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3,427,928

COMPRESSED AIR-OPERATED DRIVE-IN APPARATUS TO DRIVE-IN FASTENERS

Filed July 6, 1966

Sheet 1 of 5

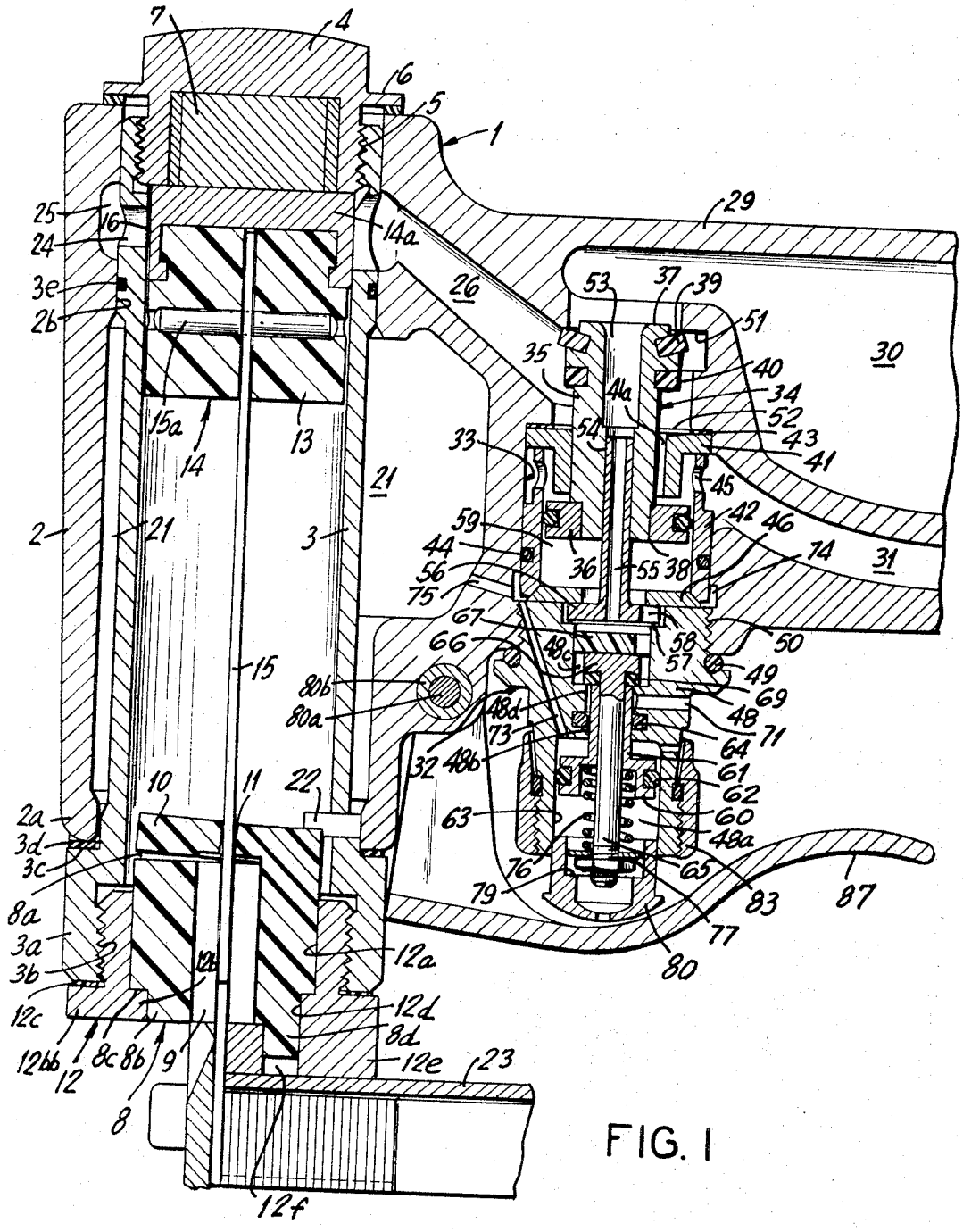


FIG. 1

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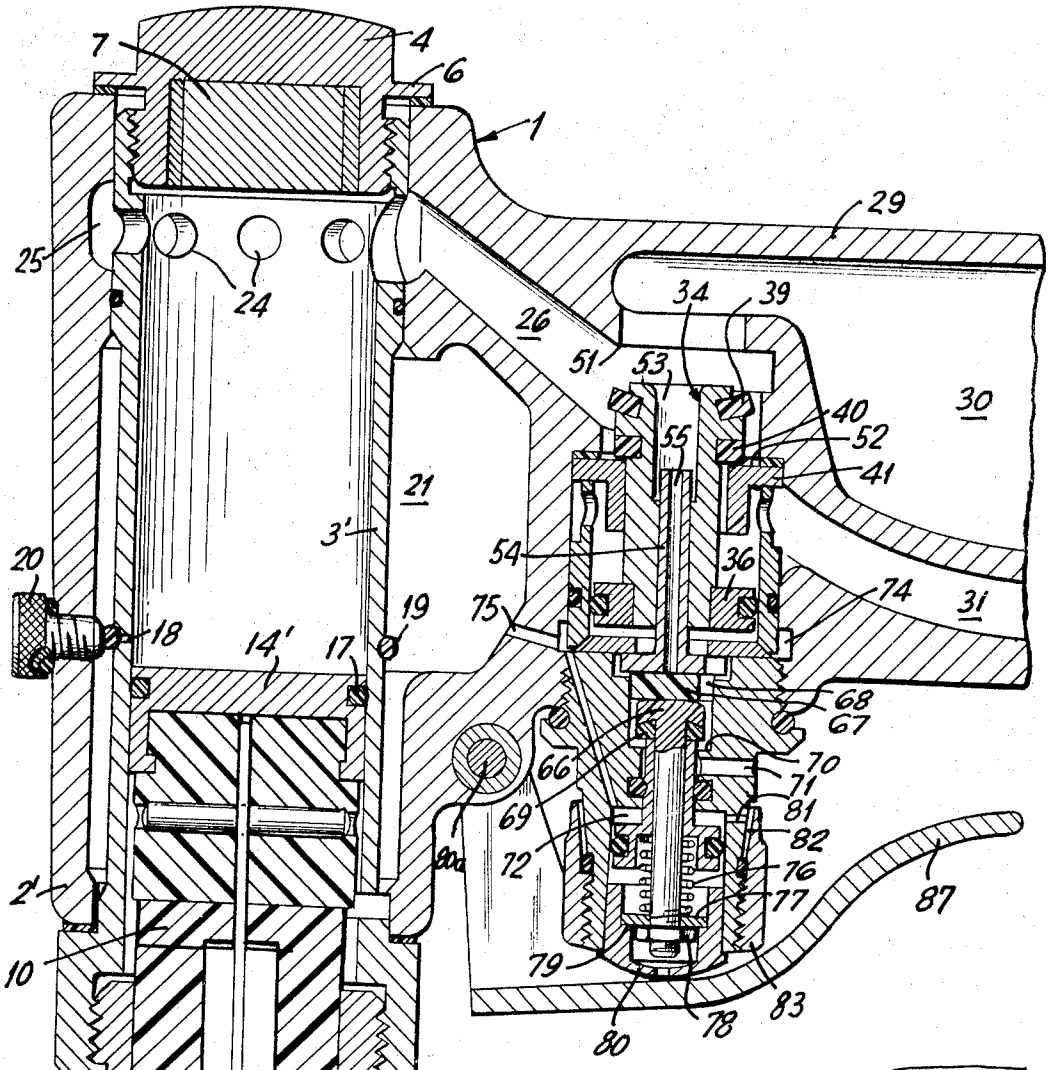


FIG. 2

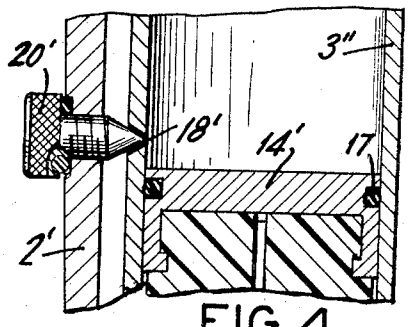


FIG. 4

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Sheet 3 of 3

FIG. 5

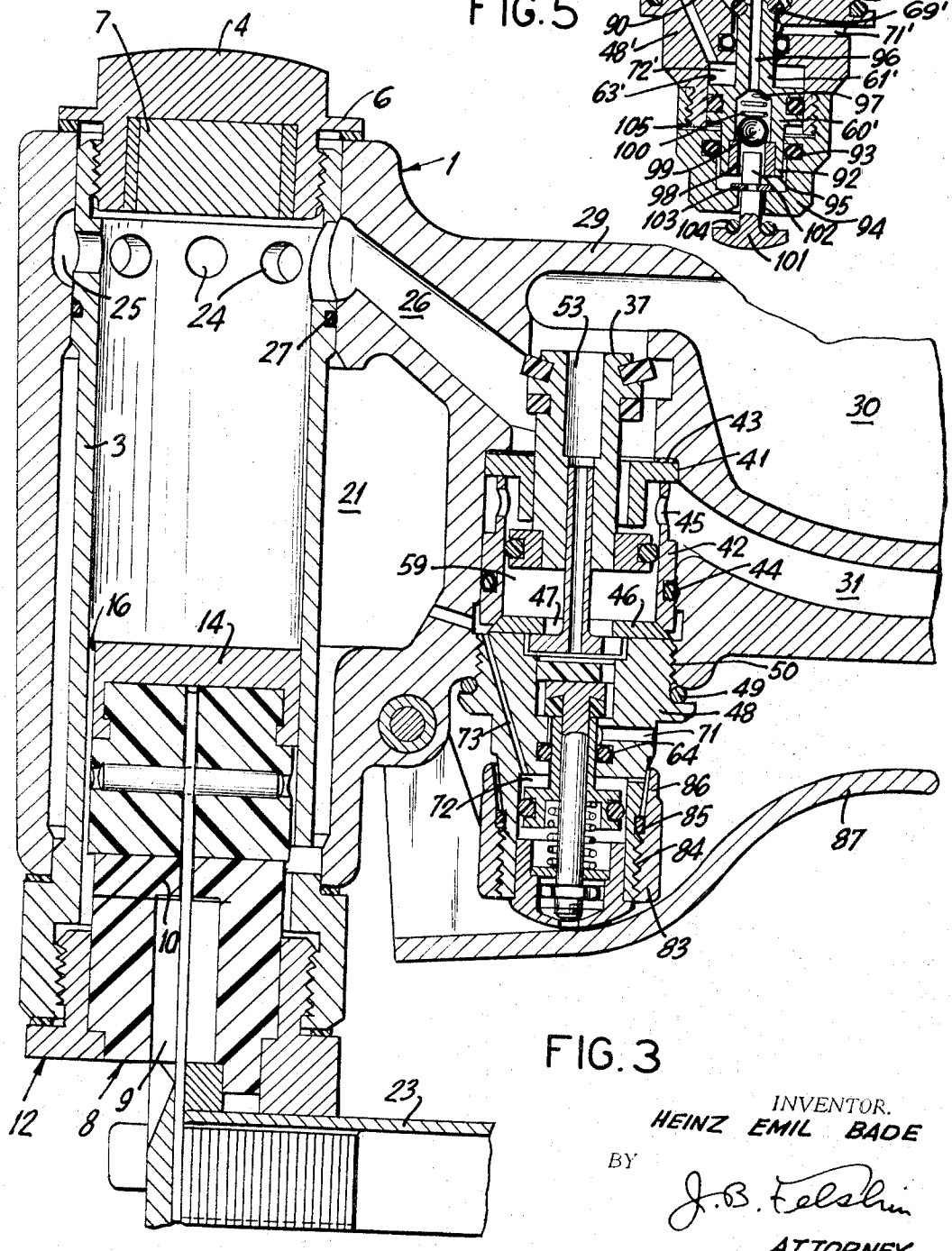


FIG. 3

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U.S. Cl. 91—305 22 Claims
Int. Cl. F15b 11/15; B25c 5/06, 5/10

ABSTRACT OF THE DISCLOSURE

The pneumatic fastener driver embodying the invention comprises a body formed with a cylinder. A working piston in the cylinder carries a fastener drive ram and is movable in said cylinder away from retracted position in a fastener drive direction to a predetermined fully driven position and back to said retracted position. A trigger is mounted on the body for movement from a normal position to an operating position and back to normal position. Compressed air operated means controlled by movement of said trigger away from its operating position automatically causes the working piston to repeatedly move in a fastener driving direction away from retracted position to fully driven position and back to retracted position, a number of successive times continuously while said trigger remains in operating position, and to terminate said repeated back and forth movement of said working piston upon said trigger moving back from its operating position to its normal position.

The invention relates to a compressed air-operated drive-in apparatus to drive in fasteners, for instance nails, staples or the like, in particular, a controlling organ to control the drive-in apparatus, said controlling organ being designed in such a manner that it is possible on the one hand to release the drive-in step singly for each fastener by the actuation of a releasing means and, on the other hand, to drive in fasteners in a sequence with only once actuating the releasing means.

Compressed air-operated drive-in apparatuses to drive in fasteners are pre-known in many embodiments. With these known apparatuses, each drive-in step must be released singly by actuating a releasing means effective on the control valve. This necessitates a limitation of the working speed with such apparatuses which, in many fields of application, is considered disadvantageous. Practical requirements thus are directed to drive-in apparatuses adapted to be used with both single operation and sequential drive-in operation.

Pneumatically operated tools continuously completing the normal working cycle after the releasing means has been actuated only once, until the actuation of the releasing means is interrupted, are already known. Pneumatically operated drive-in apparatuses, for instance, are working in the above manner. With these pre-known apparatuses, however, it is not the point to make the working piston reach two end positions in each drive-in operation which is a requirement with pneumatically operated drive-in apparatuses for fasteners because, on the one hand, the fasteners must be driven in completely because of which it is necessary that the working piston reach the one end position and, on the other hand, it is possible to seize a fastener to be taken along during the next drive-in stroke only when the piston is completely returned between two drive-in operations.

Besides, a pneumatically actuated drive-in apparatus has already become known by means of which fasteners may be driven in selectively in an uninterrupted sequence

with only one actuation of the releasing means or singly in a conventional operation. The difficulty of the complete return of the piston having to be effected before the next drive-stroke is performed, in this apparatus is solved by means of a time delay caused in the renewed compressed air bias on the control slide of the control valve by means of a throttle which is known also in connection with other pneumatically operated devices, wherein the compressed air bias to be effective on the working piston and required for the following drive-in stroke is effected by said piston when in the completely retracted position striking against an actuation member of the control valve and displacing it. This known arrangement must be considered as being highly unsatisfactory inasmuch as to solve the problem which is simple in itself, an extremely complicated control valve mechanism is employed which, in addition, is actuated by the working piston in its end position. This complicated control valve arrangement is not only expensive in manufacture but is in addition extremely susceptive to trouble. What has to be looked upon as being a particular disadvantage with this known apparatus, however, is that the working piston returns to its upper end position and may perform a new drive-in stroke regardless of whether the drive-in step was performed properly or not. As with improper performance of the drive-in stroke the upper end of the fastener still is present in the guide passage of the apparatus, the apparatus cannot be moved onward, and the fastener which is ejected during the next drive-in stroke strikes against the backside of the preceding fastener. Consequently, the guide passage may be clogged and the apparatus may possibly be damaged.

As opposed to the known arrangement, it is the object of the present invention to provide a pneumatically operated drive-in apparatus to drive-in fasteners, in particular to provide a control organ to actuate such a drive-in apparatus, said control organ selectively allowing for fasteners to be driven in sequentially in an uninterrupted succession of drive-in strokes after having once actuated the releasing means or in single operation, while comprising no mechanical control means cooperating with the working piston, respectively, and being simple in construction and thus inexpensive to manufacture.

Starting from a compressed air-operated drive-in apparatus to drive in fasteners such as nails, staples or the like, comprising a working piston guided for reciprocating movement in a working cylinder and a control valve controlling the compressed air bias of the working piston which may be influenced by the releasing means of the apparatus and comprises a pneumatically actuated valve member connecting the working cylinder with the compressed air line for operation when vented to the rear, and when biased with compressed air from the rear, connecting the working cylinder with an outlet line while closing the compressed air line for operation, and in case of actuation of the releasing means for permanent operation, automatically establishing the connection of the working cylinder with the compressed air line for operation whenever the piston has completed its return stroke, by discharging the rear side compressed air bias, the solution to the problem posed consists in that the rear side of the valve member is directly connected with the compressed air line for operation via a passage, and the compressed air bias or venting thereof, respectively, is controlled by means of a control piston which, when the release means is actuated, reaches a first end position in which the rear side biasing space of the valve member is shut-off from the compressed air line for operation, and vented; which furthermore at the end of the drive-in stroke of the working piston is connected with the compressed air line for operation and thereby is biased to a position connecting the rear side biasing space of the valve mem-

ber with the compressed air line for operation while at the same time closing the venting thereof, against a force released by the releasing means, and upon completion of the working piston return movement automatically returns to its first position releasing another drive-in stroke, under the influence of the force released by the releasing means.

Because of this arrangement, it is secured that reversal of the valve member which is formed as a differential piston, on the one hand, to a position closing the working cylinder from the compressed air line for operation and connecting it to the drain line, and on the other hand, to the position releasing the renewed compressed air bias of the working piston always is effected only after the working piston has reached its lower or upper end position, respectively. It must be considered as being especially advantageous that the control valve arrangement according to the proposal of the invention may be arranged completely separate from the working cylinder and at a location of the apparatus remote from said cylinder.

In a suitable further development of the invention the control piston forms a pressure chamber together with the cylinder bore receiving it, said pressure chamber being in direct communication with the chamber for the working piston return air via a channel. This pressure chamber of the control piston which may be biased with return air from the return air chamber for the working piston suitably may be provided with a venting passage provided in turn with an adjustable outlet throttle. In this arrangement, in accordance with another feature of the invention, the outlet throttle consists of a threaded sleeve concentrically surrounding the housing of the control piston and comprising a portion provided with a conical inner bore, said portion covering the outlet opening of the venting passage terminating in a conical outer surface of the control piston housing with adjustable radial space, so that compressed air in a more or less throttled condition may flow out of the control piston pressure space via the annular gap formed between the conical inner bore of the threaded sleeve and the conical outer surface of the control piston housing. As a result of this measure, a pressure effective on the control piston is building up in the control piston pressure space with an adjustable delay in time when the pressure space is biased with return air from the return air storage.

It is the function of the control piston on the one hand to shut off the compressed air bias for operation on the rear side of the valve member and, on the other hand, to vent the rear side bias chamber of the valve member. For this purpose, there is a valve plate provided between the head of the control piston and a sealing surface which, with the control piston axially displaced, will shut off the compressed air supply to the rear side biasing chamber of the valve member. In addition, there is a sealing ring arranged on the control piston which shuts off the venting passage of the above mentioned pressure space when the compressed air chamber is connected with the compressed air conduit for operation, however, with compressed air conduit for operation being shut off will release the venting channel with no delay.

In a further and suitable embodiment, the control piston may be connected with a releasing bushing of the apparatus via a preloaded spring, said releasing bushing with the releasing means being actuated transferring the displacement force onto the control piston, however, with the control piston being biased which is effected directly from the compressed air line when the working piston is in its lower end position, being compressed with piston return air from the return air chamber, thus making possible displacement of the control piston in such a manner that said control piston releases the connection of the compressed air line for operation with the rear side pressure chamber of the valve member for biasing same. The control piston spring preferably is formed as a coil spring

concentrically encompassing a tie rod rigidly connected with the control piston and adjustably preloaded between an end face of the control piston and a pressure ring. The pressure ring is located on the tie rod by means of a nut to accommodate the preload of the spring, but when the spring is compressed in a direction towards the control piston is supported axially displaceably with respect to the tie rod and has the outer edge thereof engaging in a flange of the release bushing such that the control piston with the tie rod may be axially displaced with respect to the release bushing under compression of the return spring.

The control piston may also be formed as a differential piston with the rear side thereof being adapted to be biased with compressed air, said rear side compressed air bias being controlled from a release pin and the two biasing surfaces of the control piston being designed in such a manner that the displacing force stemming from the working piston bias via the return air chamber outweighs the rear side bias. For this purpose a passage communicating with the compressed air conduit for operation may extend through the control piston in an especially simple manner, with a valve arranged in said passage which is kept in a closed position by the compressed air present in the passage and may be lifted from its seat by means of the releaser. The valve may also be kept in its closed position by an additional pressure spring. The rearward pressure chamber of the control piston may be provided with a venting channel, which, when the release pin is actuated is blocked by means of a sealing ring connected with the release pin and when the release pin is not actuated is opened.

It has been found to be especially advantageous if the working piston is guided within the working cylinder with a slight radial play in such a manner that at the end of the working stroke compressed air may pass by the working piston and flow into the return air reservoir connected with the lower end of the working piston. The working piston may also be provided with an axial groove through which, with the piston upper side biased by compressed air, compressed air may flow to bias the return air chamber when the piston is in its lower end position. In a further development of the invention, the working piston may also be guided sealingly in the working cylinder, for instance, with the aid of an O-ring seal, and there may be at least one radial passage bore provided in the cylinder wall which, with the piston in its lower end position connects the cylinder innerspace with the return air chamber but immediately the piston commences its return stroke is closed by the piston jacket. The opening cross sectional area of this passage bore radially extending through the cylinder wall may be adjustable, for instance, by the passage bore conically widening inside the cylinder wall and an adjusting screw received by a threaded bore in the cylindrical housing having a cone-shaped peak engaging in said passage bore. In a modified embodiment, this adjusting facility may also have the form of an annular groove arranged near the passage bore on the outer surface of the cylinder wall with an annular seal placed in said annular groove in a preloaded condition. This annular seal is effective as a check valve which releases the overflow of compressed air into the return air chamber only after a certain pressure has been reached in the cylinder inner space.

The compressed air overflow from the cylinder inner space into the return air chamber through the passage bore may be adjusted ad libitum by means of an adjusting screw, the end face thereof is disposed at the annular seal more or less subjected to pressure in the region of the passage bore extending through the cylinder wall, said adjusting screw being accommodated by a threaded bore in the cylinder housing in the manner as described above.

According to another feature of the invention, the working cylinder underside is provided with a valve compris-

ing a closing member held in the open position under an elastic bias with the underside of the working piston striking against said closing member at the end of the drive-in stroke, whereby the closing member is brought into its closed position and due to the return air bias becoming immediately effective on the working piston underside from the return air chamber, remains in the closed position until after completion of the piston return movement owing to partial venting of the cylinder inner space below the working piston through the guiding slot for the drive-in slide, the elastic return forces of the closing member overcome the return air bias thereof and the working cylinder below the working piston is completely vented. In order to secure a quick venting of the cylinder space below the working piston and of the return air space after the return of the working piston, that portion of the drive-in piston which with the working piston disposed in the upper position, lies in the region of the guiding slot of the closing member, may be provided with a longitudinal groove extending on both sides beyond the ends of the guiding slot.

In the following, the invention will be described with the aid of the examples of embodiments shown in the accompanying drawings wtihout, however, being restricted to these embodiments.

In the drawings,

FIG. 1 shows a longitudinal sectional view of the drive-in apparatus with the working piston in its position of rest;

FIG. 2 shows likewise a longitudinal sectional view of the drive-in piston but at the end of the drive-in stroke;

FIG. 3 shows the drive-in apparatus with the valve member reversed immediately before the beginning of the piston return movement;

FIG. 4 shows a modification for the piston return air overflow from the working cylinder into the return air space; and

FIG. 5 shows a modified embodiment of the control valve arrangement.

The drive-in apparatus **1** essentially consists of the housing **2** with the working cylinders **3** (FIG. 1), **3'** (FIG. 2), **3''** (FIG. 4) and the handle **29**, rigidly connected therewith and accommodating the control valve arrangement **32**. The working cylinder is pushed into the reception bore of the housing **2** from below and is closed at the upper end thereof by means of a cylinder head **4** threadedly connected with the thread **5**. In this arrangement, the flange **6** engages over the housing of the apparatus. A permanent magnet **7** is inserted in the cylinder head **4** on that side facing towards the cylinder inner space. The lower end of the working cylinder is closed by means of a guiding member **8** which is retained by means of a screw threaded closure member **12**.

Cylinder **3**, at its lower end, has an enlarged skirted portion **3***a*, formed with internal screw threads **3***b* and is provided with an outer shoulder **3***c* carrying a gasket **3***d* contacted by the lower edge of annular portion **2***a* of housing **2**.

Guiding member **8** may be made of plastic, rubber or rubber-like resilient material. Said member **8** is formed with a transverse slit **8***a* below the upper end of said member, extending to the upper end of an axial opening **9** in said member. Said opening **9** extends to the lower end of said member **8**. The transverse slit **8***a* extends to just beyond opening **9** thereby providing an integral closure member or lip **10** at the upper end of guiding member **8**. Closure member or lip **10** is formed with a diametric through guide slot **11** for the plunger blade or driving ram **15**. Said piston **14** comprises a top metal cup **14***a* carrying a lower piston member **13** made of plastic, rubber or rubber-like resilient material, to which the plunger blade **15** is fixed by means of a cross-pin **15***a*.

Said screw threaded member **12** has a central bore **12***a* receiving member **8**, and an outer screw threaded portion **12***b* engaging the internally screw threaded portion **3***b* of cylinder portion **3***a*.

Said member **12** has a bottom wall **12***b* formed with a lower outwardly extending flange **12***bb* carrying a gasket **12***c* contacted by the lower annular edge of portion **3***a* of the cylinder. The bottom wall **12***b* of member **12** has a central reduced hole **12***d* receiving a reduced portion **8***b* of member **8** and forming a shoulder **8***c* contacting the top of wall **12***b*.

Extending down from the bottom wall **12***b* of member **12** is a lug **12***e* extending down to the top of magazine **23** and formed with a hole **12***f* into which projects a lug **8***d* extending downwardly from member **8**, to prevent said member from turning in bore **12***a*. The upper end of member **8** is of less diameter than the interior of cylinder **3**.

The outer side of cylinder **3** carries an O-ring **3***e* which presses against the inner annular surface **2***b* of the housing **2**, located below the openings **24**.

The working cylinder **3** is surrounded by a return air space **21** essentially extending the whole length of the housing **2** receiving it, said return air space **21** being connected above the closure member **10** with the lower end of the cylinder innerspace via a channel or transverse slot **22** formed in said cylinder. The working piston **14** is guided within the working cylinder. The working piston may either have some radial play with respect to the cylinder walls, may be provided with an axial groove **16** (FIG. 1) or sealingly guided within the working cylinder by means of an annular seal **17** (FIG. 2). The working piston **14** is connected with a driving ram **15** extending through the guide slot **11** provided in the closing member **10** and expelling fasteners supplied from the magazine **23** arranged below the cylinder responsive to the movement of the piston. At the upper end of the working cylinder there are arranged passage bores **24** immediately below the threadedly inserted cylinder head assembly **4**, said bores **24** being distributed all over the periphery and surrounded by an annular passage **25** formed in the housing, which is in communication with a compressed air biasing passage **26**.

If the upper side of the working piston is biased with compressed air via the compressed air biasing passage **26**, the annular passage **25** and the passage bores **24** provided in the cylinder wall, then the working piston will perform a downwardly directed drive-in stroke. The air displaced in this operation from the cylinder inner sapce below the piston by the piston in its downward movement leaves through a passage provided in the lower assembly **8** with the closing member **10** owing to the bias imposed thereon remaining in the open position thereof, as shown in FIG. 1. At the end of the drive-in stroke, the underside of the piston **14** strikes against the closing member **10** causing it to engage the assembly **8** retained by the screw threaded member **12**. With this operation, the cylinder underside is closed. When the working piston is disposed in its lower end position and the discharge channel **9** in the assembly **8** is closed by the closing member **10**, the space **21** will be biased with compressed air. With a working piston having a slight radial play with respect to the cylinder walls this may be effected by compressed air flowing from the cylinder inner space above the piston which is biased with compressed air from the compressed air line **30** for operation, past the working piston and through the overflow channel **22** placed at the lower end of the working cylinder, into the return air space **21**. In the embodiment shown in FIG. 1 and FIG. 3, the working piston is guided in the working cylinder without radial play, however, is provided with an axial groove **16** extending the whole length of its guiding portion through which the overflow of compressed air may take place towards the piston underside and thence through the above-mentioned overflow channel **22** into the return air space **21**. With the embodiment shown in FIGS. 2 and 4, the working

piston is sealed with respect to the working cylinder walls by means of an annular seal **17**, so that no compressed air may flow past the working piston to bias the return air space. There is, however, at least one passage bore **18** (FIG. 2), **18'** (FIG. 4) provided for compressed air overflow extending through the cylinder walls which is slightly spaced from the upper side of the working piston when said working piston is lying in its lower end position. The amount of compressed air overflowing through said passage bore **18, 18'** may be adjusted, on the one hand, in accordance with FIG. 2, by means of a sealing ring **19** arranged in an annular groove of the cylinder wall and adapted to be pressed more or less strongly into the annular groove accommodating it in the region of the through-bore **18** by means of an adjusting screw **20** received in a threaded bore in the cylinder housing **2'**, and on the other hand, in accordance with FIG. 4, by means of an adjusting screw **20'** received in a threaded bore in the housing **2'**, said adjusting screw **20'** being provided with a conical peak engaging within a conical enlargement of the passage bore **18'**.

After the bias of the piston upper side has been interrupted in a manner still to be descirbed in the following, return air from the return air space **21** flows through the channel **22** back into the working cylinder and biases the underside of the working piston **14** whereby the latter is returned to the position as shown in FIG. 1. In this operation, the cylinder inner space above the working piston is connected with the atmosphere which will also be described in more detail in the following. If at the beginning of the return phase, the underside of the working piston **14** lifts from the closing member **10**, the return air bias from the return air space **21** becomes effective in the cylinder inner space below the working piston whereby the closing member **10** is kept in its closing position until after completion of the piston return stroke. During the piston return stroke, a throttled venting of the cylinder inner space below the working piston will take place through the gaps existing between the guide **11** and the drive-in blade **15**, which venting, after the working piston has reached its upper end position, will proceed to such a degree that the biasing forces inherent to the closing member will outweigh the pressure bias on the closing member so that the closing member will pass over into the opening position as shown in FIG. 1 and both the inner space below the working piston and the return air space **21** are completely vented. In order to secure a quick venting of the cylinder inner space below the working piston and the return air space after the return movement of the piston has taken place, that portion of the drive-in blade which, with the working piston disposed in the upper end position, is situated in the region of the guiding slot of the closure member, may be provided with a longitudinal groove, extending beyond both sides of the ends of the guiding slot. A compressed air reservoir **30** for operation as well as an outlet line **31** are provided in the handle **22** of the apparatus, said reservoir being in communication with the compressed line and connected in a compressed air line for operation. A bore **33** in the handle accommodates the control valve arrangement **32** which, in a manner still to be described, is capable of connecting the compressed air biasing channel **26**, on the one hand, with working pressure line **30** and on the other hand with the outlet line **31**.

The control valve arrangement **32** comprises a valve member **34** which is axially displaceably supported within the housing bore **33** by means of the guiding sleeves **41, 42** and in its one limit position, connects the compressed air biasing channel **26** with the working pressure line **30** while blocking the connection between the compressed air biasing channel and the outlet line **31** and in the other limit position connects the inner space of the working cylinder with the outlet line **31** via the compressed air biasing channel **26** while blocking the connection with the working pressure line **30**. The shaft **35** of the valve member **34** at the upper end thereof carries two sealing rings **39, 40**. In each limit position of the valve member **35**, a sealing ring **39, 40** cooperates with a sealing surface **51** in the housing or a sealing surface **52** of the guiding ring **41**, respectively.

At the lower end of the valve member **34**, there is arranged a guide ring, differential piston or piston head **36** rigidly connected with the valve member **35**, said guide ring being sealed and displaceably supported with respect to the guide bushing **42** inserted in the housing bore **33** by means of an annular sealing. The sealing ring **36** is provided with a biasing surface notably in excess of that of the opposite end face **37** of the valve member.

The guiding sleeves **41, 42** are inserted into the housing bore **33** receiving the valve arrangement in such a manner that the guiding sleeve **41** is supported by a shoulder in the housing bore with the interposition of a sealing ring **43** and is pressed against said shoulder by means of the guiding sleeve **42**. The guiding sleeve **42** is retained by an intermediate plate **46** which is clamped between the lower end of the guiding sleeve **42** and the front end face of a screw member **48** received by a threaded bore **50**. The guiding sleeves **41, 42** are sealed with respect to the housing by means of the sealings **43, 44**. The guiding sleeve **42** is provided with radial passage channels **45** which connect the space included by the two guiding sleeves with an outlet channel **31**. Between the upper guiding sleeve **41** and valve member shaft **35**, there extends at least one axial passage channel **41*a*** which connects the space included by the guiding sleeves with the compressed air biasing channel **26** when the valve member is situated in a position in which it blocks the compressed air pressure line **30** for operation. Thus, with the valve member **34** in the above mentioned position, the inner space of the working cylinder is connected with the outlet line **31** through this axial passage channel **41*a*** of the guiding sleeve **41**.

The valve member **34** is provided with a center throughbore **53** extending the whole length of the center shaft thereof with a sleeve **54** likewise having a throughbore **55** extending through the lower portion of the throughbore **53**, said sleeve having a lower flange **56** by means of which it is located inside the valve arrangement. The sleeve shaft is concentrically and substantially sealingly enclosed by the lower portion of the passage bore **53** extending through the valve member **34**. The valve member is, however, capable of performing axial movements with respect to the stationarily arranged sleeve. The flange **56** engages within and end face recess of the threaded member **48** which is screwed into the threaded bore **50** of the housing accommodating the valve arrangement from below with the interposition of an annular seal **49**. The threaded member **48** is provided with an axial bore **63**, with a control piston **60** supported therein for axial displacement. This control piston is provided with an axially extending piston shank **61** of reduced diameter which extends as far as near the sleeve flange **56** and is provided with seals **67, 69** at its end facing the sleeve flange. The sealing **67** is formed in the manner of a sealing plate arranged at the end face of the head **66** of a tie rod **65** extending through the piston shank, and when the control piston head **66** by means of the sealing **69**. The the sleeve flange **56**, is pressed against the sleeve flange, so that the throughbore **55** formed by the sleeve **54** is closed.

The bore **48*b*** guiding the control piston shank **61** is provided with a radial enlargement **48*c*** adjacent its end facing the sleeve flange. The control piston shank is sealed in the throughbore **48*b*** receiving it, by means of a sealing ring **64**. A venting bore **71** is provided between the sealing **64** and the enlargement bore **48*c*** receiving the seals **67, 69** cooperating with the control piston shank, said venting passage **71** being in communication with the enlargement bore due to the radial play provided between the control piston shank **61** and the enlarged bore **48*d***

receiving it. The venting passage **71**, however, may be sealed against the enlargement bore **48***c* receiving the control pitson head **66** by means of the sealing **69**. The sealing **69** is formed in the manner of an annular sealing and is arranged between the front end face of the control piston shank **61** and the head portion **66** of the tie rod **65**. With an axial displacement of the control piston in a direction away from the sleeve flange **56**, the sealing ring **69** comes to lie closely against the bottom surface of the enlargement bore **48***c* receiving the control piston shank thus closing the communication between the venting channel **71** and the said enlargement bore. The enlargement bore in the threaded member **48** is in communication with the biasing space **59** on the rear side of the valve member via at least one passage channel. This passage channel is formed by at least one recess **68** in the sealing plate **67**, at least one recess **58** at the sleeve flange **56** and a center bore **47** in the intermediate disc **46** through which the shaft of the sleeve **54** extends.

The control piston **60** is provided with a diameter considerably in excess of that of the control piston shank **61** and is guided within a cylinder bore **63** of the threaded member **48** and is sealed against the walls of the cylinder bore by means of an annular seal **62**. The control piston on that side thereof facing the control piston shank, forms a pressure chamber **72** together with the cylinder bore, which is in direct communication with the return air space **21** for the return air of the working piston via the passages **73, 74, 75**. The pressure chamber **72** is provided with a discharge channel **81** the exit opening of which is covered by a threaded sleeve **83** concentrically surrounding the housing of the control piston cylinder. The threaded sleeve is threadedly connected with a receiving thread **84** formed on the outside of the lower portion of the threaded member **48** forming the housing for the control piston, and is provided with an upper portion **86** comprising a conical inner bore cooperating with a corresponding conical outer surface of the control piston housing. The discharge opening of the venting channel **81** of the control piston pressure chamber **72** terminates in the said conical outer surface and is covered by the upper portion **86** of the threaded sleeve **83** which is provided with the conical inner bore. An annular sealing **85** is arranged between the thread **84** of the receiving threaded sleeve and the conical portions. The upstream flow of compressed air from the control piston biasing chamber **72** through the venting channel **81** takes place through annular gap formed between the conical outer surface **82** of the control piston housing and the conical inner bore of the upper portion **86** of the threaded sleeve, said annular gap being adapted to be adjusted ad libitum through axial displacement of the threaded sleeve due to rotation thereof.

A cylindrical coil spring **76** is arranged on the side opposite the control piston shank **61**, said coil spring concentrically surrounding the tie rod **65** rigidly connected with the control piston **60** and being supported under adjustable bias between the rear end face of the control piston and a pressure plate **77**, said pressure plate **77** being retained at the tie rod by means of the nut **78**. The pressure plate **77** in this arrangement is retained by means of the nut **78** screwed onto the tie rod **65** to accommodate only pressure forces but may perform axial displacing movement with respect to the tie rod under compression of the coil spring **76**. A radially displaceably guided release bushing **80** is inserted from below in the cylinder bore **63** accommodating the control piston **60**, said bushing comprising an inner shoulder or flange **79** with the pressure disc **77** lying close thereto. The underside of the release bushing **80** lies close to the triggering lever **87** and with the triggering lever being operated, may be displaced in a direction towards the control piston **60**. Lever **87** is pivoted to housing **2** as by pivot pin **80***a* journalled in bearing **80***b* and normally swings in a clockwise direction to abut the housing in a position where it underlies bushing **80** in the lower position of said bushing. When the lever **87** is swung up in a counterclockwise direction, bushing **80** is raised.

FIG. 1 of the drawing shows the drive-in apparatus in its position of rest. The working piston is in its upper end position, and the valve member **34** blocks the communication between the working cylinder and the compressed air conduit **30** for operation. In this position, the upper seal **39** of the valve member **34** closely contacts its seating surface **51**. The working cylinder communicates with the discharge line **31** via the compressed air biasing channel **26**, the axial communication passage **41***a* between the valve member stem **35** and the upper guiding sleeve **41**, the chamber included by the guiding sleeves **41, 42** and the passage bores **45** in the guiding sleeve **42**. The sealing disc **67** connected with the head **66** of the control piston shank is spaced from its sealing surface at the underside of the sleeve flange **56**, and the rearward biasing chamber **59** of the valve member is biased with compressed air for operation so that the valve member is retained in the position in which the compressed air line **30** for operation is shut off from the working cylinder. In this position of the working piston, the venting channel **71** is shut off with respect to the rearward biasing chamber **59** of the valve member **34** by means of the annular seal **69** on the control piston shank **61**. If now the triggering lever **87** and with it the release bushing **80** are actuated upwardly, the control piston **60** experiences an axial displacement by means of the coil spring **76** whereby the sealing disc **67** cooperating with the head **66** of the rod **65** which is fixed to the control piston shank **61**, is pressed against the sleeve flange **56** and the connection between the rearward biasing space **59** of the valve member and the compressed air line **30** for operation is interrupted, whereby at the same time the biasing space **59** is connected to the venting channel **71** because the annular seal **69** is lifted from its sealing surface **70**. Because of this, the rearward biasing space **59** of the valve member is vented, and an axial displacement of the valve member **34** takes place because of the compressed air bias for operation effective on the valve member front side **37**, so that owing to the sealing **40** closely contacting the associated sealing surface **52** the connection of the working cylinder with the discharge line **31** is interrupted and the compressed air biasing channel **26** is connected to the compressed air line **30** for operation of the piston **14**. Hereby, the working piston experiences a compressed air bias for operation on its upper side so that the drive-in stroke is performed. At the end of the drive-in stroke, the compressed air flows into the return air space **21** in the manner as described above and from there into the pressure chamber **72** via the passages **73, 74, 75**. It will be noted that this last mentioned compressed air bias via the working cylinder, the return air chamber **21** and the above mentioned passages takes place directly from the compressed air biasing line **30** for operation. Part of this compressed air flows through the venting channel **81** and the annular gap between the above described conical surfaces which is adjustable by means of the threaded sleeve **83** so that a delayed pressure build-up is taking place in the pressure chamber **72** in dependence upon the throttling adjusted at the annular gap.

As soon as the displacing force acting on the control piston **60** owing to the bias on its pressure space **72** outweighs the oppositely directed pressure force of the cylindrical coil spring **76**, the control piston will experience an axial displacement in which the coil spring will be compressed and the sealing plate **67** will release the end face of the sleeve flange **56** and the annular seal **69** disposed at the valve member shank will close the venting channel **71**. With this, the rearward compressed air biasing space **59** of the valve member **34** will be biased with compressed air for operation anew and the valve member **34** will be axially displaced, wherein the connection

between the working cylinder and the compressed air line **30** for operation will be interrupted by means of the annular seal **39** disposed on the valve member and communication between the working cylinder and the outlet line **31** will be established. With this, the inner space of the working cylinder above the working piston will be vented, and the working piston will be biased on its underside by the return air flowing from the return air space **21** whereby the working piston is returned to its upper end position as shown in FIG. 1. Owing to the return movement of the working piston a pressure drop will occur in the return air entering the cylinder inner space below the working piston from the return air chamber **21**. In spite of this pressure drop the closing member **10** blocking the center passage channel **9** of the insert **8** remains in its closed position until the working piston reaches its upper end position and is retained in said position by the permanent magnet **7** arranged in the cylinder head **4** and a further pressure drop has occurred in the cylinder inner space below the working piston through the guiding slot **11** in the closing member **10**. Only after this throttled and thereby time-delayed venting of the cylinder inner space has been effected will there occur a lowering of the compressed air bias holding the closing member **10** in its closing position in such an extent that said closing member moves into an opening position due to the bias imparted thereto, thus completely venting both the cylinder inner space below the working piston and the return air space **21**.

Owing to the pressure drop in the return air space **21** occurring after the complete return of the working piston and thereby in the biasing space **72** of the control piston, the resilient force effective on the control piston overcomes the compressed air bias effected from the pressure space **72**, so that at the end of the working piston return movement, the control piston is again axially displaced in such a manner that the compressed air bias for operation effective on the rearward biasing space **59** of the valve member **34** is shut off and said valve member **34** is simultaneously vented via the venting passage **71**, whereby the valve member **34** is anew axially displaced in the manner described above and closes the outlet line **31** from the working cylinder connecting it with the compressed air line **30** for operation. Thus, the working piston is anew biased with compressed air whereby another drive-in stroke is performed. Further operation of the apparatus runs off in the same manner, in which it will be noted in particular that on principle a continuous automatic release of the drive-in steps is taking place only if each drive-in stroke is properly carried out, that means, when with each drive-in stroke the closing member **10** has been brought into a position in which it closes the underside of the working cylinder by contact with the underside of the working piston.

If during a working stroke, the working piston does not reach its lower limit position it is impossible for the return air pressure necessary for the piston return movement to build up in the return air space **21** because the overflowing compressed air intended to fill it leaves the working cylinder through the open outlet channel **9** in the insert member **8**. In this case, it is also impossible for any air pressure to build up in the pressure chamber **72** of the control piston **60** for the displacement of the control piston against the effect of the coil spring **76**.

In the modified embodiment of the control valve arrangement as shown in FIG. 5, the control piston **60'** is designed in the shape of a differential piston and is guided within a cylinder bore **72'** in the threaded member **48'** for axial displacement in the same manner as in the embodiment described above.

Contrary to the first embodiment, an axial passage channel **96** extends through the control piston shaft **61'** which is in constant communication with the compressed air line **30** for operation. On its end opposite the control piston shaft **61'**, the control piston is provided with an axially extending shank **92** which is guided in a bore while being sealed by means of an annular seal **93**, said bore being located in a box nut **94** threadedly connected with the threaded member **48'**. This rear end control piston shank **92** is provided with a bore **97** enlarging the passage channel **96**, with a sleeve **98** inserted therein cooperating with a ball valve closure member **99** which, owing to the compressed air bias of the passage channel **96** or a weak compression spring **100**, respectively, is retained in its closed position. An axially displaceably guided release pin **101** extends through the rear side of the box nut **94**, the shank **102** of said pin cooperating with the valve closure member **99** and displacing it from its closed position when being axially displaced. In case of such a displacement of the valve member **99**, the end face **95** of the control piston shank **92** is biased with compressed air for operation whereby the control piston is pressed against an annular seal **67'** inserted in the end face of the flange **56'** of the sleeve by the end face of its control piston shank **61'**. With this, the connection of the compressed pressure line **30** for operation with the rearside biasing space of the valve member is interrupted and the valve member releases the connection of the compressed air line **30** for operation with the inner space of the working cylinder in the manner as described above. With the control piston **60'** in this position, the rear side biasing space **59** of the valve member **34** is connected with the venting passage **71'** in the manner likewise described above, and thus vented.

In this embodiment, the lower flange **56'** of the sleeve **54'** extending through the center bore of the valve member is fixed in the same manner as with the embodiment described above, i.e. between the shoulder of an end face recess in the threaded member **48'** and the intermediate ring **46** pre-loaded between the end face of the threaded member and the lower portion of the guiding sleeve **42**. With the embodiment in accordance with FIG. 5, the sealing gasket **67'**, however, is inserted in an end face recess of the flange **56'** of the sleeve and thus fastened. The end face of the through-bored valve member stem **61'** cooperates with the thus fixed sealing disc **67'**. The passage **55** extending through the sleeve **54'** is in communication with the rearward biasing space **59** of the valve member, through recesses **90, 91** at the flange **56'** of the sleeve **54'** and the center bore **47** of the intermediate ring **46**.

Also with this embodiment the compressed air biasing space **72'** of the control piston is in communication with the return air space **21** via the passages **73', 74, 75**. The biasing surface of the control piston disposed in the pressure space **72'** is substantially greater than the rearside biasing surface **95** of the control piston stem **92**. Insofar as a bias of the control piston pressure space **72'** takes place from return air space **21** as described above, the axial displacement force due to this bias outweighs the rearside bias on the biasing surface **95** of the control piston stem **92**, whereby due to the annular seal **69'** disposed on the control piston stem, the rearside biasing space **59** of the valve member is shut off from the venting channel **71'** and due to the end face of the control piston stem **61'** being lifted from the annular seal **67'**, is connected with the compressed air line **30** for operation via the channel **55** of the sleeve **54'** and, consequently, is biased with compressed air for operation. Owing to this bias, the valve member is displaced into a position in which the connection between the compressed air line **30** for operation and the working cylinder is shut off, with the working cylinder connected to the discharge line **31**. If after the return movement of the working piston, the pressure bias in the control piston pressure space **72'** breaks down, the control piston will again block the compressed air bias of the biasing space **59** of the valve member and connect the biasing space **59** to the venting channel **71'**, whereby the valve member **34** is again dis-

placed axially, shutting off the working cylinder from the discharge line **31** and connecting it with the compressed air line **30** for operation. With this, a new bias of the working piston with compressed air is effected so that the working piston may carry out another drive-in stroke in the manner as described above. Further operation of the apparatus will run off automatically in the same manner as long as the valve closure member **99** is kept in its open position by means of the release pin **101.**

Upon an interruption of the actuation of the release pin **101**, the valve closure member **99** owing to its constant bias with compressed air and by the compression spring **100** will reach its closing position. With this, the bias on the end face **95** of the control piston stem **92** is interrupted, and the associated biasing space vented. The space formed between the rearside of the control piston and the rearside control piston stem **92** is constantly communicating with the atmosphere via venting channel **105.**

It will thus be seen that there is provided an apparatus in which the several objects of this invention are achieved, and which is well adapted to meet the conditions of practical use.

As possible embodiments might be made of the above invention, and as various changes might be made in the embodiment above set forth, it is to be understood that all matter herein set forth or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A pneumatic fastener driver comprising a body, a cylinder in said body, a working piston in said cylinder, a fastener drive ram fixed to said working piston, said working piston being movable in said cylinder away from retracted position, in a fastener drive direction to a predetermined fully driven position and back to said retracted position, an operating member mounted for movement on said body away from and back to a normal position, and being movable away from normal position to an operating position, and compressed air operated means controlled by movement of said operating member away from its normal position, to automatically cause said working piston to repeatedly move in a fastener driving direction away from retracted position to fully driven position and back to retracted position, a number of successive times, while said operating member remains in said operating position, and to terminate said repeated back and forth movement of said working piston, upon said operating member moving back from its operating position to normal position, said means to automatically cause said working piston to repeatedly move including valve means at the lower end of said cylinder, said valve means being normally biased to open position to establish communication between the interior of the cylinder and the atmosphere and closed by the working piston when said piston moves down to its fully driven position, and after closure by said piston, said valve means remaining closed by air pressure in the cylinder above a predetermined pressure after said working piston is retracted away from said valve means, and said valve means being self opening when said piston is retracted and the air pressure in said cylinder is reduced below said predetermined pressure and said compressed air is vented from said cylinder, said means to automatically cause said working piston to repeatedly move further comprising a reservoir of air under pressure in said body, a main air vent in said body, a valve chamber in said body communicating with said reservoir and with said main vent, said body being formed with a passage connecting said valve chamber with the upper end of said cylinder and above the working piston when said working piston is in its uppermost position in sad cylinder, a first sliding valve member in said valve chamber having means in one position to connect said main vent with said connecting passage and to interrupt flow of air under pressure from said reservoir to said connecting passage, and in another position, to allow flow of air under pressure from said reservoir to said connecting passage and interrupt flow of air from said connecting passage to said main vent, and means utilizing air from said reservoir to move said first sliding valve member from its said one position to its said another position, said means to automatically cause said working piston to repeatedly move further comprising another sliding valve member in said body, controlling flow of air under pressure from said reservoir to control movement of said first mentioned sliding valve member, and means controlled by said operating member to control operation of said another sliding valve member.

2. The combination of claim **1**, a return air space chamber formed in said body, means establishing communication between said return air space chamber and said cylinder, and means to control movement of said another sliding valve member by air under pressure coming from said return air space chamber.

3. The combination of claim **2**, said means to automatically cause said working piston to repeatedly move further including auxiliary means to vent air from the reservoir, to allow movement of said first mentioned sliding valve member from a position where the main vent is connected to said connecting passage, to a position where said reservoir is connected to said connecting passage.

4. The combination of claim **3**, said another sliding member having a differential piston head slidably moving in a chamber with a sliding seal fit with the inner surface thereof, and said means to control movement of said another sliding valve member including a passage connecting said return air space chamber with said last chamber, on one side of said piston head of said another sliding valve member.

5. The combination of claim **4**, and means to vent said last chamber on one side of said piston head.

6. The combination of claim **2**, said means establishing communication between said return air space chamber and said cylinder, comprising an opening in said cylinder adjacent the lower end of said cylinder connecting said return air space chamber and said cylinder.

7. The combination of claim **6**, said means establishing communication between said return air space chamber and said cylinder, further comprising an opening in said cylinder above the working piston, when the piston is in its lowermost position.

8. The combination of claim **7**, and screw threaded means to control the effective size of said opening in said cylinder above the working piston, when the working piston is in its lowermost position.

9. The combination of claim **1**, said valve means comprising a member made of resilient material in the lower end of said cylinder, and having an opening at its underside communicating with the atmosphere, and with a transverse slit below its upper end extending to said opening, and forming a top flexible lip normally self-maintained in a raised position opening said slit, and said lip being formed with a hole, and said drive ram passing through said hole with a loose fit to open said hole when said lip is depressed to close said slit.

10. The combination of claim **1**, there being a limited air passage between said working piston and cylinder to allow compressed air to flow through said passage from the upper to the lower side of said working piston.

11. The combination of claim **1**, said valve chamber having an inner cylindrical surface, said first sliding valve member having a throughbore and being provided with a piston head having a sliding sealing contact with said inner cylindrical surface, said valve chamber having an opening above said piston head connecting said valve chamber with said main vent, said means controlled by said operating member further comprising means to control the closure of said thoroughbore, said valve member having a greater surface at its underside than at its upper side, means to allow air under pressure to flow from said

reservoir through said throughbore to the underside of said sliding valve member when said throughbore is not closed, to thereby keep the sliding valve member in position for allowing flow of air from said sliding valve chamber to said main vent through said opening in said sliding valve chamber and above said piston head, auxiliary vent means, and means to connect said valve chamber below said piston head, when said throughbore is closed, to said auxiliary vent, to allow air under pressure from said reservoir to move said sliding valve member to said position allowing flow of air under pressure from said reservoir to said connecting passage, and said means to control closure of said throughbore, comprising another sliding auxiliary vent when said throughbore is open.

12. The combination of claim **11**, said means to control closure of said thoroughbore, comprising another sliding valve member formed with a piston head, a chamber having an inner cylindrical surface, said piston head of said another sliding valve member having a sealing sliding fit with said last mentioned cylindrical surface, passage means to connect said return air space chamber with said last mentioned chamber on the upper side of said last mentioned piston head, to bring air under pressure from said return air space to said last mentioned chamber to move said another sliding valve member in one direction to seal said auxiliary vent and allow air under pressure from said reservoir to move said first sliding valve member in a direction to interrupt flow of air under pressure to said connecting passage, and means controlled by movement of said operating member to cause movement of said another sliding valve member in an opposite direction to open said auxiliary vent and seal said throughbore, to cause air to flow from said connecting passage to said main vent.

13. The combination of claim **11**, said means to control closure of said throughbore comprising another sliding valve member having a head at its upper end and a piston, a seal on said head movable to close said throughbore when said another sliding member moves in one direction, a second seal on said another sliding valve member to seal said auxiliary vent when said another sliding valve member moves in an opposite direction, a chamber for said piston on said another sliding valve member, a sliding seal fit between said last piston and the inner surface of its chamber, a member positioned to be raised by said operating member and spring means interposed between and positioned member and said piston, and passage means connecting said return air space chamber and said last chamber above said piston on said another sliding valve member.

14. The combination of claim **13**, and means to vent the space in said last chamber above the piston therein.

15. The combination of claim **1**, and means to prevent a succeeding driving movement of said working piston, unless in the next preceding movement of said piston, said piston moved toward the fully driven position a distance sufficient to close said valve means.

16. A compressed air-operated drive-in apparatus to drive in fasteners such as nails, staples or the like, comprising a body provided with a working cylinder, a working piston guided for reciprocating movement in said working cylinder, a control valve in said body, means to provide a compressed air bias, a trigger on said body, means controlled by said trigger to actuate said control valve, said control valve comprising means controlling said compressed air bias means and provided with a differential piston having a front side and a rear side, means to cause the front side of said differential piston to be constantly biased with compressed air from said compressed air bias means for operation of said differential piston, means to bias said rear side of said differential piston with compressed air for operation of said control valve when the control valve is not actuated by operation of the trigger, and to move the control valve into a predetermined position, said control valve having means to cut off the working side of the working piston from the compressed air bias means and to vent the compressed air in the cylinder and on the working side of the working piston to the atmosphere for pressure relief when in said predetermined position, and means to cut off the rear side of the differential piston from the compressed air and to connect said rear side of the differential piston with an outlet to the atmosphere when the control valve is actuated by means of the trigger, so that the control valve moves into a position in which the working side of the working piston is connected with the compressed air bias means for operation thereof, an auxiliary control valve between the control valve and the trigger, and means dependent on continued actuation of the trigger to connect the rear side of the differential piston of the control valve with the atmosphere, a reservoir for compressed air communicating with the cylinder when the working piston is in its downward operated position in the cylinder, and means responsive to a control pressure in the reservoir occurring approximately at the end of the working stroke of the working piston to communicate compressed air to the rear side of the differential piston of the control valve for operation of said control valve.

17. The combination of claim **16**, and an additional control piston operatively connected with the auxiliary control valve.

18. The combination of claim **17**, means to provide a working chamber for said auxiliary control valve, said additional control piston being located within said chamber, said air reservoir which is adapted to be biased with compressed air at the end of the working stroke of the working piston, being connected with said working chamber containing the additional control piston for the control of said auxiliary control valve.

19. A pneumatic fastener driver comprising a body, a cylinder in said body, a working piston in said cylinder, a fastener drive ram fixed to said working piston, said working piston being movable in said cylinder away from retracted position, in a fastener drive direction to a predetermined fully driven position and back to said retracted position, an operating member mounted for movement on said body away from and back to a normal position, and being movable away from normal position to an operating position, and compressed air operated means controlled by movement of said operating member away from its normal position, said compressed air operated means comprising a reservoir of air under pressure in said body, a main air vent in said body, a valve chamber in said body, communicating with said reservoir and with said main vent, said body being formed with a passage connecting said valve chamber with the upper end of said cylinder and above the working piston when said working piston is in its uppermost position in said cylinder, a first sliding valve member in said valve chamber having means in one position to connect said main vent with said connecting passage, and to interrupt flow of air under pressure from said reservoir to said connecting passage, and in another position, to allow flow of air under pressure from said reservoir to said connecting passage and interrupt flow of air from said connecting passage to said main vent, and means utilizing air from said reservoir to move said first sliding valve member from its said one position to its said another position, another sliding valve member in said body controlling flow of air under pressure from said reservoir to control movement of said first mentioned sliding valve member, and means controlled by said operating member to control operation of said another sliding valve member, a return air space chamber formed in said body, means establishing communication between said return air space chamber and said cylinder, and means to control movement of said another sliding valve member by air under pressure coming from said return air space chamber.

20. The combination of claim **19**, auxiliary means to vent air from the reservoir, to allow movement of said

first mentioned sliding valve member from a position where the main vent is connected to said connecting passage, to a position where said reservoir is connected to said connecting passage.

21. The combination of claim **20**, said another sliding member having a differential piston head slidably moving in a chamber with a sliding seal fit with the inner surface thereof, and said means to control movement of said another sliding valve member including a passage connecting said return air space chamber with said last chamber, on one side of said piston head of said another sliding valve member.

22. The combination of claim **21**, and means to vent said last chamber on one side of said piston head.

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