conductive liquid in the legs of said manometer, an electrical resistance partially submerged in said liquid in one of said legs, an electric motor for moving said control member, and electrical means responsive to variations in said resistance for operating said motor, said manometer and resistance being connected to cause said motor and control member to increase compressor speed as flow rate increases through said Venturi tube.

2. In apparatus, comprising a gaseous fluid compressor and a prime mover for operating the same and a receiver for storing the compressed fluid and an outlet line from the receiver for the flow of compressed fluid for use, the combination of a control member controlling the speed of said prime mover, a differential device operatively connected with said control member to control the speed of said compressor in step with the flow of compressed fluid for use, said differential device having two sides balanced against each other, one side thereof in the outlet line of said receiver substantially responsive to receiver pressure and the other side thereof responsive to a pressure generally in step with the velocity of compressed fluid for use, and said device responsive to the differential of said pressures on its two sides, said differential device being connected to cause said pressure differential to increase with increase in fluid flow rate from said compressor, and means for causing

said device to move said control member to cause increase in compressor speed as said fluid flow rate increases and to cause decrease in compressor speed as said fluid flow rate decreases.

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