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- [54]

APPARATUS AND METHOD FOR FILLING AND SEALING INTRAVENOUS SOLUTION BAGS
- [75]

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- [22]

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U.S. Cl. 53/410; 53/426; 53/461; 53/133.2; 53/167; 53/284.7; 53/253; 53/DIG. 2
- [58]

Field of Search 53/410, 425, 468, 53/471, 133.2, 284.7, DIG. 2, 253, 167, 426, 469

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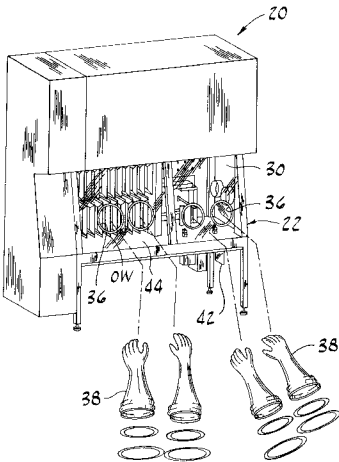
Primary Examiner—Linda Johnson

Attorney, Agent, or Firm—Senniger, Powers, Leavitt & Roedel

ABSTRACT

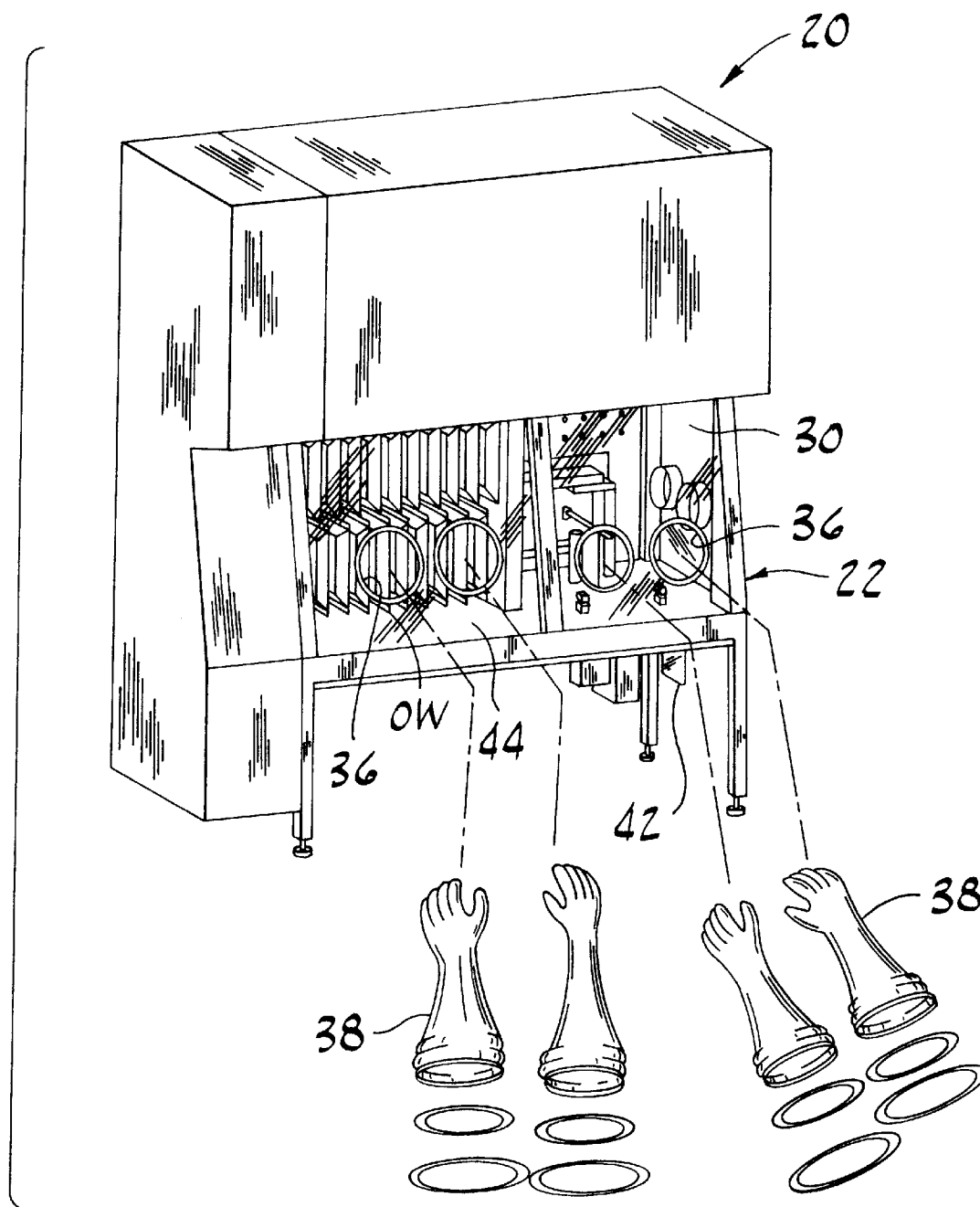
An apparatus for filling and sealing intravenous solution bags in a sterile environment. Each bag has a weldably sealable opening for introducing intravenous solution into the bag. The apparatus includes a generally sealed enclosure defining an enclosed interior space sized and shaped for simultaneously containing a plurality of the intravenous solution bags to prevent contamination of the bags. Further, the apparatus includes an intravenous solution delivery system positioned at least partially inside the interior space of the enclosure for delivering intravenous solution through the openings of the bags to fill the bags while the bags are in the enclosure. In addition, the apparatus includes a welder positioned at least partially inside the interior space of the enclosure for hermetically sealing the openings of the bags after they have been filled with intravenous solution and while they are in the enclosure.

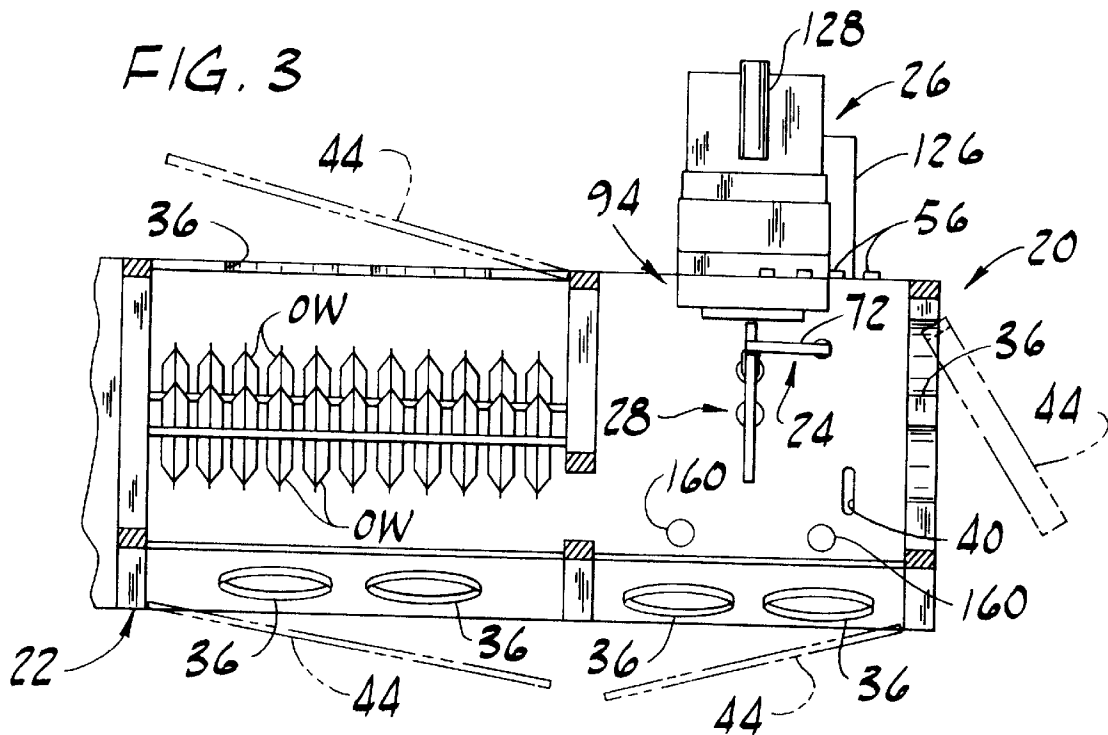
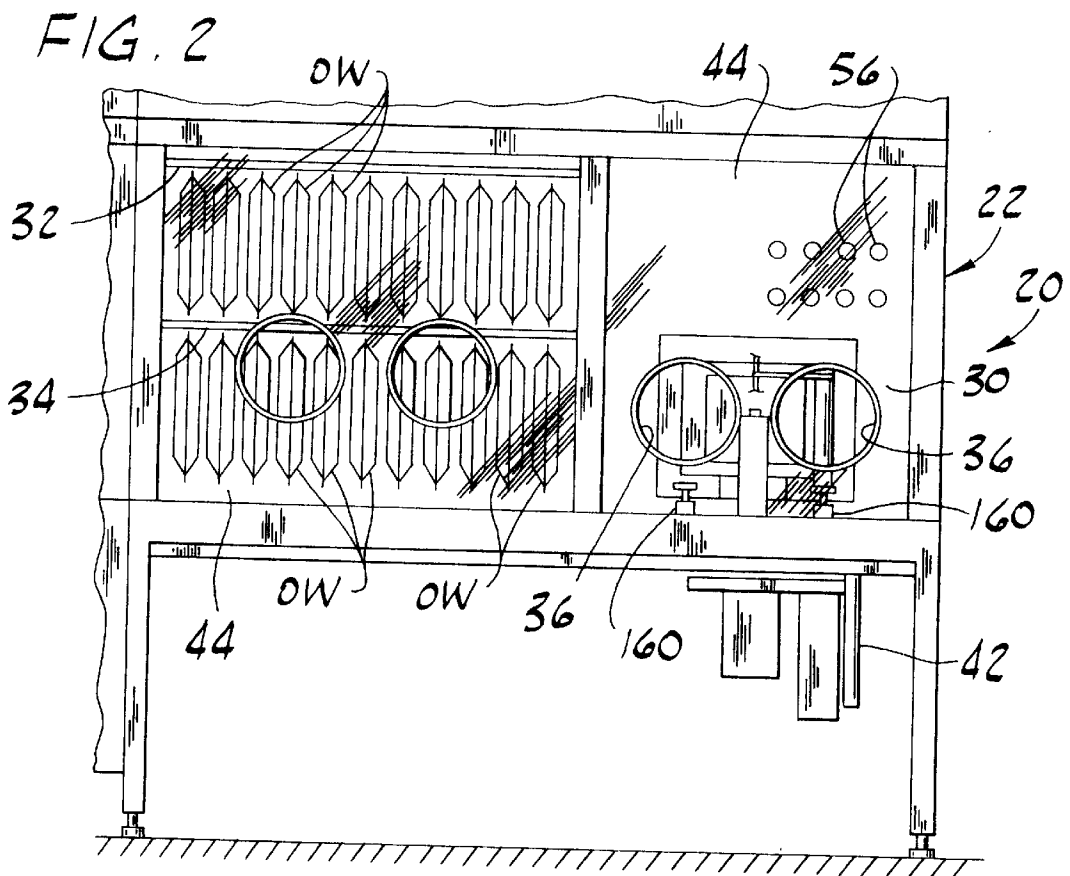
20 Claims, 9 Drawing Sheets



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FIG. 1





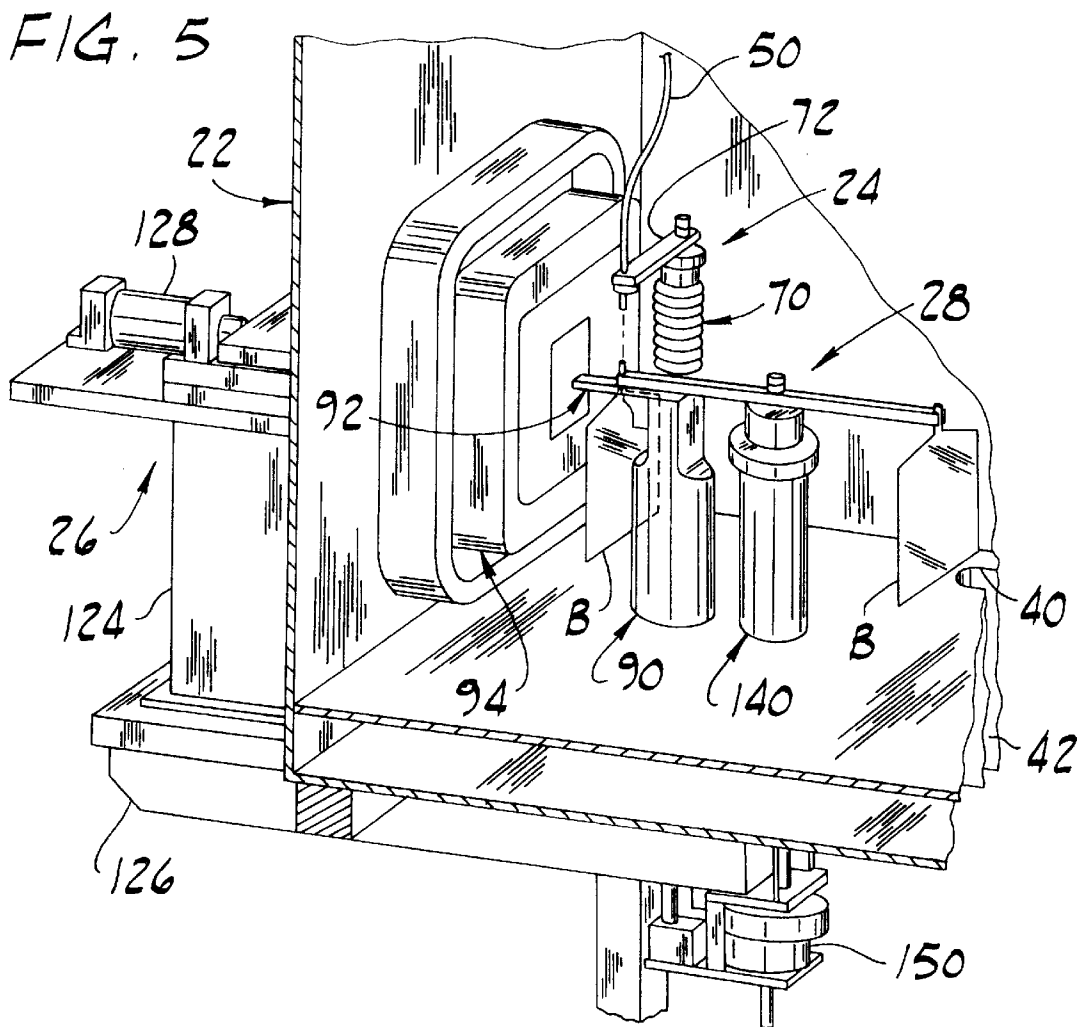
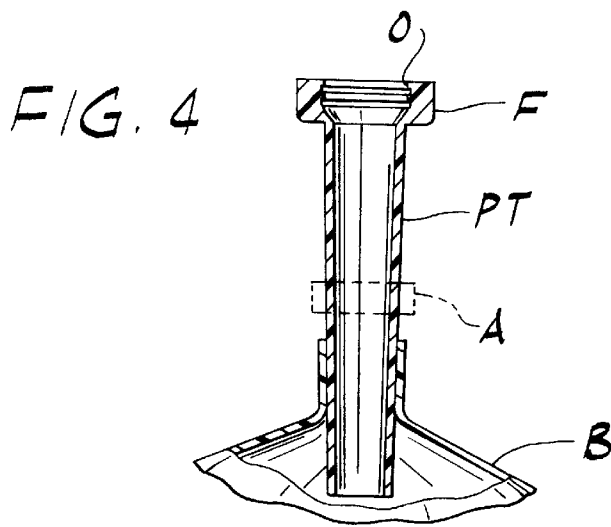


FIG. 6

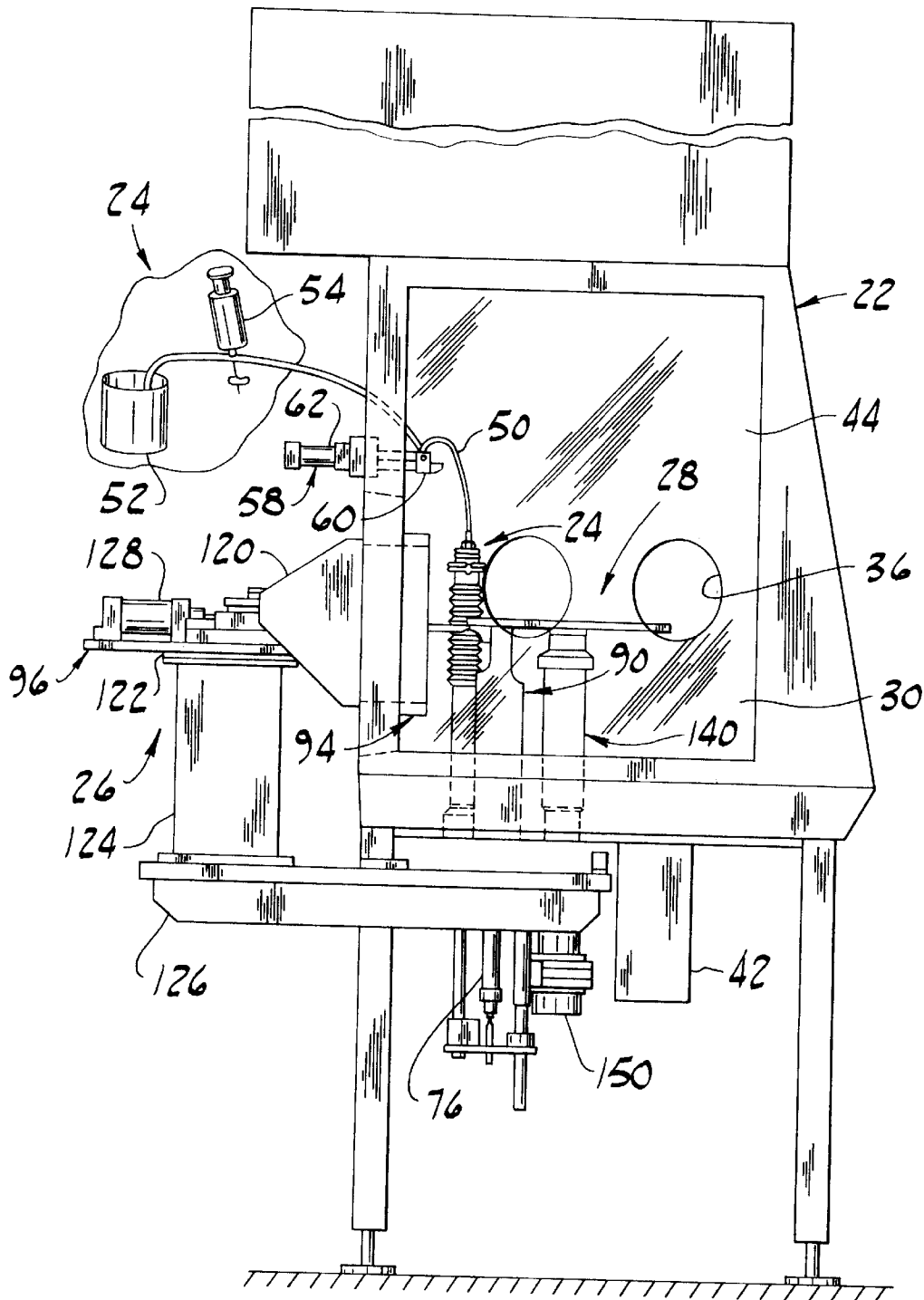


FIG. 7

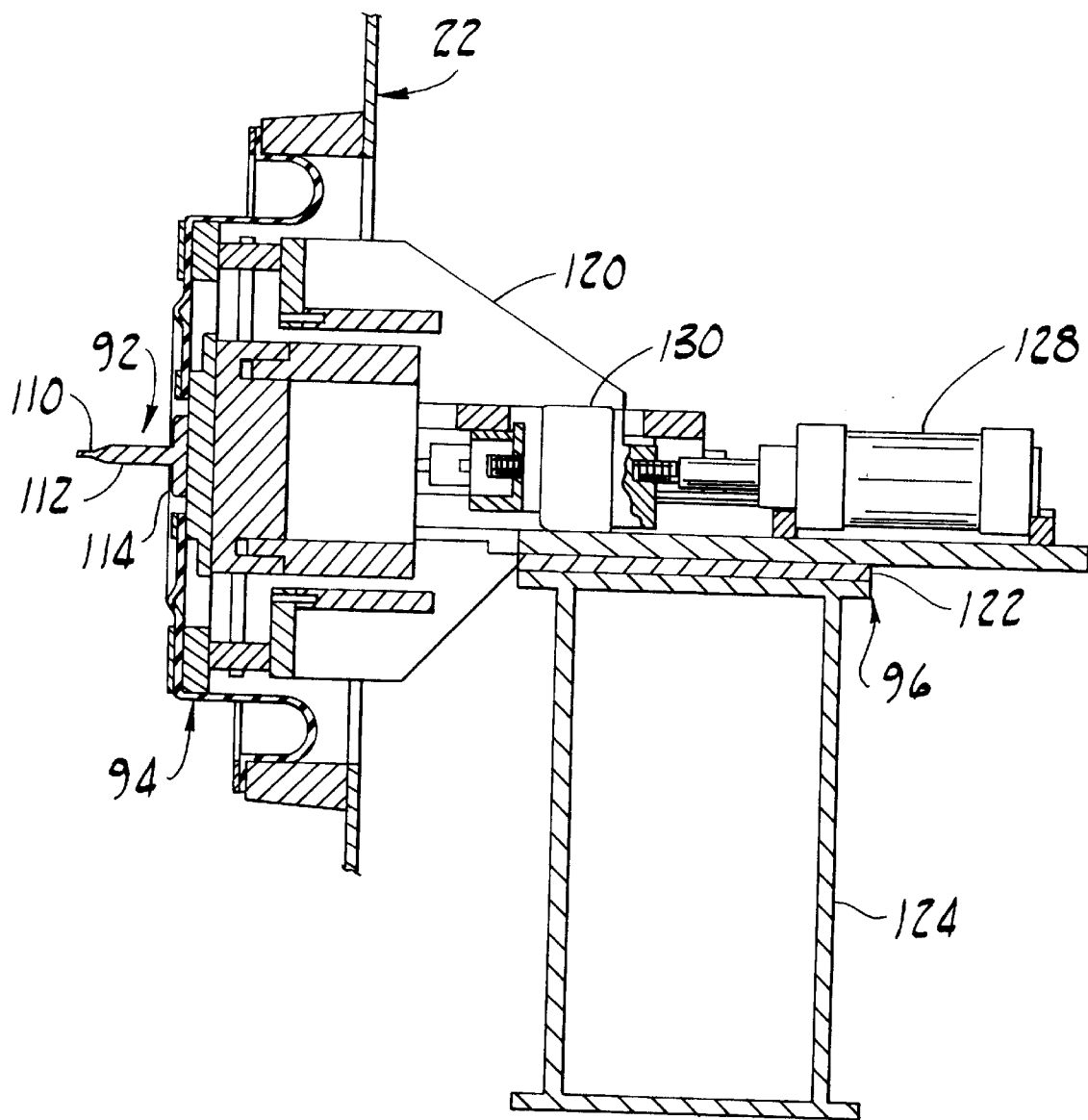


FIG. 8

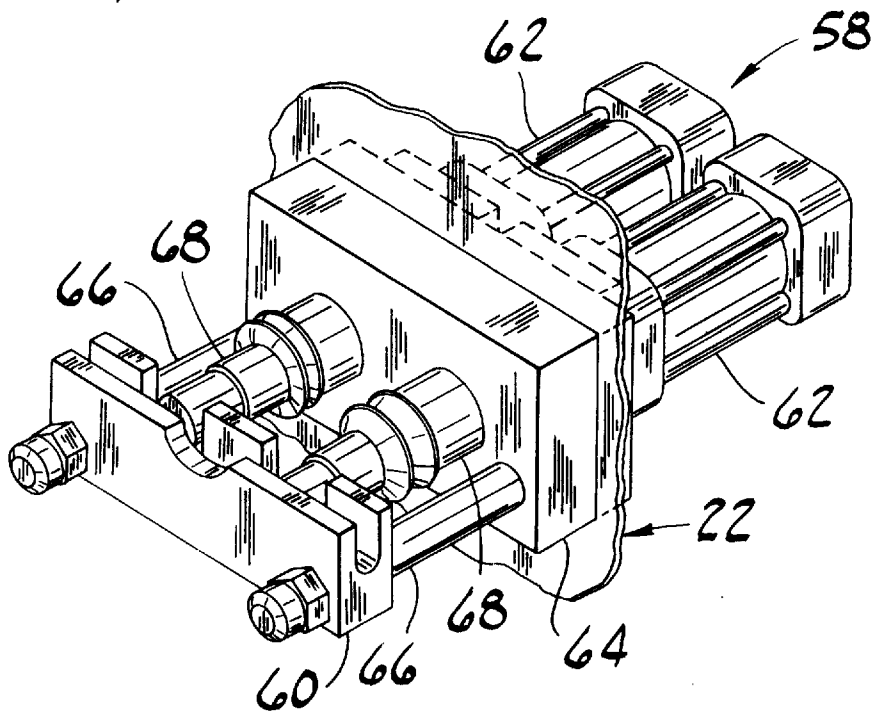


FIG. 9

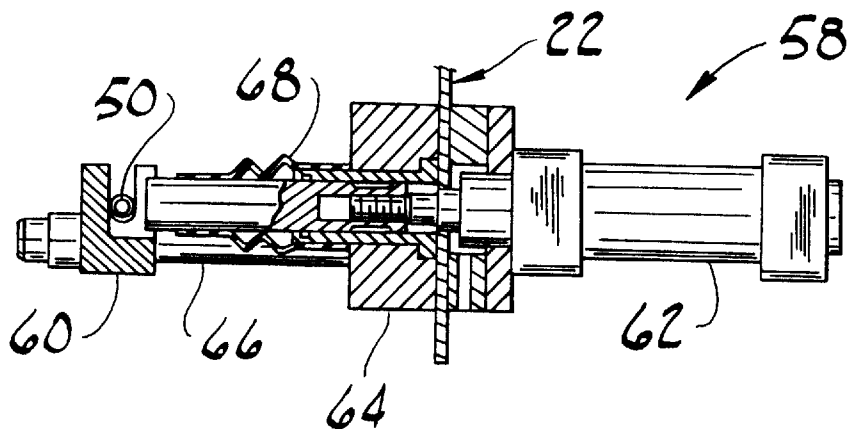


FIG. 10

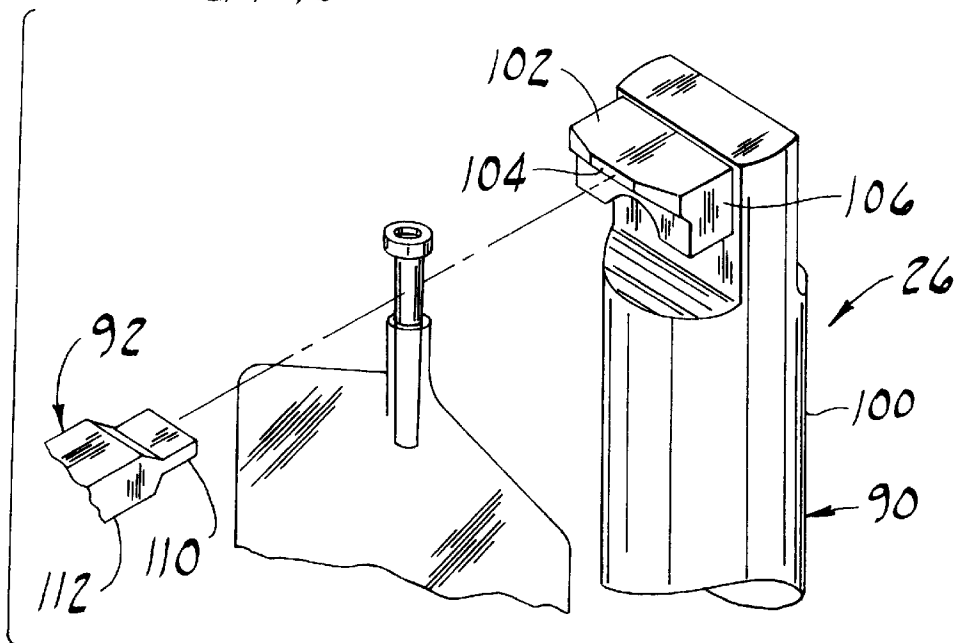


FIG. 11

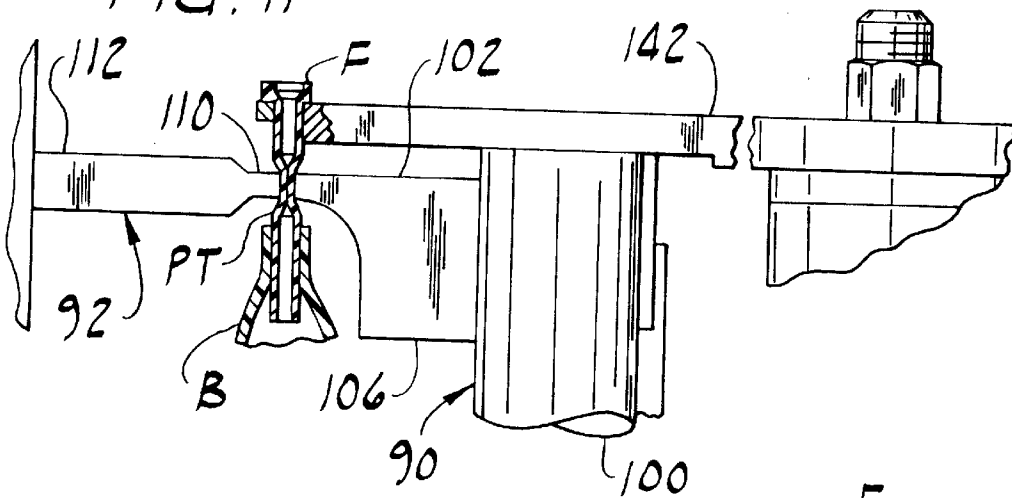


FIG. 12

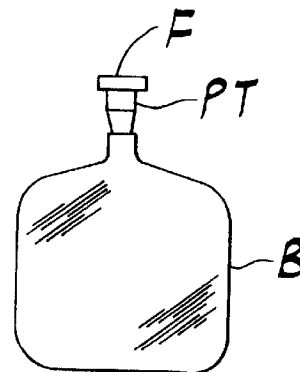


FIG. 13

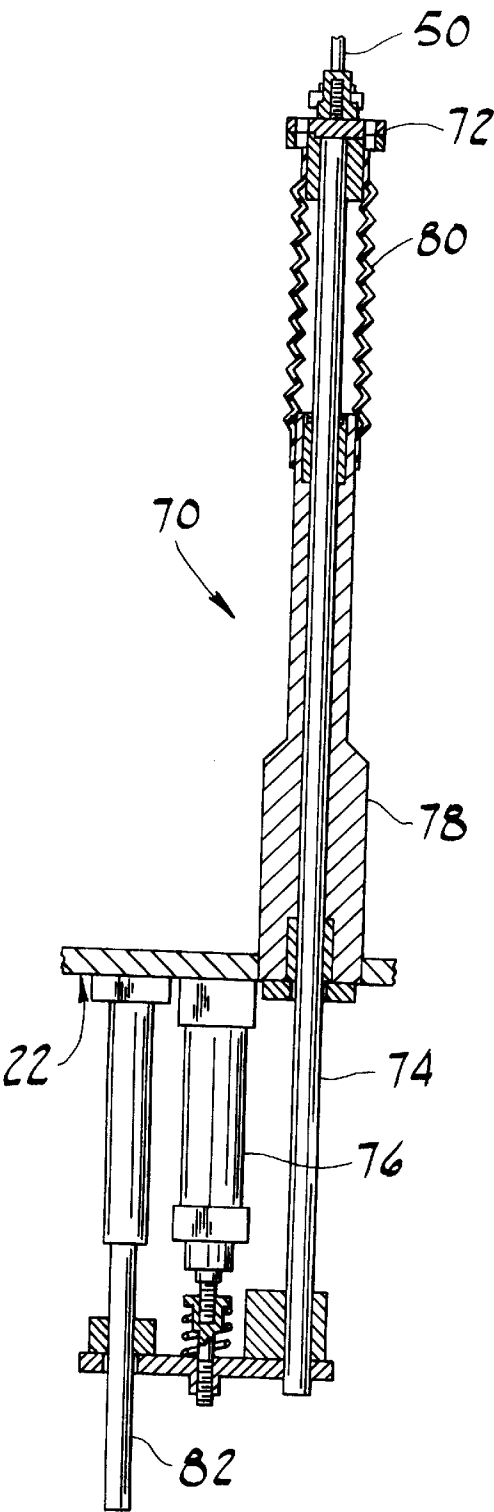


FIG. 14

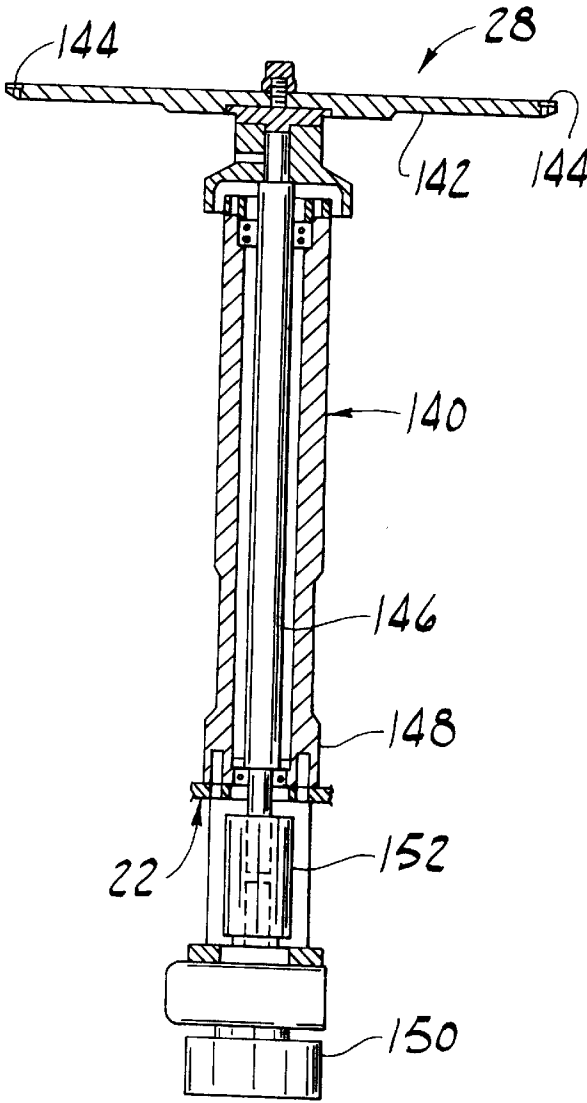


FIG. 15

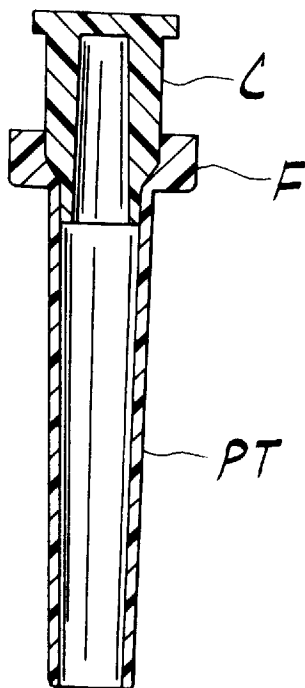
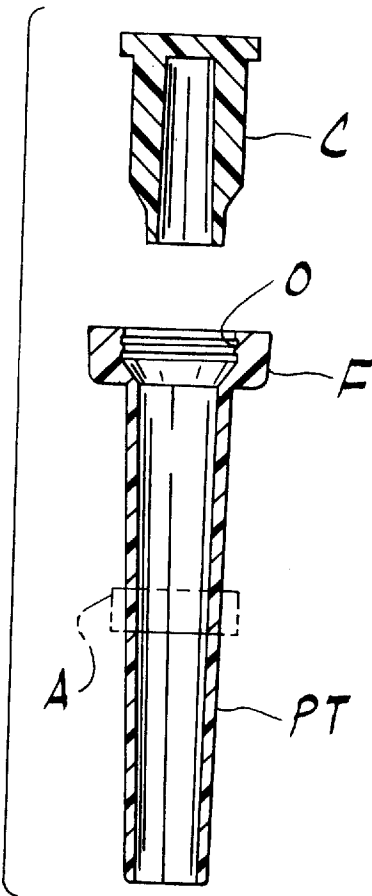


FIG. 16



APPARATUS AND METHOD FOR FILLING AND SEALING INTRAVENOUS SOLUTION BAGS

CROSS-REFERENCES TO RELATED APPLICATIONS

This is a continuation-in-part of application Ser. No. 08/595,996, filed Apr. 9, 1996, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to filling and sealing intravenous solution bags and, more particularly, to a method and apparatus for filling intravenous solution bags in a sterile, sealed enclosure and sealing the bags by vibration welding.

Previously, intravenous solution bags have been filled in clean rooms under hoods capable of maintaining sterile conditions within specified limits. The bags are sterilized before being taken into the room to prevent the room from being contaminated, and they are re-sterilized after being filled to ensure sterility of the bag as shipped. However, some solutions are damaged if the bags are sterilized after being filled. Thus, the bags must be processed in a very sterile environment to prevent contamination during the filling and sealing processes so that re-sterilization is not required. Clean rooms capable of maintaining the necessary sterile environment are expensive to build and operate. Further, these rooms are highly inefficient because everything in the room, including any workers, must be sterilized before entering the room.

Conventional intravenous solution bags are made of thermoplastics such as vinyl. Usually, the opening through which the bag is filled is sealed by heating the bag in the vicinity of the opening to a temperature sufficient to melt portions of the bag and then pressing the melted portions of the bag together as they cool to weld the opening shut.

Several methods have been used to heat the bag. One such method is radio frequency welding in which high frequency electromagnetic radiation is directed toward the bag to heat the plastic. If any solution is present on the outside surface of the bag, electrical arcing can occur which may damage the bag and/or the radio frequency welding machine. Another method of sealing the bag is ultrasonic welding in which a portion of the bag is clamped between a sonic horn and an anvil. The horn vibrates against the bag at very high speeds (e.g., 20–40 kHz or more). As the horn vibrates, it moves toward and away from the bag and heats the bag, first at the outside surface and then farther inward. Because the outside surface of the bag is heated first and the inside surface must be melted to weld the opening shut, the bag melts through its entire thickness during ultrasonic welding. Melting weakens the bag and prevents it from being suspended from above the weld. Therefore, the bag must be supported both below the weld to prevent it from rupturing and above the weld to prevent it from spilling. Further, the operating parameters used in ultrasonic welding must be closely controlled or inferior welds are made. Thus, ultrasonic welding is difficult to perform consistently.

SUMMARY OF THE INVENTION

Among the several objects and features of the present invention may be noted the provision of an apparatus which fills and seals intravenous solution bags in a highly sterile environment; the provision of such an apparatus which eliminates the need to post-sterilize the bags; and the pro-

vision of such an apparatus which is relatively inexpensive to build and operate.

Briefly, an apparatus of this invention fills and seals intravenous solution bags in a sterile environment. Each bag has a weldably sealable opening for introducing intravenous solution into the bag. The apparatus comprises a generally sealed enclosure defining an enclosed interior space sized and shaped for simultaneously containing a plurality of the intravenous solution bags to prevent contamination of the bags. Further, the apparatus comprises an intravenous solution delivery system positioned at least partially inside the interior space of the enclosure for delivering intravenous solution through the openings of the bags to fill the bags while the bags are in the enclosure. In addition, the apparatus comprises a welder positioned at least partially inside the interior space of the enclosure for hermetically sealing the openings of the bags after they have been filled with intravenous solution and while they are in the enclosure.

In another aspect, the invention includes a method of filling and sealing intravenous solution bags in a sterile environment. The method comprises the steps of enclosing the bags in a generally sealed enclosure, filling the interior chambers of a bag with intravenous solution, and hermetically sealing the opening of the bag by welding the opening closed with a welder while in the enclosure.

Other objects and features of the invention will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective of apparatus for filling and sealing intravenous solution bags;

FIG. 2 is a fragmentary front elevation of the apparatus;

FIG. 3 is a fragmentary horizontal cross section of the apparatus;

FIG. 4 is a fragmentary front elevation of an upper portion of a solution bag;

FIG. 5 is a perspective, partially broken away, of the apparatus showing a solution delivery system and a welder;

FIG. 6 is a fragmentary side elevation of the apparatus;

FIG. 7 is a vertical cross section of the welder;

FIG. 8 is a perspective of a pinch-and-draw valve for controlling solution delivery to the bag;

FIG. 9 is a vertical cross section of the valve;

FIG. 10 is a fragmentary perspective of the welder and a solution bag;

FIG. 11 is a side elevation of the welder shown welding a bag held by a turntable, with parts shown in partial cross section;

FIG. 12 is a front elevation of an intravenous solution bag;

FIG. 13 is a vertical cross section of a fill nozzle actuator for raising and lowering a filling tube;

FIG. 14 is a vertical cross section of the turntable;

FIG. 15 is a vertical cross section of a port tube and port tube cap of an intravenous solution bag; and

FIG. 16 is a cross section of the tube and cap schematically showing a sealing area of the tube.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and in particular to FIG. 1, an apparatus for filling and sealing intravenous solution bags

B (FIG. 5) in a sterile environment is generally designated by the reference numeral 20. As illustrated in FIGS. 5 and 6, the apparatus 20 includes a sealed enclosure (generally designated 22), an intravenous solution delivery system (generally designated 24) to fill the bags B, and a welder (generally designated 26) for hermetically sealing the bags after they have been filled with intravenous solution. The apparatus also includes a transport system, generally designated 28, for transporting each of the bags B between a station where the bag is filled and sealed (i.e., a filling and sealing station) and a station where the bags are removed from the enclosure (i.e., a bag removal station).

The apparatus may be used to fill bags B of the type shown in FIG. 4, for example. The bag B includes a port tube PT having an opening O extending through the tube and a radial flange F at its distal end. The flange F is sufficiently rigid so that the entire bag B may be suspended from the flange when the bag is full. The port tube PT is inserted either manually or mechanically into the bag B and attached to the bag by adhesives or welding prior to placing the bag in the enclosure 22. The port tube PT is preferably constructed of a thermoplastic such as a blend of ethyl vinyl acetate (EVA) and ethylene. For instance, the port tube PT may be made of ESCORENE UL00218MED random EVA copolymer available from Exxon Chemical. ESCORENE is a federally registered U.S. trademark owned by Exxon Corporation of Flemington, N.J. Port tubes PT constructed of ESCORENE copolymer comprise about 12 to about 18 percent EVA and a blend of polyethylene. Alternatively, the bags B may be constructed of blends of polyolefins and butyl rubbers or thermoplastic elastomers such as KRATON elastomers in a 50/50 blend, as known in the prior art. KRATON is a federally registered U.S. trademark owned by Shell Oil Company of Houston, Tex.

Before the bag B is filled and after it is sealed, a cap C may be inserted into the port tube PT and frictionally held in place as shown in FIG. 15. FIG. 16 illustrates the cap C removed from the port tube PT of the bag B. In addition FIG. 16, shows an area A in phantom where the port tube PT is sealed with the welder 26.

As illustrated in FIG. 2, the enclosure 22 defines an enclosed interior space 30 sized and shaped for simultaneously containing a plurality of the intravenous solution bags B (not shown in FIG. 2) to prevent contamination of the bags. Upper and lower racks 32, 34, respectively, extend across a portion of the enclosure 22 for providing a staging area for storing the bags B prior to filling. Each rack has a series of slots (not shown) for receiving the bags. The bags B are stored in individual envelopes or overwrap OW to protect them from contamination before being filled and sealed. Portholes 36 are provided in the walls of the enclosure 22. As illustrated in FIG. 1, flexible rubber gloves 38 are attached by conventional means to the portholes 36 for manipulating bags B and overwrap OW in the enclosure 22. Thus, the gloves 38 form part of the transport system 28 for transporting the bags from the staging area (i.e., the racks 32, 34) to the filling and sealing station. Although stationary racks 32, 34 are used in the preferred embodiment for storing the bags B, other storage means such as conveyors are also envisioned as being within the scope of the present invention.

Air handling equipment (not shown) is housed in the enclosure 22 above the interior space 30 for pressurizing the space with filtered air to prevent contamination from entering the enclosure. Electronic controls (not shown) are housed in the enclosure 22 beside the interior space 30 (to the left as shown in FIG. 1) for controlling operation of the

apparatus 20. As illustrated in FIG. 3, a slot 40 extends through the floor of the enclosure 22 defining the interior space 30. Bags B may be dropped through this slot 40 after they are sealed to remove them from the enclosure 22 without opening the enclosure and contaminating its contents. The enclosure 22 may be positioned over a conveyor (not shown) to transport the bags B away from the enclosure after they have dropped through the slot 40.

As illustrated in FIG. 2, a tubular chute 42 extends down from the slot 40 to prevent contamination from entering the interior space 30 as bags B fall through the slot. It will be noted in this regard that as a bag B falls through the slot 40, the air pressure decreases immediately above the bag due to aerodynamic effects. This pressure decrease might draw contaminated air into the enclosure 22 if the chute 42 were not present. The chute 42 acts as a physical barrier to prevent air outside the enclosure 22 from backflowing into the interior space 30 as the bag B falls through the slot 40. The positive air pressure in the interior space 30 also ensures that the space is not contaminated.

Although other materials may be used to construct the enclosure 22 without departing from the scope of the present invention, the enclosure of the preferred embodiment is primarily constructed of stainless steel and has glass doors 44 to permit operators to view the bags B in the enclosure. As illustrated in phantom in FIG. 3, the doors 44 are mounted on hinges (not shown) so they can be swung open before and after each production run to load bags B in their individual overwraps OW and unload spent overwrap OW after a batch is completed as will be explained in greater detail below. At the beginning of each production run, bags B are loaded into the racks 32, 34 through the open doors 44, the doors are closed, and the interior space 30 is sterilized using a hydrogen peroxide spray.

The intravenous solution delivery system 24 is positioned at least partially inside the interior space 30 of the enclosure 22. As illustrated in FIG. 6, the solution delivery system 24 includes a filling tube 50 for filling bags B with intravenous solution. A sealed receptacle 52 is connected to the filling tube 50 outside the enclosure 22 for holding a supply of intravenous solution, and an automatic or manual syringe pump 54 is positioned along the filling tube for delivering a predetermined amount of solution from the receptacle to an awaiting bag B (FIG. 5). The filling tube 50 enters the enclosure 22 through one of eight conventional connectors 56 (FIG. 2) positioned on the back wall of the enclosure. As further illustrated in FIG. 6, a pinch-and-draw valve, generally designated 58, is positioned between the pump 54 and the outlet (i.e., lower end) of the filling tube 50 for controlling flow of solution through the filling tube.

As illustrated in FIGS. 8 and 9, the pinch-and-draw valve 58 comprises a channel member 60 which holds the filling tube 50, and two pneumatic actuators 62 which extend to pinch the filling tube against the channel member to prevent flow through the filling tube and retract to permit flow through the filling tube. When solution is dispensed from the receptacle 52 by the syringe pump 54, both actuators 62 of the pinch-and-draw valve 58 are retracted to permit flow through the filling tube 50. After the pump piston is completely compressed, thereby forcing the predetermined amount of solution through the tube 50 to an awaiting bag B, both actuators 62 are extended to pinch the tube and stop flow through the tube. Once flow is stopped, the downstream actuator 62 is retracted, allowing the corresponding pinched portion of tubing 50 to expand for drawing a small portion of the solution up the filling tube to ensure that the meniscus at the outlet of the tube is concave so solution does not drip

from the tube. The actuators **62** are attached to the enclosure by a mounting block **64**. Threaded rods **66** extend from the block **64** into the interior space **30** for holding the channel member **60** in position relative to the actuators **62**. Elastomeric boots **68** surround the actuators **62** to seal against contamination of the enclosure **22**.

As illustrated in FIG. 5, an insertion mechanism, generally designated **70**, is provided to raise and lower the filling tube **50** relative to the bag **B**. The filling tube **50** is held by a holder **72** which is attached to a vertical rod **74** as illustrated in FIG. 13. The rod **74** is connected to a pneumatic actuator **76** mounted below the enclosure **22** for moving the holder **72** and filling tube **50** up and down relative to the bag **B**. The arrangement is such that when the actuator **76** extends, the filling tube **50** is lowered into the bag **B**, and when it retracts, the filling tube is raised out of the bag. A housing **78** surrounds the rod **74** to guide it up and down, and an elastomeric bellows **80** extends between the housing **78** and the holder **72** to seal against contamination of the enclosure **22**. A second rod **82** extending down from the enclosure **22** guides the actuator **76** to prevent it from bending. This configuration also prevents the rod **74** from turning so the filling tube **50** remains aligned with the bag **B**.

As illustrated in FIG. 10, the welder **26**, which hermetically seals the bags after they have been filled with intravenous solution, comprises an anvil (generally designated **90**), a sealing head (generally designated **92**), a vibrator mechanism (generally designated **94** in FIG. 7) which vibrates the sealing head transversely (i.e., in and out of the page as shown in FIG. 7) with respect to the anvil, and a slider mechanism (generally designated **96** in FIG. 7) which moves the sealing head and the vibrator mechanism toward and away from the anvil to permit a port tube **PT** of a bag **B** to be inserted into and removed from the filling and sealing station. As illustrated in FIG. 10, the anvil **90**, comprises a rigid, steel shaft **100** having a hardened body **102** extending laterally from an upper end of the shaft. The shaft **100** is rigidly attached to the floor of the enclosure **22** as shown in FIG. 5. As will be apparent to those skilled in the art, the size and shape of the anvil **90** may vary without departing from the scope of the present invention. However, the anvil **90** of the preferred embodiment has a sealing surface **104** which is about 0.125–1.0 in. high and about 1.0–1.25 in. wide. The sealing surface **104** is knurled to grip the bag **B** and provide improved sealing characteristics. The body **102** of the preferred embodiment has a base **106** which is approximately 1.5625 in. thick, 2.0 in. high, and 2.75–3.0 in. wide.

As will be apparent to those skilled in the art, the size and shape of the sealing head **92** may also vary without departing from the scope of the present invention. However, as illustrated in FIGS. 10 and 11, the sealing head **92** of the preferred embodiment has a tip portion **110** which is approximately 0.10–0.25 in. high, and most preferably about 0.142 in. high. The tip portion **110** of the preferred embodiment is approximately 0.10–0.25 in. long, and most preferably is about 0.125 in. long. The tip portion **110** flares outward over a length of about 0.25 in. The edges of the tip portion **110** are rounded to prevent it from puncturing or cutting a bag **B** during sealing. The sealing head **92** also includes a main portion **112** which in the preferred embodiment is about 2.5 in. long and about 0.3125 in. high. As illustrated in FIG. 7, the sealing head **92** also has a base portion **114** which in the preferred embodiment is about 0.25–0.5 in. thick and about 1.0–2.5 in. wide. The main portion **112** of the sealing head **92** extends from the center of the base portion **114**. As shown in charts provided in the appendix, a variety of sizes of sealing heads may be used.

The vibrator mechanism **94** (e.g., a Branson Series 90 Mini-Vibration Welder) vibrates the sealing head **92** transversely with respect to the anvil **90** (i.e., in and out of the page as shown in FIG. 7) to seal the bag **B** in area **A** of the port tube **PT**. As shown in FIG. 7, the vibrator mechanism **94** is mounted on a carriage **120** which in turn is mounted on the slider mechanism **96** having one or more platforms **122** connected by linear bearings (not shown) to permit extension and retraction of the sealing head **92** with respect to the anvil **90**. The platforms **122** are arranged on a pedestal **124** which extends up from a shelf structure **126** attached to the back of the enclosure **22**. A pneumatic actuator **128** mounted on the pedestal **124** and connected to the carriage **120** moves the sealing head **92** and vibrator mechanism **94** toward and away from the anvil **90**. An air bladder **130** is positioned between the carriage **120** and the actuator **128**. This bladder **130** compresses as the bag **B** is gripped between the sealing head **92** and the anvil **90**. When the bladder **130** is compressed a predetermined amount corresponding to a desired tool pressure on the bag, a trigger switch (not shown) closes to signal the vibrator mechanism **94** to begin vibrating the sealing head **92**. As the sealing head **92** vibrates, it generates heat in area **A** between the inside surfaces of the port tube **PT**. When the heat becomes great enough, the tube melts. After the vibrator mechanism **94** stops vibrating, pressure is maintained between the sealing head **92** and anvil **90** for a predetermined dwell interval, so the port tube **PT** is hermetically sealed as it cools.

In the preferred embodiment, the sealing head **92** vibrates at a frequency of about 200 Hertz to 300 Hertz and at an amplitude of about 0.070 in. peak to peak, plus or minus 0.002 in. for approximately 1–2 seconds. Further, a pressure of about 40 to 70 pounds per square inch is applied to the bag. The bag **B** is permitted to cool for about 1 second plus or minus a half second before the pressure is released and the bag is transferred to the removal station. A gap of no less than about 0.004 in. is maintained between the sealing head **92** and the anvil **90** during welding. One of the advantages of the present invention is that vibration welding is very forgiving, so that, for example, a weld time of six seconds may be utilized without burning or puncturing of the bag **B**. The port tube **PT** is preferably sealed while the filling tube **50** is in the port tube **PT**.

In order to verify the efficacy of the previously-described apparatus **20** for sealing bags **B**, a series of tests were conducted varying the sealing parameters. The results of these tests are provided in the appendix. As shown in the charts provided in the appendix, the previously described pressure and dwell times provide strong hermetic seals in port tubes **PT** made of the previously described materials.

As illustrated in FIG. 5, the transport system **28** of the preferred embodiment includes a turntable, generally designated **140**, provided in the enclosure **22**. As further illustrated in FIG. 14, the turntable **140** includes an arm **142** having an aperture or slot **144** at each end for holding bags **B**. The arm **142** is fastened to a shaft **146** which is rotatably held by a tubular housing **148** attached to the floor of the enclosure **22**. The shaft **146** is turned for rotating the arm **142** by means of a drive connected to the bottom of the shaft by a coupling **152**. The drive may comprise a rotary actuator **150** such as a FESTO Rotary Actuator. In an alternative embodiment, not shown in the drawings, the transport system **28** may comprise a conventional conveyor.

To use the apparatus **20** described above, the glass doors **44** are opened and empty intravenous solution bags **B** in individual overwrap **OW** are loaded in the racks **32**, **34** on the left side of the enclosure **22** (as viewed in FIGS. 1–3).

The bags B may be sterilized before being loaded into the enclosure 22, or they may be sterilized while in the enclosure. In a preferred embodiment, the bags B are pre-sterilized by gamma radiation in the overwrap OW or sealed trays (not shown) before being loaded into the enclosure 22.

Once the bags B are loaded, the doors 44 are closed and the interior space 30 is sterilized by spraying a sterilizing agent such as hydrogen peroxide, ethylene oxide or other chemical or commonly known gaseous sterilization agents into the interior space. In order to maintain sterility, sterile air is blown into the enclosure 22 by the air handling equipment housed above the interior space 30.

A first operator places his or her hands in a pair of gloves 38 in front of the racks 32, 34. This operator removes a bag B from one of the racks and removes the overwrap OW from the bag. Although other provisions may be made for the spent overwrap OW, in the most preferred embodiment the overwrap is simply discarded on the floor of the enclosure 22 until after the entire batch of bags in the enclosure is processed. A second operator places his or her hands in a second pair of gloves 38 in front of the turntable 140. The first operator hands the unwrapped bag B to the second operator who finishes processing this bag, so the first operator is free to remove the next bag B to be filled and sealed from the overwrap OW. The second operator suspends the bag B from the turntable 140 by inserting the port tube PT of the bag into the slot 144 on the closer end of the turntable arm 142 so the flange F of the bag is above the arm.

Once the bag is suspended from the turntable, the second operator simultaneously presses two palm buttons 160 (FIG. 2) on the floor of the enclosure 22 for a predetermined period of time (e.g. two seconds). When the palm buttons have been pressed for the predetermined period of time, the controller mounted in the left portion of the enclosure 22 signals the rotary actuator 150 to spin the turntable 180° to position the port tube PT of the bag B below the filling tube 50 and between the anvil 90 and the sealing head 92 of the welder 26. The controller next signals the actuator 76 of the insertion mechanism 70 to lower the filling tube 50 into the port tube PT of the bag B, following which the controller opens the pinch-and-draw valve 58 to dispense a predetermined amount of intravenous solution delivered by the syringe pump 54 into the bag B. Both actuators 62 of the valve 58 then close and the downstream actuator opens to draw a small amount of solution up into the filling tube to prevent dripping.

The controller next signals the actuator 124 on the welder 26 to slide the sealing head 92 toward the anvil 90 to pinch the port tube PT of the bag B at area A. When the predetermined amount of pressure is achieved between the port tube PT, sealing head 92 and anvil 90, the bladder 126 compresses sufficiently to close the trigger switch (not shown) and the vibrator mechanism 94 vibrates the sealing

head 92 transversely relative to the anvil 90. The vibration causes heat to generate between the inside surfaces of the port tube PT so the inside of the port tube melts. After a predetermined period of time, the vibrator mechanism 94 stops moving and the pressure between the sealing head 92 and the anvil 90 is maintained until the melted portion of the port tube PT in area A is sealed.

Once the bag B is sealed, the actuator 124 is retracted to slide the sealing head 92 away from the anvil 90, and the actuator 76 on the insertion mechanism 70 is retracted to raise the filling tube 50 out of the port tube. After the second operator has loaded the next bag B to be filled and sealed on the other end of the arm 142 and has again pressed the palm buttons 150, the turntable turns 180° to fill and seal the next bag. When the turntable 140 turns, it returns the filled and sealed bag to a position near the operator's gloved hands, where he or she may cap the bag B and remove it from the slot 144 in the turntable arm 142. The operator then drops the bag through the slot 40 in the floor of the enclosure 22 where it can be transported to another location for further processing and shipment. Alternatively, the second operator may pass the bag back to the first operator who may load the filled bag back into one of the racks 32, 34. When all of the bags have been filled and sealed, the doors 44 are opened and the spent overwrap OW is removed prior to beginning the next batch of bags.

As an additional feature of the invention, a check weigher may be provided either attached to arm 142 or as a separate station within the enclosure 22 for precisely controlling the weight and therefore the volume of each bag B.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained. In particular, the apparatus and method described above enables intravenous solution bags to be filled and sealed inside a comparatively inexpensive enclosure 22 rather than in an expensive clean room. Further, the apparatus and method eliminates the need for post-processing sterilization which can damage the solution in the bags. In addition, because vibration welding is used, rather than ultrasonic welding, the bag is not melted through its entire thickness. Thus, the bag may be suspended from above during processing, and the process is not as sensitive to variations in operating parameters. Still further, since the bags are suspended by their port tubes, a variety of different size bags may be processed without changing the mechanical settings of the device, as long as the port tubes are substantially uniform.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

APPENDIX2ND GENERATION VIBRATION WELDER PROTOTYPE
(AIR BLADDER/PNEUMATIC)

Subject BURST TEST STRENGTH OF 18 $\frac{1}{2}$ EVA vs. 18 $\frac{1}{2}$ /12 $\frac{1}{2}$ 50 $\frac{1}{2}$ -50 $\frac{1}{2}$. BLEND PORT TUBES
WELDED WHILE EXTERNAL WEIGHT PULLS ON SEAL.
USE WIDE AND NARROW WIDTH HORNS

Weld Parameters: Weld Time 1.6 seconds
Cool Time 1.0 seconds
Knurl Horn and Anvil
Horn/Anvil Gap .004"
Bladder Air Pressure 70 PSIG
Narrow, Long Horn

Method:

Dip the port tube in water to wet.
Clamp a Vise Grip plier with auxiliary weight, having a total
accumulated weight of 2.2 pounds or 1 kilogram, to the small
end of the port tube.
Hang the port tube assembly in anvils' part holding fixture.

Weld fifteen port tubes of 18 $\frac{1}{2}$ EVA Material with the Wide,
Long Horn
Weld fifteen port tubes of the 1 $\frac{1}{2}$ /18 $\frac{1}{2}$ 50 $\frac{1}{2}$ /50 $\frac{1}{2}$ Blend Material with
the Wide, Long Horn.
Weld fifteen port tubes of 18 $\frac{1}{2}$ EVA Material with the Narrow,
Long Horn.
Weld fifteen port tubes of the 18 $\frac{1}{2}$ /12 $\frac{1}{2}$ 50 $\frac{1}{2}$ /50 $\frac{1}{2}$ Blend Material
with the Narrow Long Horn.

Freeze parts for a minimum of 48 hours.
Thaw and burst test.
Record the results.

Definitions:

WF	WELD FRACTURE	The hydraulic pressure of the water has torn through and delaminated the weld.
WFW WEEP	WELD FRACTURE	The hydraulic water pressure has allowed small capillary flow through the weld; producing water weep.
PD	PARTIAL DELAMINATION	The weld has started to delaminate along the inner seal but has not fractured through the weld.
SW - BURST	SIDE WALL BURST	The burst pressure was strong enough to balloon out and burst the side, port tube wall. Sometimes accompanied by Partial Delamination.
SC -	SEAL CUT	The failure of the port tube wall on the solution side of the seal during burst; due to its' being weakened by the exaggerated penetration of the sharp or serrated, lower edge of the horn.

RUN 1

Port Tube Manufacturer: Baxter Healthcare Mold Shop RLT-10
 Port Tube Material: Escorene Ultra EVA
 Weld Time- 1.6 sec.
 Cool Time: 1.0 sec.
 Cylinder Pressure 125 PSIG
 Bladder Pressure: 70 PSIG
 Knurling: Horn and Anvil (did not want to remove anvil knurling for this test)
 Horn Width: NARROW

Port Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Burst Pressure (PSI)
1	2	203	203		201 SC
2	2	210	210		208 SC
3	2	211	211		209 SC
4	2	214	214		212 SC
5	2	207	207		205 SC
6	2	211	211		209 SC
7	2	247	247		245 SC
8	2	207	207		205 SC
9	2	225	225		223 SC
10	2	232	232		230 SC
11	2	247	247		245 SC
12	2	218	218		216 SC
13	2	232	232		230 SC
14	2	211	211		209 SC
15	2	222	222		220 SC
Mean Burst Pressure = 217.8					

mean 217.8
 sum x 3267
 sum x squared 714337
 sample standard deviation 14.103

RUN 2
 Port Tube Manufacturer: STEDIM
 Port Tube Material: 18%XL2% EVA 50%/50% Blend
 Weld Time: 1.6 sec.
 Cool Time: 1.0 sec.
 Cylinder Pressure: 125 PSIG
 Bladder Pressure: 70 PSIG
 Knurling: Horn and Anvil (did not want to remove anvil knurling for the 5 test)
 Horn Width: NARROW

Port Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Burst Pressure (PSI)
1	2	239		239	237 SW
2	2	236		234	234 SW
3	2	251	251		249 SC
4	2	243	243		241 SC
5	2	Damaged in test fixture			
6	2	236	236		234 SC
7	2	228	228		226 SC
8	2	240		240	238 SW
9	2	273		273	271 SW
10	2	232		232	231 SW
11	2	218		218	216 SW
12	2	225	225		223 SC
13	2	228		228	226 SW
14	2	232		232	230 SW
15	2	232		232	230 SW
Mean Burst Pressure = 234.7					

sum 3286
 n 14
 sum x squared 773546
 mean 234.7
 sample standard deviation 13.228

RUN 3
 Port Tube Manufacturer: Baxter Healthcare Mold Shop RLT-10
 Port Tube Material: Escorene Ultra EVA
 Weld Time: 1.6 sec.
 Cool Time: 1.0 sec.
 Cylinder Pressure: 125 PSIG
 Bladder Pressure: 70 PSIG
 Knurling: Horn and Anvil (did not want to remove anvil knurling for this test)
 Horn Width: NARROW

Port Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Burst Pressure (PSI)
1	2	203	203		201 SC
2	2	210	210		208 SC
3	2	211	211		209 SC
4	2	214	214		212 SC
5	2	207	207		205 SC
6	2	211	211		209 SC
7	2	247	247		245 SC
8	2	207	207		205 SC
9	2	225	225		223 SC
10	2	232	232		230 SC
11	2	247	247		245 SC
12	2	218	218		216 SC
13	2	232	232		230 SC
14	2	211	211		209 SC
15	2	222	222		220 SC
Mean Burst Pressure = 217.8					

sum x3267
 sum x squared 714337
 mean 217.8
 sample standard deviation 14.103

RUN 4

Port Tube Manufacturer: STEDIM
 Port Tube Material: 18%/12% EVA 50%/50% Blend
 Weld Time: 1.6 sec.
 Cool Time: 1.0 sec.
 Cylinder Pressure: 125 PSIG
 Bladder Pressure: 70 PSIG
 Knurling: Horn and Anvil (did not want to remove anvil knurling for this test)
 Horn Width: WIDE

Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Burst Pressure (PSI)
1	2	240		240	238 SW
2	2	251		251	249 SW
3	2	239		239	237 SW
4	2	236	236		234 SC
5	2	240		240	238 SW
6	2	240		240	238 SW
7	2	239		239	227 SW
8	2	239		239	237 SW
9	2	239		239	237 SW
10	2	239		239	237 SW
11	2	236		236	234 SW
12	2	243		243	241 SW
13	2	251		251	249 SW
14	2	251		251	249 SW
15	2	239		239	237 SW
Mean Burst Pressure = 239.5					

sum x 3592
 sum x squared 860542
 mean 239.5
 sample standard deviation 5.194

Results:**Material: Escorene Ultra EVA****Horn:** NARROW
Mean Burst Pressure: 284.5
100% SCWIDE
217.8
100% SC**Material: 18%/12% EVA** 50%/50% Blend**Horn Width:** NARROW
Mean Burst Pressure: 234.7
64% SW
36% SCWIDE
239.5
93% SW
7% SC

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VIBRATION WELDER PROTOTYPE
(PNEUMATIC/AIR BLADDER)

Subject: STATISTICAL RESULTS - FIRST SCREENING STUDY
Statistical Results from the Applied Sciences Group at Baxter
Round Lake - William Graham Building Regarding the First Screening Study using the Short
Sonic Horn.

Results:

Goal was to: 1) Maximize Burst Pressure Mean
2) Minimize Burst Pressure Standard Deviation

Key to both above objectives was to: Maximize Total Weld Time
i.e. 1.2 seconds

Marginal improvement on Mean and Significant (statistically but probably not practically)
Improvement of Standard Deviation by

- 1) Maximizing Weld Time Proportion > 0.5
- 2) Maximizing Trigger Pressure, P ex. 70 psi

There is a very marginal improvement of both the mean and SD gained by:
Minimizing Trigger Pressure, P

Cool time is not important at all.

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VIBRATION WELDER PROTOTYPE
(PNEUMATIC/AIR BLADDER)

Subject: BLADDER GAGE PRESSURE VS. FORCE PRODUCED

MEASURED BLADDER LENGTHS

Measured Uncompressed Bladder Length - 2-7/16" - 2.4375"
Measured Compressed Bladder Length = 2-3/16" = 2.1875"

CONSTANT PRESSURE CHARACTERISTICS
(taken from Data Sheet on Air Spring Model IS3-013)

Bladder Height	Bladder Pressure	Force Produced	Calculated Cross-sectional Area
1.5 "	20 lb/in ²	125 lbs delta = 10	6.25 in ² delta = .5
--- 2.0 "	20 lb/in ²	115 lbs	5.75 in ²
Operating Range	delta = 10		delta = .5
--- 2.5 "	20 lb/in ²	105 lbs delta = 15	5.25 in ² delta = .75

Interpolated Force over the linear range at a Bladder Pressure of 20 PSI.

<u>Bladder Height</u>	<u>Bladder Pressure</u>	<u>Force Produced</u>	<u>Calculated Cross-sectional Area</u>
	2		2
* 2.0 "	20 lb/in	115 lbs	5.75 in
	2		2
2.1 "	20 lb/in	113 lbs	5.65 in
	2		2
2.2 "	20 lb/in	111 lbs	5.55 in
	2		2
2.3 "	20 lb/in	109 lbs	5.45 in
	2		2
2.4 "	20 lb/in	107 lbs	5.35 in
	2		2
* 2.5 "	20 lb/in	105 lbs	5.25 in

* Given Values from Data Sheet.

y-intercept = 155 lbs

slope = -20

Force at 2.1875" height = 111.25 lbs

Force = -20(height) + 155

CONSTANT PRESSURE CHARACTERISTICS
(taken from Data Sheet on Air Spring Model IS3-013)

<u>Bladder Height</u>	<u>Bladder Pressure</u>	<u>Force Produced</u>
2.0"	30 psi	180 lb
2.5"	30 psi	170 lb
* 2.0"	40 psi	230 lb
* 2.5"	40 psi	220 lb
2.0"	50 psi	290 lb
2.5"	50 psi	290 lb
<u>Height</u>	<u>Bladder Pressure</u>	<u>Force Produced</u>
* 2.0"	60 psi	345 lb
* 2.5"	60 psi	335 lb

Drive cylinder behind Bladder as FESTO Type DNN-50-50-PPV-A-S2
 Double-Acting Cylinder
 50mm Bore
 50mm Stroke
 Max 180 PSI
 Series E041
 Adjustable Cushioning
 Acid-Resistant

50mm BORE CYLINDER = 1.9685039" DIA

Shaft Diameter = .786"

Cylinder Bore Cross-Sectional Area = $\pi \times .98425^2$ =
 3.0434234 sq. in.

Cylinder Shaft Cross-Sectional Area = $\pi \times .353^2$ =
 .4852 sq.in.

Working area of cylinder = Bore Area - Shaft Area

= (3.0434 - .4852) Sq. in.

= 2.5582 sq.in.

Pressure Force

125 PSI	320 LB
120 PSI	307 LB
115 PSI	294 LB
110 PSI	281 LB
100 PSI	256 LB
95 PSI	243 LB
90 PSI	230 LB
85 PSI	217 LB
80 PSI	215 LB
75 PSI	192 LB
70 PSI	179 LB
65 PSI	166 LB
60 PSI	153 LB
55 PSI	141 LB
50 PSI	120 LB
45 PSI	115 LB
40 PSI	102 LB
35 PSI	90 LB
25 PSI	77 LB
20 PSI	51 LB
15 PSI	38 LB
10 PSI	26 LB

NEW CYLINDER
 (changed Drive Cylinder on 2/23/95)

Drive Cylinder behind Bladder is FESTO Type DNN-63-60-PPV-A
 Double-Acting Cylinder
 63 mm Bore

60 mm Stroke
 MAX 150 PSI
 Series 0690400
 Adjustable Cushioning
 Acid-Resistant

60 mm STROKE = 2.362"

63 mm BORE CYLINDER - 2.4803149" DIA

Cylinder Bore Cross-Sectional Area = $\pi \times 1.2402^2$
 = $\pi \times 1.538096$
 = 4.832071 sq. in.

<u>Pressure</u>	<u>Force</u>
125 PSI	604 LB
120 PSI	578 LB
115 PSI	556 LB
110 PSI	532 LB
100 PSI	256 LB
95 PSI	243 LB
90 PSI	230 LB
85 PSI	217 LB
80 PSI	215 LB
70 PSI	192 LB
65 PSI	166 LB
60 PSI	153 LB
55 PSI	141 LB
50 PSI	128 LB
45 PSI	115 LB
40 PSI	102 LB
35 PSI	90 LB
30 PSI	77 LB
25 PSI	64 LB
20 PSI	51 LB
15 PSI	38 LB
10 PSI	26 LB

SUBJECT: BRANSON MINIWELDER LIFT TABLE PRESSURES APPLIED TO PART.

Information obtained from Kevin Buckley at Branson Plastic Joining in Henrietta, New York on 2-8-95

Miniwelder has a 4" BORE CYLINDER

The following was determined through the use of a strain gage load cell.

25 PSIG = 130 LBS.. ON PART
50 PSIG = 430 LBS. ON PART
80 PSIG = 800 LBS. ON PART

To make a good weld you want an applied force of 250 to 300 lbs per square inch of welding area.

4" Bore Cylinder Cross-Sectional Area = 12.566 in²

<u>Pressure</u>	<u>Force</u>
100 PSI	1257 LB
95 PSI	1194 LB
90 PSI	1131 LB
85 PSI	1068 LB
80 PSI	1005 LB
75 PSI	1005 LB
70 PSI	879 LB
65 PSI	817 LB
60 PSI	754 LB
55 PSI	691 LB
50 PSI	628 LB
45 PSI	565 LB
40 PSI	503 LB
35 PSI	440 LB
30 PSI	377 LB
25 PSI	314 LB
20 PSI	251 LB
15 PSI	188 LB
10 PSI	126 lb.

Note: Force on part = Force of cylinder - Weight of lift table

And, Weight of lift table = 150 lbs

Checking the Load Cell measurements for accuracy:

Therefore,

Force on part = Force of cylinder - 150

@ 25 PSI 314lb - 150lb = 164lb

VIBRATION WELDER - FINAL DESIGN
(AIR BLADDER/PNEUMATIC)

Subject: FINAL DESIGN TESTING WITH KNURLED HORN AND ANVIL
PRISM FEEDBACK VOLTAGE MEASUREMENTS

Port Tube Material is the Ultra Escorene EVA
BSG-913
RL-2-10-95A S-D

PRISM operating voltage: 451vac 3 phase 50Hz incoming power.

Gap: .004"

Trigger Distance: 2.320"

Bladder Pressure: 70 PSIG

Cylinder Pressure: 100 PSIG

Welded on 5-21-95

Wet

Weighted 1kg (2.21lb)

No freeze

Burst Tested on 5-24-95

Weld Time: 1.6 sec

Cool Time: 1.0 sec

Horn/Anvil Alignment: Radius to Radius mirror image on lower edges.

Setup 1 Uses the Final Long Horn - Wide width Radiused and Knurled Final Design Anvil -
Radiused and Knurled.

Setup 2 Uses the Welded version of the Long, Wide Area Horn that has been stepped down at
the horn tip to make it equivalent to a Narrow, Radiused, Knurled horn.

Setup 3 Uses the same configuration as in Setup 1 for a repeat condition after physical
breakdown and regapping.

Setup 1 Long, WIDE, radiused, knurled horn

Voltage feedback on Pickup Coil consists of a sinewave signal where every other cycle alternates at a different peak to peak level.
 Major peak to peak swing = 25 vp-p
 Minor peak to peak swing = 21 vp-p
 Period = 3.4 msec
 Frequency = 294.1Hz

Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)	Reason
1	-7	269		269	276	SW
2	-7	302		302	309	B+S
3	-7	320		320	327	SW
4	-7	306		306	313	B+S
5	-7	305		305	312	SW
6	-7	280		280	287	B+S
7	-7	305		305	312	SW
8	-7	283		283	290	SW
9	-7	290		290	297	B+S
10	-7	283		283	290	B+S

Setup 2 Long. NARROW. Radiused. Knurled Horn

Voltage feedback on Pickup Coil consists of a sinewave signal where every other alternates at a different peak to peak level.
 Major peak to peak swing = 26 vp-p
 Minor peak to peak swing = 21 vp-p
 Period = 3.4 msec
 Frequency = 294.1Hz

Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)	Reason
1	-7	319		319		SW
2	-10	301		301		SW
3	-10	319		319		SW

4	-10	294		294		B+S
5	-10	319		319		SW
6	-10	286		286		SW
7	-10	305		305		B+S
8	-10	286		286		B+S
9	-10	272		272		B+S
10	-10	305		305		SW

00074994 061397
262190 46642600

Setup 3 Long, WIDE, radiused, knurled horn

Voltage feedback on Pickup Coil consists of a sinewave signal where every other cycle alternates at a different peak to peak level.

Major peak to peak swing = 26 vp-p

Minor peak to peak swing = 21 vp-p

Period = 3.4 msec

Frequency = 294.1Hz

Port Tube No	Initial Displayed Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)	Reason
1	-10	282		282	292	B+S
2	-10	290		290	300	B+S
3	-10	273		273	283	B+S
4	-10	272		272	282	B+S
5	-10	265		365	275	B+S
6	-10	290		290	300	B+S
7	-10	305		305	315	B+S
8	-10	286		286	296	B+S
9	-10	272		272	282	B+S
10	-10	235		235	245	B+S

VIBRATION WELDER - FINAL DESIGN
(AIR BLADDER/PNEUMATIC)

SUBJECT: Port Tube Bursting Test with Varying Bladder Pressures on the Final Design.

Port tube material is the Ultra Escorene EVA
BSG-913
RL-2-10-95A 5-D

PRISM operating voltage 451vac 3 phase 50Hz incoming power.

Gap .004"

Trigger Distance 2.320"

Bladder Pressure: Will be varied from 20 to 60 PSI in 10 psi increments.

Cylinder Pressure: 100 PSIG

Welded on 7-25-95.

Wet

Weighed

No freeze

Burst tested on 7-31-95.

Weld Time 1.6 seconds

Cool Time 1.0 seconds

Horn/anvil alignment: radius to radius mirror image on lower edges

Horn Description: Long, wide, internally knurled face with a 1/16" radius along the lower edge.

Anvil Description: Wide, final design with internal, knurled diamond pattern and 1/16" radius along lower edge of face.

Bladder Pressure 30 PSIG

Port Tube No	Initial Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)	
1	-10	240		240	250	SW
2	-10	258		258	268	SW
3	-10	247		247	257	SW
4	-10	254		254	264	SW
5	-10	257		257	267	BS
6	-10	269		269	279	SW
7	-10	272		272	282	SW
8	-10	269		269	279	SW
9	-10	250		250	260	SW
10	-10	280		280	290	SW

A-17

Bladder Pressure 30 PSIG

Port Tube No	Initial Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)
1	-14	239		239	253 SW
2	-14	261		261	275 SW
3	-14	239		239	253 SW
4	-14	243		243	257 SW
5	-14	269		269	283 SW
6	-14	243		243	257 BS
7	-14	239		239	253 SW
8	-14	251		251	265 SW
9	-14	232		232	246 BS
10	-14	257		257	271 BS

Bladder Pressure 40 PSIG

Port Tube No	Initial Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)
1	-14	261		261	275 SW
2	-14	261		261	275 SW
3	-14	272		272	286 SW
4	-14	247		247	261 SW
5	-14	239		239	253 SW
6	-14	261		261	275 SW
7	-14	269		269	283 SW
8	-14	232		232	246 BS
9	-17	247		247	264 SW
10	-17	254		254	271 SW

Bladder Pressure 50 PSIG

Port Tube No	Initial Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)
1	-17	261		261	278 SW
2	-17	257		257	274 SW
3	-17	239		239	256 BS
4	-17	251		251	268 SW
5	-17	239		239	256 BS
6	-17	254		254	271 SW
7	-17	280		280	297 SW
8	-17	254		254	271 BS
9	-17	246		246	263 SW
10	-17	282		282	299 BS

Bladder Pressure 60 PSIG

Port Tube No	Initial Pressure (PSI)	Rupture Pressure (PSI)	No Burst Pressure (PSI)	Burst Pressure (PSI)	Actual Pressure (PSI)
1	-17	265		265	282 BS
2	-17	286		286	303 SW
3	-17	239		239	256 BS
4	-17	257		257	274 BS
5	-17	250		250	267 BS
6	-17	282		282	299 BS
7	-17	254		254	271 BS
8	-17	250		250	267 SW
9	-17	243		243	260 BS
10	-17	239		239	256 BS

VIBRATION WELDER PROTOTYPE
(AIR BLADDER/PNEUMATIC)

Subject: STATISTICAL RESULTS OF SCREENING STUDY NO 2

PROJECT NAME KIVALT.ECP

Created: Tue Apr 18 16:01 55 1995

***** Coefficients for response 'Mean-logit'

Centered continuous variables

COEFFICIENTS	SD	P	CONDITION	TERM
-1.52619				0 CONSTANT
17.3166	0.384504	0.0000	0.706	1 Weld-Time-Tot
1.80716	0.954332	0.791	0.260	2 Weld-Time
0.0250475	0.0086903	0.0121	0.248	3 Trig-Press
-0.0145366	0.00807536	0.0934	0.246	4 Trig-Press2
-0.444243	0.111825	0.0014	0.973	5 Cool-Time
0.000549966	0.0122511	0.9648-	0.791	7 Weld-Time-Tot*Trig-Press
-0.0118983	0.0115285	0.3195-	0.819	8 Weld-Time-Tot*Trig-Press2
-2.15134	0.570482	0.0021	0.963	9 Weld-Time-Tot-Cool-Time
0.0521895	0.0323042	0.1285	0.264	10 Weld-Time*Trig-Press1
-0.0070417	0.01048	0.5126-	0.780	11 Weld-Time*Trig-Press2
-0.000391146	0.000275724	0.1779	0.238	13 Trig-Press*Trig-Press2

N trials = 26

N terms = 12

Residual SD = 0.276687

Residual DF = 14

Residual SD used for tests

Replicate SD = 0.271336

Replicate DF = 5

R squared = 0.997, P=0.0000 ***

Adj R Squared = 0.994

Maximum Cook-Weisberg LD influence (scaled 0-1) = 0.915

- This term may be eliminated

***** Coefficients for response 'SD-BURST'

Log e transformation used

Centered continuous variables

COEFFICIENTS	SD	P	CONDITION	TERM
1.68562				0 CONSTANT
8.76468	0.254351	0.0000	0.706	1 Weld-Time-Tot
-1.38569	0.631294	0.0455	0.260	2 Weld-Time
-0.00554859	0.00574866	0.3508	0.248	3 Trig-Press
-0.00485027	0.00534188	0.3793	0.246	4 Trig-Press2
0.0866238	0.0739728	0.2611-	0.973	5 Cool-Time
-0.0209489	0.00810414	0.0216	0.791	7 Weld-Time-Tot*Trig-Press
0.0141208	0.00762615	0.0853	0.819	8 Weld-Time-Tot*Trig-Press2
0.303637	0.377376	0.4345-	0.963	9 Weld-Time-Tot-Cool-Time
-0.0440941	0.0213694	0.0581	0.264	10 Weld-Time*Trig-Press2
0.0144737	0.00693256	0.0556	0.780	11 Weld-Time*Trig-Press2
-0.0002510540	0.00182392	0.1903	0.238	13 Trig-Press*Trig-Press2

N trials = 26
N terms = 12

Residual SD = 0.183030
Residual DF = 14
Residual SD used for tests

Replicate SD = 0.150857
Replicate DF = 5

R Squared = 0.995, P=0.0000 ***
Adj R Squared = 0.990
Maximum Cook-Weisberg LD influence (scaled 0-1) = 1.000
- This term may be eliminated

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Parameters: Weld-Time = 0.500000
 Trig-Press = 10.000
 Cool-Time = 1.00

Mean $1 + 315 e$ mean - logit
 Burst = $\frac{1}{1 + e^{\text{mean - logit}}}$

Weld-Time=1.2 Cool-Time=1.000

Value	Low Limit	High Limit
1.89	1.13	2.65

Mean
 Burst 273.789 238.333 315.0707

Important variables to maximize Mean Burst

Weld-Time-Tot = 1.2 seconds
 Cool-Time = 1 second
 Trig-Press = 10 PSIG

Parameters: Weld-Time = 0.500000
 Trig-Press = 10.000
 Cool-Time = 1.00

Weld-Time=1.2 Trig-Pre=10.00

Value	Low Limit	High Limit
28.01	16.53	47.01

Important Variables to minimize Standard Dev. Burst

Weld-Time-Tot = 1.2 seconds
 Trig-Press = 10 PSIG
 Weld-Time = 0.5 seconds

Best setting found for Trig-Press2 = 10 PSIG But not important.

VIBRATION WELDER PROTOTYPE

Subject: 2ND SCREENING STUDY GROUPED RESULTS

WT=WELDTIME

CT=COOLTIME

P1 = FIRST BLADDER PRESSURE

P2 = SECOND BLADDER PRESSURE

PR = PROPORTION RATIO OF THE TIME SEGMENT AT THE FIRST BLADDER PRESSURE TO
THE OVERALL WELD TIME

S = SMALL HORN WIDTH

L = LARGE HORN WIDTH

N = NO KNURL PATTERN ON HORN OR ANVIL

H = KNURL PATTERN ON HORN, NONE ON ANVIL

B = KNURL PATTERN ON BOTH HORN AND ANVIL

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5 PORT	GROUPS	WT	CT	PR	P1	P2	Mean Burst Pressure	VARIANCE Lo	Hi	Horn Width	Horn Knurl
RUN 1	TRIAL 4	1.4,	1,	.5,	40,	70	278.2	-4.2	+24.8	S N	
RUN 2	TRIAL 1	1,	1,	.5,	70,	70	38.8	-23.8	+44.2	S N	
RUN 3	TRIAL 22	1,	1,	.5,	40,	40	24.0	-8.0	+17.0	S N	
RUN 4	TRIAL 23	1.4,	1,	.5,	40,	40	267.2	-51.2	+31.8	S N	
RUN 5	TRIAL 4	1.4,	1,	.5,	40,	70	278.4	-4.25	+16.75	S N	
RUN 6	TRIAL 13	1.4,	1,	.5,	70,	70	278.25	-27.25	+16.75	S N	
RUN 7	TRIAL 36	1,	1,	.5,	40,	70	27.2	-4.2	+15.8	S N	
RUN 8	TRIAL 27	1,	1,	.5,	55,	55	21.8	-10.8	+4.2	S N	
RUN 9	TRIAL 1	1,	1,	.5,	70,	70	20.8	-1.8	+5.2	S N	
RUN 10	TRIAL 26	1.4,	1,	.5,	55,	55	298.6	-20.6	+33.4	L N	
RUN 11	TRIAL 2	1,	1,	.5,	40,	70	78.0	-64.0	+61.0	L N	
RUN 12	TRIAL 20	1.4,	1,	.5,	40,	70	321.4	-29.4	+27.6	L N	
RUN 13	TRIAL 3	1.4,	1,	.5,	40,	40	48.4	-37.4	+34.6	L N	
RUN 14	TRIAL 14	1.4,	1,	.5,	40,	40	282.4	-15.4	+16.6	L N	
RUN 15	TRIAL 19	1,	1,	.5,	70,	70	23.8	-8.8	+24.2	L N	
RUN 16	TRIAL 2	1,	1,	.5,	40,	70	40.0	-25.0	+47.0	L N	
RUN 17	TRIAL 40	1.4,	1,	.5,	70,	70	297.6	-23.6	+23.4	L N	
RUN 18	TRIAL 3	1,	1,	.5,	40,	40	38.4	-27.4	+73.6	L N	
RUN 19	TRIAL 9	1.4,	1,	.5,	40,	70	275.2	-12.2	+16.8	L H	
RUN 20	TRIAL 8	1,	1,	.5,	40,	70	15.4	-8.4	+13.6	L H	
RUN 21	TRIAL 21	1.4,	1,	.5,	70,	70	271.0	-26.0	+9.0	L H	
RUN 22	TRIAL 39	1.4,	1,	.5,	40,	40	268.0	-30.0	+6.0	L H	
RUN 23	TRIAL 17	1,	1,	.5,	70,	70	18.6	-5.6	+10.4	L H	
RUN 24	TRIAL 43	1.4,	1,	.5,	55,	55	277.8	-14.8	+10.2	L H	
RUN 25	TRIAL 15	1,	1,	.5,	40,	40	17.6	-2.6	+1.4	L H	
RUN 26	TRIAL 36	1,	1,	.5,	40,	40	28.6	-17.4	+21.6	S H	
RUN 27	TRIAL 25	1,	1,	.5,	55,	55	44.6	-22.6	+60.6	S H	
RUN 28	TRIAL 29	1,	1,	.5,	40,	70	30.2	-4.2	+6.8	S H	
RUN 29	TRIAL 51	1,	1,	.5,	70,	70	237.0	-200.0	+65.0	S H	
RUN 30	TRIAL 37	1,	1,	.5,	70,	70	29.8	-11.8	+10.2	S H	
RUN 31	TRIAL 10	1.4,	1,	.5,	40,	40	298.2	-17.2	+7.8	S H	
RUN 32	TRIAL 42	1.4,	1,	.5,	55,	55	295.4	-17.6	+14.6	S H	
RUN 33	TRIAL 35	1.4,	1,	.5,	40,	70	297.4	-27.4	+23.6	S H	
RUN 34	TRIAL 5	1.4,	1,	.5,	70,	70	306.2	-32.2	+21.8	S H	
RUN 35	TRIAL 7	1.4,	1,	.5,	40,	70	275.6	-15.6	+16.4	S B	
RUN 36	TRIAL 18	1,	1,	.5,	40,	70	26.0	-8.0	+11.0	S B	
RUN 37	TRIAL 11	1,	1,	.5,	40,	40	19.8	-4.8	+6.2	S B	
RUN 38	TRIAL 33	1.4,	1,	.5,	40,	40	258.8	-20.8	+11.2	S B	
RUN 39	TRIAL 16	1,	1,	.5,	70,	70	30.0	-15.0	+35.0	S B	
RUN 40	TRIAL 28	1,	1,	.5,	55,	55	19.0	-8.0	+7.0	S B	
RUN 41	TRIAL 34	1.4,	1,	.5,	70,	70	268.8	-19.8	+9.2	S B	
RUN 42	TRIAL 41	1.4,	1,	.5,	70,	70	254.4	-17.4	+40.6	L B	
RUN 43	TRIAL 6	1.4,	1,	.5,	40,	40	251.2	-13.2	+28.8	L B	
RUN 44	TRIAL 30	1.4,	1,	.5,	40,	70	271.2	-12.2	+33.0	L B	
RUN 45	TRIAL 32	1.4,	1,	.5,	55,	55	260.8	-8.8	+13.2	L B	
RUN 46	TRIAL 24	1,	1,	.5,	70,	70	24.6	-17.6	+55.4	L B	
RUN 47	TRIAL 12	1,	1,	.5,	40,	70	70.8	-60.8	+31.2	L B	
RUN 48	TRIAL 31	1,	1,	.5,	40,	40	79.4	-72.4	+28.6	L B	

One Second Weld Group Organized by Pressure

S PORT	GROUPS	WT	CT	PR	P1	P2	Mean	VARIANCE		Horn Width	Horn Knurl
							Burst Pressure	Lo	Hi		
RUN 3	TRIAL 22	1, 1,	.5,		40, 40		24.0	- 8.0	+17.0	WF	
RUN 18	TRIAL 3	1, 1,	.5,		40, 40		38.4	-27.4	+73.6	WF	
RUN 25	TRIAL 15	1, 1,	.5,		40, 40		17.6	- 2.6	+ 1.4	WF	
RUN 37	TRIAL 11	1, 1,	.5,		40, 40		19.8	- 4.8	+ 6.2	WF	
RUN 26	TRIAL 36	1, 1,	.5,		40, 40		28.6	-17.4	+21.6	WF	
RUN 48	TRIAL 31	1, 1,	.5,		40, 40		79.4	-72.4	+28.6	WF	
Avg Mean 18											
RUN 7	TRIAL 36	1, 1,	.5,		40, 70		27.2	- 4.2	+15.8	WF	
RUN 11	TRIAL 2	1, 1,	.5,		40, 70		78.0	-64.0	+61.0	WF	
RUN 16	TRIAL 2	1, 1,	.5,		40, 70		40.0	-25.0	+47.0	WF	
RUN 20	TRIAL 8	1, 1,	.5,		40, 70		15.4	- 8.4	+13.6	WF	
RUN 28	TRIAL 29	1, 1,	.5,		40, 70		30.2	- 4.2	+ 6.8	WF	
RUN 36	TRIAL 18	1, 1,	.5,		40, 70		26.0	- 8.0	+11.0	WF	
RUN 47	TRIAL 12	1, 1,	.5,		40, 70		70.8	-60.8	+31.2	WF	
Avg Mean 41.1											
RUN 8	TRIAL 27	1, 1,	.5,		55, 55		21.8	-10.8	+ 4.2	WF	
RUN 27	TRIAL 25	1, 1,	.5,		55, 55		44.6	-22.6	+60.6	WF	SW PD
RUN 40	TRIAL 28	1, 1,	.5,		55, 55		19.0	- 8.0	+ 7.0	WF	
Avg Mean 28.5											
RUN 9	TRIAL 1	1, 1,	.5,		70, 70		20.8	- 1.8	+ 5.2	WF	
RUN 2	TRIAL 1	1, 1,	.5,		70, 70		38.8	-23.8	+44.2	WF	
RUN 15	TRIAL 19	1, 1,	.5,		70, 70		23.8	- 8.8	+24.2	WF	
RUN 23	TRIAL 17	1, 1,	.5,		70, 70		18.6	- 3.6	+10.4	WF	
RUN 29	TRIAL 5	1, 1,	.5,		70, 70		237.0	-200.0	+65.0	SW,PD,WF	
RUN 30	TRIAL 37	1, 1,	.5,		70, 70		29.9	-11.8	+10.2	WF	
RUN 39	TRIAL 16	1, 1,	.5,		70, 70		30.0	-15.0	+35.0	WF	
RUN 46	TRIAL 24	1, 1,	.5,		70, 70		24.6	-17.6	+55.4	WF	
Avg Mean 32.6											

1.4 Second Weld Group Organized by Pressure

5 PORT	GROUPS	WT	CT	PR	P1	P2	Mean Burst Pressure	VARIANCE		Horn Width	Horn Knurl
								Lo	Hi		
RUN 4	TRIAL 23	1.4,	1,	.5,	40,	40	267.2	-51.2	+31.9	SW	WF
RUN 13	TRIAL 3	1.4,	1,	.5,	40,	40	48.4	-37.4	+34.6	WF	*?
RUN 14	TRIAL 14	1.4,	1,	.5,	40,	40	282.4	-15.4	+16.6	SW	PD
RUN 22	TRIAL 39	1.4,	1,	.5,	40,	40	268.0	-30	+16.0	WF	SW PD
RUN 31	TRIAL 10	1.4,	1,	.5,	40,	40	298.2	-17.2	+ 7.8	SW	PD
RUN 38	TRIAL 33	1.4,	1,	.5,	40,	40	258.8	-20.8	+11.2	WF	SW PD
RUN 43	TRIAL 6	1.4,	1,	.5,	40,	40	251.2	-13.2	+28.8	WF	
Avg Mean 239.2											
RUN 12	TRIAL 20	1.4,	1,	.5,	40,	70	321.4	-29.4	+27.6	SW	PD
RUN 1	TRIAL 4	1.4,	1,	.5,	40,	70	278.2	- 4.2	+24.8	SW	PD
RUN 5	TRIAL 4	1.4,	1,	.5,	40,	70	278.4	- 4.25	+16.75	WF	SW,PD
RUN 19	TRIAL 9	1.4,	1,	.5,	40,	70	275.2	-12.2	+16.8	WF	SW PD
RUN 33	TRIAL 35	1.4,	1,	.5,	40,	70	297.4	-27.4	+23.6	SW	PD
RUN 35	TRIAL 7	1.4,	1,	.5,	40,	70	275.6	-15.6	+16.4	WF	SW
RUN 44	TRIAL 30	1.4,	1,	.5,	40,	70	271.2	-12.2	+33	WF	SW
Avg Mean 285.3											
RUN 10	TRIAL 26	1.4,	1,	.5,	55,	55	298.6	-20.6	+33.4	SW	WF
RUN 24	TRIAL 43	1.4,	1,	.5,	55,	55	277.8	-14.8	+10.2	WF	
RUN 32	TRIAL 42	1.4,	1,	.5,	55,	55	295.4	-17.6	+14.6	SW	PD
RUN 45	TRIAL 32	1.4,	1,	.5,	55,	55	260.8	- 8.8	+13.2	WF	SW PD
Avg Mean 283.2											
RUN 6	TRIAL 13	1.4,	1,	.5,	70,	70	278.25	-27.75	+22.25	WF	SW PD
RUN 17	TRIAL 40	1.4,	1,	.5,	70,	70	297.6	-23.6	+23.4	SW	PD
RUN 21	TRIAL 21	1.4,	1,	.5,	70,	70	271.0	-26.0	+ 9.0	WF	SW,PD
RUN 34	TRIAL 5	1.4,	1,	.5,	70,	70	306.2	-32.2	+21.8	SW	PD
RUN 41	TRIAL 34	1.4,	1,	.5,	70,	70	268.8	-19.8	+ 9.2	SW	PD WF
RUN 42	TRIAL 41	1.4,	1,	.5,	70,	70	254.4	-17.4	+40.6	WF	SW PD
Avg Mean 279.4											

1.4 Second Weld Groups Organized by Horn Pattern

S PORT	GROUPS	WT	CT	PR	P1	P2	Mean Burst Pressure	VARIANCE Lo Hi	Horn Width	Horn Knurl
RUN 4	TRIAL 23	1.4,	1,	.5,	40,	40	267.2	-51.2 +31.8	S N	SW WF
RUN 1	TRIAL 4	1.4,	1,	.5,	40,	70	278.2	- 4.2 +24.8	S N	SW PD
RUN 5	TRIAL 4	1.4,	1,	.5,	40,	70	278.4	- 4.25 +16.75	S N	WF SW PD
RUN 6	TRIAL 13	1.4,	1,	.5,	70,	70	278.25	-27.25 +16.75	S N	WF SW PD
Mean Avg 275.5										
RUN 31	TRIAL 10	1.4,	1,	.5,	40,	40	298.2	-17.2 + 7.8	S H	SW PD
RUN 33	TRIAL 35	1.4,	1,	.5,	40,	70	297.4	-27.4 +23.6	S H	SW PD
RUN 32	TRIAL 42	1.4,	1,	.5,	55,	55	295.4	-17.6 +14.6	S H	SW PD
RUN 34	TRIAL 5	1.4,	1,	.5,	70,	70	306.2	-31.2 +21.8	S H	SW PD
Mean Avg 299.3										
RUN 38	TRIAL 33	1.4,	1,	.5,	40,	40	258.8	-20.8 +11.2	S B	WF SW PD
RUN 35	TRIAL 7	1.4,	1,	.5,	40,	70	275.6	-15.6 +16.4	S B	WF SW
RUN 41	TRIAL 34	1.4,	1,	.5,	70,	70	268.8	-19.8 + 9.2	S B	SW PD WF
Mean Avg 267.7										
RUN 13	TRIAL 3	1.4,	1,	.5,	40,	40	48.4	-37.4 +34.6	L N	WF
RUN 14	TRIAL 14	1.4,	1,	.5,	40,	40	282.4	-15.4 +16.6	L N	SW PD
RUN 12	TRIAL 20	1.4,	1,	.5,	40,	70	321.4	-29.4 +27.6	L N	SW PD
RUN 10	TRIAL 26	1.4,	1,	.5,	55,	55	298.6	-20.6 +33.4	L N	
RUN 17	TRIAL 40	1.4,	1,	.5,	70,	70	297.6	-23.6 +23.4	L N	
Mean Avg 249.68 With Outlier										
Mean Avg 300.00 Without Outlier										
RUN 22	TRIAL 39	1.4,	1,	.5,	40,	40	268.0	-30.0 + 6.0	L H	
RUN 19	TRIAL 9	1.4,	1,	.5,	40,	70	275.2	-12.2 +10.8	L H	
RUN 24	TRIAL 43	1.4,	1,	.5,	55,	55	277.8	-14.8 +10.2	L H	
RUN 21	TRIAL 21	1.4,	1,	.5,	70,	70	271.0	-26.0 + 9.0	L H	
Mean Avg 273.00										
RUN 43	TRIAL 6	1.4,	1,	.5,	40,	40	251.2	-13.2 +28.8	L B	
RUN 44	TRIAL 30	1.4,	1,	.5,	40,	70	271.2	-12.2 +33.0	L B	
RUN 45	TRIAL 32	1.4,	1,	.5,	55,	55	260.8	- 8.8 +13.2	L B	
RUN 42	TRIAL 41	1.4,	1,	.5,	70,	70	254.4	-17.4 +40.6	L B	
Mean Avg 259.4										

Results:

In the prior Screening Study No. 1, it was indicated that a .8 second weld resulted in weld fractures.

A 1.2 second weld resulted in sidewall bursts.

Cool Time was not significant and could be held constant at the minimum tested (1 second).

The bladder pressure proportion of .5 seemed to achieve slightly higher mean burst pressures and is well constant in this experiment.

These welds were done with the short sonic horn having a knurl pattern in the horn and a blank relief of .050" on the lower edge. The anvil was also knurled.

Bladder pressures below 40 pounds resulted in very poor burst pressures.

In this Screening Study, No. 2, it was thought to test the area around 1.2 seconds to see if going longer on weld time would improve burst strength. The range of weld time becomes 1 to 1.4 seconds and we test these limits.

Changes from the previous experiment are:

- 1) Long Horn instead of short.
- 2) Symmetrical Chisel to the line of center.
- 3) Large and Small width versions of the long horn.
- 4) Start with Blank Faced Horns and Anvil;
knurl progressively horn and then both horn and
anvil; do experiments after each transition.

From the tables above, all 1 second weld times resulted in weld fractures. These port tubes were delaminated on one or both sides of the weld pattern when thawed from the freezer.

The weld fracture pressures indicated above for these tubes were, in fact, the initial driving pressure indication of the burst testing machine. These ports will weep at lower pressures.

The burst pressures for 1.4 second weld resulted in a mixture of Weld Fractures and Side Wall Bursts.

What is claimed is:

1. An apparatus for filling and sealing batches of separate, premanufactured intravenous solution bags in a sterile environment, each bag having a weldably sealable opening for introducing intravenous solution into the bag, said apparatus comprising:

a generally sealed enclosure defining an interior space sized and shaped for simultaneously containing a plurality of separate, premanufactured intravenous solution bags to prevent contamination of the bags;

a rack positioned within the interior space of the enclosure configured for suspending said plurality of separate, premanufactured bags in the enclosure in a generally stationary location until ready for filling;

an intravenous solution delivery system positioned at least partially inside the interior space of the enclosure for delivering intravenous solution through the openings of said plurality of solution bags to fill the bags while the bags are in said enclosure;

a welder positioned at least partially inside the interior space of the enclosure for hermetically sealing the openings of the bags after they have been filled with intravenous solution and while they are in the enclosure; and

a transport system positioned at least partially inside the interior space of the enclosure adapted for separately transporting each bag of said plurality of intravenous bags from the rack to a filling station where the bag is filled by said intravenous solution delivery system.

2. The apparatus as set forth in claim 1 wherein said transport system is further adapted for transporting each of said plurality of intravenous bags between a sealing station where the opening is sealed and a bag removal station.

3. The apparatus as set forth in claim 2 wherein the bag has a port tube defining the opening of the bag, and wherein the transport system suspends the bag from the port tube.

4. The apparatus as set forth in claim 3 wherein the transport system comprises a turntable and a drive for rotating the turntable to transport a filled and sealed bag from said filling and sealing station to said bag removal station.

5. The apparatus as set forth in claim 4 wherein the turntable includes an arm having an aperture for suspending a bag as the bag is transported between said stations.

6. The apparatus as set forth in claim 1 wherein the enclosure has a slot communicating with the interior space of the enclosure to permit removal of said bags from the enclosure.

7. The apparatus as set forth in claim 1 further comprising a glove sealingly attached to the enclosure and extending into the interior space of the enclosure for manually manipulating the bags within the enclosure.

8. The apparatus as set forth in claim 1 wherein the interior space of the enclosure is pressurized to inhibit entry of contaminants into the interior space of the enclosure.

9. The apparatus as set forth in claim 1 wherein the intravenous solution delivery system includes a filling tube and a pump for pumping intravenous solution through the tube.

10. The apparatus as set forth in claim 9 wherein the intravenous solution delivery system further includes a valve for controlling delivery of intravenous solution to said bags.

11. The apparatus as set forth in claim 9 wherein the intravenous solution delivery system further includes an actuator for inserting the filling tube into the openings of said bags before filling and for removing the filling tube from said openings after filling.

12. The apparatus as set forth in claim 1 wherein the welder comprises an anvil and a vibrating sealing head, at least one of said anvil and sealing head being movably disposed with respect to the other of said anvil and sealing head for applying pressure to a bag, the sealing head being operable to vibrate with respect to the anvil while applying pressure to the bag for hermetically sealing the opening of the bag to prevent the escape of intravenous solution from the bag.

13. The apparatus as set forth in claim 12 wherein the welder further comprises an actuator for moving the sealing head with respect to the anvil.

14. The apparatus as set forth in claim 1 wherein said transport system includes:

a turntable for transporting each bag of said plurality of intravenous bags to the filling station and from a sealing station where the opening is sealed.

15. A method of filling and sealing a batch of separate, premanufactured intravenous solution bags in a sterile environment, each bag having a weldably sealable opening for introducing intravenous solution into the bag, said method comprising the steps of:

loading a plurality of separate, premanufactured intravenous solution bags into a staging area of a generally sealable enclosure, each of said separate, premanufactured bags being wrapped in a sealed container to prevent contamination prior to loading;

sealing said enclosure loaded with bags;

opening said sealed container inside the sealed enclosure; removing at least one of the plurality of bags from the container;

transporting said at least one bag from the staging area to a filling station;

filling said at least one bag with intravenous solution at the filling station; and

hermetically sealing the opening of said at least one bag filled with intravenous solution by welding the opening closed with a welder while said bag is in said enclosure.

16. A method as set forth in claim 15 wherein a vibration welder is used to perform the step of sealing the opening.

17. A method as set forth in claim 15 further comprising the step of sterilizing said plurality of intravenous solution bags before filling the bag with intravenous solution.

18. A method as set forth in claim 17 wherein the step of sterilizing said bags is performed by spraying a chemical sterilization agent into the enclosure when said bags are inside the enclosure.

19. A method as set forth in claim 15 further comprising the step of transporting one of said bags from a staging area where the bags are stored prior to filling to a filling and sealing station where the bag is filled and the opening is sealed.

20. A method as set forth in claim 19 further comprising the step of transporting one of said bags from said filling and sealing station to a bag removal station.

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