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(54) RIVET INJECTOR SYSTEM FOR AN AUTOMATIC RIVETING MACHINE

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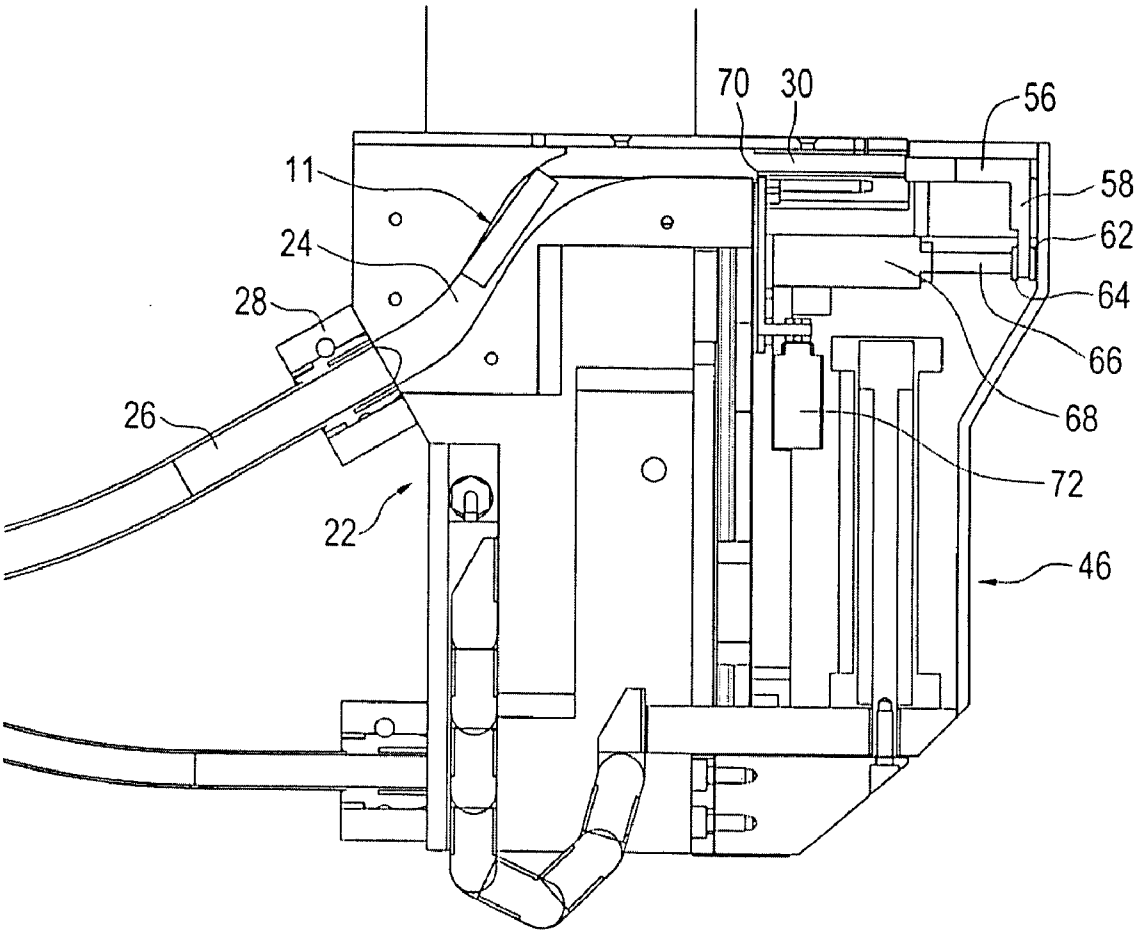
(52) **U.S. Cl.** **221/267**; 227/112

(57) **ABSTRACT**

The rivet injector system includes a set of grasping spring-loaded rivet fingers which are mounted on a rivet ram portion of an automatic riveting machine. The rivet injector assembly receives a rivet from a feed tube into a chamber in the assembly. A stopper pin and a moveable forward end stop within the chamber are operated to hold the rivet axially, the rivet being supported on a rivet pad in the chamber. A tower portion of the injector assembly is slidably mounted to raise the rivet, forcing it between the spring-loaded rivet fingers, which firmly grasp the rivet. The forward end stop and the stopper pin are then retracted and the tower portion lowered, leaving the rivet grasped by the rivet fingers, permitting the rivet to be moved forwardly into a hole in the workpiece.



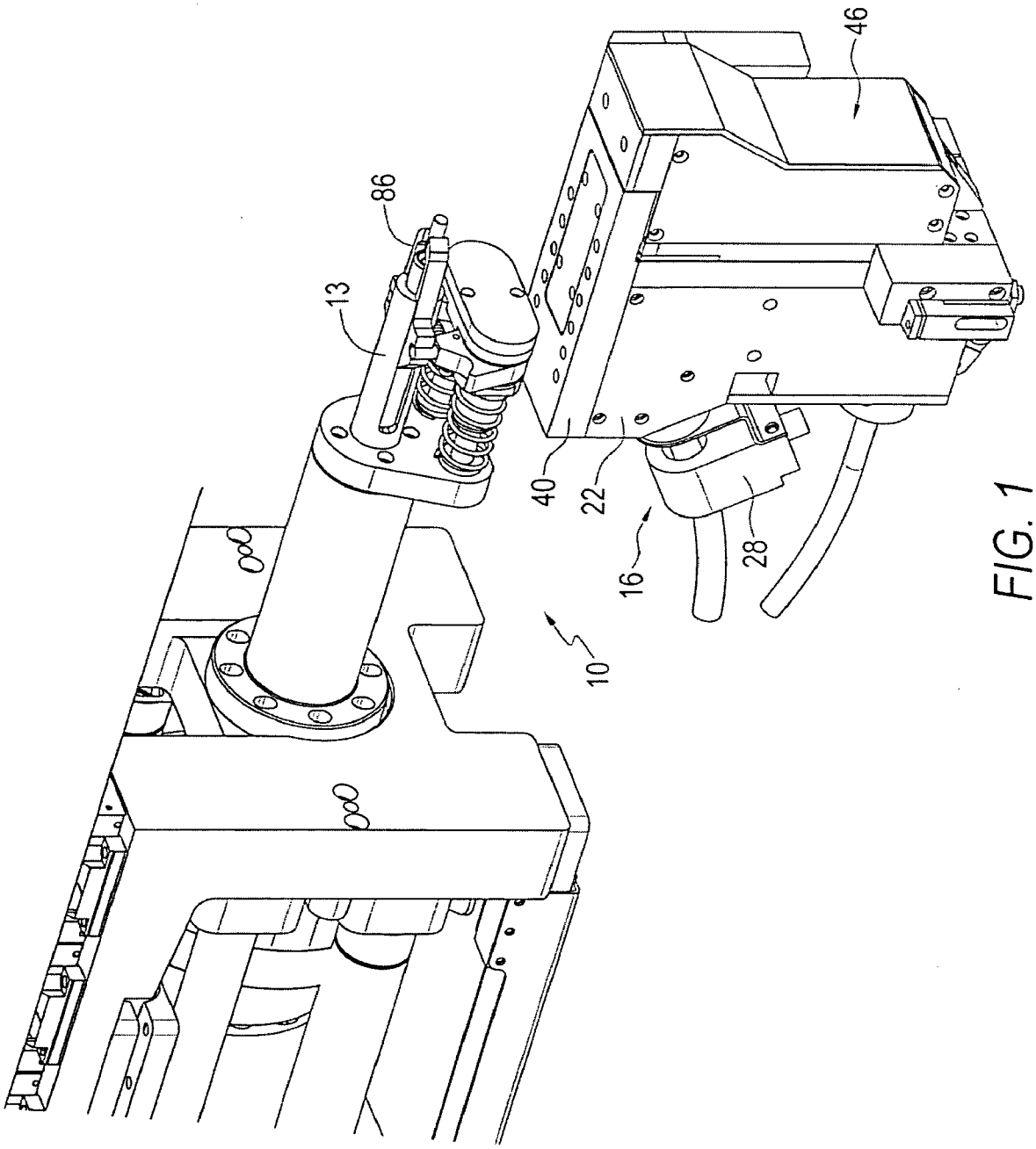


FIG. 1

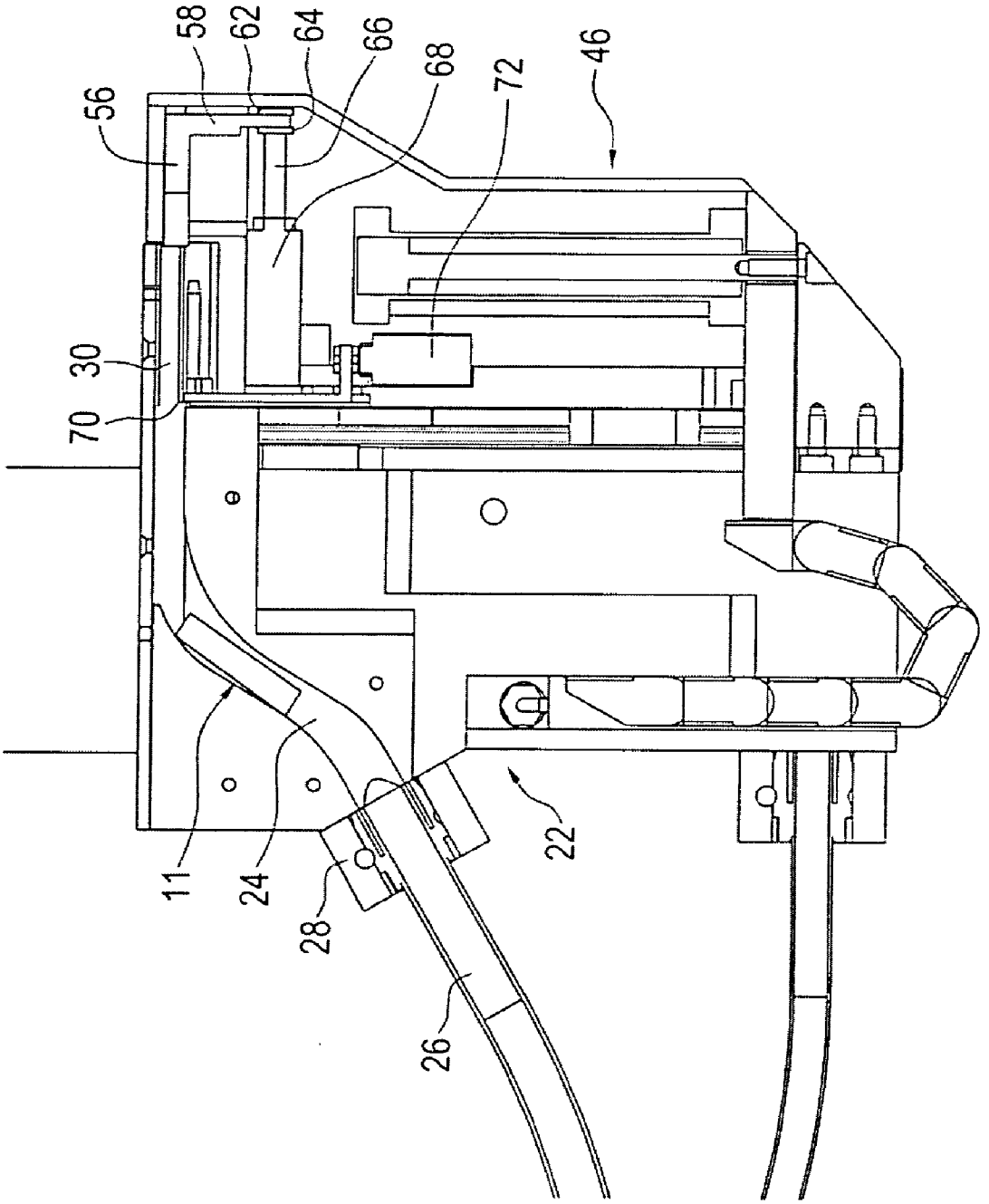


FIG. 2

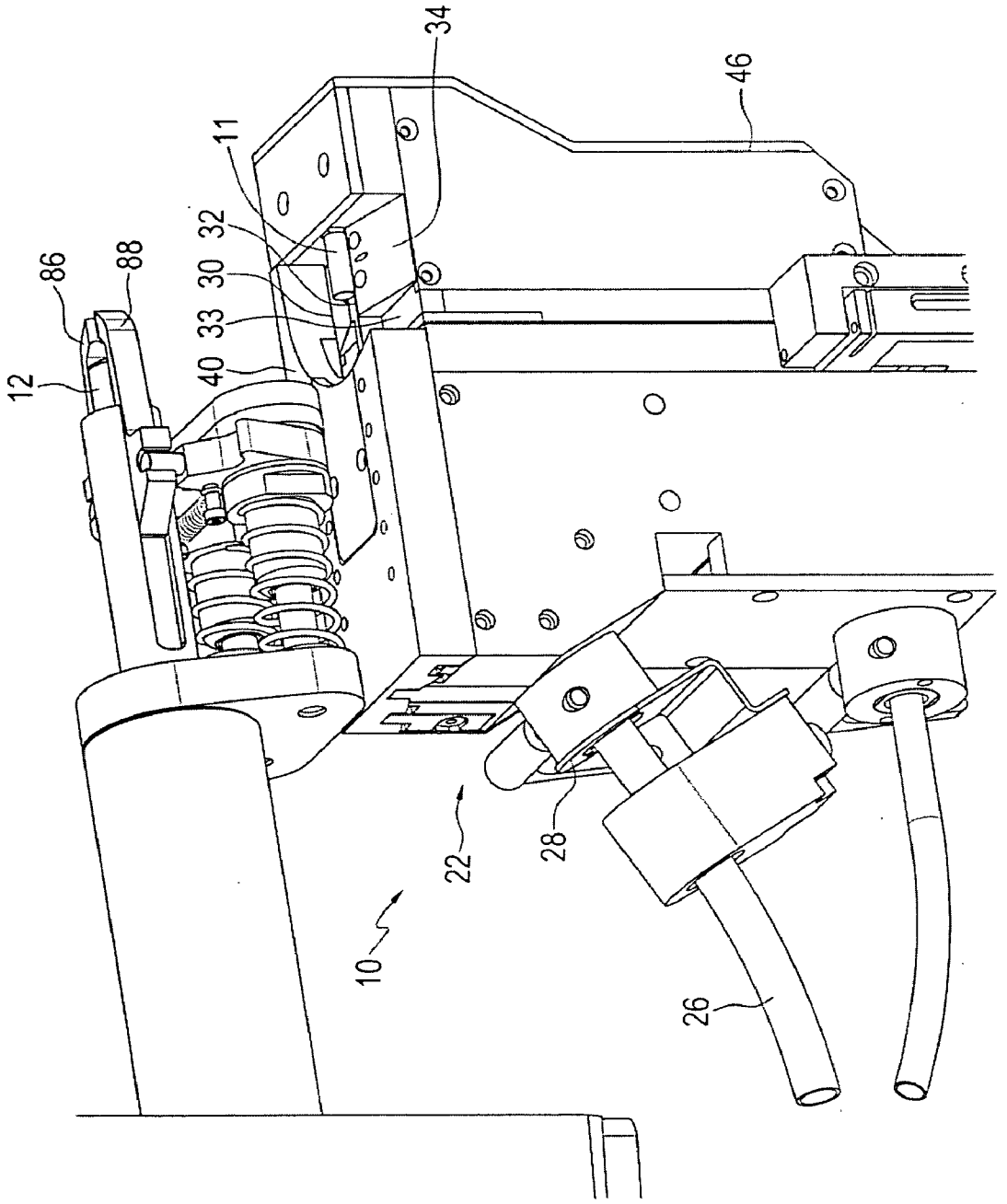


FIG. 3

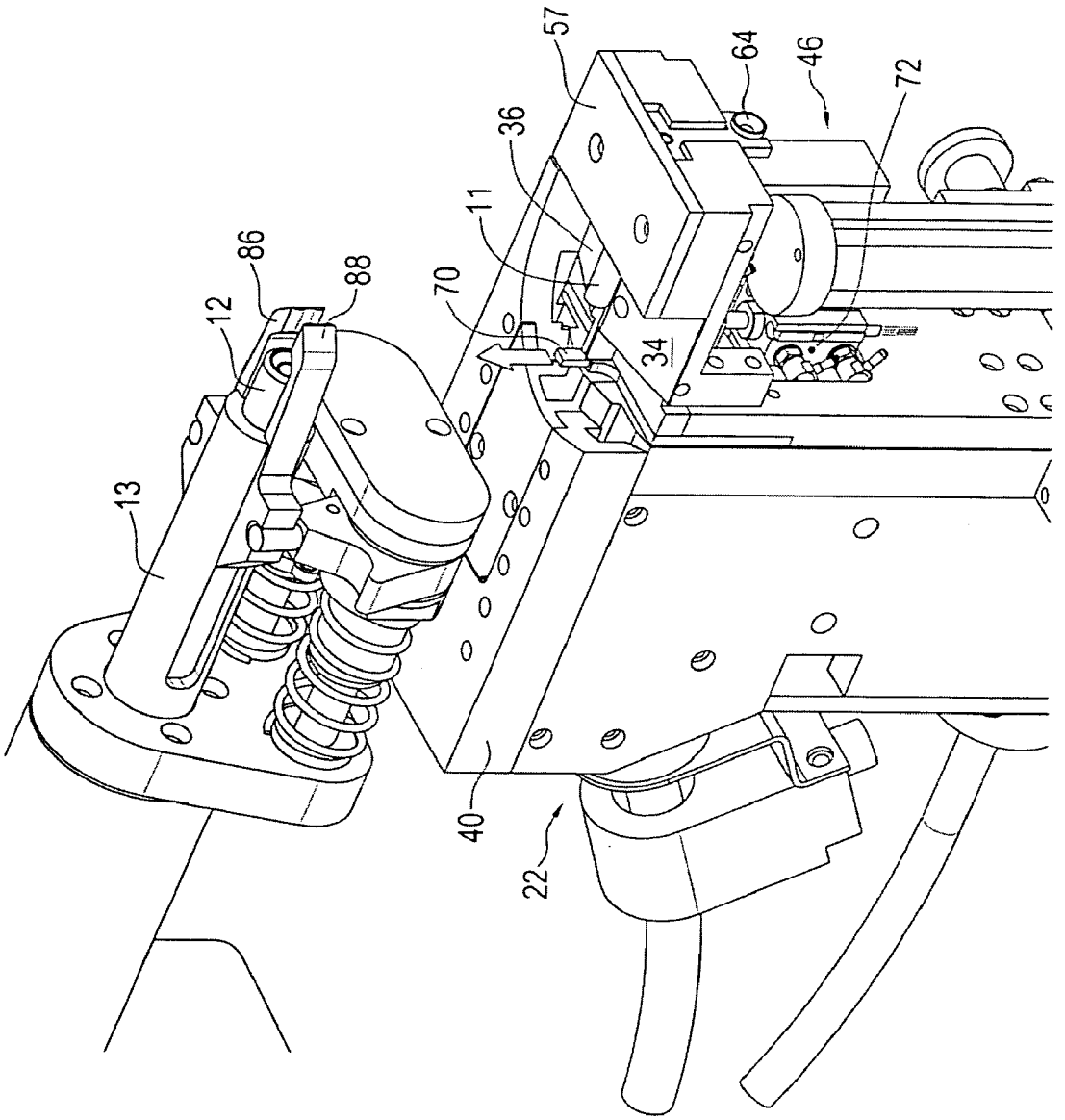


FIG. 4

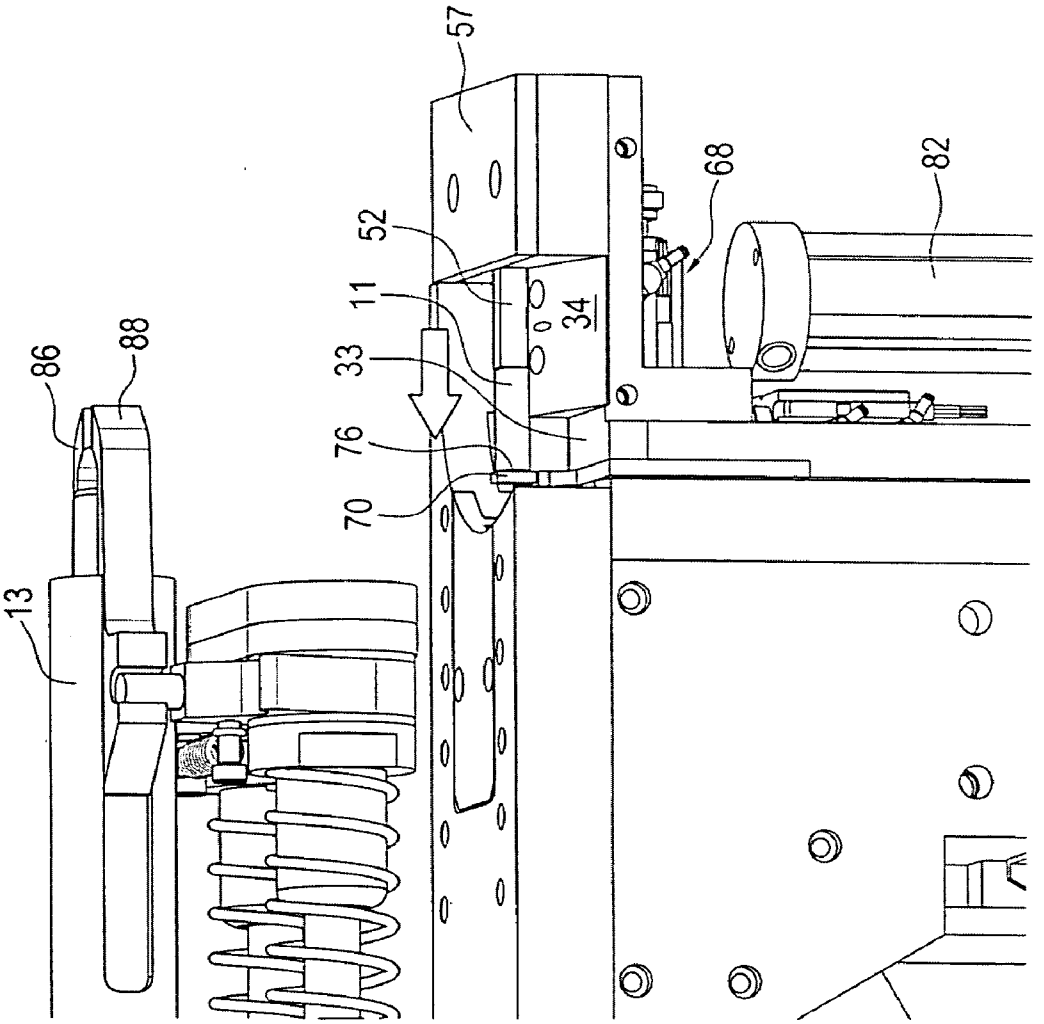


FIG. 5

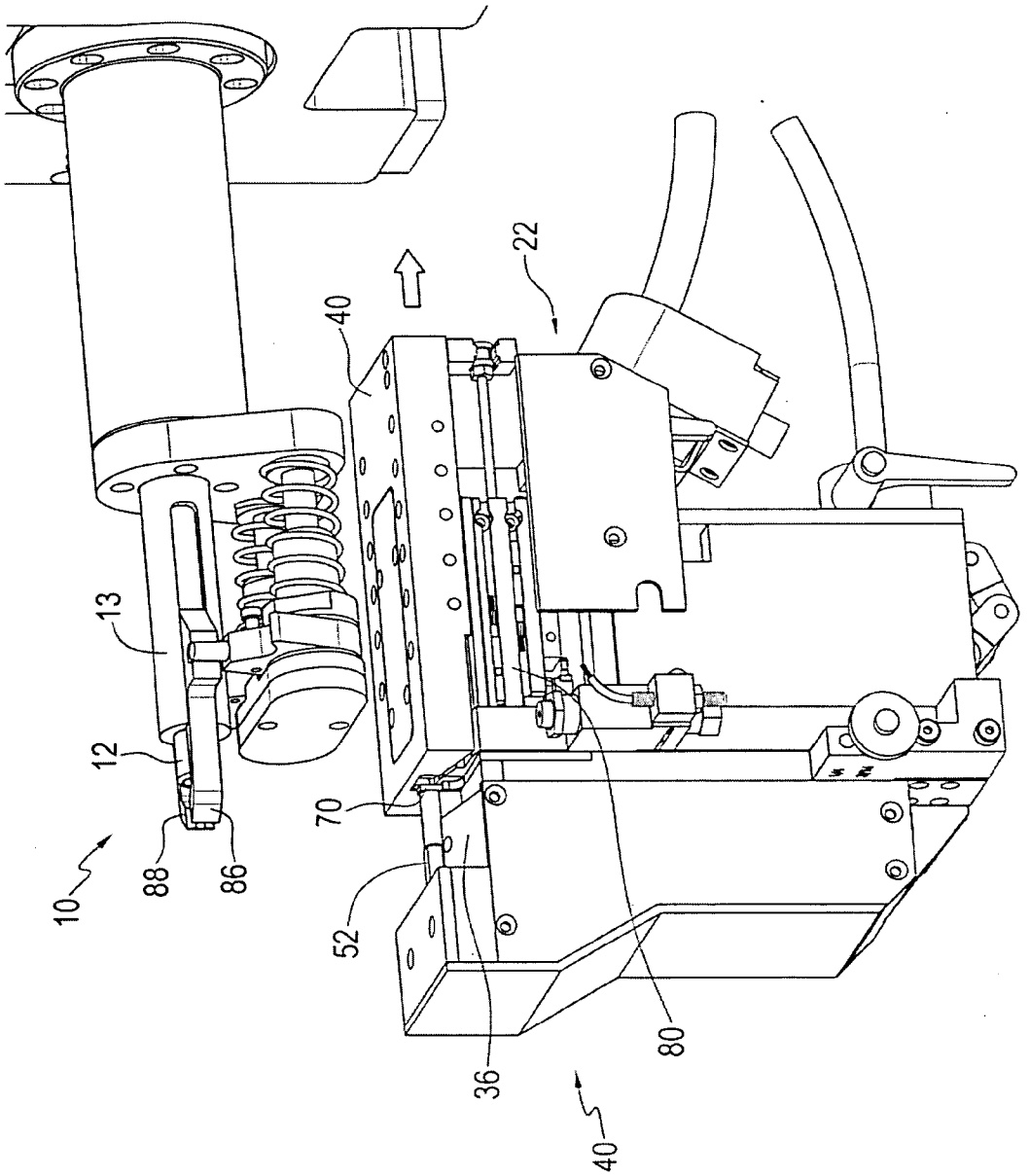


FIG. 6

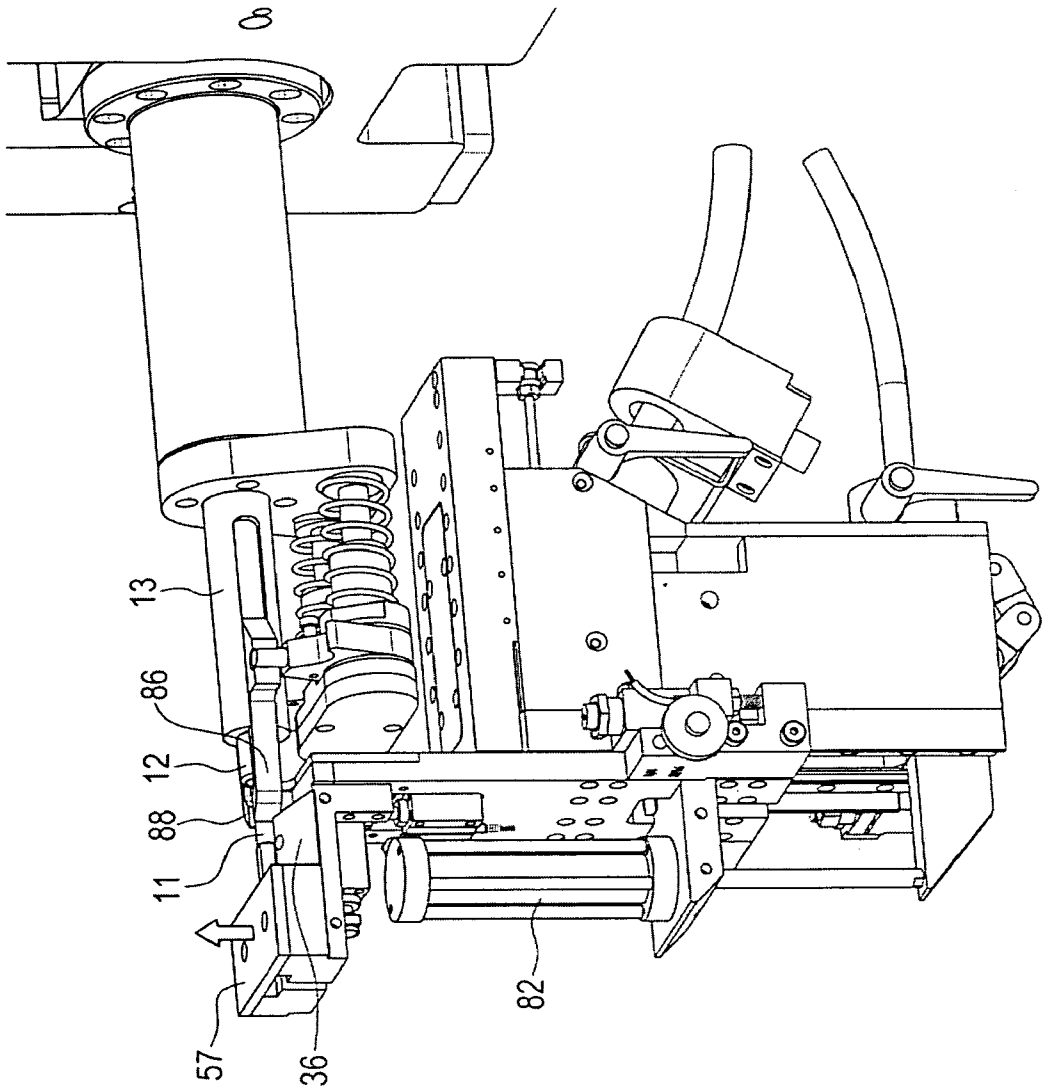


FIG. 7

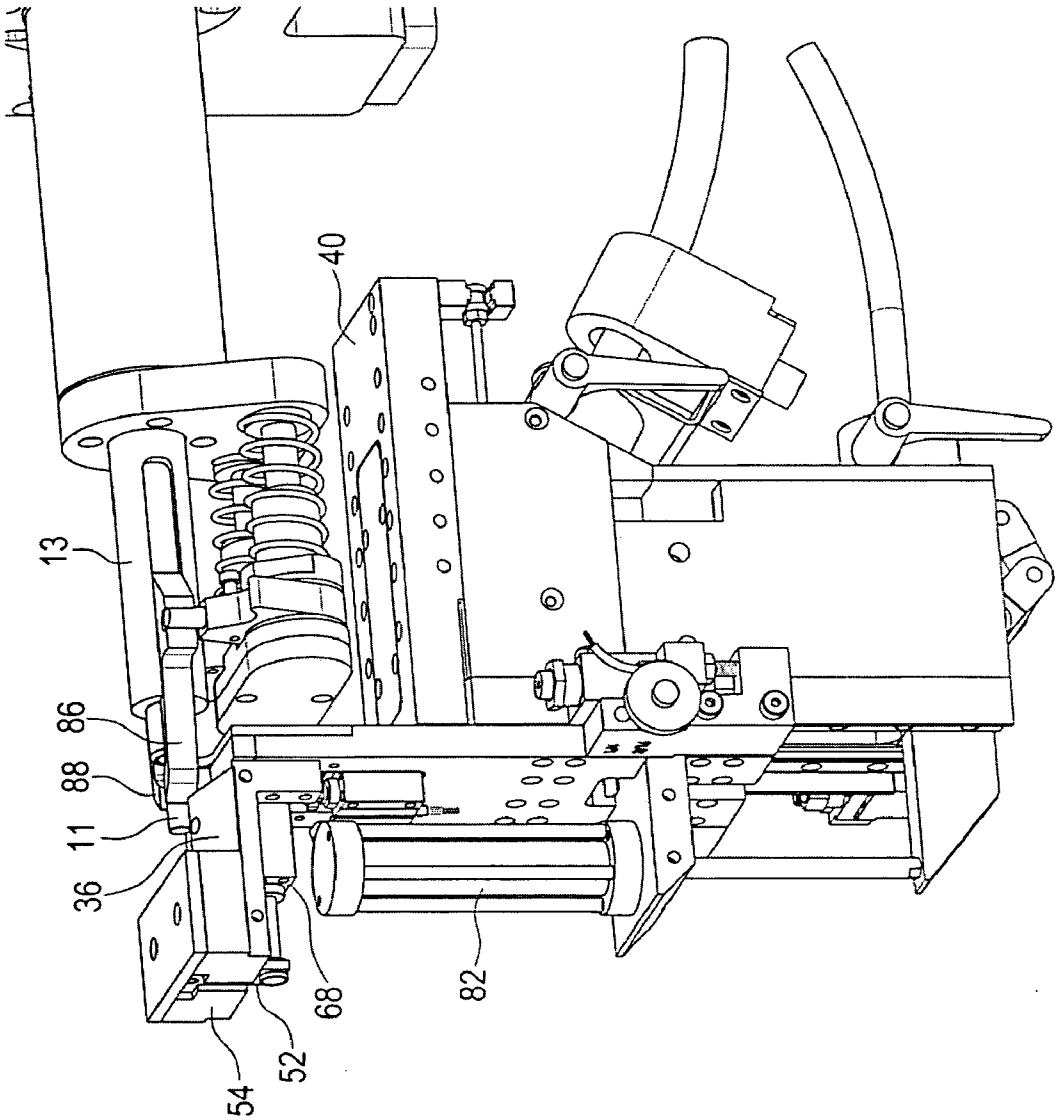


FIG. 8

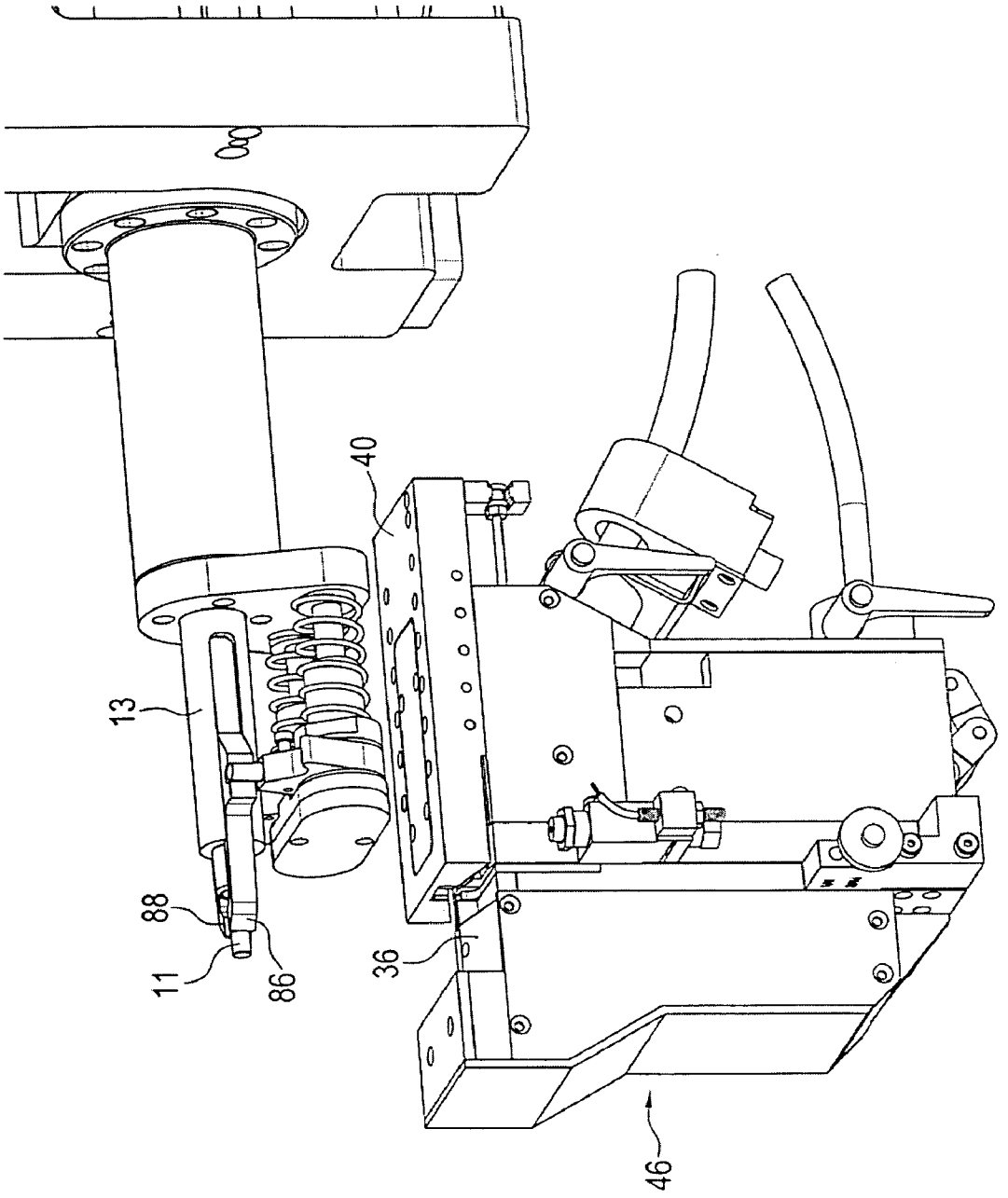


FIG. 9

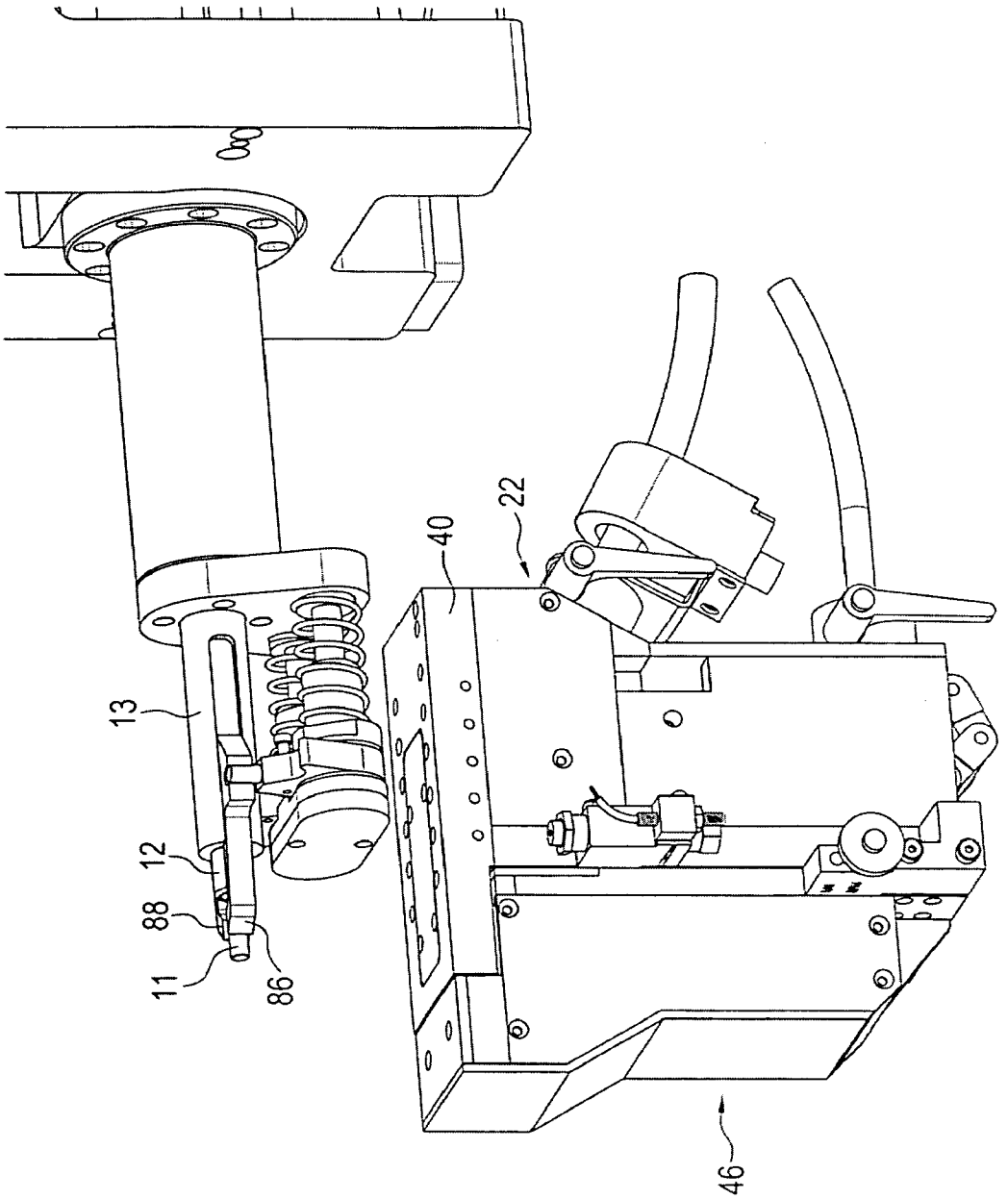


FIG. 10

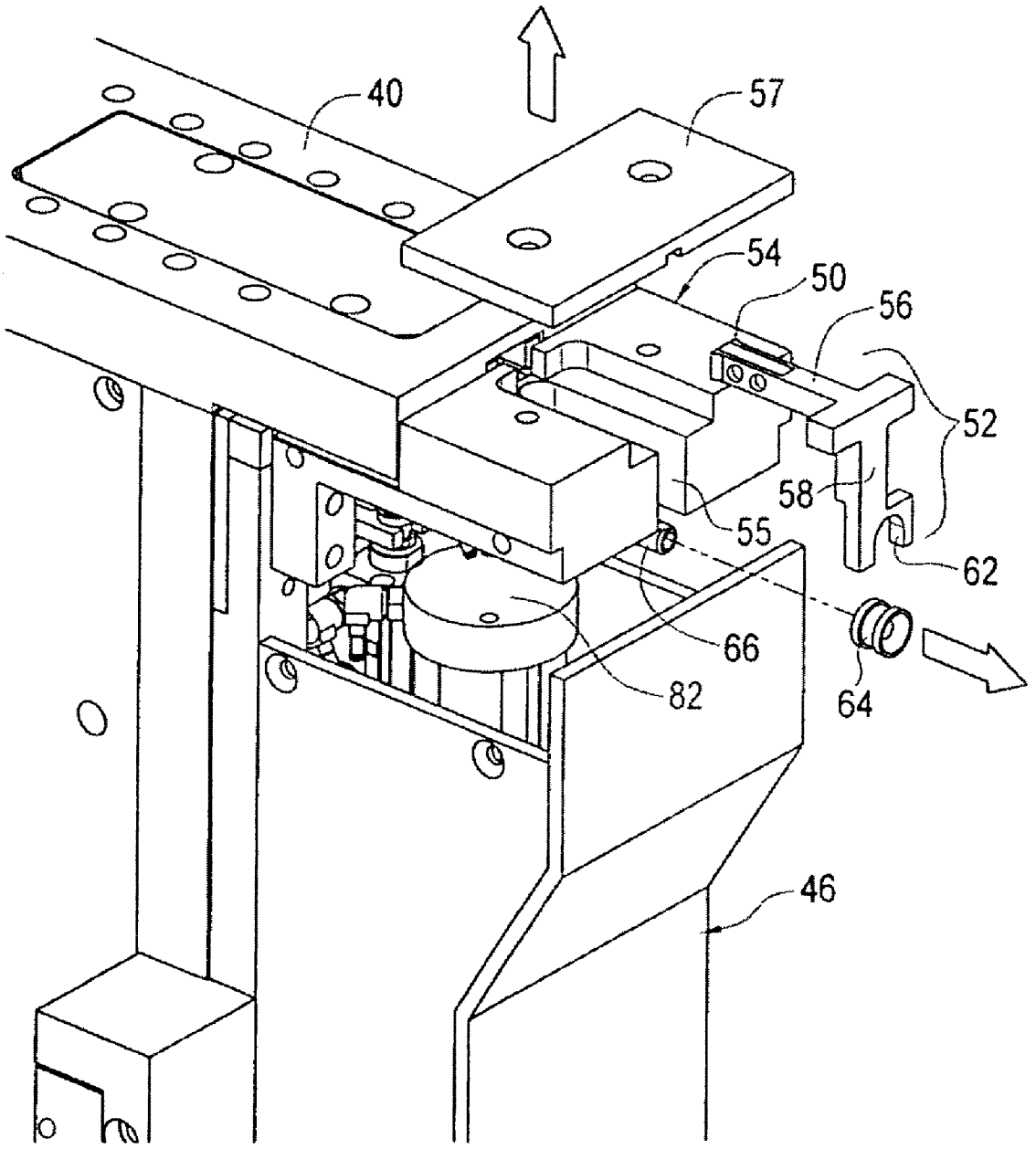


FIG. 11

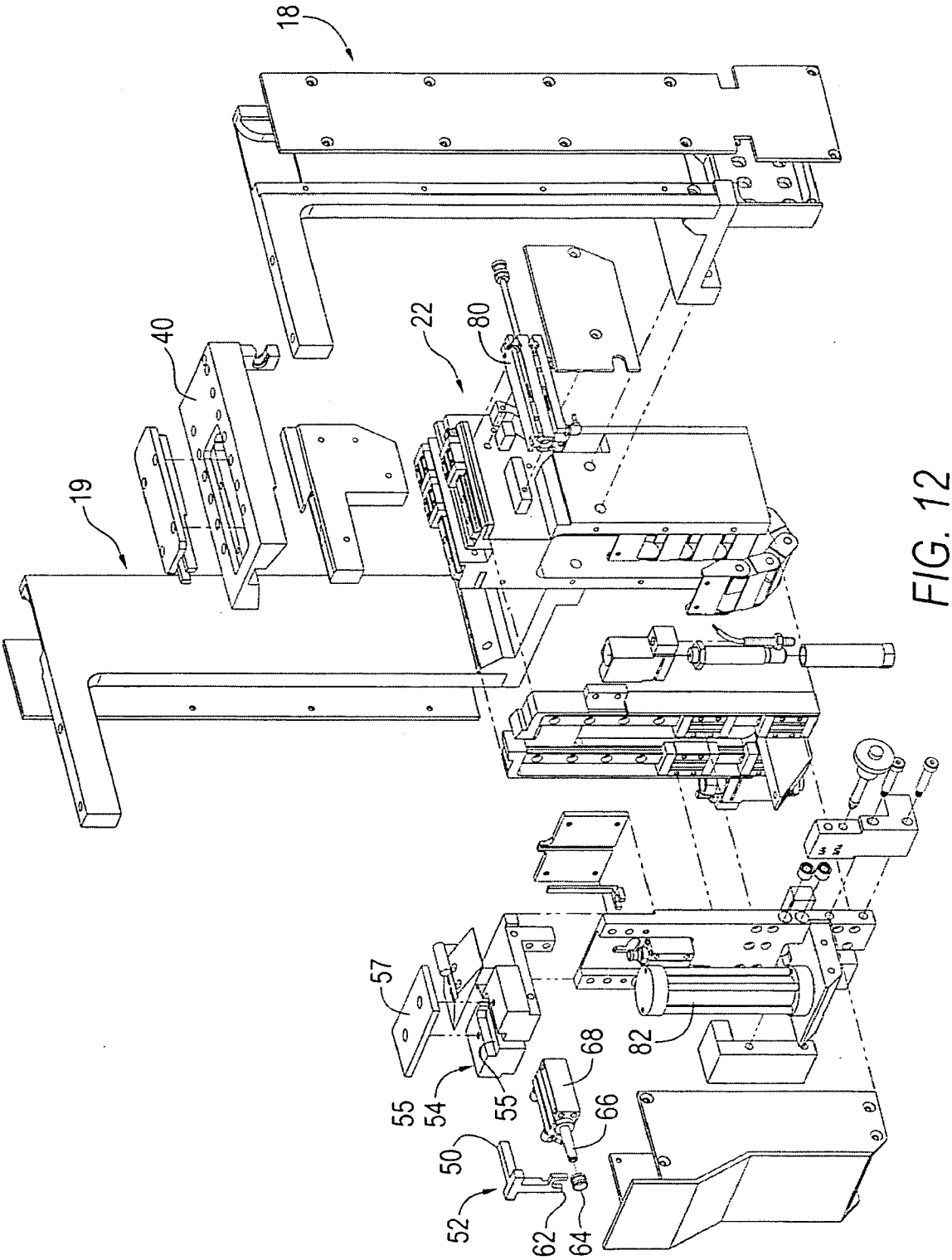


FIG. 12

RIVET INJECTOR SYSTEM FOR AN AUTOMATIC RIVETING MACHINE

TECHNICAL FIELD

[0001] This invention relates generally to automatic riveting machines used in large-scale riveting operations, and more specifically concerns a rivet injector system for moving an incoming rivet from a feed tube to spring-closed fingers on a rivet ram which thereafter insert the rivet into a previously drilled hole in a workpiece, where it is formed by action of the ram.

BACKGROUND OF THE INVENTION

[0002] Automatic riveting machines are frequently used for large-scale riveting operations such as in the manufacture of aircraft wing panels. In a typical riveting operation, the machine first clamps together the workpiece parts to be joined. A hole is then drilled in the workpiece parts by one tool mounted on a transfer mechanism, such as a tool shuttle. A rivet is transferred/injected to the riveting assembly, which moves the rivet into the hole. A ram portion of the riveting assembly then forms the rivet in the hole. The ram is withdrawn and then another tool on the tool shuttle is typically moved into position to shave the head of the formed rivet flush to the wing panel or other workpiece, although in some cases, the rivets are not shaved. The tool shuttle is then moved to the next rivet location.

[0003] One widely-used commercial rivet injection system is manufactured by Gemcor Engineering Corporation, shown in a variety of U.S. patents, among them U.S. Pat. No. 5,065,818. In that patent, rivets are delivered down a tube, coming to rest on a bottom plate. The rivet is then moved between two jaw-like members and from the jaw-like members the rivet moves across a gap to opposing grasping fingers, which clamp against the outside surface of the rivet. In such a system, however, the rivet is not securely held at all times during injection, and hence there is the possibility of a misalignment of the rivet or a dropped rivet during injection. Further, different length rivets change the axial position of the rivet relative to the ram, resulting in a variable gap between the rivet and the ram. This typically requires that the position of the ram be moved, which can be problematic.

SUMMARY OF THE INVENTION

[0004] Accordingly, disclosed and claimed herein is a system for transporting rivets, for use in all automatic riveting machine, provided from a feed tube, comprising: a set of rivet fingers mounted on a ram portion of the automatic riveting machine for grasping a rivet; and a rivet injector assembly for receiving a rivet by air pressure from a feed tube, holding the rivet first at opposing longitudinal ends of the rivet, moving it into the grasp of the rivet fingers and then releasing the rivet so that the ram portion can move the rivet held by the rivet fingers into a drilled hole in a workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a perspective view showing an electromagnetic riveting apparatus and the rivet injector assembly system described herein.

[0006] FIG. **2** is a partially cut-away perspective view showing an initial rivet position in the rivet injector system after the rivet has left the feed tube.

[0007] FIGS. **3-10** are partially cut-away perspective views showing successive rivet positions in the rivet injector system as it moves to riveter apparatus which includes fingers for holding the rivet as it is moved into an opening in the workpiece.

[0008] FIG. **11** is a partially cut-away view showing a portion of the rivet injector assembly.

[0009] FIG. **12** is an exploded view of the entire rivet injector assembly.

BEST MODE FOR CARRYING OUT THE INVENTION

[0010] FIG. **1** shows a low-voltage electromagnetic riveting machine (EMR) **10** for moving a rivet **11** (FIG. **2**) into a drilled hole in a workpiece, such as an aircraft wing panel structure, and then forming the rivet in the hole by a forward movement of a rivet die **12**, mounted on a ram **13**. The electromagnetic riveter **10** is one tool in the riveting operation/cycle. It is used with a hole drilling tool arid in some cases with a rivet shaving tool, all arranged on a tool shuttle assembly, to accomplish a complete riveting operation. The electromagnetic riveter **10** shown in FIG. **1** is only one example of a riveting machine used in large-scale riveting operations. The present system is primarily useful with a slug-type rivet, i.e. a rivet with no head, although it could possibly be used with small-headed (index-style) rivets as well.

[0011] The description of the rivet injection system herein follows the movement of a rivet from an infeed tube to a final position in the grasp of a pair of spring-loaded rivet fingers oil ram **13**, with a series of partially cutaway views of the injection system and a detailed exploded view of the entire assembly in FIG. **11**. The present rivet injection system is useful with the EMR **10**, but can also be adapted for use with other riveting machines. The system can work equally well, for instance, with hydraulic or roller screw machines.

[0012] In FIG. **1**, EMR **10** is supported either below or to the side of a support assembly (not shown). A rivet injector assembly **16** includes a rivet transport body **22** which includes a generally S-shaped feed channel **24** in the embodiment shown. Connected to an input end of the feed channel **24** is a feed tube **26** through which rivets are moved by compressed air. Surrounding the feed tube **26** at the entrance to the rivet transport body **22** is a ring sensor **28**, which detects the presence of a rivet as it passes through feed tube **26**. The rivet proceeds through feed channel **24** into a rivet chamber **30**, as shown generally in FIG. **3**. The rivet chamber **30** has a rivet pad **32** positioned therein. Rivet pad **32** is made of plastic so as not to damage or mark the rivet, and is approximately 2 inches long by 2 inches wide. Rivet pad **32** has an upper surface which comprises two opposing, slightly sloped surface portions **34**, **36** extending at a small angle below the horizontal. Between the two sloped surface portions **34** and **36** is a shallow groove which is configured to support the rivet **11** in a horizontal position, in the embodiment as shown in FIG. **3**.

[0013] Although the Figures and their description have the system in a particular orientation, it should be understood that the system can work with the chamber and rivet pad in any orientation.

[0014] The rivet chamber **30** is defined by a surface **33** on which the rivet pad **32** is positioned and a slidable cover **40** which is mounted for to-and-fro movement at the top of the rivet transport body **22**. Within the forward end of cover **40** is an internal cavity which forms the upper boundary or ceiling

of and the sides of chamber **30**. Surface **33** of chamber **30** is a portion of a top surface of tower assembly **46**. Tower assembly **46** is mounted for up/down sliding action on the forward surface of the rivet transport body **22**.

[0015] As a rivet **11** is moved through feed channel **24** and then into chamber **30** (FIG. **3**) by compressed air, it is stopped at the forward end of chamber **30** by a rear end of grip bar **52** which initially is in its retracted (forward) position. Grip bar **52** is positioned for back-and-forth (forward and rearward into the chamber **30**) movement in a carriage **54**, which is mounted to the top surface of tower assembly **46**. Grip bar **52**, which is one piece (unitary) includes a horizontal portion **56** the rear end **50** of which is contacted by an incoming rivet, and a vertical portion **58** which extends down through a cut-out portion **55** in carriage **54**. The lower end **62** of vertical portion **58** is U-shaped, into which a pull disc **64** is fitted. Pull disc **64** is mounted on the end of an air cylinder actuator rod **66** which moves horizontally back and forth under the control of air cylinder **68**. The cut-out portion **55** in carriage **54** is configured to support the back-and-forth movement of grip bar **52**. The carriage includes a cover **57** which fits over cut-out portion **55**.

[0016] At the rear of rivet chamber **30** is mounted a moveable pop-up stopper pin **70** (FIG. **4**) which is in a lowered (retracted) position when the rivet is inserted into chamber **30** through feed channel **24**, but which is moved upwardly under the control of an air cylinder **72** into chamber **30** at a specific time following the sensing of a rivet moving through the feed tube by ring sensor **28**. The cover **40** is normally in its closed position (forward) against cover **57** of the carriage **54**. The stopper pin **70** in its up position is in the embodiment shown approximately the same dimensions as the norminal end size of the rivet (¼ inch by ¼ inch for a ¼ inch rivet) within chamber **30**. Following stopper pin **70** moving into its raised position, as shown in FIG. **4**, air cylinder **68** is operated to move grip bar **52** slidably to the rear of the transfer assembly, in cut-out portion **55** of carriage structure **54**, thereby moving the rivet **11** rearwardly until the rear end **76** of the rivet abuts stopper pin **70**, as shown most clearly in FIG. **5**. At this point, rivet **11** is held securely at its respective ends, between stopper pin **70** and end **50** of the grip bar **52**. The rivet **11** is also supported by (resting on) the center groove **37** of rivet pad **32**. In this position, the rivet **11** is effectively held at three positions, its two opposing ends and its bottom longitudinal surface. When the rivet is held by stopper pin **70** and grip bar end **50**, a linear potentiometer, connected between those two elements can measure the length of the rivet, which is useful information in some applications.

[0017] The slidable cover **40** is now moved to the rear by slide cover air cylinder **80**, opening chamber **30** and exposing rivet **11** positioned on rivet pad **32**, held fast by stopper pin **70** and grip bar end **50** and groove **37** of the rivet pad, as shown in FIGS. **5** and **6**.

[0018] The tower assembly **46** is then slidably moved up the front of the rivet transport body **22** by action of the tower air cylinder **82**, until the rivet **11** encounters an opposing pair of horizontally positioned grasping rivet fingers **86** and **88**. The rivet fingers **86** and **88** are elongated metal members which are spring-loaded and mounted on opposing sides of a rivet ram **13**. The fingers include notched portions at the forward ends thereof which enable the fingers to grasp the curved outer longitudinal surface of the rivet. The spring-loading of the grasping rivet fingers tends to force the forward ends of rivet fingers **86** and **88** in a closed position (against each other). When the tower assembly **46** is raised, rivet **11** is forced between the rivet fingers **86** and **88**. The tower assembly is stopped by a mechanical stop when the rivet is positioned between the rivet fingers. The rivet is still held between stopper pin **70** and rivet bar end **50** and supported on groove **37** of the rivet pad **32** at this point, as well as between the notched portions of the forward ends of the rivet fingers. This is shown in FIG. **7**. This arrangement is made possible by the stopper pin and the grip bar end holding the ends of the rivet, not interfering with the grasping of the rivet by the rivet fingers **86** and **88** along the body of the rivet.

[0019] The stopper pin **70** is then retracted by its associated air cylinder **72** and the gripper bar **52** is retracted by air cylinder **68**, as shown in FIG. **8**, leaving the rivet held by fingers **86** and **88**, and supported along a longitudinal side by rivet pad **32**. The tower assembly **46** is then lowered by air cylinder **82** to its original position, as shown in FIG. **9**. At this point, the slidable cover **40** is moved back to its original forward position, as shown in FIG. **10**, by its associated air cylinder **80**. This completes the action of the rivet injection assembly. The EMR **10** is then moved forward to position the rivet into the hole in the workpiece. The rivet ram **13** is then activated, forming the rivet in the hole.

[0020] One important aspect of the system is that the rivet is first held at three surfaces, between its respective ends by the stopper pin **70** and the grip bar end **50**, and supported on a side surface by rivet pad **32**. The holding of the respective ends is referred to as an axial hold or gripping of the rivet. This arrangement helps to maintain proper alignment and secure holding of the rivet during the injection process. This three-surface holding of the rivet (the two ends and the side support) is maintained until the rivet is positioned between the spring-loaded rivet fingers. For a brief time, before assembly **46** is lowered, the rivet is held at both ends, opposing sides by the grasping fingers and supported along another side surface, i.e. it is held at five surfaces, prior to the rivet being held just by the two fingers. The rivet is held positively by the injector system at all times.

[0021] The axial gripping arrangement, as the rivet is moved into the chamber **30**, always results in the rivet being moved first against the grip bar end **50**, and then to the rear in chamber **30**, against the stopper pin **70**, which is fixed in position relative to the ram. Hence, there is always a fixed distance between the rear end of the rivet and the die **12**, regardless of the length of the rivet. The system thus easily accommodates different length rivets, without having to change the position of the ram. The difference in rivet length simply changes the distance between the forward end of the rivet and the workpiece.

[0022] The rivet chamber, specifically the slidable cover **40**, can have openings therein to permit airflow to pass around the rivet and out of the chamber, while still holding it against the grip bar end. The present arrangement allows only one rivet in the chamber **30** at a time. The operating distance (defined as the distance from the grip bar end **50** to the stopper pin **70** within chamber **30**) is longer than the longest rivet to be injected but shorter than twice the shortest rivet. If more than one rivet is fed into the chamber **30**, then the stopper pin is not able to fully extend from its retracted position (it will hit the rear-most rivet). This produces an automatic purge sequence in which the rivet chamber is opened and all the rivets are blown out of the chamber **30**. A new rivet is then fed into the chamber.

[0023] Accordingly, the rivet injector system described and shown herein accomplishes the injection of rivets and the subsequent feeding of rivets into a workpiece fast and reliably, by combining a rivet injection assembly which axially holds a rivet and supports a side surface thereof with a pair of horizontally arranged grasping rivet fingers to which the rivet is transferred by the injection system for subsequent insertion into the workpiece opening and forming of the rivet. The rivet is positively held at all times.

[0024] Although a preferred embodiment of the invention has been disclosed here for the purposes of illustration, it should be understood that various changes, modifications and substitutions may be incorporated in the embodiment without departing from the spirit of the invention, which is defined by the claims which follow.

What is claimed is:

1. A system for transporting rivets, for use in an automatic riveting machine, provided from a feed tube, comprising:

a set of rivet fingers mounted on a ram portion of the automatic riveting machine for grasping a rivet; and

a rivet injector assembly for receiving a rivet by air pressure from a feed tube, holding the rivet first at opposing longitudinal ends of the rivet, moving it into the grasp of the rivet fingers and then releasing the rivet so that the ram portion can move the rivet held by the rivet fingers into a drilled hole in a workpiece.

2. The system of claim **1**, wherein the rivet injector assembly is mounted on the automatic riveting machine but away from the ram portion, permitting the ram portion to pass by the injector assembly to insert the rivet in the hole in the workpiece.

3. The system of claim **1**, wherein the rivet is positively held at all times by either or both of the rivet injector assembly and the rivet fingers.

4. The system of claim **1**, wherein the rivet fingers are spring-loaded on the ram portion.

5. The system of claim **1**, wherein the rivet fingers are horizontally positioned on the ram portion and are spring-loaded in a closed position.

6. The system of claim **1**, wherein the rivet injector assembly includes a chamber into which the rivet is moved from the feed tube by compressed air, the chamber being partially defined by a slidable cover having an internal cavity defining upper and side surfaces of the chamber.

7. The system of claim **6**, wherein the rivet injector assembly includes a moveable forward end stop mounted at a forward end of the chamber, wherein a rivet fed into the chamber is forced against the forward end stop by compressed air, the rivet injector assembly further including a stopper pin positioned in the vicinity of a rear end of the chamber, the stopper pin being mounted so that it is in a retracted, lowered position when a rivet is moved into the chamber, and then is moved to an extended, raised position following a rivet being fed into the chamber against the forward end stop, wherein subsequent movement of the forward end stop rearwardly toward the stopper pin results in the rivet being held axially at its respective ends between the stopper pin and the forward end stop.

8. The system of claim **7**, wherein the stopper pin is at a fixed axial location relative to the ram portion of the automatic riveting machine, such that a rear end of the rivet is always at the same position relative to the ram portion regardless of the length of the rivet.

9. The system of claim **7**, including a rivet sensor positioned around the feed tube in the vicinity of the rivet injector assembly for determining movement of the rivet in the feed tube and a signal system which raises the stopper pin a selected time following recognition of a rivet by the rivet sensor.

10. The system of claim **1**, wherein the rivet injector system includes a chamber and a rivet pad positioned within the chamber, the rivet pad configured with a central longitudinal groove therein such that a rivet entering the chamber is supported by the central groove, the rivet pad arranged to support the rivet along a side opposite from a side of the rivet which initially contacts the rivet fingers.

11. The system of claim **10**, wherein the rivet pad is plastic.

12. The system of claim **7**, wherein the rivet injector assembly includes a tower portion which includes the chamber and which moves upwardly with the rivet held in the chamber, following movement of the slidable cover to the rear which exposes the rivet, such upward movement sufficient to force the rivet between the spring-loaded closed rivet fingers, wherein the rivet is thereafter released by the forward end stop and the stopper pin and the tower portion lowered sufficiently that the ram and the rivet fingers grasping the rivet can move forwardly to insert the rivet into the hole in the workpiece.

13. The system of claim **1**, wherein the distance between the forward end stop in its retracted position and the stopper pin in its raised position is greater than the length of a single longest rivet used in the system but less than the combined length of two shortest rivets used in the system, and wherein the system removes rivets present in the chamber when the stopper pin cannot be moved to its raised position by opening the chamber and blowing the rivets present out of the chamber.

14. The system of claim **1**, wherein the workpiece is an aircraft wing panel.

15. The system of claim **1**, including a circuit, which includes a linear potentiometer, for determining the length of the rivet when it is held between the stopper pin and the forward end stop.

16. A system for use with an automatic riveting machine for transporting rivets provided from a feed tube, comprising:

a grasping finger assembly for moving rivets to a drilled hole in a workpiece; and

a rivet injector assembly for receiving a rivet under air pressure from a feed tube, the rivet injector assembly including axial rivet holding elements and a control system therefor for holding a received rivet at the ends thereof, the rivet injector assembly being movable to force the rivet into the grasping finger assembly and then releasing the rivet after the finger assembly has grasped the rivet so that the rivet can thereafter be moved into the drilled hole in the workpiece.

17. The system of claim **16**, wherein the rivet injector assembly is mounted on the automatic riveting machine but is movable sufficiently away from a ram portion thereof to permit the ram to pass by the injector assembly to insert the rivet in the hole in the workpiece.

18. The system of claim **16**, wherein a received rivet is grasped positively at all times as it is moved into the grasping finger assembly.

* * * * *