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Schmitz

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(54) **WASHER FEEDING AND POSITIONING ATTACHMENT FOR FASTENER DRIVER**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **B25C 7/00**
(52) **U.S. Cl.** **227/119**; 227/15; 227/18
(58) **Field of Search** 227/15, 18, 119

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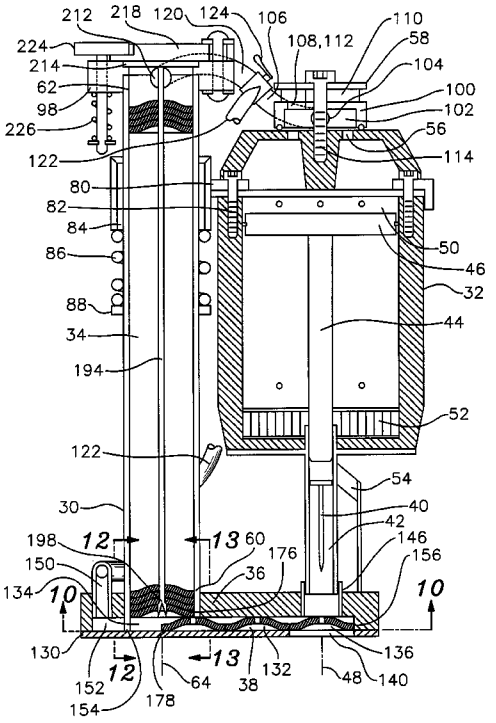
(57) **ABSTRACT**

A pneumatically operated washer feeding attachment for use with a fastener driver of the type having a driver stroke axis and an exit barrel. A delivery channel has an acceleration chamber at one end for receiving washers one at a time from a magazine, and a retention region at the other end to which washers are pneumatically driven. The retention region has an exit aperture aligned with the fastener driver exit barrel and with the exit aperture. The attachment is powered by collected exhaust gas from the fastener driver. Some embodiments require no moving parts.

17 Claims, 9 Drawing Sheets



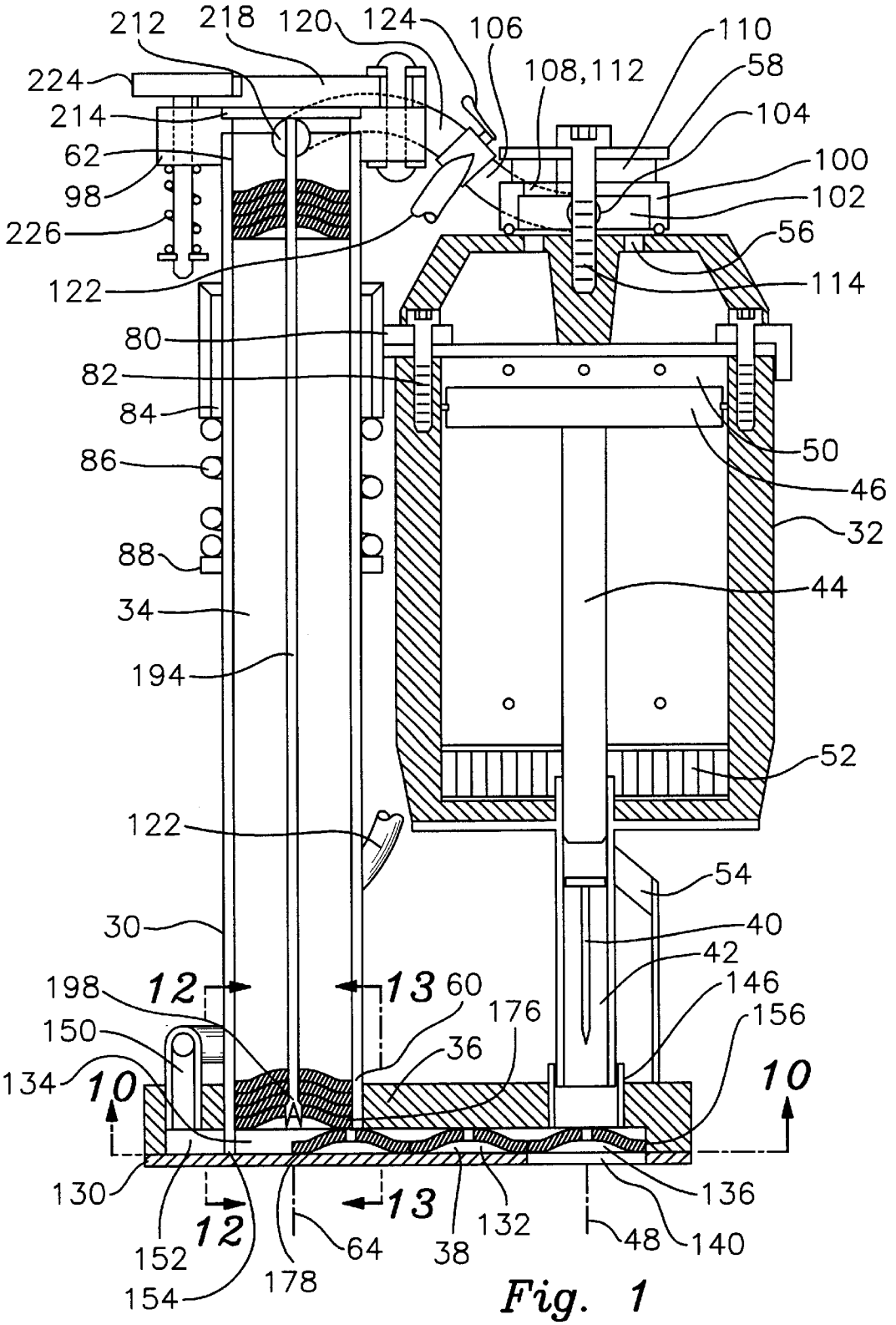

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Fig. 1

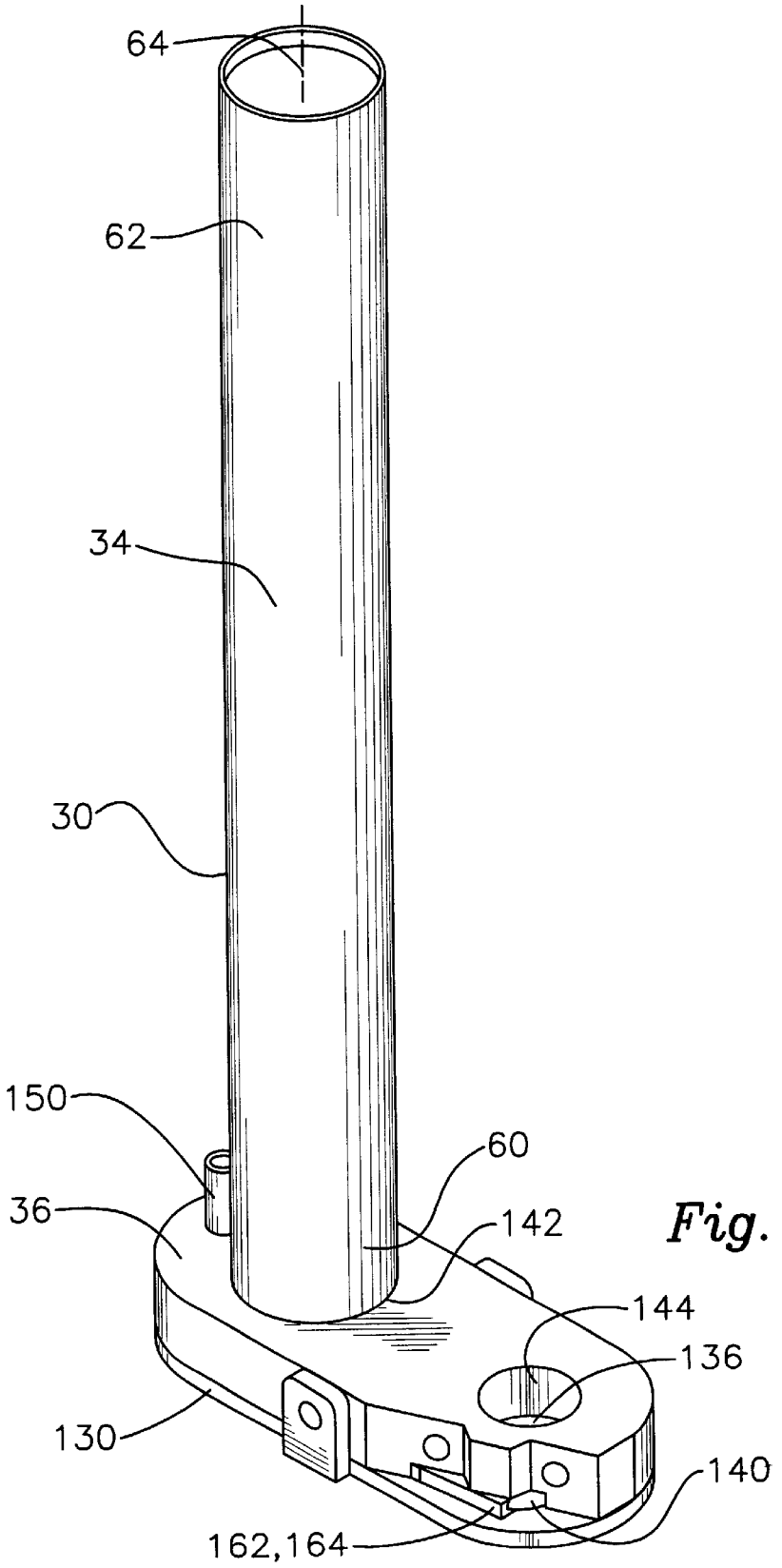

Fig. 2

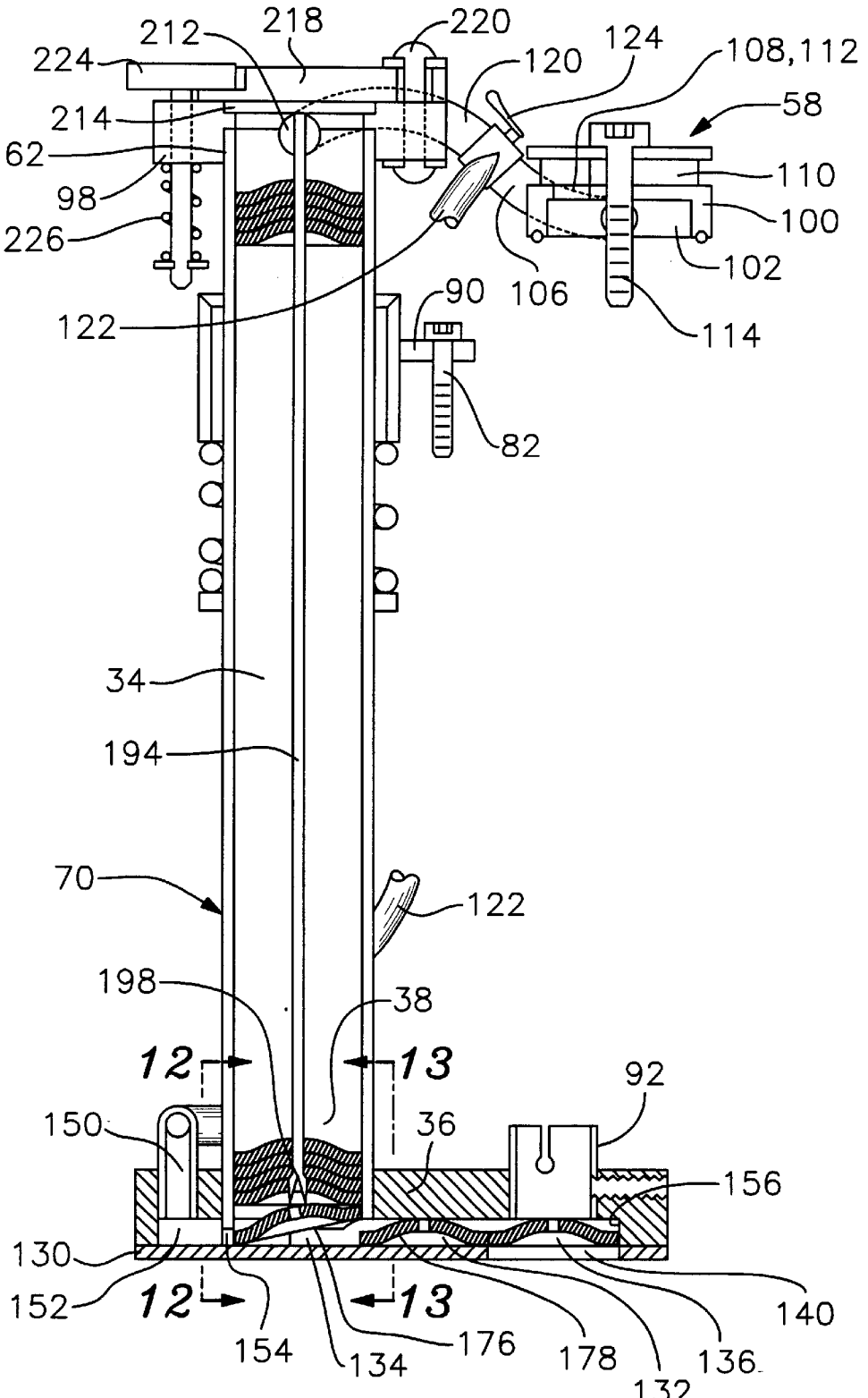
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Fig. 3

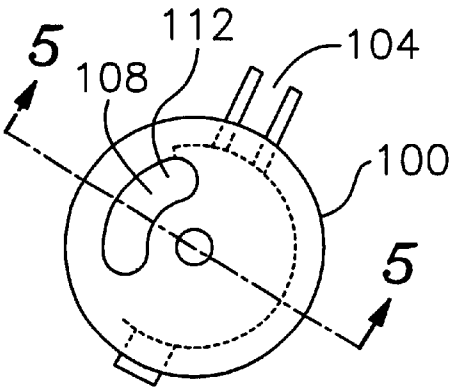


Fig. 4

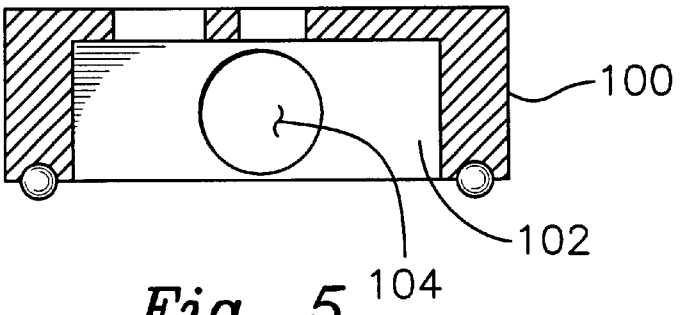


Fig. 5

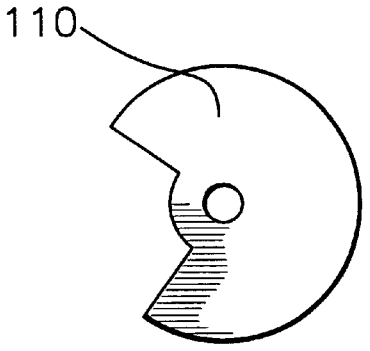
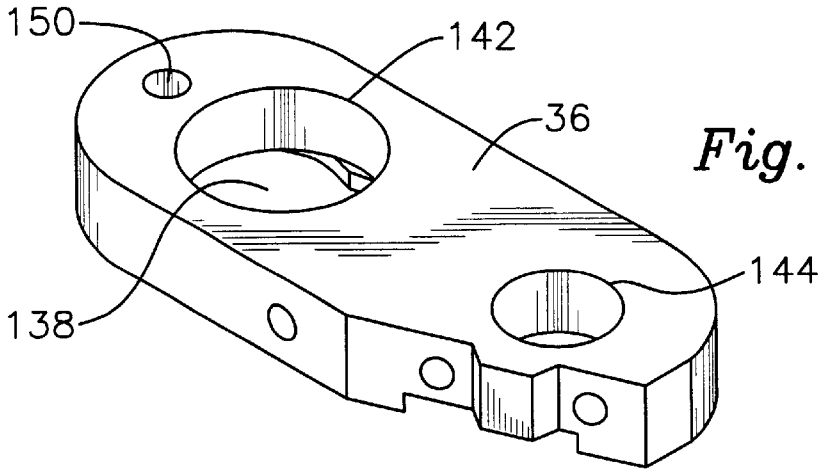


Fig. 6



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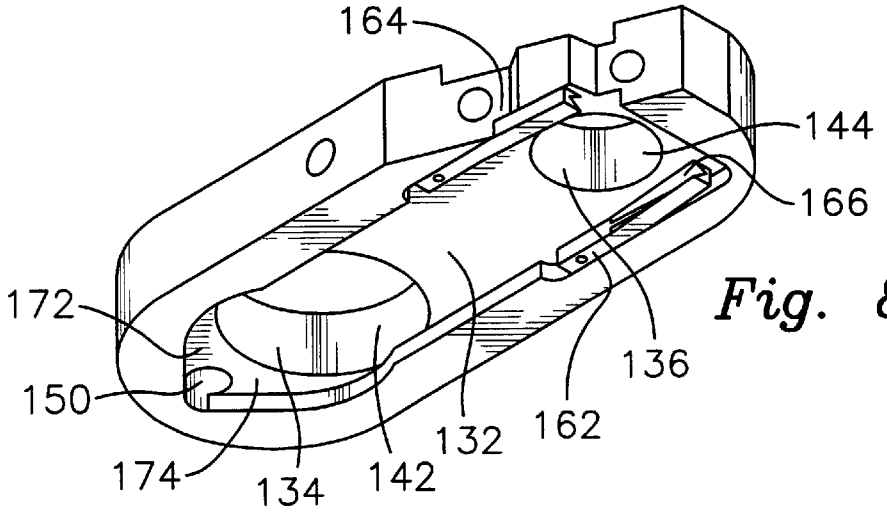
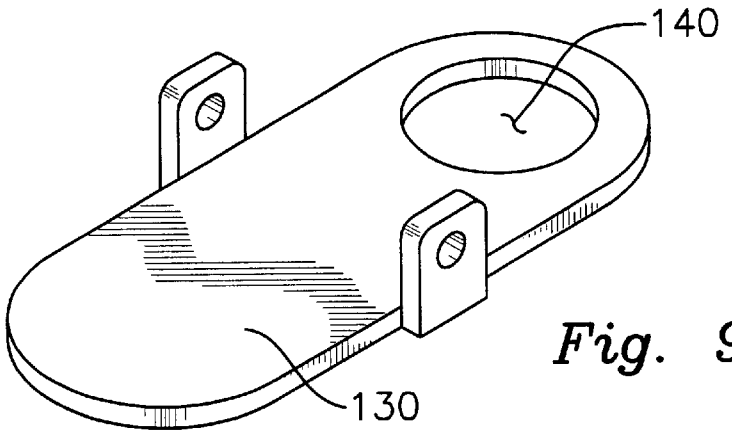


Fig. 8



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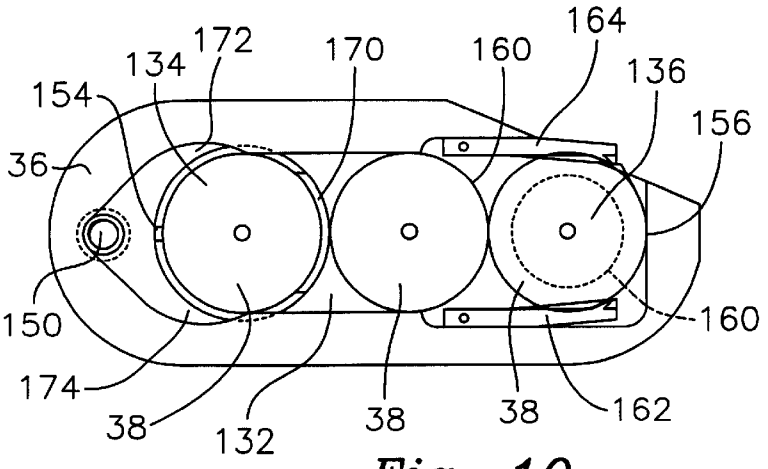
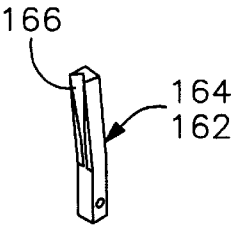


Fig. 10



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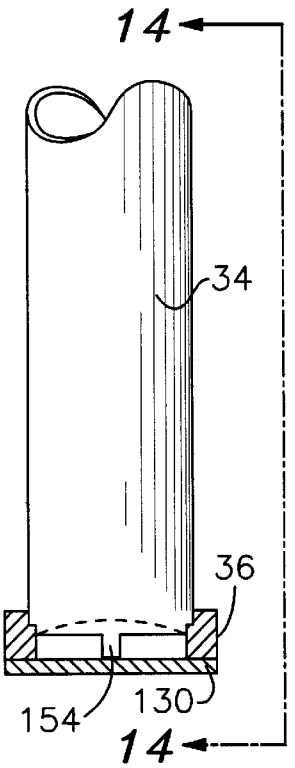

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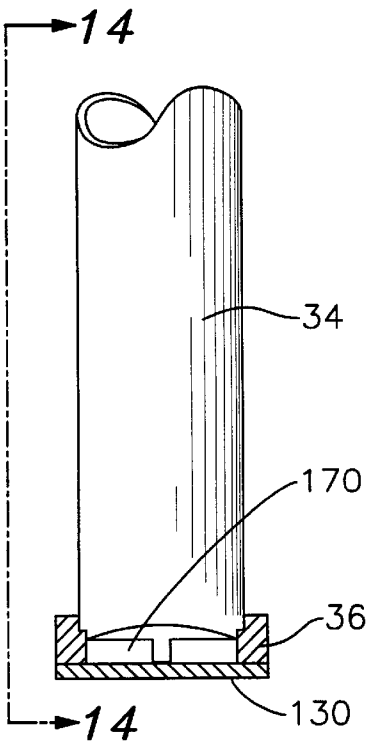

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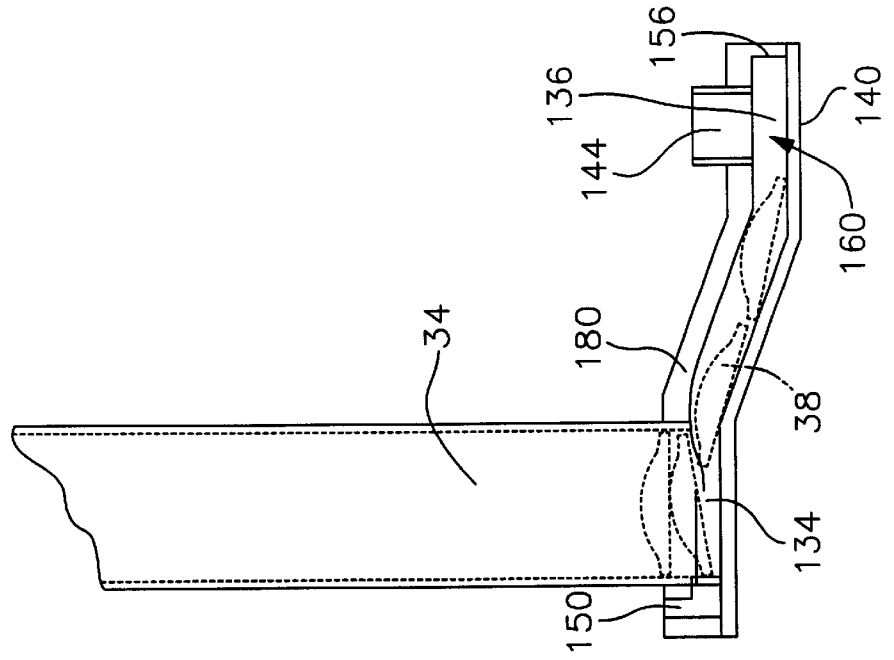
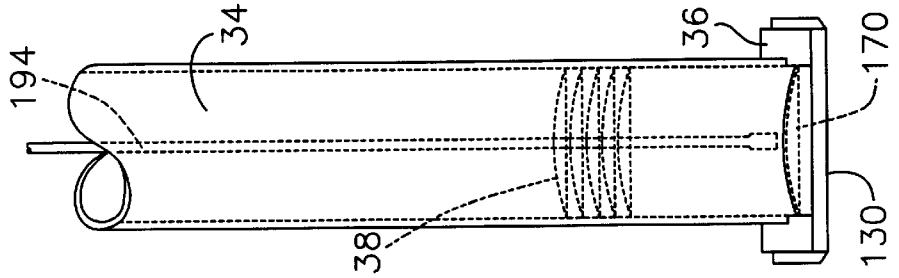


Fig. 16



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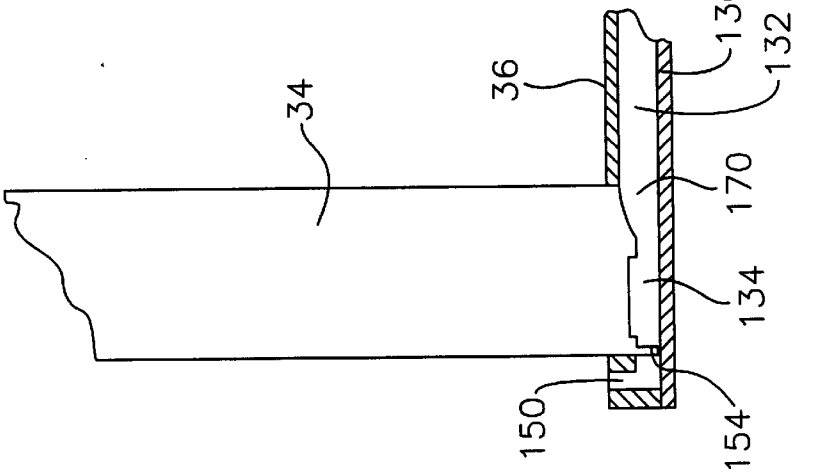

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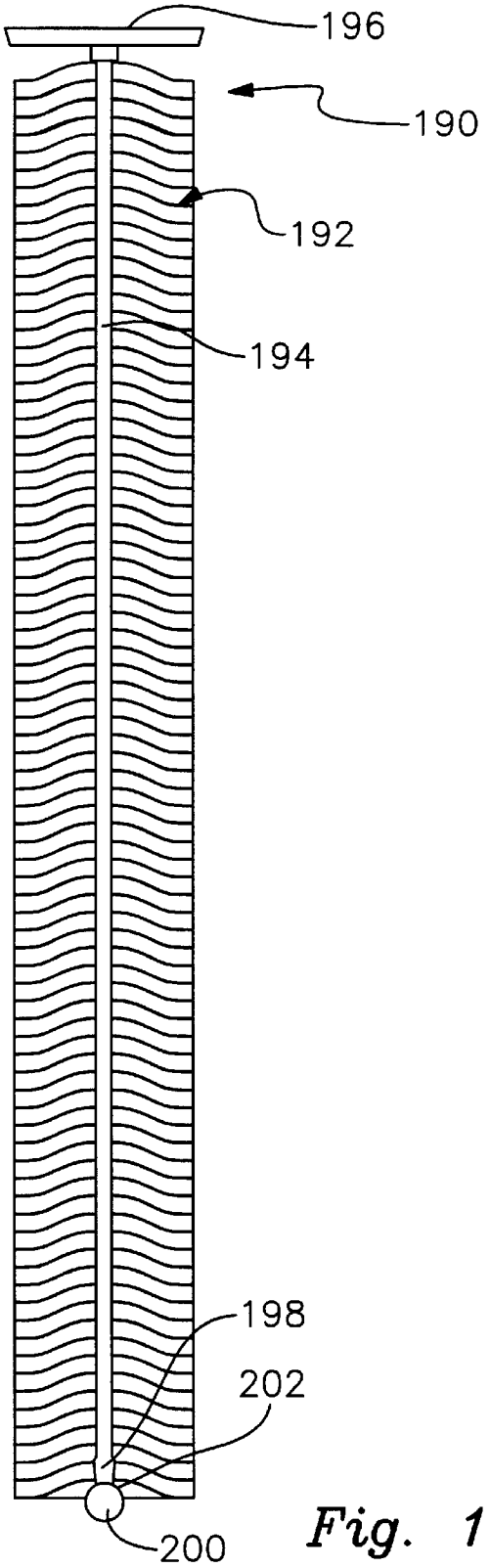


Fig. 17

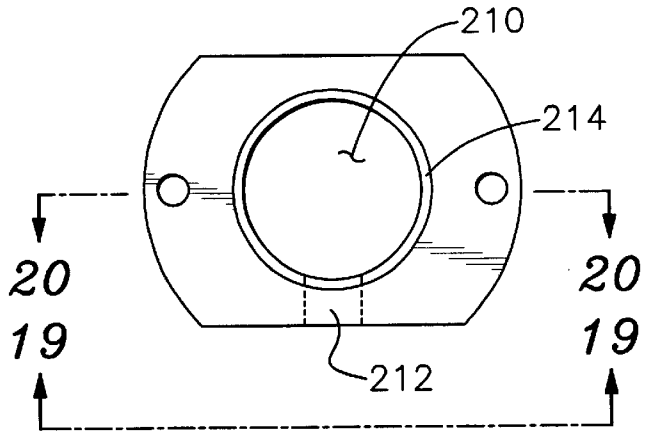
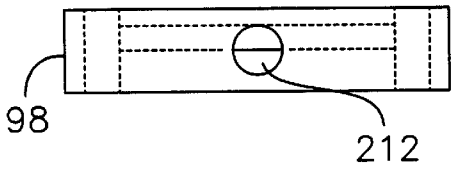


Fig. 18



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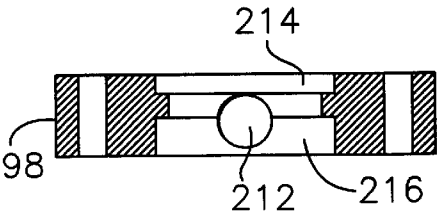

Fig. 20

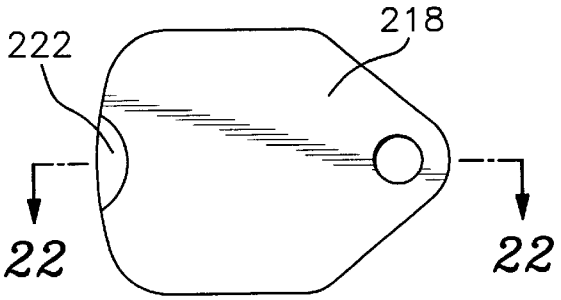

Fig. 21

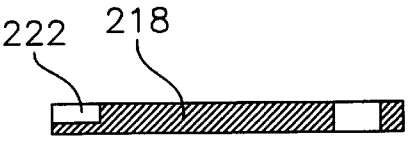

Fig. 22

WASHER FEEDING AND POSITIONING ATTACHMENT FOR FASTENER DRIVER

CROSS-REFERENCE TO PROVISIONAL PATENT APPLICATION

The benefit of U.S. provisional patent application Ser. No. 60/175,887, filed Jan. 13, 2000, is claimed.

BACKGROUND OF THE INVENTION

Nails fitted with plastic or metal load dispersion and sealing washers are typically employed in applications such as attaching roof underlayment, tar paper, metal lath, foam board, and vapor barrier, as examples. Nails fitted with washers are not well suited for feeding from a nail magazine into a power operated fastener driver. Accordingly, and even though power operated fastener drivers are commonly used in modern construction methods, nails fitted with washers are typically hand driven, with a hammer.

SUMMARY OF THE INVENTION

It is therefore seen to be desirable to provide a washer feeding attachment which is readily adaptable to commonly employed power operated fastener drivers, especially pneumatically powered fastener drivers, for individually positioning washers for engagement by fasteners driven by the fastener driver. The washer is thus assembled onto the fastener as the fastener is driven by the fastener driver, resulting in proper washer and fastener installation into the work surface with which the fastener driver is in contact. It is further seen to be desirable to provide such an attachment that is non-encumbering, space-efficient, reliable, easy to use, low maintenance and cost efficient. Beyond the primary consideration of a fully functioning attachment which employs washers similar to or of the kind already manufactured for fitting in advance to nails, it is desirable to facilitate packaging and reloading of the washers. It is also desirable to provide for simple mounting to a variety of existing pneumatic fastener driver tools. In addition, it is desirable to employ the existing exhaust from the pneumatic fastener driver for powering the attachment.

Embodiments of the invention are attached to fastener drivers of the type having a driver stroke axis and an exit barrel. In an exemplary embodiment of the invention, washer feeding apparatus includes a magazine for holding a plurality of washers. A delivery channel has an acceleration chamber at one end for receiving washers one at a time from the magazine, and a retention region at the other end to which washers are pneumatically driven. The retention region has an exit aperture aligned with the exit barrel and arranged such that a washer retained in the retention region is in alignment with the fastener driver exit barrel and with the exit aperture. A supply of pressurized gas propels washers from the acceleration chamber to the retention region for subsequent engagement by fasteners driven by the fastener driver. The washers then exit from the retention region through the exit aperture.

The invention advantageously may be embodied in a feeding attachment which contains no moving parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view, partially sectioned, of a washer feeding apparatus embodying the invention assembled to a fastener driver;

FIG. **2** is a three dimensional view of the tubular magazine and channel housing of the washer feeding apparatus of FIG. **1**;

FIG. **3** is a side view, partially sectioned, of another washer feeding apparatus embodying the invention, shown in isolation;

FIG. **4** is a top plan view of an exhaust collection manifold housing of the washer feeding apparatus of FIGS. **1** and **2**.

FIG. **5** is a cross section taken on line **5**—**5** of FIG. **4**.

FIG. **6** is a top view of an adjustment plate contained within the exhaust collection manifold housing of FIGS. **4** and **5**;

FIG. **7** is a three dimensional view of the channel housing of FIG. **2** in isolation, with the bottom cover plate removed;

FIG. **8** is a three dimensional underside view of the channel housing of FIG. **2** in isolation, with the bottom cover plate removed;

FIG. **9** is a three dimensional view of the bottom cover plate of the FIG. **2** channel housing in isolation;

FIG. **10** is a view, taken generally on line **10**—**10** of FIG. **1** or FIG. **3**, showing a plurality of washers within the acceleration chamber, washer delivery channel and retention region of the channel housing;

FIG. **11** is a three dimensional view of a restrictor spring in isolation;

FIG. **12** is a partially sectioned view, taken generally on line **12**—**12** of FIG. **1** or FIG. **3**, of the lower end of the tubular magazine in full, in particular depicting a barrier pin, and a portion of the channel housing in cross section;

FIG. **13** is a partially sectioned view, taken generally on line **13**—**13** of FIG. **1** or FIG. **3**, of the lower end of the tubular magazine in full, in particular depicting a separation and alignment orifice, and a portion of the channel housing in cross section;

FIG. **14** is a partially sectioned view, taken generally on line **14**—**14** of FIG. **12** or FIG. **13**, of the lower end of the tubular magazine in full, and a portion of the channel housing in cross section;

FIG. **15** is a view in the same orientation as FIG. **13** depicting a washer passing through the separation and alignment orifice;

FIG. **16** is a side elevational view showing another embodiment of a channel housing;

FIG. **17** is a view, partly in section, of a plurality of washers retained on a skewer prior to loading into the tubular magazine of FIGS. **1**, **2** and **3**;

FIG. **18** is a top plan view of the magazine lid housing;

FIG. **19** is a side elevational view taken on line **19**—**19** of FIG. **18**;

FIG. **20** is a cross sectional view taken on line **20**—**20** of FIG. **18**;

FIG. **21** is a top plan view of the magazine lid; and

FIG. **22** is a cross section taken on line **22**—**22** of FIG. **21**.

DETAILED DESCRIPTION

Referring first to FIGS. **1** and **2**, FIG. **1** depicts a washer feeding apparatus **30** embodying the invention assembled to a fastener driver **32**, in the exemplary form of a pneumatically operated nail gun **32**. The washer feeding apparatus **30** in overview comprises a magazine **34** for holding a plurality of washers, as well as a channel housing **36**, which are shown in the three-dimensional view of FIG. **2**. Plastic washers **38** (also known as fastener caps **38**) are shown, but the apparatus **30** may be employed to feed and position metal washers as well, with or without a pre-formed central aperture. The apparatus **30** can also be used with washers that are stapled.

The fastener driver **32** of FIG. **1** is representative of any one of a variety of commercially available fastener drivers, and for purposes of example is a pneumatically operated nail gun **32** for driving fasteners such as a representative roofing nail **40**. Briefly, the pneumatic fastener driver **32** includes an exit barrel **42** from which fasteners, such as the representative roofing nail **40**, are driven by a hammer **44** connected to a piston **46**. The hammer **44** and piston **46** reciprocate on a driver stroke axis **48**. The pneumatically operated nail gun **32** is connected to a source of compressed air (not shown). Valving and porting (not shown) within the nail gun **32** direct compressed air to a chamber **50** above the piston **46** when a nail is to be driven, driving the piston **46** downwardly to a resilient rebound element **52**. The pneumatic fastener driver **32** includes a trigger (not shown), as well as a contact safety mechanism represented by a linkage **54** which is connected to a trigger mechanism (not shown) and which prevents the fastener driver **32** from operating unless it is pressed against a work surface, such as a roof, to be nailed. As part of the fastener driver **32** operation cycle, in particular, as the piston **46** and **44** return to the upper position shown in FIG. **1**, compressed air exits the fastener driver **32** through a plurality of exhaust gas ports **56**.

The pneumatic fastener driver **32** of FIG. **1** has been slightly modified by removing the shoe (not shown) associated with the contact safety mechanism linkage **54**, which is instead connected to the channel housing **36** of the washer feeding apparatus **30** embodying the invention, thereby saving space by integrating the contact safety mechanism with the washer feeding apparatus **30**. In addition, the top of the pneumatic fastener driver **32** is fitted with an exhaust collection system generally designated **58**. The exhaust collection system **58** replaces the original exhaust gas manifold (not shown) of the pneumatic fastener driver **32**, and captures at least a portion of the exhaust gas exiting the exhaust ports **56** for operating the washer feeding apparatus **30**. Constructional details of the exhaust collection system **58** are described hereinbelow with reference to FIGS. **4–6**.

In the illustrated embodiment, the magazine **34** for holding a plurality of washers **38** is a tubular magazine **34**. The tubular magazine **34** has two ends **60** and **62**. The end **60** is fixed to the channel housing **36**, and may also be referred to as the lower or exit end **60** of the magazine **34**. The other end **62** of the tubular magazine **34** may also be referred to as the upper or filling end **62**.

The tubular magazine **34** has a central axis **64**, and is mounted such that the magazine axis **64** is at least approximately parallel to the driver stroke axis **48**.

In the embodiment of FIG. **1**, the tubular magazine **34** and channel housing **36** are mounted for axial movement relative to the fastener driver **32**, and this axial movement is integrated with the contact safety mechanism linkage **54**. FIG. **3**, described hereinbelow, depicts an alternative embodiment of a washer feeding apparatus **70**, in which the tubular magazine **34** and the channel housing **36** are rigidly attached to the fastener driver **32**.

In FIG. **1**, the washer feeding apparatus **30** has an upper mounting bracket **80** which is securely attached to the pneumatic fastener driver **32** by an upper mounting bracket fastener **82**. The upper mounting bracket **80** has a magazine slide surface **84** such that the tubular magazine **34** can slide along its axis **64** with reference to the pneumatic fastener driver **32**, carrying with it the channel housing **36** connected to the contact safety mechanism linkage **54** of the fastener driver **32**. The magazine slide surface **84** is sized and shaped such that the magazine **34** is free to move to allow for free operation of the contact safety mechanism linkage **54**, while at the same time providing a radial bearing surface such that the tubular magazine **34** is constrained against lateral or skewing motion with reference to the nail gun **32**.

To compensate for any drag on the contact safety mechanism **54** induced by the magazine slide surface **84**, a contact safety assist spring **86** is compressed between the upper mounting bracket **80** and a spring stop ring **88** on the tubular magazine **34**. The contact safety assist spring **86** accordingly urges the assembly of the tubular magazine **34** and channel housing **36**, and thus the contact safety mechanism **54**, downwardly (in the orientation of FIG. **1**).

Referring to FIG. **3**, the alternative washer feeding apparatus **70** differs from the apparatus **30** of FIG. **1** in that, in FIG. **3**, the tubular magazine **34** and the channel housing **36** are rigidly fixed to the fastener driver **32**. In that event, the contact safety mechanism **54** of the fastener driver **32** is fitted with a suitable foot (not shown) which can move relative to and is shaped to clear the washer feeding apparatus **70**. In FIG. **3**, an upper mounting bracket **90** is attached to the tubular magazine **34** in a fixed yet adjustable manner, employing a clamp or set screws (not shown). The channel housing **36** in FIG. **3** is filled with a sleeve **92** that receives the exit barrel **42** of the fastener driver **32**. The exit barrel **42** is secured to the channel housing **36** by a set screw **94** received in a threaded bore **96**.

In both the washer feeding apparatus embodiments **30** and **70** of FIGS. **1** and **3**, at the upper end **62** of the tubular magazine **34** is a magazine lid housing **98**, which is securely affixed to the tubular magazine **34**. The magazine lid housing **98** is described in greater detail hereinbelow with reference to FIGS. **18–22**. The magazine lid housing **98** is mounted at approximately the height of the host pneumatic fastener driver **32**.

With reference to FIGS. **4–6**, in addition to FIGS. **1** and **3**, the exhaust collection system **58** includes an exhaust collection housing **100** defining a plenum **102** positioned over the exhaust gas ports **56**. The plenum **102** is connected via a port **104** to a gas pressure supply conduit **106** which supplies pressurized gas for operation of the washer feeding apparatus **30** or **70**. As a typical pneumatically operated nail gun generates a volume of exhaust gas well in excess of what is required for operation of the washer feeding apparatus **30** or **70**, a gas escape port **108** is provided in the exhaust collection housing **100**, the degree of opening of which is controlled by rotation of an adjustment plate **110** having an arcuate gap **112** which permits the effective area of the gas escape port **108** to be varied as required. The exhaust collection housing **100** is secured by a machine screw **114**, as is best seen in FIGS. **1** and **3**.

Different exhaust collection systems **58** may be required for different models of pneumatically operated fastener drivers made by various manufacturers. Some commercially available pneumatic fastener drivers are manufactured with a plugged port containing an exhaust pressure supply, and this can be directly accessed without altering the exhaust manifold of the pneumatic fastener driver **32**. Other available fastener drivers require some modification of the exhaust manifold.

In the illustrated embodiments, the exhaust collection housing **100** is interfaced with the exhaust gas ports **56** by replacing the original exhaust manifold (not shown) of the pneumatic fastener driver **32** with the exhaust collection housing **100**. The machine screw **114** is thus an existing part of the fastener driver **32** associated with the original exhaust manifold (not shown).

The gas pressure supply conduit **106** branches into a magazine gas pressure supply conduit **120** connected to the upper end **62** of the tubular magazine **34** for urging washers **38** contained within the magazine **34** towards the lower, exit end **60**; and into a delivery channel gas pressure supply conduit **122** connected generally to the channel housing **36** for propelling washers **38** as described in greater detail hereinbelow. Also provided and illustrated in highly schematic fashion is an exhaust gas pressure supply shutoff or diverter **124** which allows the pneumatically operated fastener driver **32** to be used for simply driving nails, without operation of the washer feeding apparatus **30** or **70**.

Referring now to FIGS. **7–10**, in addition to FIGS. **1–3**, defined within the channel housing **36** and an associated bottom cover plate **130** is a washer delivery channel **132**. At one end of the washer delivery channel **132** is an acceleration chamber **134** which receives washers **38** one at a time from the magazine **34**. At the other end of the delivery channel **132** is a retention region **136** to which washers **38** are pneumatically driven. Washers **38** enter the acceleration chamber **134** from the exit end **60** of the tubular magazine **34**, which is pressed into a magazine receiving aperture **138** within the channel housing **36**, just above the acceleration chamber **134**. Washers eventually exit the retention region **135** via an exit aperture **140**, formed in the bottom cover plate **130**. The retention region **136** is arranged such that a washer **38** retained therein is in alignment with the exit barrel **42** of the fastener driver **32**, as well as in alignment with the exit aperture **140**.

In the top of the channel housing **36** are two apertures **142** and **144**. The aperture **142** receives the lower end **60** of the tubular magazine **34**, which may be pressed in, welded, or screwed by means of threads (not shown). The other aperture **144** is lined with a hardened metal sleeve **146** which slidably engages the exit barrel **42** of the fastener driver **32** for relative movement of the exit barrel **42** with reference to the channel housing **36** which, in the FIG. **1** embodiment, is connected to the contact safety mechanism **54**.

The channel housing **36** has a gas supply port **150** connected to a supply of pressurized gas, in particular to the delivery channel gas pressure supply conduit **122**. The gas supply port **150** delivers pressurized gas to a gas channel **152** adjacent the acceleration chamber **134**. This supply of pressurized gas propels washers **38** from the acceleration chamber **134** to the retention region **136** for subsequent engagement by fasteners, such as the representative fastener **40**, driven by the fastener driver **32** and exiting from the retention region **136** through the exit aperture **140**. A barrier pin **154**, which as a matter of convenience in construction, is integral with and depends from the lower end **60** of the tubular magazine **34**, keeps washers **38** out of the gas channel **152**.

Within the retention region **136** at the end of the washer delivery channel **132** opposite the gas channel **152** and the acceleration chamber **134** is a stop **156** for preventing further travel of a washer **38** once pneumatically propelled to the retention region **136**. The stop **156** stops each washer **38** in correct alignment for proper placement of a fastener as it exits the fastener exit barrel **42**. The stop **156** may be of any size, shape or mechanism so as to allow for proper alignment of washers within the retention region **136**. Excessive rebound can be prevented in a variety of ways, including the use of a restrictor.

Thus, a restrictor, generally designated **160**, is provided. In an illustrated embodiment, the restrictor **160** comprises a pair of restrictor springs **162** and **164**, which are shown in isolation in FIG. **11**. The illustrated restrictor springs **162** and **164** each have a V-shaped channel **166** for engaging the edge of a washer **38**. The restrictor **160** retains a washer **38** within the retention region **136** prior to be engaged by a fastener such as the roofing nail **40**, driven by the fastener driver **32**. The restrictor **160** in particular prevents a washer **38** from prematurely exiting through the exit aperture **140** by any force, such as gravity, recoil from firing or impact, cycling of air pressure, or any other unintentional force, other than the actual driving of a fastener such as the roofing nail **40** by the fastener driver **32**.

As alternatives to the restrictor springs **162** and **164** illustrated, other forms of mechanical retention devices can be employed. In the case of washers made of ferrous metal, the restrictor **160** may comprise a magnet (not shown).

As yet another alternative, the restrictor **160** can comprise simply the elasticity of washers **38** themselves, in the case of plastic washers, in which case the side walls of the retention region **136** are sized to a precise tolerance to effect proper gripping of the washers **38**, aided by washer elasticity.

A washer thus retained by the restrictor **160**, and in contact with the stop **156**, is in alignment with the exit aperture **140**. The exit aperture is shaped such that a washer does not pass through due to any incidental forces yet, when the fastener is driven, the washer is ejected without excessive damage to the washer. Thus, the fastener, such as the representative roofing nail **40**, is projected through the central aperture in the washer and driven into the work piece while, at the same time, the washer is properly placed in its installed position on the fastener, such as the representative roofing nail **40**.

With reference now to FIGS. **12–15**, in addition to FIGS. **1**, **3** and **10**, the manner in which washers **38** are supplied from the magazine **34** to the acceleration chamber **134** and delivered through the channel **132** for positioning in the retention region **136** is now described in greater detail.

The magazine **34** thus terminates into the acceleration chamber **134**, and is securely adhered to the channel housing **36** such that washers **38** contained within the magazine **34** can pass one at a time into the acceleration chamber **134**. The washer delivery channel **132** is shaped to allow free passage of washers **38**, while restricting washers **38** from overlapping each other or become misaligned. The bottommost washer **38** exits the magazine **34** in such a manner that it fully enters the washer delivery channel **132** before the next washer **38** in the magazine **34** is able to enter the shaped channel **132**, regardless of variable factors such as pressure supply, fastening device sequence, or other occurrent forces.

This operation is aided by a separation and alignment orifice **170** which, like the barrier pin **154**, as a matter of convenience in construction, is formed as part of the lower end **60** of the tubular magazine **34**, as is best seen in FIGS. **13** and **14**. The separation and alignment orifice **170** ensures the separation and alignment of washers **38** as they leave the acceleration chamber **134** and enter the washer delivery channel **132**.

Gas pressure supplied via the delivery channel gas pressure supply conduit **122** and the gas supply port **150** is directed into the gas channel **152** and then into the acceleration chamber **134** opposite the separation and alignment orifice **170** such that channel feed pressure propels washers **38** from the acceleration chamber **134** through the separation and alignment orifice **170**, along the washer delivery channel **132** to the retention region **136**, in alignment with the exit barrel **42**. Pressure bypass channels **172** and **174** (FIG.

10) prevent blockage of the channel feed pressure by a subsequent washer entering the acceleration chamber **134** from the magazine **34** such as the washer **176** in FIGS. **1** and **3** that is tipped.

Once a washer **38** is at a point in the acceleration chamber **134** where it is aligned such that it is ready to enter the washer delivery channel **132**, it is also in a position such that the pressure difference across the acceleration chamber **134** propels the washer into the washer delivery channel **132** to a point where it reliably reaches its destination, in particular, the retention region **136**. The acceleration chamber **134** serves several functions in the exemplary embodiment, and could be employed for additional functions. Thus, the acceleration chamber **134** is primarily an area at which washers **38** are individually aligned for entry into the washer delivery channel **132** such that a pressure difference will propel the washer **38** out of the acceleration chamber **134** into the washer delivery channel **132** with sufficient force.

In the illustrated embodiments employing a tubular magazine **34** and the acceleration chamber **134**, there is a tendency for a subsequent washer in the magazine **34**, such as the washer **176** in FIGS. **1** and **3**, to partially advance into the acceleration chamber **134** before a previous washer, such as washer **178** in FIGS. **1** and **3**, which is exiting the acceleration chamber **134** has fully entered the washer delivery channel **132**. In order to avoid the use of a retaining device or force to prevent this partial entry, the bypass channels **172** and **174** are provided so that the washer **178** continues to be propelled. Only after the first washer **178** has fully entered the washer delivery channel **132** should a subsequent washer **176** be fully aligned or positioned within the acceleration chamber **134** for its entry into the washer delivery channel **132**.

The washer delivery channel **132** extends at least approximately perpendicularly to the driver stroke axis **48**. This relationship may vary depending upon the mounting of the channel housing **36** to the fastener driver **32**. For example, a pivot mount (not shown) may be employed. This relationship is not critical.

FIG. **16** shows a modified channel housing **180** wherein the washer delivery channel **132** sweeps vertically up from the retention region **136** to the acceleration chamber **134**, while still extending approximately perpendicular to the driver stroke axis **48**. This modification reduces the contact area of the channel housing **180** on the work surface (not shown).

The washer delivery channel **132** need not be linear so long as its shape allows for proper washer **38** flow. A washer **38** in an intermediate position within the washer delivery channel **132**, whether in motion or at rest, can therefore be at any point within the channel **132** between the acceleration chamber **134** and the retention region **136**. Although generally not necessary, stops or catches (not shown) may be provided within the washer delivery channel **132** to position or regulate the flow or backflow of washers **38**.

Thus any washer **38** occupying space in any portion of the acceleration chamber **134**, separation and alignment orifice **170** or channel **132** at any time does not cause the interruption or restriction of proper cycling of any washer **38** in the magazine **34** or channel **132**. Once a washer **38** has entered the channel **132** through the orifice **170** from the acceleration chamber **138**, it is capable of coming to rest in one or more positions. Accordingly, in the illustrated embodiment, during normal operation there are a plurality of washers within the washer delivery channel, in edge to edge contact. All channels are designed to prevent any misalignment of washers with respect to their prospective destinations or each other.

The channel **132** can be as long or as short as desired. Since no position of a washer **38** at the acceleration chamber **134** end of channel **132** interrupts the cycle, the channel **132** can be of any length or relation to washer diameter.

Exhausting of excess pressure is accomplished in retention region **136** in a manner such that the washer is not forced past restrictors **160** through exit aperture **140** by remaining pressure from preceding cycle, leading pressure from the following cycle, or full pressure from cycle in the fastener or fastening device's drive pin does not contact and cause exit of washer in barrel chamber.

The washer feeding apparatus **30** and **70** thus can operate with a continuous gas pressure supply. As a washer **38** exits the retention region **136** upon operation of the hammer **44** of the fastener driver **32**, subsequent washers **38** in the delivery channel **132** move forward. When the acceleration chamber **134** is clear, a washer **38** enters from the magazine **34**. The restrictor **160** prevents washers **38** from prematurely exiting the retention region **136**.

The washer feeding apparatus **30** and **70** also operate when supplied with periodic gas pressure pulses. Thus, with each cycle of the fastener driver **32**, exhaust gas through the exhaust gas port **56** is collected by the exhaust collection system **58**, and is used to generally advance washers **38** and, in particular, to deliver another washer **38** into position within the retention region **136**.

In an embodiment where the channel **132** is such that there is space for one or more washers **38** or portions of washers **38** in the channel **132**, the system is capable of working with washers **38** occupying any and all positions either simultaneously or in any combination. A washer **38** also is capable of traveling from the acceleration chamber **134** through orifice **170** and channel **132** past any restrictions or retainers to a position properly aligned in the retention region **136** in one cycle of pressure difference; this allows for continuous cycle of washers **38** regardless of number of washers **38** greater than zero in or remaining in magazine **34**, acceleration chamber **134**, channel **132**, or retention region **136**.

Another result is that, as long as a washer **38** is in the retention region **136** at loading or in the acceleration chamber **134**, no fastener/washer cycle will be missed and, if run dry, only one cycle of pressure is required to fully load from acceleration chamber **134** to retention region **136**. In the case of synchronized or combined pressure supply to magazine feed, a washer or several washers can flow from any point in the magazine **34** through the acceleration chamber **134** and channel **132** into the retention region **136** in one pressure cycle if of adequate pressure and duration.

FIG. **17** illustrates a washer skewer assembly **190** supporting a stack **192** of washers prior to being loaded into the tubular magazine **34**. Thus, a skewer **194** at its upper or handle end has an attached disk **196**, which serves dual purposes of a handle for manual manipulation, and as a retention device when the washer skewer assembly **190** is mounted within the tubular magazine **34**. At the free end **198** of the skewer **194** is a removable retention ring **200**, which passes through a transverse aperture **202** at the free end **198**. The removable retention ring **200** is for shipping purposes. In addition, the free end **198** is split slightly wider so as to retain washers **38** on the skewer **194** after removal of the retention ring **200** as the washer skewer assembly **190** is inserted into the magazine **34**.

Accordingly, the stack **192** of washers is mounted on the skewer for convenient transportation and storage in a space efficient manner. The diameter of the skewer **194** is less than

the diameter of the central aperture in the washer such that washers can freely move along the skewer **194**.

Typically, there are approximately fifteen washers per inch of stack. A typical skewer **194** or stack height is eleven inches, giving the skewer assembly **190** and thus the tubular magazine **34** a capacity of approximately one hundred sixty five washers.

With reference to FIGS. **18–22**, the magazine lid housing **98** has a central opening **210** defining a small chamber, into which pressurized gas is directed from the magazine gas pressure supply conduit **120** via a port **212**. At the upper end of the central opening **210** is a recess **214** for receiving the skewer disk **196**. At the lower end of the central opening **210** is a recess **216** for receiving the upper end **62** of the tubular magazine **34**. A lid **218** is secured over the lid housing **98** by means of a screw **220**, and pivots sideways to allow access to the interior of the magazine **34**. For securing the lid **218** in position, there is a lid latch recess **222** which is engaged by a lid latch **224** (FIGS. **1** and **3**), urged into position by a lid latch spring **226**.

When the washer skewer assembly **190** is mounted within the magazine **34**, and the disk **196** at the top of the skewer **194** captured within the recess **214** and retained by the lid **218** itself, the free end **198** of the skewer **194** is positioned just above the acceleration chamber **134**, allowing washers to freely enter the acceleration chamber **134**.

Embodiments of one class of plastic washer feeding and positioning devices contain absolutely no moving components, with all necessary functions being accomplished either by specific shaping of all pressure supplies, magazines, acceleration/pressure chambers, restrictors, barrels, exhausts, etc., or by use of elastic and spring-like property of washers themselves, or in conjunction with each other and/or the pressure differences and material surfaces they contact or come to rest upon. In some embodiments a single continuous static passage which functions as all described pressure supplies, magazines, acceleration chambers, separation/orientation orifices, channels, barrel chambers, restrictors, barrels, exhausts, etc. Many other assembly/disassembly, collating, orienting, etc., procedures could also be added by same or other methods at any point prior to, during, or following this class of embodiments.

While specific embodiments of the invention have been illustrated and described herein, it is realized that numerous modifications and changes will occur to those skilled in the art. It is therefore to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What is claimed is:

1. Washer feeding apparatus for a fastener driver having a driver stroke axis and an exit barrel, said apparatus comprising:

a magazine for holding a plurality of washers;

a delivery channel having an acceleration chamber at one end for receiving washers one at a time from said magazine, and a retention region at the other end to which washers are pneumatically driven, said retention chamber having an exit aperture aligned with the exit barrel and arranged such that a washer retained therein is in alignment with the fastener driver exit barrel and with said exit aperture; and

a supply of pressurized gas for propelling washers by gas contact from said acceleration chamber to said retention region for subsequent engagement by fasteners driven by the fastener driver and exiting from said retention region through said exit aperture.

2. The washer feeding apparatus of claim **1**, wherein said supply of pressurized gas supplies pressurized gas in periodic pulses synchronized with operation of the fastener driver.

3. The washer feeding apparatus of claim **2**, wherein said supply of pressurized gas comprises a connection to an exhaust gas port of the fastener driver.

4. The washer feeding apparatus of claim **1**, which has no moving parts for transporting washers through said delivery channel.

5. The washer feeding apparatus of claim **1**, wherein a plurality of washers may at one time be contained within said delivery channel and retention region.

6. The washer feeding apparatus of claim **1**, wherein said delivery channel extends at least approximately perpendicularly to the driver stroke axis.

7. The washer feeding apparatus of claim **1**, which further comprises a stop within said retention region for preventing further travel of a washer once pneumatically propelled to said retention region.

8. The washer feeding apparatus of claim **1**, which further comprises a restrictor for retaining a washer within said retention region prior to being engaged by a fastener driven by the fastener driver.

9. The washer feeding apparatus of claim **8**, wherein said restrictor comprises a spring.

10. The washer feeding apparatus of claim **1**, wherein said magazine comprises a tube having a filling end and an exit end and within which washers are stacked, and wherein washers enter said acceleration chamber one at a time from said exit end.

11. The washer feeding apparatus of claim **10**, wherein said tube has an axis which is at least approximately parallel to the driver stroke axis.

12. The washer feeding apparatus of claim **11**, wherein said delivery channel extends at least approximately perpendicularly to the driver stroke axis and to said tube axis.

13. The washer feeding apparatus of claim **10**, which further comprises a supply of pressurized gas connected to said filling end for urging washers within said tube towards said exit end.

14. The washer feeding apparatus of claim **10**, which further comprises a lid over said filling end.

15. The washer feeding apparatus of claim **10**, wherein said tube has a central axis, and which apparatus further comprises a skewer extending along said tube central axis and passing through apertures in the washers, said skewer having a fixed end secured to said filling end and a free end terminating adjacent to said exit end.

16. The washer feeding apparatus of claim **10**, wherein said acceleration chamber and said delivery channel are shaped such that a subsequent washer cannot fully enter said acceleration chamber until an immediately prior washer has fully entered said delivery channel.

17. The washer feeding apparatus of claim **1**, wherein said acceleration chamber and said delivery channel are shaped such that a subsequent washer cannot fully enter said acceleration chamber until an immediately prior washer has fully entered said delivery channel.

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