

Oct. 9, 1962

W. R. BECKMAN ET AL

3,056,964

PNEUMATICALLY OPERATED FASTENER DRIVING MACHINE

Filed March 31, 1960

4 Sheets-Sheet 1

FIG. 1

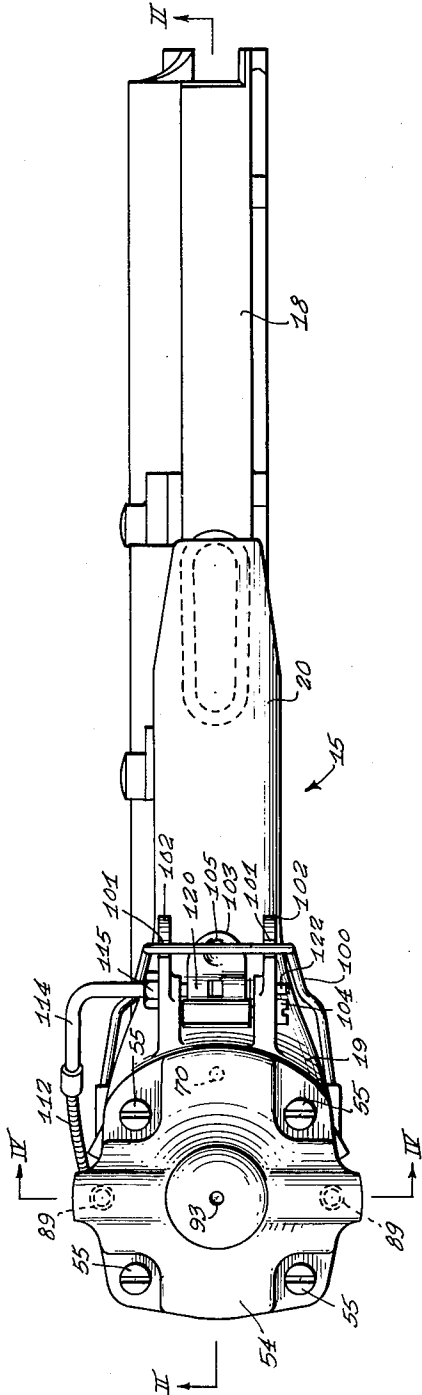


FIG. 6

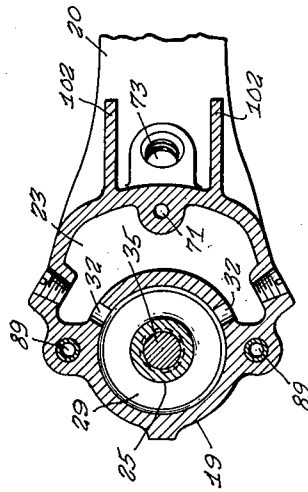
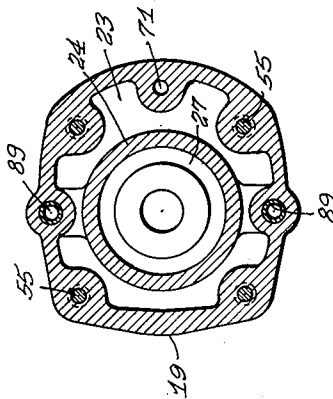


FIG. 5



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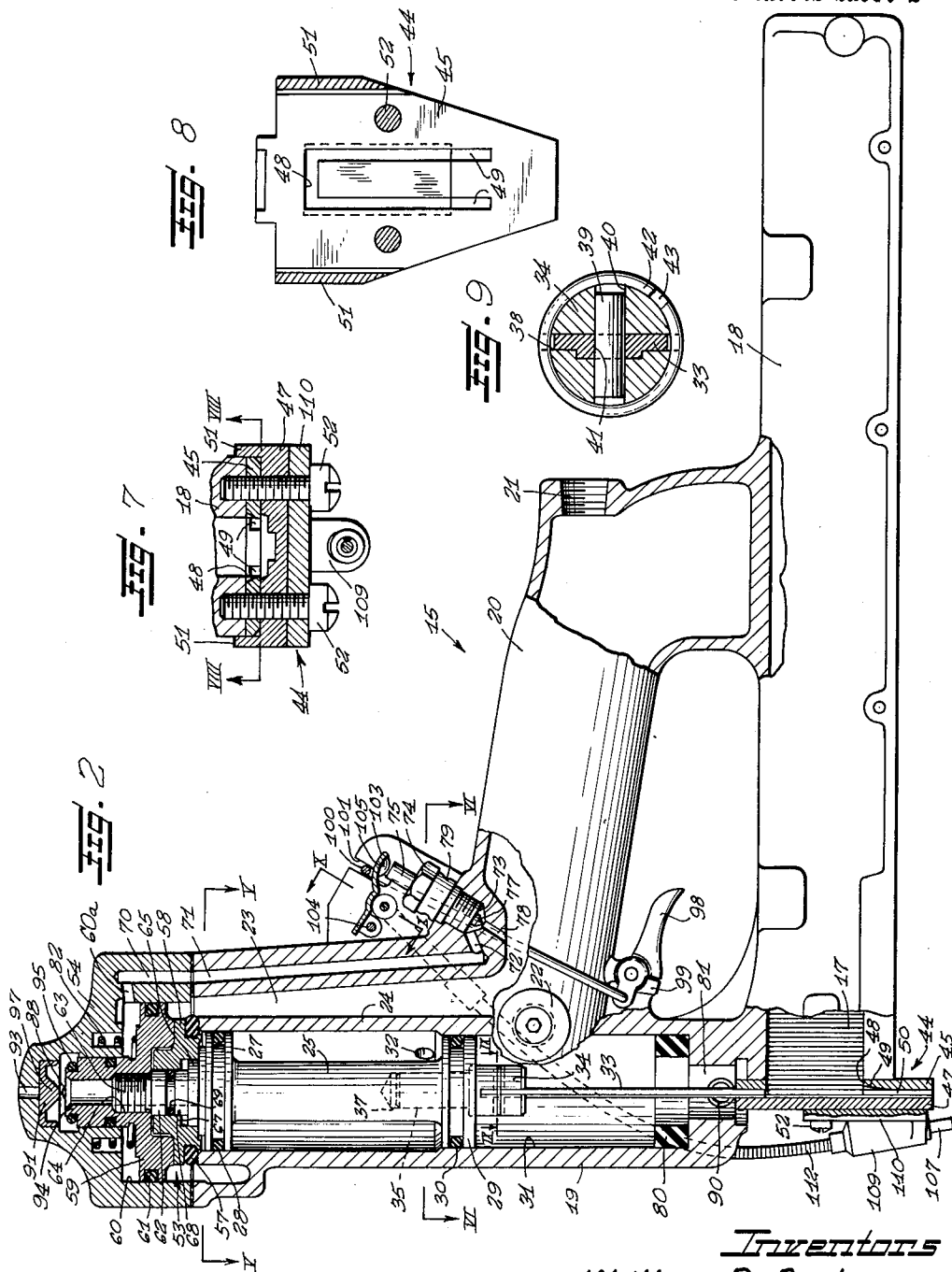
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4 Sheets-Sheet 2



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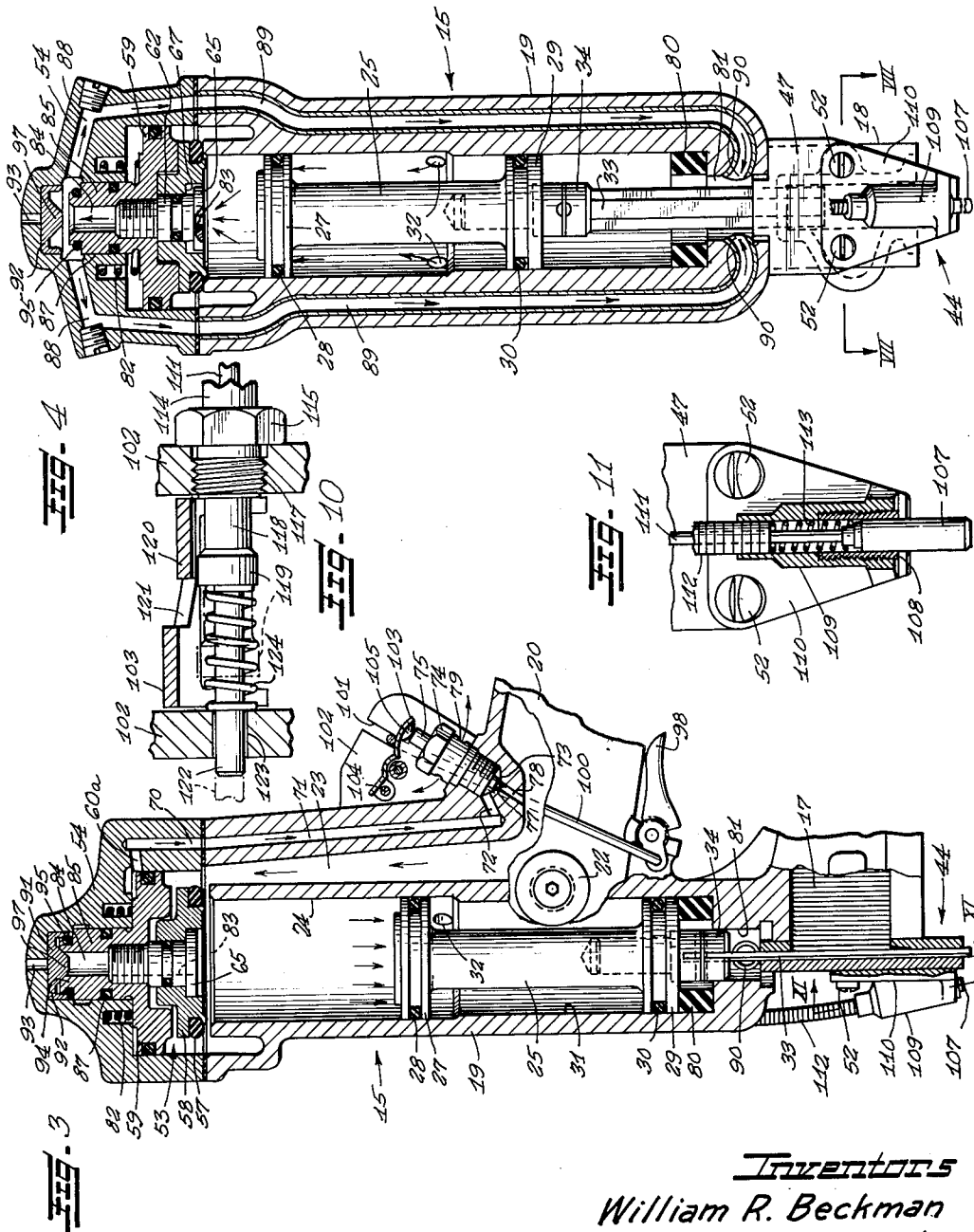
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PNEUMATICALLY OPERATED FASTENER DRIVING MACHINE

Filed March 31, 1960

4 Sheets-Sheet 3



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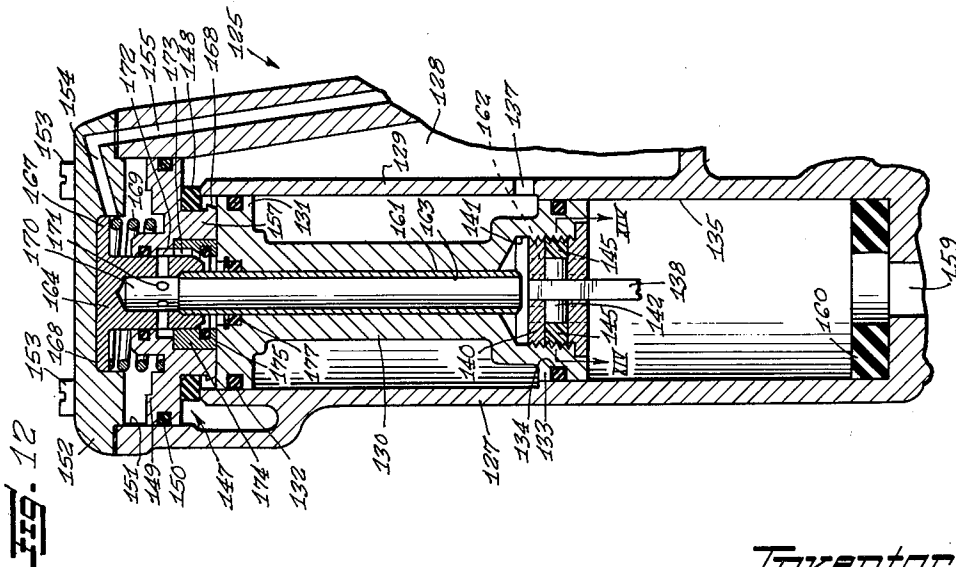
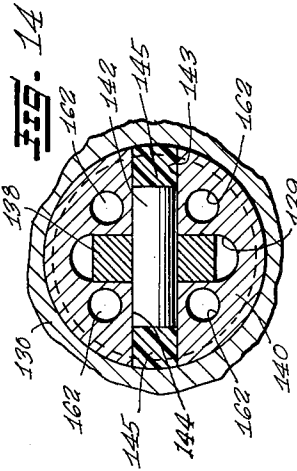
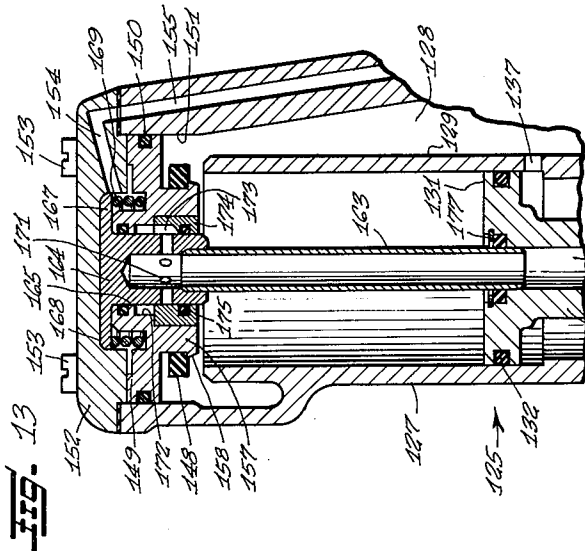
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3,056,964

PNEUMATICALLY OPERATED FASTENER DRIVING MACHINE

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Filed Mar. 31, 1960, Ser. No. 19,020
13 Claims. (Cl. 1—44.4)

The present invention relates to improvements in fastener driving machines and more particularly concerns pneumatically operated machines, that is, wherein the motivating force for driving a piston to actuate a driving member is afforded by fluid under pressure such as compressed air.

Among the objects of the present invention is that of improving the efficiency of pneumatically operated fastener driving machines in several respects, including enabling operation with minimum pressure fluid expenditure, that is, with a minimum of loss of pressure fluid volume from the pressure fluid supply in each cycle of operation of the fastener driving piston and driver.

Another object of the invention is to provide a pneumatically operated fastener driving machine wherein the pressure fluid which must necessarily be exhausted from the cylinder on the working stroke thrust head side of the piston is utilized to important advantage for self-cleaning and lubrication purposes in that portion of the cylinder which is opposite to the working stroke thrust head of the piston.

A further object of the invention is to provide an improved air return arrangement in a pneumatically motivated fastener driving machine.

Still another object of the invention is to provide an improved motivating air control valve structure for hydraulically actuated driving machines.

Yet another object of the invention is to provide an improved piston construction for pneumatically actuated fastener driving machines.

A still further object of the invention is to provide improved means for attaching a driving blade to a piston in a fastener driving machine.

It is still another object of the invention to provide improved safety means which will prevent unintentional firing of a pneumatically operated fastener driving machine.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a top plan view of a pneumatically operated fastener driving machine embodying features of the invention;

FIGURE 2 is a longitudinal sectional elevational detail view taken substantially along the line II—II of FIGURE 1 insofar as those portions which are shown in section are concerned;

FIGURE 3 is a fragmentary vertical sectional detail view similar to FIGURE 2 and showing the forward portion of the machine during a driving stroke of the piston and driver;

FIGURE 4 is a vertical sectional elevational detail view taken substantially on the line IV—IV of FIGURE 1;

FIGURE 5 is a horizontal sectional detail view taken substantially on the line V—V of FIGURE 2 but with certain parts omitted for illustrative purposes;

FIGURE 6 is a fragmentary horizontal sectional elevational detail view taken substantially on the line VI—VI of FIGURE 2 but with certain parts omitted for illustrative purposes;

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FIGURE 7 is a fragmentary sectional elevational detail view taken substantially on the line VII—VII of FIGURE 4;

FIGURE 8 is a fragmentary sectional elevational detail view taken substantially on the line VIII—VIII of FIGURE 7;

FIGURE 9 is an enlarged fragmentary sectional elevational detail view taken substantially on the line IX—IX of FIGURE 2;

FIGURE 10 is an enlarged fragmentary sectional elevational detail view taken substantially on the line X—X of FIGURE 2;

FIGURE 11 is a fragmentary sectional elevational detail view on an enlarged scale taken substantially on the line XI—XI of FIGURE 3;

FIGURE 12 is a fragmentary vertical sectional elevational view through the head end portion of a modification of the machine and with certain parts broken away for illustrative purposes;

FIGURE 13 is a fragmentary sectional view similar to FIGURE 12 but showing the relationship of parts during a driving stroke of the piston; and

FIGURE 14 is an enlarged fragmentary sectional detail view taken substantially on the line XIV—XIV of FIGURE 12.

For purpose of illustration, there has been shown in FIGURES 1–11 a manual pneumatically actuated fastener driving machine 15, and various details thereof, which is readily adapted to drive pin, nail or staple type fasteners 17 housed within a base magazine 18 of the machine. Any suitable construction within the magazine 18 may be employed for supporting adhered "sticks" of the fasteners 17 and for feeding the fasteners forwardly in the magazine into position under a head portion 19 of the machine which may conveniently be an integral casting with the magazine housing 18 and reinforcingly attached at its rear side to a hollow handle 20 which is also integrally attached to the top of the magazine housing 18. Aluminum or other lightweight material may be employed in the machine casing or housing structure.

The handle 20 serves as part of a substantial volume reservoir for pneumatic fluid such as compressed air which may be supplied thereto from a suitable source through an inlet opening 21 at the rear of the handle or alternatively at the forward end and at one side of the handle through an opening that otherwise may be closed by means of a plug 22. The usual air hose and attachment nipple structures (not shown) are employed for feeding the pressure fluid into the reservoir space within the handle.

In unrestricted communication with the substantial pressure fluid reservoir space within the hollow handle 20 and actually forming part of a relatively large volume pressure fluid reservoir within the casing of the machine is a reservoir space 23 within the head section 19 of the machine and more particularly in a substantial upwardly projecting portion of such head section extending above the handle 20. In and forming an integral part of the head section 19 is a vertical hollow cylinder 24 having its upper end arranged to be exposed fully to the reservoir space 23 which in the upper end portion of the head section 19 preferably completely surrounds the upper mouth end portion of the cylinder 24 as best visualized in FIGURES 2, 3 and 5.

Vertically reciprocally disposed within the bore of the cylinder 24 is a piston 25 preferably of generally spool shape with the body of the piston of substantial length and smaller diameter than the cylinder bore. At its upper end the piston 25 has an enlarged preferably grooved circular head having a peripheral annular groove carrying a sealing ring 28 which engages slidably with the surrounding cylinder wall. At its lower end, the piston

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25 has in substantially vertically spaced relation to the upper head 27 a circular peripherally annularly grooved head 29 of slightly smaller diameter than the upper head 27 and carrying in its peripheral groove a sealing ring 30 which engages slidably the wall of a slightly reduced diameter lower cylinder bore portion 31.

Normally the piston 25 is urged upwardly in the cylinder 24 by fluid pressure introduced from the reservoir space 23 through communicating passageway means provided herein by a pair of continually open passageway bores 32 (FIGS. 2, 3, 4 and 6) through the cylinder wall at the lower end of the larger diameter upper portion of the cylinder bore closely adjacent to juncture with the smaller diameter bore portion 31 of the cylinder. Since there is a differential in the effective pressure area wherein the upper piston head 27 has a slightly larger effective area as compared to the opposed effective area of the smaller lower piston head 29, the unrestricted force of the pressure fluid from the reservoir 23 through the communicating passages 32 normally urges the piston 25 upwardly to a starting or what may also be referred to as a return position wherein the piston crown provided by the head 27 is adjacent to the upper, mouth end of the cylinder 24.

On and depending from its lower end, the piston 25 carries a driver 33 comprising an elongated member properly dimensioned both cross-sectionally and as to length for engaging the fasteners 17 on their crowns to drive the same successively in driving strokes imparted to the piston as will be described more fully hereinafter. Herein, the driver 33 is in the form of a blade made from suitable durable, hard material and properly proportioned for driving staples. Since the driver blade 33 is of hard material and for purpose of lightweight the piston 25 is preferably made from a lightweight and thus softer material a connector or coupling member 34 is provided which is conveniently in the form of a stud having a threaded shank secured into an axial downwardly opening bore 37 in the lower end of the piston including the integral head 29. The body of the coupling stud 34 extends coaxially below the lower piston head 29 and has a transverse slot 38 therein opening downwardly and within which the upper end portion of the driver blade 33 is engaged and retained by a slip fit coupling pin 39 which is engaged within a bore 40 through the stud body 34 normal to the slot 38 and an aligned bore 41 in the upper or head end portion of the driver blade 33. The pin 39 is shorter than the coupling stud bore 40 and is retained against endwise movement out of the bore by a split spring wire retainer ring 42 engaging in an annular seating groove 43 intersecting the opposite ends of the pin bore 40. This affords a loose enough connection between the driver blade 33 and the coupling stud 34 to provide adequate operating tolerances and thereby avoid strains upon the driving blade and associated structure, but at the same time the coupling of the blade to the coupling stud 34 is maintained positively. Moreover, the coupling pin 39 is held positively against escape from the bore 40 but may nevertheless have a slight range of longitudinal free movement within the bore.

A driver guide and fastener driveway is provided at the forward end of the magazine section 18 and under the lower end of the head section 19 by a nose assembly 44 (FIGS. 2, 7 and 8) comprising a pair of substantially coextensive plates 45 and 47. The function of the plate 45 is to provide a backing support and guide for the driver blade 33 and for this purpose the plate 45 is adapted to be mounted against the forward end of the fastener magazine section 18, with a doorway opening 48 registering with the magazine chamber within the magazine section for passage of the fasteners 17. Downwardly and forwardly sloping guide ramp grooves 49 lead from the lower end of the doorway opening 48 in the forward guide face of the backing plate 45 to ac-

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commodate the tips of the staple legs. The forward guide plate 47 is constructed and arranged to bear flatwise against the forward face of the backing plate 45 and is provided with a vertical driver blade guiding and fastener driveway channel 50 into which the fasteners are successively fed from the magazine of the machine through the doorway 48 to be successively driven downwardly through the driveway 50 to emerge from a lower end or nose tip toward which the sides of the matchingly assembled nose plates converge. On the upper portion of its sides, the guide plate 47 has rearwardly extending respective engagement flanges 51 which are of sufficient width not only nestably to coact with the side edges of the backing plate 45 but also to engage the respective opposed sides of the forward end of the casting of the magazine section 18 for centering purposes. Securing means such as a pair of screws 52 secure the nose plates 45 and 47 together and to the machine housing casting at the forward end of the magazine section 18.

Although there is a constant, unrestricted full pressure volume of pressure fluid in the total reservoir of the machine 15 in constant supply communication with the pressure fluid source, the upper end or mouth of the cylinder 24 is normally closed off and sealed against inflow of the pressure fluid from the reservoir 23 into the cylinder by means including a valve mechanism 53 (FIGS. 2, 3 and 4) in the form of a "pop-off" piston mechanism in the present instance conveniently housed within a closure cap 54 for the top of the head section 19. In this unitary relationship of the control valve 53 and the cap 54, attachment of the cap by means such as screws 55 (FIG. 1) places the control valve mechanism in operative relation to the mouth of the cylinder 24, with a resilient sealing ring 57 engaging the upwardly facing edge surface of the cylinder 24.

A circular valve ring member 58 carries the sealing ring 57 and is mounted in slight lost motion reciprocal movement relation on a control piston 59 which is reciprocally mounted within a cylinder space 60 opening downwardly within the cap 54, the diameter of the piston 59 and the cylinder space or chamber 60 being larger than the outside diameter of the control valve ring member 58 so that the lower side of the overhanging portion of the valve member 59 is constantly exposed to the force of pressure fluid within the reservoir 23. A sealing O-ring 61 mounted in the perimeter of the piston 59 provides a seal against leakage of pressure fluid thereby to the upper side of the valve piston.

Means are provided for connecting the sealing ring carrying member 58 and the poppet or pop-off valve piston 59 for relative and joint reciprocal movements in operation, herein comprising a cylindrical connector stud member 62 having on one end portion a threaded shank 63 secured in a central bore in the piston member 59. On its opposite and lower end the connector 62 has an enlarged flange head 65 disposed within a downwardly opening complementary recess 67 in the lower face of the valve ring member 58 which has above and concentric with the recess 67 a cylindrical bearing surface 68 slidably guidedly engaging the cylindrical body of the connector 62 which is provided with a peripheral sealing O-ring 69.

Normally the piston member 59 presses downwardly against the valve member 58 with sufficient force to maintain the sealing ring member 57 sealingly against the mouth edge of the cylinder 24, this being accomplished primarily by means of pressure fluid from the reservoir of the machine acting upon the upper side of the control piston member 59 which is provided with a crown surface affording a larger area exposed to pressure fluid than the differentially smaller annular area exposed to the pressure fluid in the reservoir on the lower marginal side of the control piston. Pressure fluid for normally depressing the control piston 59 and thus maintaining the control valve seated on the cylinder 24 is

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delivered into a chamber space in the closure cap 54 in the upper end of the cylinder 60 therein through a valve controlled passage leading from the pressure fluid reservoir, herein including a delivery port 60a opening into the roof of the cap cylinder chamber and leading from a downwardly directed passage 70 in the rear portion of the cap communicating with a duct passage 71 in the rear portion of the head section 19. At its lower end, the duct 71 communicates by way of a lead-off passage or port 72 with the lower end of a recess chamber bore 73 which opens from substantially the reentrant corner of the juncture between the head section 19 and the handle 20 and has secured therein a valve housing 74 reciprocally carrying and guiding a needle type valve member 75 which has an upper outer end projecting outwardly beyond the housing 74 and has an inner end valve tip 77 on the axis of and normally biased away from, that is, into open relation to a port 78 communicating with the interior of the machine housing reservoir space. Thus, pressure fluid passing from the reservoir through the port 78 is conducted to the top of the control valve piston 59 and thus normally drives the control piston toward the end of the cylinder 74 and maintains the control valve assembly in closing relation thereto.

In order to effect a fastener driving stroke of the driver piston 25, the needle valve member 75 is depressed to seat the valve tip 77 in substantially sealing relation to the mouth of the port 78, thereby cutting off pressure fluid to the upper side of the control valve piston 59 (FIG. 3). In this same action of the valve member 75, it opens a bleed-off passage through the valve body 74 whereby the chamber above the control piston 59 is exhausted to atmosphere through exhaust ports 79 in the valve body, as indicated by directional flow arrows in FIG. 3. As a result, the force of pressure fluid in the reservoir 23 working against the exposed overhanging underside margin of the control valve piston 59 forces it upwardly away from the mouth of the cylinder 24. In the first increment of upward displacement of the piston member 59, it moves relative to the control valve member 58 to the limited extent provided for by the lost motion differential spacing of the retainer head flange 65 relative to the opposing shoulder afforded within the valve member recess 67. Thereby, the control piston member 59 attains instantaneous maximum unseating velocity without initial drag and as the retainer head flange 65 engages the opposing shoulder within the valve member recess 67, the valve member 58 and the sealing ring 57 are snapped off of the mouth end seat of the cylinder 24 to expose the entire perimeter of the cylinder mouth to influx of pressure fluid onto the crown of the driving piston head 27. Thereby, the full force of pressure fluid in the reservoir 23 is, literally, dumped onto the driving piston 25 to actuate it with instantaneous maximum acceleration and full force of the pressure fluid in a driving stroke of the driving piston and the driver 33. Since the total area on the crown of the piston head 27 is far greater than the area on the underside margin of the head and there is only a slight air return area differential between said underside and the opposing upper side of the lower piston head 29, such differential is easily and instantaneously overcome by the driving fluid pressure. Any slight displacement of air from the reduced diameter lower end cylinder bore portion 31 as the piston drives down into it causes such displaced air to return to the reservoir 23 through the continuously open ports 32 in supplement to the driving force of the pressure fluid from the reservoir during the driving stroke.

During the driving stroke of the piston 25, air under the lower piston head 29 exhausts freely to atmosphere through a central opening in a resilient annular cushion 80 seated in the bottom of the cylinder bore and through a lower end coaxial exhaust opening port 81 in the bottom of the cylinder and of a diameter which may be substantially greater than, but may be just slightly over-size relative to the diameter of the connector stud 34

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to receive the lower end portion of the body of the stud in the final increment of the driving stroke of the piston 25 and just before the piston head 29 strikes the cushion 80 which is shorter than the length of the stud body. Thereby, in the final increment of the piston driving stroke there is a small volume of air trapped under the lower piston head 29 serving as a compressible fluid deceleration cushion coactive with the resilient, rubber cushion 80 to stop the driving piston 25 with minimum terminal jarring. Because of the sliding fit between the connector stud 34 and the exhaust bore 81, there is rapid enough leakage of air thereby to avoid any air lock under the lower piston head 29 which might interfere with rapid return of the piston 25.

Completion of the cycle of operation of the piston 25 by return thereof to starting position at the end of a driving stroke is effected by release of the operation controlling valve member 75 to return to open relation of the valve tip 77 with respect to the pressure port 78 and closing of the bleed exhaust through the ports 79. Instantly the pressure fluid acts to snap the control piston valve assembly 53 back into cylinder closing position, aided by a light coiled compression biasing spring 82 acting between the top of the control valve piston 59 and the overlying portion of the cap 54. This action also activates the air return fluid pressure relationship on the underside of the piston head 27.

All of the air trapped in the cylinder space between the upper cylinder head 27 and the control valve member 58 at the conclusion of a driving stroke of the piston 25 and at the beginning of the return stroke of the piston is utilized to advantage during the return stroke on the underside of the piston, namely, under the lower head 29 of the piston. To this end, as best shown in FIG. 4, as the piston 25 rises in a return stroke under the impulse of pressure fluid force entering through the ports 32, as indicated by directional flow arrows, the air trapped above the upper piston head 27 passes upwardly through a central bore passage extending through the poppet valve connector member 62 and through a coaxial upwardly opening bore 84 in an upwardly projecting head stem 85 on the control valve piston 59 which is reciprocally slidably engaged in a central downwardly opening blind end bore 87 in the cap member 54 communicating in the upper portion thereof with a pair of laterally and downwardly directed passage ducts 88 which in turn communicate at their lower ends with respective ducts 89 in the side wall portions of the head section 19 and provided with respective discharge ports 90 opening toward one another and in a generally upward direction through the lower relief bore 81 in the head section. Thereby, during the return stroke of the drive piston 25 the air in the cylinder 24 above the upper piston head 27 is exhausted, as shown by directional flow arrows in FIGURE 4 through the intercommunicating passages starting with the bore 83 and discharging through the ports 90 under substantial expulsion force imparted by the piston head 27. This has the beneficial result of filling the expanding chamber area in the cylinder under the lower piston head 29 with the exhaust air from the ports 90 under sufficient pressure to preclude drawing in of atmospheric air through the lower exhaust bore 81, thereby avoiding drawing in of dust into the cylinder, thereby keeping the cylinder clean and avoiding dirt abrasion damage to the piston O-rings 28 and 30. In addition, the exhaust air contains a small amount of lubricating oil, customary to compressed air supplied for pneumatic tool operation and this is carried by the exhaust air into the cylinder chamber under the piston for lubrication, complementary to the lubrication afforded through the pressure fluid air above the piston from the reservoir and to the intermediate air return area of the cylinder between the piston heads 27 and 29 through the air ports 32.

Since the upper end portions of the nose assembly plates 45 and 47 have central upwardly projecting driver

blade guideway extension portions thereof extending into the lower end portion of the exhaust bore 81, and above lateral shoulders of the plates that bear against the underside of the casing of the head section 19, and in general alignment and bridging between the lower sides of the exhaust ports 90, inspiration of atmospheric air as a result of pressurized emission of exhaust air from the ports 90 is avoided by reason of the barrier thus afforded. Nevertheless, ample space exists at least at the forward side of the upper portion of the plate 47 and the exit end of the exhaust bore 81 for exhaust of the excess pressurized exhaust air blown into the cylinder chamber from the exhaust ports 90. Such exhaust gap space also functions during the driving stroke of the piston 25 for free pressure relief under the piston.

Conveniently, the ducts 89 may be copper or other tubing cast directly into the casing of the head section 19 of the machine, or the ducts can be cored directly into the casting.

During driving strokes of the piston 25, as depicted in FIG. 3, the exhaust passage bore 84 is sealed against pressure fluid escape through the exhaust system by suitable valve means herein comprising a suitable circular fixed valve insert 91 of generally inverted cup shape press fitted into a crown recess 92 comprising an extension of the bore 87 and from which recess it is adapted to be driven if necessary by means of a tool (not shown) inserted through an access knockout aperture 93 in the tip of the cap crown. On its inner underside, the valve insert member is provided with an annular groove receptive of an upstanding reduced diameter neck projection 94 on the control valve piston stem 85 about the mouth of the exhaust bore 84 and which carries externally a sealing ring 95 engageable in shut-off relation with the inside of a depending skirt peripheral portion of the valve insert member 91, substantially as shown in FIG. 3. Thereby, loss of pressure fluid during driving stroke motivation of the piston 25 is effectively precluded. It will be observed that the valve becomes operative in the differentially advance pop-off movement of the control valve piston 59 before the valve rings 57—58 are snapped from the cylinder end seat and thus avoid pressure fluid leakage on fastener driving firing of the machine.

For reinforcing the valve insert 91 it is provided with a central depending frusto-conical boss 97, and the mouth of the exhaust bore is enlarged to receive the same.

While for firing, that is, triggering operation of the air gun pneumatic fastener driving machine 15, direct digital actuation of the valve member 75 may be effected, there is some preference for use of an actuating trigger lever 98 advantageously located for operation by index finger pressure within the hand hole under the forward portion of the handle 20 and in this instance pivotally mounted on an appropriate bracket boss 99 provided at the juncture of the underside of the handle 20 with the portion of the housing casting affording the lower end portion of the nose section 19. Suitably connected at its opposite end portions to the trigger lever 98 is a generally U-shaped bail member 100 which, as best seen in FIG. 1 extends up over the upper forward side of the handle 20 and has the bight portion thereof guidedly engaged within suitable generally upwardly opening slots 101 provided in alignment in spaced apart substantially identical protective upstanding rigid ear flanges 102 located at the juncture of the upper side of the handle 20 with the rear side of the head section 19 and between which the valve body 74 is located. A thrust transmission lever plate 103 is disposed between the bail 100 and the upstanding valve member 75 and is pivotally mounted on a journal pin member 104 extending between the ear flanges 102 spaced forwardly from the guide slots 101. Thereby, the rear end portion of the transmission lever plate 103 overlies the head end of the valve member 75, with a friction-reducing rounded node 105 dimpled in the lever plate and aligned for thrusting con-

tact with the valve head. Through this arrangement, drawing up on the trigger 98 as shown in FIG. 3 pulls down on the bail link member 100 to depress the transmission plate lever 103 and thereby drives the control valve 75 into its pressure port closing and poppet valve bleed-off position for effecting a driving stroke firing of the machine.

Since by virtue of the full pressure fluid force with which driving of the driver piston 25 is effected, the driver blade 33 ejects the fasteners 17 from the nose 44 at high velocity, it is desirable to provide restraining safety means which will avoid accidental, unintentional firing of the machine. To this end, safety mechanism is operatively associated with the operating trigger structure in a manner to prevent actuation of the trigger 98, and more particularly to transmission lever plate 103 until the driveway orifice tip of the nose assembly 44 is properly disposed in closed relation to a point on the work piece which is to receive one of the fasteners 17 driven thereinto. Suitably, this safety mechanism includes a plunger 107 (FIGS. 2, 3 and 11) located normally to project substantially below the tip of the nose assembly 44 and operative to effect release of the trigger mechanism only when displaced into a position about in a horizontal plane relative to the fastener driveway nose tip.

In a practical construction, the plunger 107 is reciprocably slidably guided within a bushing 108 (FIG. 11) secured into the lower end of a hollow rigid supporting boss 109 forming a rigid integral part of a supporting bracket plate 110 constructed and arranged to be secured rigidly in place on the outer face of the nose plate 47 by the attaching screws 52. Attached fixedly to the inner end portion of the plunger 107 is a Bowden wire-like transmission cable flexible member 111 having thereabout a tubular guide sheath 112 which is coaxially secured at its lower end into the upper end of the bore within the plunger housing bracket boss 109 and provides at its extremity a shoulder against which a compression biasing spring 113 thrusts at one end while its opposite end thrusts against the inner end of the plunger 107 normally to project the plunger into its safety position as best seen in FIG. 2 directed downwardly and with its distal end or outer tip as nearly as practicable aligned below the tip of the nose assembly 44.

From the plunger housing boss 109 the guide tube 112 for the flexible thrust member, Bowden wire transmission 111 extends generally upwardly and along one side of the head section 19 to the outer side of one of the ear flanges 102. In the lower portion thereof, the guide tube 112 is preferably of flexible tubing to withstand resiliently yieldably impacts thereagainst, the upper portion is conveniently a more rigid tubing section 114 (FIGS. 1 and 10) which is secured by a suitable threaded coupling member 115 into a tapped bore 117 in the associated flange 102 disposed on an axis adjacently below the lever plate 103 between the lever plate pivot member 104 and the adjacent guide slot 101.

On its end that projects through the coupling member 115, the flexible thrust transmission member 111 carries an interlock member 118 provided with an enlarged diameter interlock head 119 which normally interlockingly underlies a depressed interlock portion 120 of the lever plate 103 located on the margin thereof adjacent to the ear flange 102 from which the interlock member 118 projects and separated from the opposite and relatively thrusting at its opposite ends against the head 119 and raised marginal portion of the lever plate, as best seen in FIGURE 10, by a clearance aperture 121 in the lever plate, facilitating forming of the plate by a stamping operation. Coaxially projecting from the head 119 is an elongated reduced diameter guide pin projection 122 extending slidably through a bearing aperture 123 in the remaining one of the ear flanges 102 and having located thereabout a coiled compression biasing spring 124 against the inner side of the ear flange 102 through which

the guide pin 122 projects for normally thrusting the interlock member 118 into the interlock position relative to the lever plate 103. Through this arrangement, the thrust transmission lever plate 103 is normally held by the interlocked relationship of the interlock head 119 and the interlock portion 120 of the plate in an inactive position relative to the valve member 75, as best seen in FIGS. 2 and 10, and from which the thrust transmission plate 103 cannot be depressed for actuating the valve member 75 until the interlock head 119 is moved axially from its interlock position into release position as shown in dot dash outline in FIG. 10 by action of the flexible thrust transmission member 111.

In summation of operation of the pneumatic fastener driving machine 15, and assuming it to be connected to a source of pressure fluid such as compressed air at suitable constant pressure as, for example, 100 lbs. p.s.i., and the machine loaded with the desired form of the fasteners 17, the machine is manipulated by means of the handle 20 into the desired operative relation to a work piece and the tip of the nose assembly 44 engaged against the spot into which a fastener is to be driven. As an incident to such tip engagement, the safety device plunger 107 is shifted by engagement with the work piece into retracted position whereby to actuate the flexible thrust transmission member 111 to unlock the safety latch interlock head 119 with respect to the interlock portion 120 of the transmission and latch plate 103 to thereby release the trigger mechanism for pivotal operation of the trigger 98 to depress the transmission link bail 100, depressing the lever plate 103 and thereby the valve 75 to block the pressure orifice port 78 and bleed-off fluid pressure from above the control poppet valve assembly 53 which is thereupon blown by the pressure fluid force in the reservoir 23 into open position relative to the cylinder 24 as shown in FIG. 3 to effect full force driving of the driver piston 25 and the driving blade 33 to drive one of the fasteners 17 from the nose assembly 44 into the work.

Immediately upon release of the trigger 98, accompanied by raising of the bail link 100 to release operating thrust upon the transmission lever latch plate 103, the valve member 75 returns to open position wherein the valve tip 77 thereof opens the pressure fluid orifice 78 so that the force of pressure fluid is again established over the control valve piston 59 to close the cylinder 24 as shown in FIGS. 2 and 4 so that pressure fluid from the reservoir through the ports 32 into the air return chamber between the piston heads 27 and 29 drives the piston 25 in a return stroke during which the air above the piston head 27 within the cylinder 24 is exhausted into the exhaust ducts 89 and issues from the orifice discharge ports 90 into the lower end portion of the cylinder under the lower piston head 29 as previously described. At the end of the return stroke of the piston 25, it comes to rest by thrust of the crown of the upper end head portion 27 thereof against the underside of the control valve member 58 as shown in FIGURE 2, ready for recycle of operation.

In the modification of FIGURES 12, 13 and 14, a fastener driving machine 125 is depicted which except for the details of structure to be particularly described will be understood to embody suitable details of operative structure substantially the same as already described in connection with the machine 15, and where desired the details of structure of the modified machine 125 may be substituted for the substantially equivalent details of the machine 15. In FIGURE 12, a vertical head section 127 has therein a pressure fluid reservoir 128 to which the upper end of a hollow vertical cylinder 129 is arranged to be fully exposed.

Within the cylinder 129 is reciprocally vertically longitudinally operable a driving piston 130 of generally spoon shape having an upper lateral flange head 131 peripherally carrying a sealing O-ring 132, while at the lower end of the piston is a lateral flange head 133 carrying pe-

ripherally an O-ring seal 134. The lower piston head 133 is of slightly smaller diameter than the upper piston head 131 complementary to a slightly reduced diameter lower portion 135 of the bore of the cylinder 129, thereby providing an air return differential in the effective areas of the piston heads within a chamber afforded therebetween into which pressure fluid is introduced through one or more free ports 137 communicating with the reservoir 128 for piston return air pressure.

Attached to the lower end portion of the piston 130 is a depending fastener driving blade member 138 (FIGS. 12 and 14) which has its upper end portion connected coaxially relative to the piston 130 within a vertical slot 139 in a flanged connector block member 140 which is threadedly secured into a downwardly opening recess 141 in the lower end of the piston. A removable connection between the driving blade 138 and the connector 140 is effected by means of a connecting pin 142 received within a transverse complementary bore 143 through the connector 140 and extending through a matching coupling hole 144 through the engaged end portion of the driver blade. The connecting pin 142 is shorter than the bore 143 and is held centered therein and against endwise escape by respective retainer plugs 145 which may be of nylon type plastic and also serve as friction locks coactive with the tapped threads on the wall of the recess 141.

Normally the upper mouth end of the cylinder 129 is sealed from the reservoir 128 by a control valve poppet assembly 147 including an annular sealing ring valve member 148 which is sealingly engageable with the upper tip end of the cylinder 129 under sealing thrust imparted by a circular piston member 149 of larger diameter than the sealing ring 148 to overhang the sealing ring concentrically thereabout for exposure of the underside of the piston member to fluid pressure in the reservoir 128 while the perimeter of the control valve piston member 149, within which is mounted a peripheral sealing ring 150, is slidably related to an upper cylinder extension 151 of the head section 127 affording a limited range of vertical reciprocal operating movement of the control valve piston 149 between the upper end of the driver piston cylinder 129 and a closure cap 152 secured as by means of screws 153 to the top of the head section. Pressure fluid for normally driving the control valve piston 149 into driver cylinder closing relation is conducted into the top of the chamber space within the control valve cylinder portion 151 above the control valve piston 149 through a duct system including a duct portion 154 in the closure cap 152 communicating with a duct 155 in the rear portion of the head section 127 and through which pressure fluid is delivered to the upper side of the control valve piston 149 or bled-off, if preferred, for example in the same manner as described with respect to the machine 15.

In the at rest, inactive position of the piston 130, the upper piston head 131 abuts the lower end of a depending boss portion 157 on the control valve piston 149 of smaller diameter than the inside diameter of the cylinder 129 and of a length to carry the valve sealing ring 148 thereabout and depend a short distance into the mouth end of the cylinder 129 as shown in FIG. 12. A narrow lateral annular shoulder flange 158 on the lower end portion and about the outer perimeter of the depending valve portion 157 is spaced a slightly greater distance from the overhanging portion of the control valve piston 149 than the thickness of the valve sealing ring 148 whereby to afford a slight lost motion relationship during valve opening movement of the piston 149 for drag-free snap-off of the valve ring 148 at the initiation of a driving stroke of the driving piston 130. Thus, during bleed-off of pressure fluid from above the control valve piston 149 there is a slight acceleration movement of the valve piston before the shoulder flange 158 closes the normal gap between it and the opposing inner marginal portion of the sealing ring member 148 as shown in FIGURE 12, whereupon the valve seating ring member 148 is snapped off of the

seat on the upper end of the cylinder 129 and carried into separated relation thereto as shown in FIG. 13 for full force dumping of pressure fluid from the reservoir 128 into the cylinder 129 onto the upper head 131 of the piston 130 to motivate it in a full force driving stroke.

According to this modified arrangement, during return stroke of the piston 130, the static air between the top of the piston and the pop-off cylinder control valve assembly 147 is utilized by exhausting it through the piston 130 to the underside of the piston into the reduced diameter cylinder portion 135 to prevent indrawing of atmospheric air through an exhaust passage 159 and through a bumper ring 160 in the lower end portion of the driver cylinder. To this end, the piston 130 has a central bore 161 therethrough communicating at its lower end with a chamber space provided by the larger diameter recess bore 141 above the connector member 140 which has therethrough a plurality of exhaust openings 162 (FIG. 14) providing exhaust passage from the chamber space into the cylinder chamber below the member 140.

Extending slidably down through the exhaust bore 161 is an exhaust duct tube 163 fixedly connected to and maintained in a normal position by a stud member 164 of a diameter to extend slidably through a sealing ring sealed bore 165 centrally through the control valve piston 149. A lateral head flange 167 on the member 164 is seated in a centering recess 168 in the inner face of the closure cap 152 and is thrustingly engaged by a coiled compression spring 169 serving as a biasing primer thrusting against the control valve piston 149 normally urging it toward closing of the cylinder 129 but light enough to be overcome and compressed in response to fluid pressure in the reservoir 128 when the control valve piston is unbalanced by bleeding of pressure fluid from the upper side of the valve piston to atmosphere.

Within the stud member 164 is a downwardly opening central blind end bore 170 with which the upper end of the exhaust blow-off tube 163 communicates and from which extends a plurality of exhaust ports 171 to the outer periphery of the body of the member 164 to communicate in the valve closing position of the piston member 149 with an annular groove 172 in the wall defining the central bore 165 in the control valve piston member. This groove in turn communicates with a passage 173 in a valve insert ring 174 carried within the depending portion 157 of the control valve piston and provided on its inside diameter with a sealing O-ring 175 which in the valve closing relation of the control valve piston 149 is clear of the lower end portion of the stud member 164 but in the open valve position of the control valve piston 149 as shown in FIGURE 13 seals off the passage to the exhaust ports 171 so as to prevent leakage loss of pressure fluid from the reservoir 128 during a driving stroke operation of the piston 130. Leakage of pressure fluid past the tube 163 into the exhaust bore 161 of the driving piston 130 is prevented by a sealing ring 177 mounted in the upper head end portion of the piston about the head end portion of the exhaust bore.

In operation of the modified machine 125, assuming the relationship of parts to be in the non-operating position shown in FIG. 12, bleeding of the cylinder chamber 151 above the control valve piston 149 to atmosphere causes the control valve piston to snap into its upper limit position against the underside of the closure cap 152 as shown in FIG. 13. In the initial phase of unseating movement of the piston member 149 the exhaust passage sealing ring valve 175 closes the exhaust passage by engaging the lower end portion of the stud member 164 and at about the same time the valve ring 148 is snapped off of the cylinder tip seat by the piston shoulder 158. After the driver piston 130 has completed its driving stroke and the control valve piston 149 has returned the sealing valve ring 148 to cylinder closing position, and the exhaust passage past and through the stud member 164 has been reopened, the driver piston 130 snaps back to starting position in a return stroke under

the air return differential pressure against the underside of the upper piston head 131. In this return stroke, static air trapped between the top of the driver piston 130 and the cylinder closing piston valve assembly 147 is forceably driven through the exhaust passage including the exhaust tube 163 and the exhaust bore 161 of the piston and down through the exhaust ports 162 in the driver blade connector and into the cylinder space below the driver piston in sufficient volume and under sufficient piston induced pressure to fill the under piston cylinder area and prevent ingress of atmospheric air through the relief and driver blade clearing opening 159 in the bottom of the cylinder. At the same time, lubricating oil carried in the air lubricates the under piston cylinder wall.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

We claim as our invention:

1. In a pneumatic driving machine including a cylinder having a piston reciprocable therein, means for supplying pressure fluid into one end of the cylinder to drive the piston toward the opposite end of the cylinder, said opposite end of the cylinder having a pressure relief passage to atmosphere, the piston being returnable toward said one end of the cylinder, and means operative, while the piston is returning, to exhaust static pneumatic fluid from between said one end of the cylinder and the adjacent end of the piston and including passage means for conducting and discharging the exhausted fluid in self-cleaning relation into the cylinder behind the piston adjacent to said opposite end of the cylinder for thereby preventing entry of atmospheric air into the cylinder through said pressure relief passage, said passage means for exhaust air including a bore through the piston and an extension exhaust tube telescopically engaged in said bore.

2. In a pneumatic driving machine including a housing structure having a cylinder therein and a pressure fluid reservoir to which said cylinder is exposed at one end, a piston reciprocably mounted in said cylinder, the piston being movable toward said one end, and a poppet valve assembly including means for normally biasing the same into closing relation to said one end of the cylinder, said poppet valve assembly having exhaust passage means therethrough and comprising valve mechanism for controlling the exhaust passage means, said valve assembly including two relatively movable portions one of which is in control of the valve mechanism and the other of which is in control of closing the cylinder end, said one portion being movable in advance of said other portion so that the valve mechanism closes off the exhaust means substantially before said other portion opens the cylinder to pressure fluid from the reservoir.

3. In a fastener driving machine including a head section housing having a vertical cylinder therein and a reservoir space to which the upper end of the cylinder is exposed, a piston operable in said cylinder and having a driving member extending therefrom through the lower end of the cylinder, the piston being movable toward said upper end of the cylinder, pressure fluid actuated pop-off valve mechanism for closing said upper cylinder end from the reservoir and including means for exposing the upper side of the closure valve mechanism to overbalancing pressure fluid pressure to retain the closure valve in closing relation to the upper cylinder end in opposition to less pressure fluid action from the reservoir on the closure valve tending to unseat it, control valve means including an operator externally of said housing for operating said pressure fluid exposing means, and safety mechanism mounted on the outside of said housing and connected with said operator of the control valve means and maintaining the control valve means against operation until a release member of the safety means is actuated by engagement with a work piece into which a

fastener is to be driven by operation of said piston and driving member.

4. In a fastener driving machine including a head section housing having a vertical cylinder therein and a reservoir space to which the upper end of the cylinder is exposed, a piston operable in said cylinder and having a driving member extending therefrom through the lower end of the cylinder, the piston being movable toward said upper end of the cylinder, pressure fluid actuated pop-off valve mechanism for closing said upper cylinder end from the reservoir and including means for exposing the upper side of the closure valve mechanism to overbalancing pressure fluid pressure to retain the closure valve in closing relation to the upper cylinder end in opposition to less pressure fluid action from the reservoir on the closure valve tending to unseat it, control valve means externally of the housing including a pivoted lever for operating said pressure fluid exposing means, and safety mechanism mounted on the outside of said housing and connected with said control valve means and comprising an interlock member extending across the path of movement of said lever and maintaining the lever against operation of the control valve means until a release member of the safety means is actuated by engagement with a work piece into which a fastener is to be driven by operation of said piston and driving member, said safety means release member comprising a plunger having a flexible thrust member extending about the outside of said housing and operatively connected with said interlock member.

5. In a fastener driving machine including a head section housing having a vertical cylinder therein and a reservoir space to which the upper end of the cylinder is exposed, a piston operable in said cylinder and having a driving member extending therefrom through the lower end of the cylinder, the piston being movable toward said upper end of the cylinder, pressure fluid actuated pop-off valve mechanism for closing said upper cylinder end from the reservoir and including means for exposing the upper side of the closure valve mechanism to overbalancing pressure fluid pressure to retain the closure valve in closing relation to the upper cylinder end in opposition to less pressure fluid action from the reservoir on the closure valve tending to unseat it, control valve means for operating said pressure fluid exposing means, and safety mechanism mounted on the outside of said housing and connected with said control valve means and maintaining the control valve means against operation until a release member of the safety means is actuated by engagement with a work piece into which a fastener is to be driven by operation of said piston and driving member, said safety means and control valve means including a reciprocable valve member externally disposed on said housing and an operating trigger connected thereto by a linkage said safety mechanism including a safety means interlock structure precluding actuation of the trigger and linkage until release of the interlock by operation of said work engageable member.

6. In a driving machine including a cylinder and a piston reciprocable in the cylinder, means for supplying pressure fluid for motivating the piston in the cylinder, the cylinder having a central reduced diameter opening from one end thereof, a driving member projecting through said opening, the piston having on the end thereof facing toward said opening a projection of a diameter to fit in said opening and to which projection the driver is attached, said opening serving as a pressure relief exhaust passage during driving stroke movement of the piston theretoward, said projection extending into said opening in the last part of the driving stroke of the piston and thereby substantially closing the opening to further exhaust and trapping some air as a terminal cushion between the adjacent ends of the piston and cylinder.

7. In a fastener driving machine including a housing having a head section at the forward end of a magazine

portion and with a handle above the magazine portion and rearwardly of the head section, said head section having a cylinder therein with an opening therein forwardly and above the forward end of the magazine portion, a piston reciprocably operable in the cylinder and having a driver extending therefrom through said opening means carried in and by the housing for supplying pressure fluid for reciprocably driving said piston in the cylinder in a driving stroke downwardly toward said opening, the piston being movable in a return stroke away from said opening, and a driver guideway and fastener driveway nose assembly including a pair of plates in laminar relation with the lower end portion of the driver in a vertical guideway-driveway passage defined between the plates, one of said plates being engaged with the forward end of the magazine portion and having an opening therethrough which fasteners from the magazine portion are adapted to be fed into the guideway-driveway passage for driving by the driver in the reciprocations of the piston, the other of said plates having side flanges projecting rearwardly and past the sides of and thereby nesting said one plate and engaging the sides of the forward portion of the magazine portion and being secured with said one plate to the magazine portion, said plates having an upper portion of each projecting toward and being adjacent to said opening with exhaust space gap from said opening to atmosphere past said upper portions of the plates for exhaust of air from within the cylinder in the driving stroke of the piston.

8. In a pneumatic fastener driving machine including a housing provided with a pressure fluid cylinder and a piston therein having a fastener driver, means for supplying fasteners to be driven by the driver, means for supplying pressure fluid to actuate the piston in the cylinder, control valve means operable to control said pressure fluid supplying means and including a valve actuating lever externally of the housing, safety mechanism including a movable member disposed for engagement and movement by work into which a fastener is to be driven, and mechanism connected to said member and having a portion thereof in direct holding engagement with said lever and normally preventing movement of said lever for valve actuation, said mechanism being disabled by said engagement and movement of said member by the work and thus enabling valve actuation movement of the lever.

9. In a pneumatic driving machine including a housing having a cylinder therein and a pressure fluid reservoir about the upper end of the cylinder, said housing having an opening therein above the upper end of the cylinder, a removable closure member secured to the housing in closing relation to the opening in the housing, a control piston valve member operable to close the cylinder end and having a stem projecting therefrom toward said closure member, said closure member having a cylinder recess therein opening toward said valve member, said stem being slidably engaged in said cylinder recess, said valve member and said stem having exhaust passageway extending from the end of the valve member which closes said cylinder end to the end of the stem in said cylinder recess, an exhaust passageway leading from said cylinder recess through said closure member and coacting with said cylinder recess and said passageway in the valve member and stem to provide an exhaust passage from the cylinder in the cylinder closing position of the valve member, said closure member having valve means including a portion sealingly engageable with a part on said stem in an open position of said valve member relative to said cylinder for sealing the passageway opening through said valve stem, said valve means including a boss which projects in said opening from the valve stem in said open position of the valve member relative to the cylinder.

10. In a pneumatic driving machine including a housing having a cylinder therein and a pressure fluid reservoir about the upper end of the cylinder, said housing hav-

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ing an opening thereinto opposite the upper end of the cylinder, a closure member removably secured to the housing in closing relation to said opening and having a cylinder recess therein opening toward said cylinder end, a control piston valve member operable to close said cylinder end and having a stem projecting therefrom into said cylinder recess and slidably guided therein to guide said valve member between opening and closing positions relative to said cylinder end, said valve member and said stem having an exhaust passageway therethrough from the end of said valve member which closes the cylinder and having an exhaust opening from the free end of said stem within said cylinder recess, said cylinder recess having an exhaust passageway leading therefrom, and a valve member removably engaged in said cylinder recess opposite said free end of the stem and engageable with said free end of the stem to close said passageway opening in said free end of the stem, and an access knock-out aperture in said closure member over said valve member in the cylinder recess to facilitate dislodging the latter when necessary.

11. In a fastener driving machine including a cylinder and a piston reciprocally operable therein, a driving blade, said piston having an endwise central projection on one end thereof, said projection having a slot opening through its free end and on the axis of the piston, the driving blade having an end portion fitted in said slot, a transverse bore in said projection intersecting said slot, said end portion of the blade having an aperture therethrough matching said bore, said projecting having an annular groove in its periphery across the axis of said bore, a pin in said bore and extending through said aperture and thereby retaining the blade in attached relation to the piston, said pin being engaged in said bore through an opening through one end thereof, and a split snap ring mounted in said groove across said opening and thereby retaining said pin against escape from said bore.

12. In a fastener driving machine including a head section housing having a vertical cylinder therein, a piston reciprocally operable in said cylinder and having a driving member extending therefrom through the lower end of the cylinder, a fastener guiding nose structure aligned with the lower end of the cylinder and said driving member, means for delivering pressure fluid to said cylinder

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for driving said piston, a control valve for controlling delivery of pressure fluid to said cylinder including a control lever outside of said housing, an interlock plunger extending across the path of operative movement of said lever and normally blocking such operative movement, but being shiftable out of such blocking movement, and means including a work-projecting member and connecting structure between said projecting member and said plunger and operable upon engagement with work into which a fastener is to be driven to move said plunger out of said blocking relation to the lever, said nose structure having guide means thereon maintaining said projecting member in operative relation to said nose structure.

13. In a pneumatic driving machine including a cylinder having a piston reciprocally therein, means for supplying pressure fluid into one end of the cylinder to drive the piston toward the opposite end of the cylinder, said opposite end of the cylinder having a pressure relief passage to atmosphere, the piston being returnable toward said one end of the cylinder, and means operative, while the piston is returning toward said one end of the cylinder, to exhaust static pneumatic fluid from said one end of the cylinder and the adjacent end of the piston, said exhaust means including a plurality of passageways leading to and having respective ports opening into said opposite end of the cylinder and being directed to discharge toward the opposite end of the piston for thereby conducting and discharging the exhausted fluid in self-cleaning relation into the cylinder behind and toward said opposite end of and in the direction of return movement of the piston and thus preventing entry of atmospheric air into the cylinder through said pressure relief passage.

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