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Wightman

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[45] **July 23, 1974**

[54] **CONTINUOUS STROKE TUBE INSERTION AND EXPANDING DEVICE**

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[73] Assignee: **Emerson Electric Co.**, St Louis, Mo.

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[52] **U.S. Cl.** ..... **29/202 D**, 29/211 D

[51] **Int. Cl.** **B23p 15/26**, B23q 7/10

[58] **Field of Search** ..... 29/211 D, 202 R, 157.3 A, 29/523, 202 D

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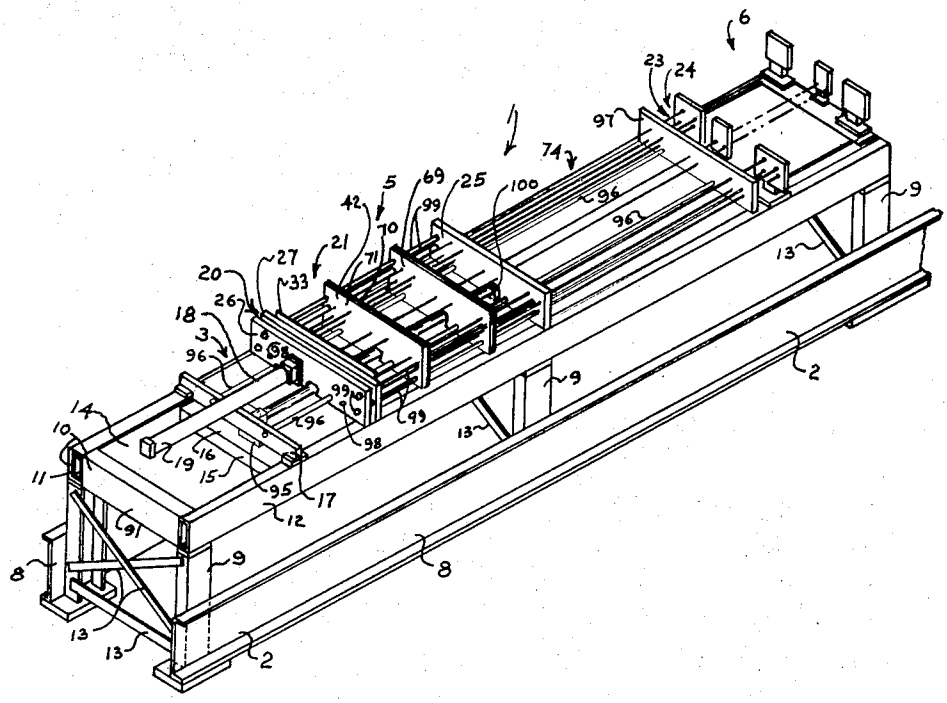
Primary Examiner—Thomas H. Eager

Attorney, Agent, or Firm—Polster and Polster

[57] **ABSTRACT**

A continuous stroke tube insertion and expanding device is provided for automatic and continuous tube insertion and expansion, useful in the manufacture of electronic air filter cells. The apparatus of this invention includes a tube magazine and a plurality of pusher rods which travel longitudinally of the apparatus, engaging the ends of a plurality of metal tubes during travel. The pusher rods have expanding means attached at their ends which engage the tubes. The pusher rods and expanding means drive the tubes through the plates of a cell assembly for an electronic air filter cell until the leading ends of the tubes engage a stop at one end of the apparatus. Tube stop engagement prevents further tube travel. However, pusher rod movement continues, driving the expanding means through the tubes in one continuous operation. Expansion of the tubes combines the tubes and plates into an integral unit. After the tube expanding means has joined a predetermined number of tubes and plates, the tube stop is removed. Tube expansion thereafter is accomplished with the tubes being held only by the expansion joint made between tubes and plates previously combined in the expansion process. Because tube expansion is progressing toward the free end of the tubes, the tubes remain in tension. Maintaining the tubes in tension during expansion enables the apparatus of this invention to prevent undesireable tube bending and distortion.

25 Claims, 11 Drawing Figures



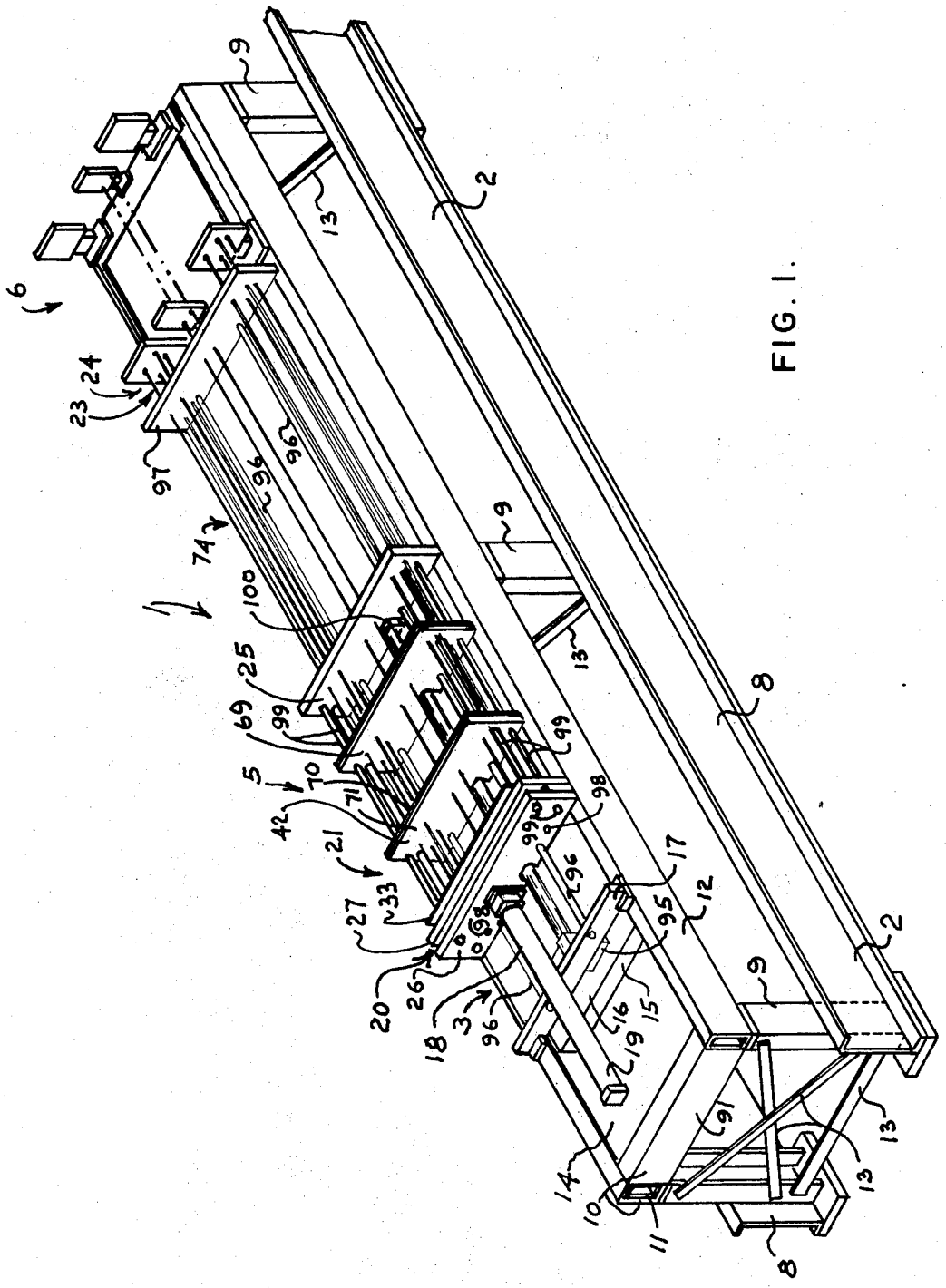

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FIG. 1.

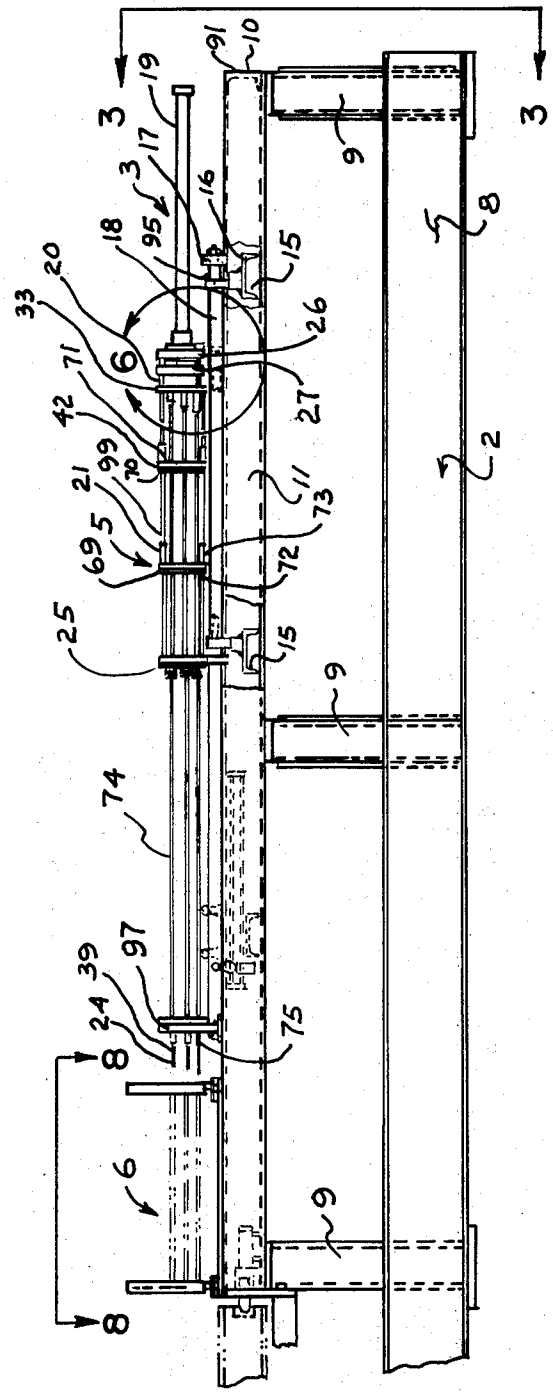

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FIG. 2.

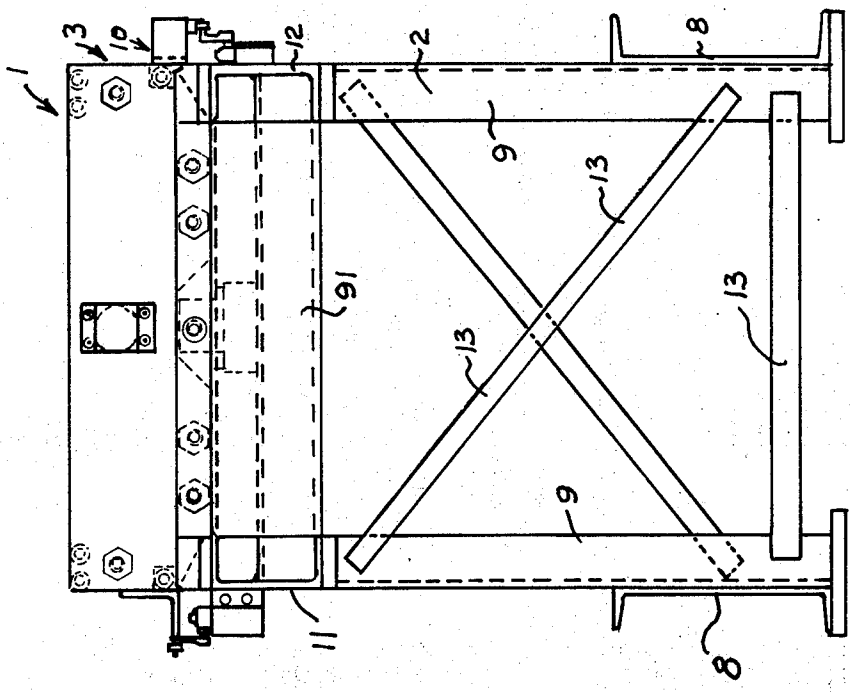
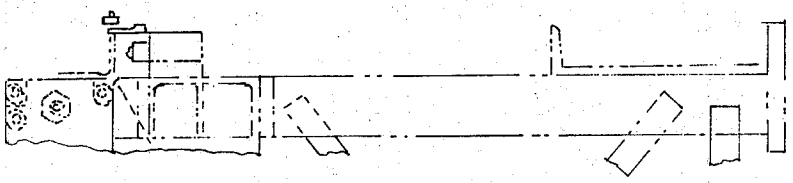


FIG. 3.



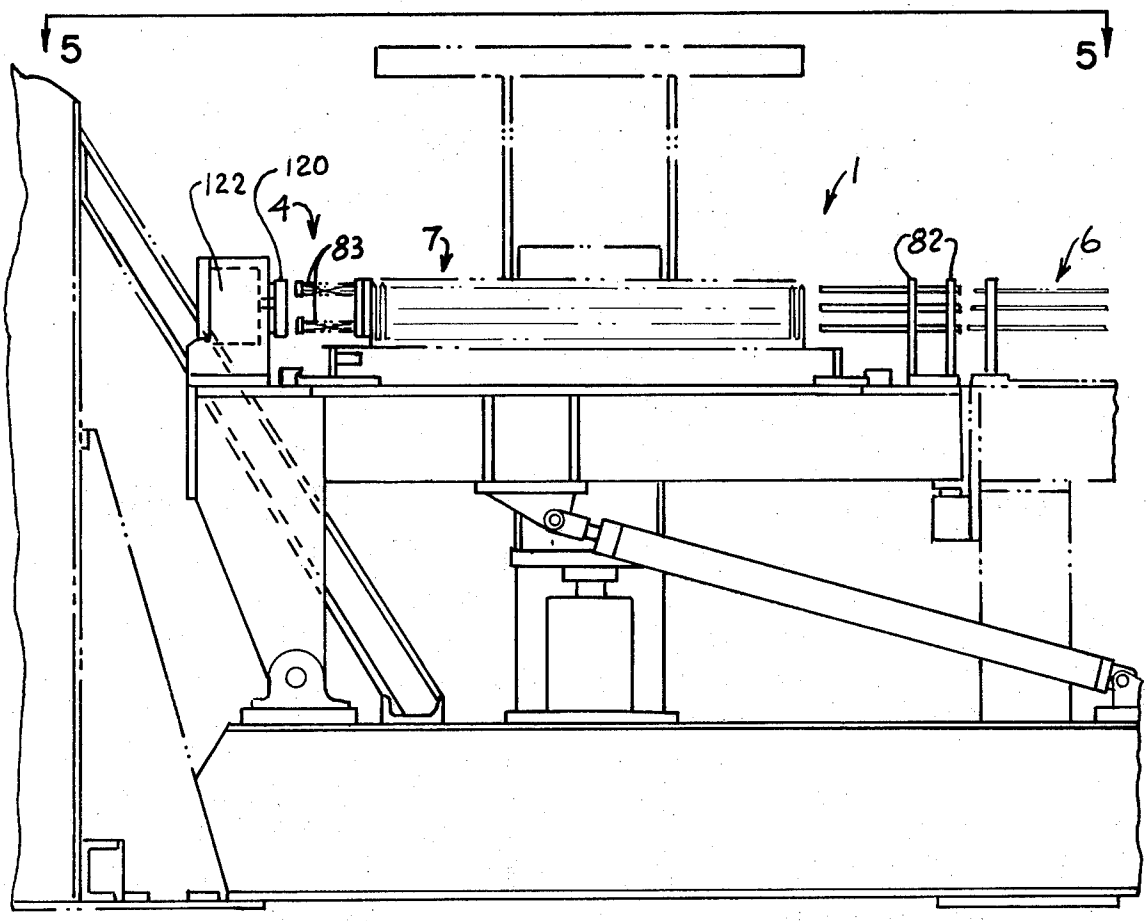


FIG. 4.

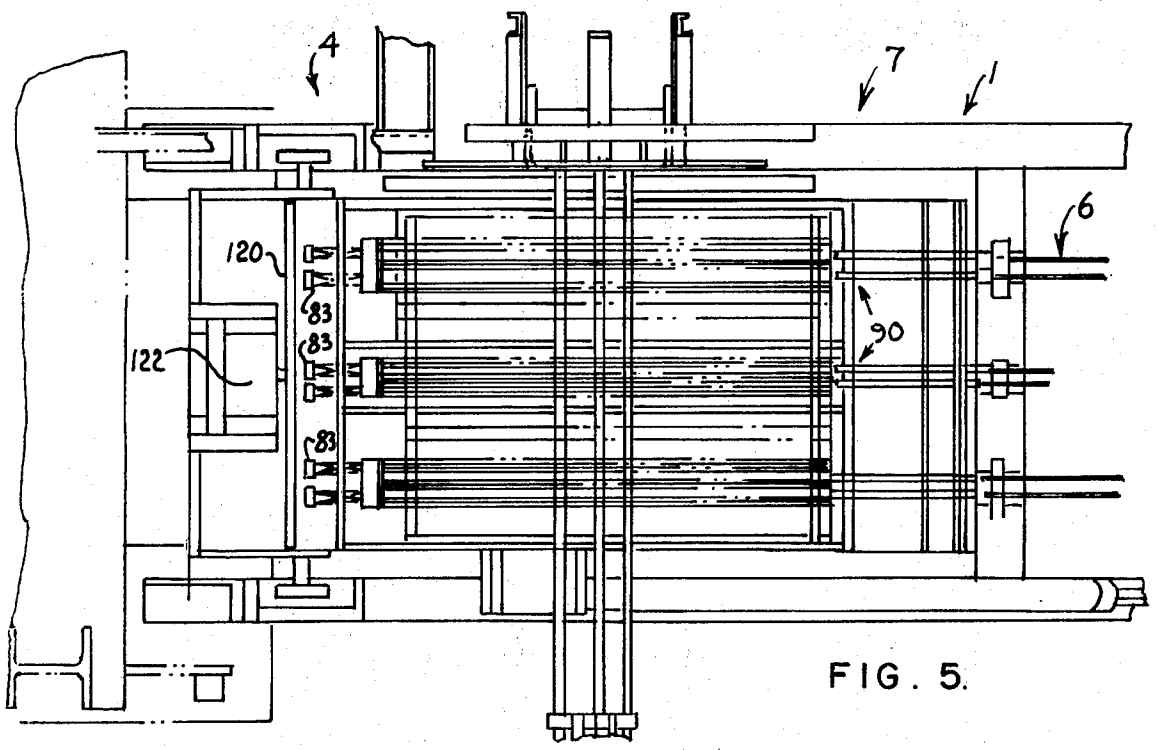


FIG. 5.

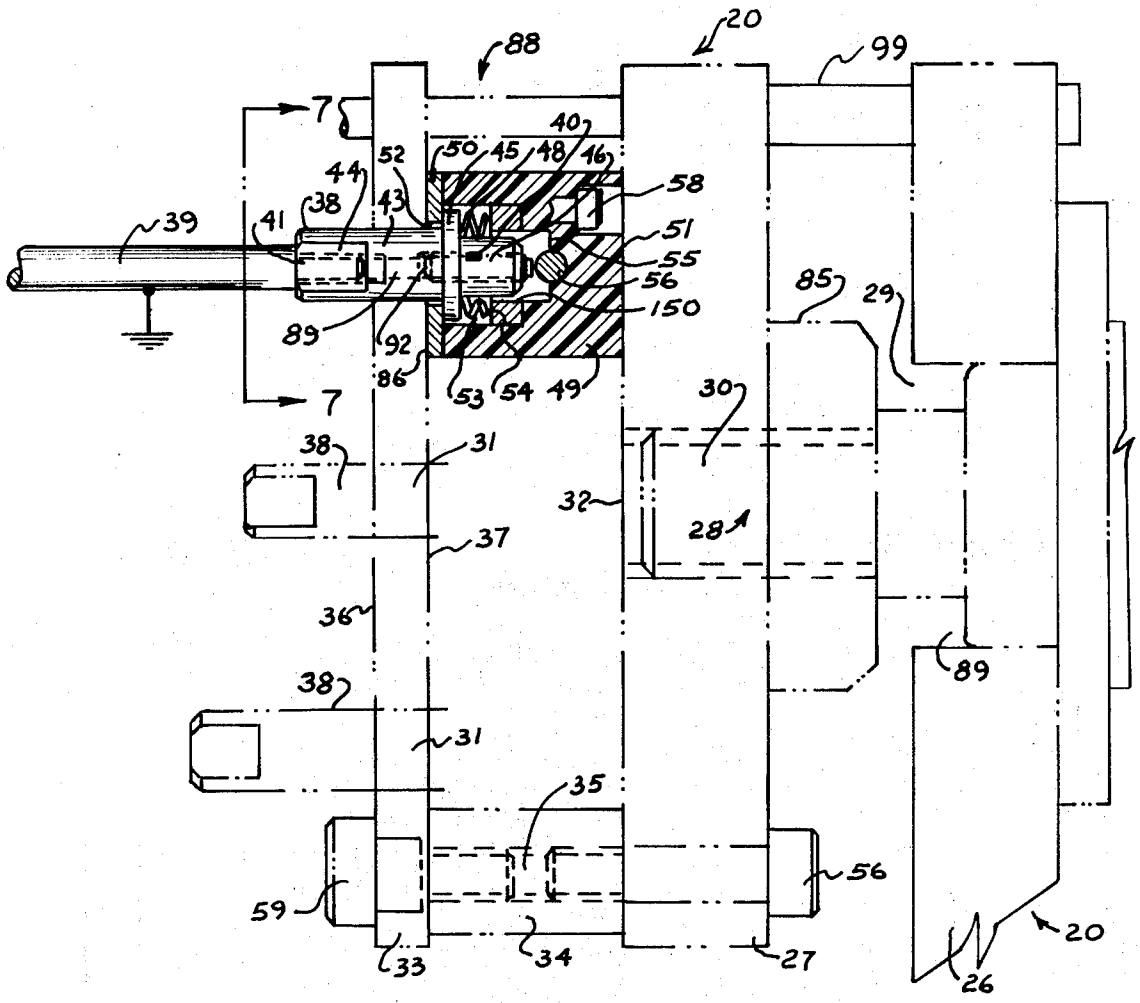

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FIG. 6.

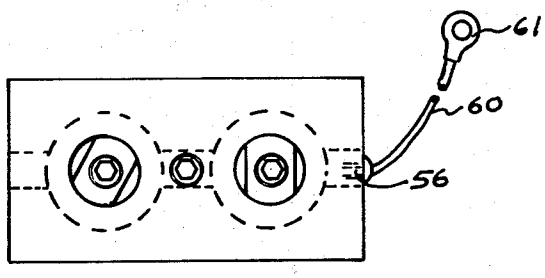

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FIG. 7.

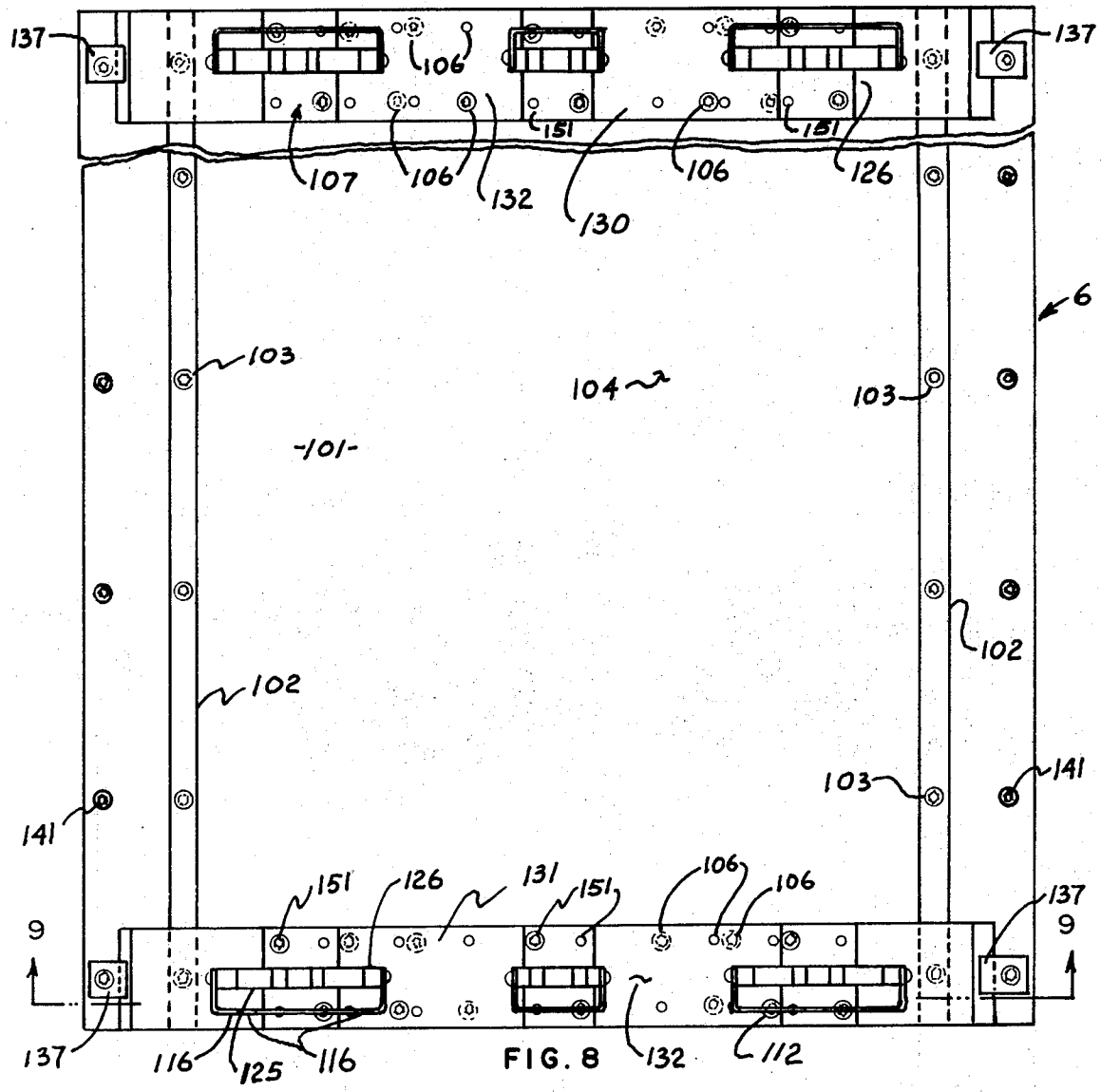

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FIG. 8

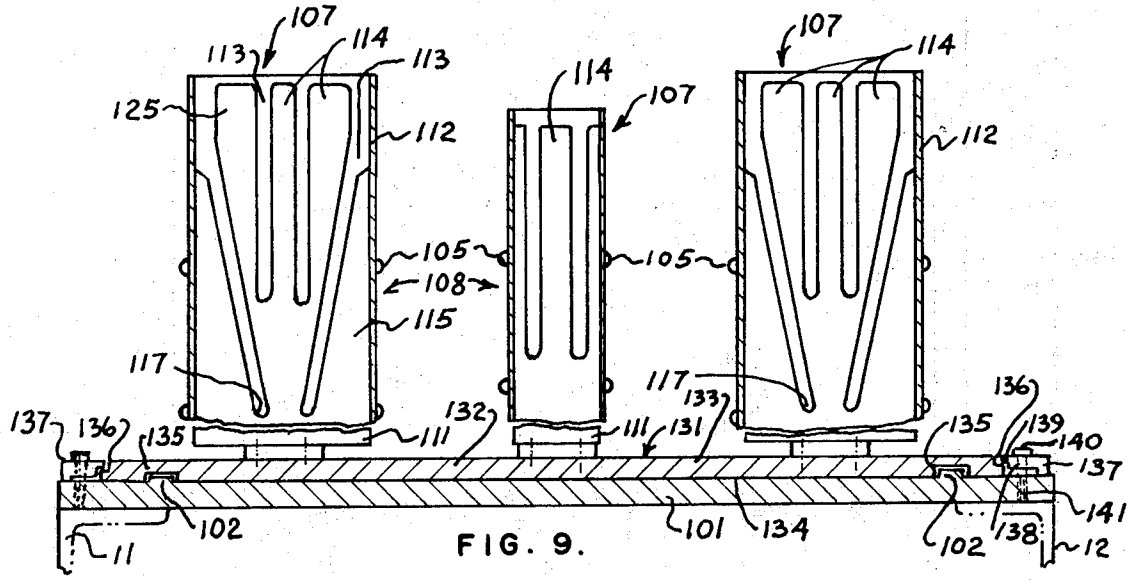

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FIG. 9.

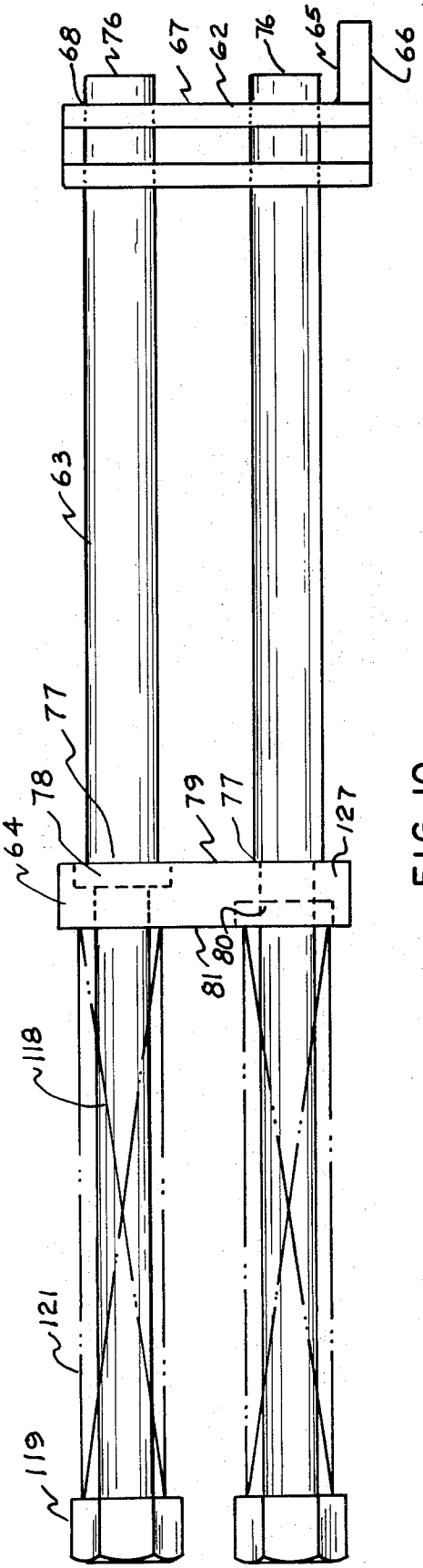


FIG. 10

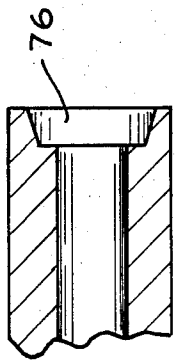


FIG. 11.

CONTINUOUS STROKE TUBE INSERTION AND EXPANDING DEVICE

BACKGROUND OF THE INVENTION

This invention relates to apparatus useful in the construction of cells formed from a plurality of parallel plates. While the invention is described in particular detail with respect to the construction of electronic air filter cells, those skilled in the art will recognize the wide applicability of my invention to other cell constructions.

It is conventional, in the construction of electronic air filter cells, to fabricate a series of plates having a plurality of openings in them. The plates conventionally are constructed from sheet aluminum generally being formed by some type of punch press operation. The press punches a predetermined plate size and punches a plurality of openings through the plate. For example, it is conventional to have a large diameter and a small diameter opening adjacent one another on each end of a substantially rectangular plate. The plates are placed alternately in cell construction so that a passage through a series of plates is provided at each end of the cell comprising sequential large and small diameter openings. Thereafter, at least two tubes for the cell are inserted through the passages.

The tubes are constructed from a material capable of conducting electricity. Aluminum tubes work well from both a cost and a handling ease standpoint. After placement in the passages, the tubes are expanded by some form of expanding means. The expansion process causes the tube to engage alternate plates along and about the small diameter openings in those plates. Expansion of the tubes conventionally is all that is required to attach the plates and tubes to one another. That is, after expansion, the tubes and plates form an integral unit containing a plurality of parallel plates, each plate being attached to at least one tube. By providing the proper distance between alternate plates, it is possible electrically to charge sequential plates to opposite polarities by applying a voltage across the tubes. The use of these oppositely charged plates is well known in the art of electronic air filters.

Prior art apparatus in the field of this invention operate on a pull theory of tube expansion. An example of prior art cell construction methods is shown and described in the Aitkenhead et al. U.S. Pat. No. 3,581,470, issued June 1, 1971. This body of prior art in general, and Aitkenhead in particular, utilizes a bullet nose type expanding means which literally is pulled through the tube to expand it. The pull method of cell construction and the devices associated with it have several inherent disadvantages. For example, the metal tubes are held against some form of stop at a first end of the tubes, and the expanding means is drawn toward the stopped end of the tubes. Consequently, the tubes are in compression during expansion. This compression tends to distort and bend the tubes, particularly along their stopped ends. Additional manufacturing steps heretofore have been required in order to correct the deformation resulting after tube expansion.

Devices for manufacturing air filter cells under pull expansion also are inefficient. Before expansion, some connection has to be made between the expanding means and the mechanism which pulls the expanding means through the tubes. This necessitates placing some form of connecting rod or line through a first end of the tube to a second end where the expanding means is positioned. After expansion, the connection between pulling mechanism and the expanding means must be disconnected so that the expanding means again may be placed on the opposite end of the cell assembly for expansion of the tubes of the succeeding assembly.

The device of this invention, on the other hand, operates on a completely different principle. That is, one of the major features of this invention lies in the fact that the expanding means is pushed through the tubes to expand them, rather than the heretofore common practice denominated herein as pull expansion. One advantage of this distinction is that the expanding means can be withdrawn through the tubes after expansion. Consequently, the expanding means can be positioned for the succeeding cycle automatically, without any connect-disconnect operations. Another advantage of this invention lies in the fact that once tube expansion attaches a predetermined number of plates to the tubes, the integral plate-tube combination can be used to hold the tubes. By removing the stops after a predetermined interval, the tubes will have tension forces acting on them for a major portion of the time required to expand the tubes, rather than the compressive forces prevalent in the prior art. Tube distortion is greatly reduced so that the manufacturing steps previously required to correct tube distortion may be eliminated.

One of the objects of this invention is to provide a tube insertion and expanding device which pushes the expanding means through the tube to be expanded.

Another object of this invention is to provide an apparatus having means for automatically feeding tubes into a cell assembly.

Yet another object of this invention is to provide an apparatus having a single, continuous stroke for both tube insertion and tube expansion.

Yet another object of this invention is to provide an apparatus which reduces direct labor costs in electronic air filter cell production.

Still another object of this invention is to provide an apparatus which reduces tube distortion when a cell is constructed from a plurality of parallel plates by expanding a rod or tube placed through the plates.

Yet another object of this invention is to provide an apparatus which maintains a tubular structure in tension as an expanding means is driven through the tubular structure.

Other objects of this invention will be apparent to those skilled in the art in light of the following description and accompanying drawings.

SUMMARY OF THE INVENTION

In accordance with this invention, generally stated, an apparatus is provided which is based on a pushing principle for expanding a tube in a cell assembly. In the preferred embodiment, the apparatus has a tube magazine which automatically feeds tubes to an insertion position. An expanding means partially engages the tubes and inserts them through a hole pattern in the cell assembly. Means are provided for stopping tube travel while the expanding means continues travel, automatically expanding the tubes into engagement with a plurality of cell plates. The means for stopping tube travel is removed after a predetermined number of plates are attached to the tubes by the expansion of the tubes. Because of the push method of expansion disclosed, dis-

tortion forces on both the tubes and the tube-plate junction of the plates previously attached to the electrode are reduced greatly. The preferred embodiment also utilizes a novel safety device to stop apparatus operation if tube jamming occurs.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings,

FIG. 1 is a view in perspective of one illustrative embodiment of apparatus of this invention;

FIG. 2 is a view in side elevation, partly broken away, of the apparatus shown in FIG. 1; FIG. 3 is an enlarged view of a first end of the apparatus shown in FIG. 1;

FIG. 4 is an enlarged view in side elevation of a second end of the apparatus shown in FIG. 1;

FIG. 5 is a top plan view taken along the line 5—5 of FIG. 4;

FIG. 6 is an enlarged view, partly broken away and partly in section, taken about the area 6 of FIG. 2;

FIG. 7 is a sectional view taken along the line 7—7 of FIG. 6;

FIG. 8 is a plan view taken along the line 8—8 of FIG. 2;

FIG. 9 is a sectional view taken along the line 9—9 of FIG. 8;

FIG. 10 is a view in side elevation of a stop mechanism used in conjunction with the apparatus of FIG. 1; and

FIG. 11 is an enlarged sectional view of an end of an individual tube stop shown in FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 through 5, reference numeral 1 indicates the apparatus of this invention. Apparatus 1 is provided with a suitable support structure 2 which has a drive means end 3 and a tube stop end 4. The structure 2 is shown broken apart and expanded in the various views in order to provide both detail and drawing simplicity. Thus, the tube stop end 4 is best seen in FIG. 4.

Interposed between the ends 3 and 4 of the structure 2 are an insertion mechanism 5, a tube magazine 6, and a cell assembly area 7.

The support structure 2 is conventional and includes a pair of oppositely opposed, parallel longitudinal beams 8 and a plurality of vertical legs 9. The legs 9 are attached to the beam 8 at a first end of each of the legs 9 and support a table top structure 10 at a second end of the legs 9. Top structure 10 is a frame, skeleton structure having side rails 11 and 12, and a plurality of cross supports 13 spaced from and between the legs 9, as best seen in FIG. 1. An end piece 91 extends from and between the rails 11 and 12 on the drive means end 3 of the apparatus 1. As indicated above, the components of the structure 2 are conventional and are illustratively shown as common box or U-shaped beam members. Interconnection of the members may be accomplished by any conventional means. Welding, riveting or common screw type fasteners work well. While a particular combination of structure 2 components are shown in the drawings, other structural combinations are compatible with the broader aspects of this invention.

The frame structure of the top 10 circumscribes an opening 14. A plurality of braces 15 are mounted from and between the sides 11 and 12, within the opening 14. Braces 15 are conventional beam structures having an upper surface 16.

Insertion mechanism 5 includes a first hydraulic cylinder 18, a second hydraulic cylinder 19, a load cell assembly 20, a telescoping section 21, a plurality of tube guides 74, a plurality of pusher rods 39, and a plurality of expanding means 24.

Referring now to FIGS. 1, 2, and 3, it may be observed that telescoping section 21 includes a first fixed plate 17. The plate 17 is attached to the top 10, from and between the sides 11 and 12. An end 95 of cylinder 18 is mounted to the upper surface 16 of the brace 15. A first pair of guide rods 96 extend from and between the plate 17 to a second fixed plate 97, spaced longitudinally along the support structure 2 from the plate 17. A rear plate 26, a load distribution plate 27, a pusher rod end plate 33, a first telescopic plate 42, a second telescopic plate 69, and a support plate 25 all are movably mounted on the guide rods 96. A second pair of guide rods 98 extend from and between rear plate 26 and support plate 25. The load distribution plate 27, the pusher rod end plate 33, the first telescoping plate 42, and the second telescoping plate 69 also are all movably mounted on the second pair of guide rods 98.

In the embodiment illustrated, insertion mechanism 5 also has a plurality of tie rods 99 extending from and between the load distribution plate 27 and the support plate 25. The pusher rod end plate 33, the first telescopic plate 42 and the second telescopic plate 69 are movably mounted on the tie rods 99. In the particular embodiment of the drawings, one tie rod 99 is positioned in each corner of the plates 27, 33, 42, 69 and 25. These plates generally are rectangular, although other shapes and designs may be utilized, if desired. The operation and interaction of the various plates and their function during tube insertion and expansion is explained in detail hereinafter. Mounting of the plates on the various guide and tie rods may be accomplished by any convenient method. For example, the various plates may have bearing openings which permit movement of the plates along the guide and tie rods. The guide rods 96 and 98, and the tie rods 99 are conventional and may comprise cylindrical shaped bodies mounted in the apparatus 1 as indicated above. While a particular mounting arrangement is indicated for the insertion mechanism 5, it may be mounted in a variety of arrangements. For example, a pair of guide rods 96 are described as extending from and between the plates 17 and 97. However, a single guide rod may be used to support the insertion mechanism 5 along the center line of support structure 2. Either arrangement works well. In the operation of the apparatus of this invention, however, it is important that the insertion mechanism 5 assembly be movable, by actuation of the cylinder 18, between at least a first and a second position. Movement of insertion mechanism 5 is responsible for insertion of a plurality of tubes into the passages defined by the plate plurality comprising the cell, as is explained in detail hereinafter.

The cylinder 18 has a drive end 100 operatively attached to support plate 25. The hydraulic cylinder 18, in turn, is operatively connected to a source of hydraulic power, not shown. It may be observed that actuation of the cylinder 18 will drive the support plate 25 forwardly on the first pair of guide rods 96. As the plate 25 moves forwardly, the plates 69, 42, 33, 27 and 26

are drawn along on the guide rods **96**, as they are interconnected with the plate **25** by the rods **98**.

The hydraulic cylinder **19** is operatively connected, cantilever fashion, to the rear plate **26** of insertion mechanism **5** and is movable therewith. The cylinder **19** also is connected to a source of hydraulic power, not shown. The cylinders **18** and **19** are conventional hydraulic cylinders and any of a variety of commercially available devices work well. The rear plate **26** is substantially rectangular in plan having a central opening **29** through it, which is utilized for coupling the cylinder **19** to load distribution plate **27**. Interconnection may be accomplished by any variety of techniques. A low cost connection technique, illustrated in the preferred embodiment, uses a threaded opening **32** in the load distribution plate **27** for engaging an end **30** of a piston rod **28** of the cylinder **19**. A load distributing bolt head **85** also may be inserted over the end **30** of piston rod **28** as an attachment aid.

Load distribution plate **27** is connected to the pusher rod end plate **33** by a plurality of connectors **34**. Connectors **34** also serve as spacers between the load distribution plate **27** and the end plate **33**. The connectors **34** generally are cylindrical shaped bodies having an internally threaded, axial opening **35** through them. The connectors **34** may be manufactured separately or they may be made integral with either the distribution plate **27** of the end plate **33**. The embodiment illustrated uses separately manufactured connectors **34** which thereafter are intermounted with conventional screw type fasteners **59** through both the end plate **33** and the distribution plate **27**.

The pusher rod end plate **33** is a generally rectangular metal plate having a front face **36** and a rear face **37**. The plate **33** has a plurality of openings **31** through it. The openings **31** are positioned so as to correspond to a hole pattern **90** punched in the cell plates of the electronic air filter cell assembly mentioned above.

The load cell assembly **20** includes a switch mechanism **88** which mechanism is positioned between the load distribution plate **27** and the pusher rod end plate **33**. Switch mechanism **88** includes a body **49** having a front plate **50** and a rear surface **51**. Body **41** extends from and between the plates **33** and **27** such that a side wall **86** of the plate **50** and the surface **51** abut the pusher rod end plate **33** and the load distribution plate **27**, respectively. The front plate **50** of switch mechanism **88** has an opening **52** in it, which leads to a cavity **53** within the body **49**. The cavity **53** has a wall **150** defining a rabbet edge **54** which is spaced above a bottom wall **55** of cavity **53**. An electrical conductor **56** is carried along the bottom wall **55** of cavity **53**. I find it convenient to embed the conductor **56** into the bottom wall. However, other methods and means of carrying the conductor **56** along the bottom wall **55** work well. A connector **38** is mounted through the opening **52** of front plate **50** and extends through the opening **31** of pusher rod end plate **33**.

The connector **38** includes a cylindrical shaped body **43** having an open mouth channel **44** in it. The channel **44** is designed to receive an end **41** of the pusher rod **39**. A second end of connector **38** has a shoulder **45** extending radially outwardly therefrom. The shoulder **45** is on the rear face **37** side of the plate **33** while the channel **44** opens on the front face **36** side of the plate **33**. An axial opening **89** extends through the body **43** of the connector **38**. The opening **89** is in communication with the channel **44** and opens on an end **46** of the body **43**. In the embodiment illustrated, the opening **89** is threaded internally and is designed to receive a set screw **92**. A locking means **40** may be placed within the opening **89** to hold the set screw **92** in position. A spring **48** is sized radially for intermounting over the end **46** of connector **38** so that a first end of the spring abuts the shoulder **45**, while a second end of the spring abuts the rabbetted edge **54**, as best seen in FIG. **5**. A fastener **58** is provided to attach the body **49** to the front plate **50**.

The pusher rods **39** are conventional, cylindrical bodies having their ends **41** attached to the connector **38**. In operational effect, the pusher rods **39** extend from the connectors **38** to the pusher rod **39** attachment with the expanding means **24**. While they may be a single, continuous rod, it is easier to support, to manufacture, and to interchange the rods **39** in the maintenance and operating procedures of the apparatus **1** if the rods **39** are made in reasonable length sections and interconnected within the apparatus **1**. Interconnection may be accomplished by any conventional method. For example, the rods **39** may be sectioned, each section having a threaded male connector on a first end and a threaded female receiver formed on a second end. The various sections may be interconnected to construct a single rod **39** by interlocking alternate male connectors and female receivers. Other connection techniques will occur to those skilled in the art.

As indicated above, pusher rod end plate **33** generally is a rectangular metal plate. The load cell assembly **20** and the connectors **38** are positioned, in relation to the front face **36** of the plate **33** so as to correspond to the hole pattern **90** punched in the plate plurality. While a plurality of pusher rod connectors **38** are diagrammatically illustrated in FIG. **6**, only a single pusher rod **39**, connector **38** and load cell assembly **20** are shown for drawing simplicity. In the embodiment illustrated, it is convenient to group operative pairs of the connectors **38** and their associated pusher rods **39** with each switch mechanism **88**.

It may be observed, in FIG. **7**, that the conductor **56** is electrically joined to a lead wire **60** having a terminal **61** attached to it. Conductor **56** is electrically connected to a low voltage source of electrical energy, not shown. The pusher rod **39** is electrically connected to machine or apparatus ground. Operation of load cell **20** and switch mechanism **88** is described in detail hereinafter. However, it is here noted that the set screw **92** may be adjusted so that a predetermined force on connector **38** will overcome the bias of the spring **48**, permitting set screw **92** contact with the conductor **56**, closing the circuit between the machine ground and the conductor. This action is utilized to stop operation of the drive mechanism of the apparatus **1**, where, for example, the pusher rod **39** or expanding means **24** encounters an obstacle in the tube insertion and expansion function of the device.

The particular embodiment of switch mechanism **88** shown in FIG. **6** illustrates the use of two pusher rod **39** assemblies with a switch mechanism **88**. Those skilled in the art will recognize that each of the pusher rods may utilize a single switch mechanism **88**, or that more than two pusher rods may be utilized with a single mechanism. It is convenient to form the body **49** of switch mechanism **88** from some type of electrically insulative material. Nylon works well.

As previously indicated, telescoping section **21**, and in particular the load distribution plate **27**, pusher rod end plate **33**, plate **42**, plate **69** and plate **25** are movably mounted on guide rods **96**. The rear plate **26** and the support plate **25** are connected to one another by a series of tie rods **99**. Tie rods **99** are solid cylindrical structures extending from and between the plates **25** and **26**. The load distribution plate **27**, pusher rod end plate **33**, plate **42**, and plate **69** are movably mounted along the tie rods **99**.

The tie rods **99** act as guide rods for both the first movable plate **42** and the second movable plate **69**. The movable plates **42** and **69** are identical and generally are rectangular structures having a front **70** and a back **71**. A plurality of openings **72** extend from and through the plates **42** and **69**. A series of sliding bearings **73** extend perpendicularly outwardly from the back **71** and surround the opening **72**. The bearings **73** merely are tubular structures having axial openings therethrough. The tie rods **99** extend through the openings **72** and the bearings **73**, permitting movement of the plates **42** and **69** along the tie rods. Spaced stops, not shown, may be used in conjunction with the movable plates **42** and **69** which stop movement of the plates at predetermined intervals. The plates **42** and **69** perform the function of supporting the pusher rods **39**, as the plates **69** and **42** also have the hole pattern **90** of the cell plate assembly running through them. The hole pattern **90** receives and supports the pusher rods **39**. The supporting function of the plates **42** and **69** is important during and after the expansion operation of the apparatus **1** explained hereinafter.

A plurality of tube guides **74** extend from and between the support plate **25** and the fixed plate **97**. The tube guides **74** are tubular structures which encase and support the pusher rods **39** along that portion of the rod length between the plates **25** and **97**. The tube guides **74** are attached to the plate **25** by any convenient means, and are movable therewith.

An end **75** of pusher rods **39** extend beyond the fixed plate **97** in an initial position of the insertion mechanism **5**. Expanding means **24** is mounted along the end **75** of the pusher rods **39**. Expanding means **24** may comprise any of a variety of low friction expanding devices. One particular device well suited for use with the apparatus of this invention is disclosed in the copending Wightman U.S. application, Ser. No. 229,457, filed Feb. 25, 1972.

Positioned adjacent the fixed plate **97** is the tube magazine **6**. Referring now to FIGS. **8** and **9**, it may be observed that the tube magazine **6** includes a base **101**. The base **101** is mounted between the side rails **11** and **12** by any convenient method. Conventional threaded fasteners work well. The base **101** has a pair of rails **102** extending upwardly from a top side **104** of the base **101**. The rails **102** are identical. They may be constructed integrally with the base **101**, or the rails **102** may be manufactured separately and later mounted to the base **101** by any convenient method. Again, conventional threaded fasteners inserted through a plurality of openings **103** in the rails **102** and base **101** work well for the mounting method.

A first cross brace **130** and a second cross brace **131** are designed to extend across the width of the base **101**. The braces **130** and **131** are identical and only a single brace is described in detail. In general, each brace includes a support area **132** having an upper surface **133** and a lower surface **134**. The lower surface **134** has a pair of parallel, spaced grooves **135** through it, which are positioned predeterminedly along the lower surface **134** so as to receive the rails **102** and to permit movement of the cross braces on the rails. Each brace **130** and **131** has a notch **136** along an outward facing edge of the support edge **132**, outboard of the grooves **135**. A fastener **137** is provided for attaching each of the cross braces **130** and **131** to the base **101**. The fastener **137** is conventional, having an axial opening **138** and a recessed edge **139** formed in it. The edge **139** and the notch **136** are intended to mate in a rabbet joint, thereby permitting attachment of the support area **132** to the base **101**. Toward this end, a common threaded fastener **140** may be inserted through the opening **138** into a corresponding opening **141** in the base **101**, thereby attaching the fastener **137**, and consequently each cross brace to the base **101**. The openings **141** may be spaced along and through the base **101** so that the cross braces **130** and **131** may be moved along the rails **102** for a plurality of predetermined positions, each of the various positions correspond to one of a variety of tube lengths. Consequently, the magazine **6** may accommodate a number of tube length sizes merely by adjustment of the cross braces. While a particular construction is described for accomplishing adjustability of the tube magazine **6**, those skilled in the art will recognize that other constructions may be utilized to give the movable mounting capability disclosed herein.

The support area **132** of the cross braces **130** and **131** has a plurality of tube supports **107** extending upwardly from it. The supports **107** include a pedestal **111** and guide means **108**. The construction of each of the tube supports **107** is similar, although the particular view in side elevation of one of the single supports **107**, as seen in FIG. **9**, may vary. These variations are a result of the number of openings in the hole pattern **90**. That is, an individual tube support **107** is intended, after loading of the tubes in the magazine **6**, to supply tubes to certain of the passageways corresponding to the hole pattern **90** in the cell assembly. Except for the variations in the number of tubes supplied, the supports **107** may be considered identical, although their design silhouettes may differ considerably in any particular application.

A less desirable method of construction may use a single plate for the tube supports **107**. A single plate is less desirable because the individual supports **107** can be adjusted along the cross braces **130** and **131**, as explained hereinafter, to correspond to a variety of different length plates in the cell plate assembly. Consequently, the individual supports **107** can be used over a range of air filter cell constructions, provided the hole pattern **90** is consistent in those constructions. Single plates require new plates for each size plate in the cell assembly.

The embodiment of the tube magazine **6** indicated in FIGS. **8** and **9** utilizes three of the tube supports **107** on each end of the base **101**. The outer tube supports **107** are identical, the central supports **107** containing fewer openings corresponding to hole pattern **90** in the cell plate assembly. As previously explained, however, each of the supports **107** may be considered identical as the number of openings in an individual support **107** may vary in other embodiments of this invention. Each of the supports **107** includes the pedestal **111** which is uti-

lized to mount the support **107** to the cross braces **130** and **131.** Pedestal **111** is a generally rectangular member having a plurality of openings **151** through it. The openings **151** are designed to align with an opening pattern **106** in the cross braces **130** and **131.** As best seen in FIG. **8,** the supports **107** may be adjusted along the cross braces **130** and **131** by aligning different groups of the openings **151** and **106.** In the embodiment illustrated, the openings **151** and **106** are threaded internally permitting use of conventional threaded fasteners for intermounting the supports **107** to the cross braces **130** and **131.**

The guide means **108** includes a plate **115** which extends upwardly from the pedestal **111** and is attached thereto by any convenient method. The plate **115** may be constructed separately and the pedestal **111** later attached to it, or the parts may be integrally constructed. Either method works well. The plate **115** has a plurality of slots **113** from and through it. The relation between the slots **113** and the plate **115** is such that the plate **115** resembles a series of fingers **114** extending upwardly from the pedestal **111.** A cover **112** extends about three sides of the plate **115,** but is spaced from it along a face **125** of the plate **115.** A face **126** of the plate **115** is free of the cover **112.** The cover **112** is U-shaped in side elevation and preferably is constructed from sheet metal. It is attached to the plate **115** by any convenient method. Fasteners **105** work well. Cover **112** has a plurality of openings **116** through it, which are aligned with a bottom **117** of the slots **113** in the plate **115.** The openings **116** also correspond to the hole pattern **90** in the plurality of plates in the cell assembly.

In the operation of the apparatus **1,** a plurality of tubes, not shown, are inserted in the slots **113.** The cover **112** is important in that one of its functions is to permit release only of individual tubes from the bottom **117** of the slots **113** while it restrains the remaining tubes in the magazine **6.** Use of the cover **112** is a particularly low cost design for permitting this single tube exit along the bottom **117** of the slots **113.** The cover **112** is required for the plates **115** on both the cross braces **130** and **131** ends of the magazine **6** because of the reciprocating nature of the apparatus operation, later described in detail. Those skilled in the art will recognize that other designs for accomplishing a similar result are available. For example, the plates **115** may be increased in thickness so that the slots **113** do not extend completely through the plates **115.** While such a design will function properly, I have found that the tubes are easier to load when the slots extend through the plates **115** to form fingers therewith. The slots **113** are sized to accept a plurality of tubes, not shown, in a loose slip fit. The bottoms **117** of the slots **113** are sized to permit passage of the tubes through the plates **115** under certain conditions.

It may be observed, by referring to FIGS. **2** and **9,** that a plurality of tubes may be inserted from and between the tube supports **107** by placing the tubes in the slots **113** between the fingers **114.** The tubes may be stacked successively and will gravity feed to the bottom **117** of the slots **113,** which places the tubes in a position corresponding to the openings comprising the hole pattern **90.** It also should be noted, that the hole pattern **90,** as described, is aligned along the entire longitudinal length of the apparatus **1.**

Referring now to FIGS. **4** and **5,** it may be observed that the cell assembly area **7** has a pair of supporting structures **82** at a first end of the area **7** and a plurality of tube stop assemblies **83** at a second end of the cell assembly area **7.** The void between the structures **82** and the stop assemblies **83** is used to receive a cell plate fixture containing a plurality of parallel plates which eventually become the air filter cell. A variety of fixtures may be utilized with the apparatus of this invention. A particular useful fixture is disclosed in the copending Wightman U.S. application, Ser. No. 327,083 Filed Jan. 26, 1973. Conventionally, these fixtures hold the plate plurality while the tubes are inserted through the hole pattern **90** and the expanding means **24** is driven through the tubes to attach the tubes to alternate plates. A particular feature of the apparatus of this invention concerns the stop assemblies **83.**

An individual stop assembly **83** is shown in FIG. **10.** As there illustrated, a support guide **62** has a plurality of tube stops **63** mounted between it and a tube stop mount **64.**

Support **62** may comprise a variety of designs. In the embodiment illustrated, it includes a mounting area **65** having an opening **66** through it. The opening **66** may be utilized to mount the support **62** to a convenient location on the apparatus **1** or the cell plate fixture used in conjunction with the apparatus **1.** Other mounting methods and means work well. Extending perpendicularly upwardly from the area **65** is a holder portion **67.** Holder portion **67** has at least one opening **68** through it. A number of openings **68** in the holder portion **67** depends on the location of the stop assembly **83.** That is, an individual tube stop **63** is provided for each of the openings in the hole pattern **90.** Consequently, where the tube supports **107** have provisions for four bottoms **117,** there correspondingly would be at least two openings in the holder portion **67,** with two of the stop assemblies **83** being arranged contiguously for the tube support **107.** Other arrangements work well and are compatible with broader aspects of this invention. Each of the openings **68** has one tube stop **63** movably mounted through it.

The tube stop **63** has a tube receiving end **76** which is adapted to receive a leading end of the tubes after tube insertion through the cell assembly. A second end **77** of the tube stop **63** is held by the tube stop mount **64.** Tube stop mount **64,** in the embodiment illustrated in FIG. **10,** is a rectangular member **127** having a counter sunk opening **78** on a side **79** and a counter sunk opening **80** on a side **81** of the member **127.** The openings **78** and **80** extend from and through the tube stop mount **64.** A spacer **118** is intermounted with tube stop **63** through the openings **80** and **78.** Spacer **118** is of sufficient length to permit a first end **119** of the spacer **118** to come into contact with an actuator bar **120,** as explained in detail hereinafter. A spring **121** is mounted over the spacer **118** and abuts tube stop mount **64** on a first end of the spring and the end **119** of the spacer **118** on the second end of the spring. It may be seen that the stop assembly **83** is spring loaded. That is, the tube stop **63** can move between at least a first and a second position in response to force applied to the end **119** of the spacer **118.** It also may be observed that the tube stop **63** and mount **64** vary the insertion depth of the tubes. That is, certain of the tubes will travel further during insertion before bottoming out because of the counter sunk opening **78** in the face

77 of mount 64. This distance need not be great but is important, for purposes later described herein.

Actuator bar 120 is operatively connected to a hydraulic cylinder 122. Cylinder 122 in turn is operatively connected to a source of hydraulic power not shown.

Operation of the apparatus of this invention greatly simplifies electronic air filter cell production. As indicated above, the fixture containing a plurality of parallel plates is placed within cell assembly area 7. Thereafter, the actuator 18 drives insertion mechanism 5 forward on the guide rods 96. As insertion mechanism 5 moves forwardly, expanding means 24 enters the hole pattern 90 openings in the tube supports 107 and engages the tubes within the magazine 6. Since the tubes are held within the magazine 6 in loose fit, they easily are driven forward by expanding means 24. The tubes pass the supporting structure 82, entering the cell assembly area 7 and in particular entering the hole pattern 90 in the plurality of parallel plates. Because the hole pattern 90 is larger than the outside diameter of the tubes prior to expansion, the tubes continue through the plate plurality until they meet the stop assembly 83. Prior to this meeting, the actuator bar 120 is moved to a first position which abuts the end 119 of the spacers 118, driving the end 76 of the tube stops 63 to a first position. As indicated above, predetermined ones of the stops 63 will enter the opening 78 in the tube continguously mount 64. As the tubes enter the end 76 of the stops 63, certain ones of the tubes will have traveled further than other ones of the tubes. This distance need not be great, and may be in the vicinity of one quarter to one half inch or less. This feature is important because it enables certain fixtures used in conjunction with the apparatus of this invention, and in particular the fixture described in the co-pending Wightman U.S. application, Ser. No. 327,083 Filed Jan. 26, 1973 mentioned above, to have two layers of plates placed continguously in the cell plate fixture. After expansion, the plates and tubes may be removed and by squaring the tube ends, the plates readily assume a correct parallel, spaced relationship.

As the cylinder 18 reaches the end of its stroke, the cylinder 19 is actuated. This continues movement of load distribution plate 27, which in turn, continues movement of the pusher rods 39 and expanding means 24. As this movement progresses, the movable plates 42 and 69 telescope toward one another on the tie rods 99. The movement of insertion mechanism 5 actually is responsible for expansion of the tubes. That is, the cylinder 19 continues to drive expanding means 24 through the tubes, expanding those tubes into engagement and attachment with the small diameter openings of the plurality of plates comprising the cell. The load cell 20 is adjusted so that the set screws 92 do not meet the conductor 54 during normal movement of insertion mechanism 5. However, the bias of spring 48 is predetermined so that excessive force exerted by any of the pusher rods 39 or expanding means 24 closes the circuit and actuates circuit means for removing power to the apparatus 1, not shown.

After tube expansion has progressed a predetermined distance, the tube stop mechanism 83 is deactivated. That is, the actuator bar 120 is driven to a second position out of contact with the end 119 of spacer 118. The spring 121 then returns the stop assembly 83 to a second position where the end 76 of the stop 63 is no longer in contact with the end of the tubes. This is an important consideration in reducing distortion forces on the tubes and the cell plate caused by tube shrinkage during expansion. Some tube shrinkage always takes place at the point of expansion of the tube. The point of concern is between the last plate fixed to the expanded tube and the tube stop. Tube shrinkage does not occur between the fixed plates. In prior art pull type expansion, tube shrinkage causes considerable stress between cell plates and the tube at the point of expansion. These stresses, in turn, were one of the factors in requiring use of the expensive and cumbersome plate fixtures of the prior art. Push expansion on the other hand, eliminates these problems of the prior art. That is, because of the unique features of the apparatus 1 described herein, the tubes need only abut the tube stop assembly 83 until a predetermined number of plates are fixed to the expanded tube. After this predetermined number of plates and tubes are fixed to one another, the tube stop mechanism 83 may be removed and the fixed plates hold the tubes while the remaining expansion process is performed. Even though the tube may contract, no undue stress is transmitted to the plates because of that contraction, since one end of the tube is free to move. In addition, there is no compression force on the tube ends, once the stops are removed. The tube is in tension, during expansion, as the expanding means 24 is driven continuously through the tubes. This combination of factors has resulted in a situation the overall effect of which is that the tubes maintain their original size, within manufacturing tolerances, and are not distorted at either of their two ends. Consequently, steps necessary in the prior art because of the variances in tube length and end distortion may be eliminated where the apparatus of this invention is used in cell manufacture.

As the actuator 19 reaches the end of its stroke, expansion is completed and the actuator 19 is reversed. Expanding means 24 easily may be withdrawn from the expanded tubes. Thereafter, actuator 18 also is reversed to reposition the insertion mechanism 5 in its initial position. As the expanding means 24 passes the tube supports 107, the tubes contained in the magazine 6 are able to gravity feed into the now empty bottom 117 of the grooves 113 automatically, and thus are ready for the succeeding operational cycle of the apparatus.

The plate-tube combination, now an integral unit, is removed from the cell assembly area 7 by any convenient method. Removal may be by hand. However, it is convenient to automate removal. A number of methods and apparatus are available for this automatic removal. For example, an additional actuator may be placed beneath the table top 10 and positioned so as to raise the cell upwardly from the top 10, where an automated arm can be positioned to sweep the platetube combination from the assembly area.

Numerous variations, within the scope of the appended claims, will be apparent to those skilled in the art in light of the foregoing description and accompanying drawings. Thus, while the various plates and guides for the hole pattern 90 were described as generally rectangular, single plates, they may be a plurality of smaller plates rather than a single integral unit. A decorative enclosure may be placed around the supporting structure 2, if desired. The design of the load cell 20 may be varied. While a cell having two pusher

rods **39** associated with it is disclosed, any reasonable number of rods may be utilized with the load cell. The apparatus disclosed is particularly useful in automated construction methods for cell assembly. Thus, the apparatus may be used in conjunction with various other devices which provide, for example, cell plate manufacture and automatic feeding, loading and cell removal. Various plate fixture designs are compatible with the broader aspects of this invention. Those skilled in the art will recognize that one or more of the apparatuses **1** may be utilized in conjunction with such automated construction. For example, pairs of the apparatus **1** as diagrammatically illustrated in FIG. **3** may be teamed with a single punch press for manufacturing plates to give a low cost, efficient manufacturing method and machine. A process for automated cell construction is disclosed in the co-pending Wightman et al. U.S. application, Ser. No. 327,018 Filed Jan. 26, 1973. The apparatus **1,** while described in detail with respect to an electronic air filter cell, may find application in the manufacture of condensor units for air conditioners, for example. Although the various cylinders, and in particular the cylinders **18, 19** and **122,** were described as a hydraulic variety, other drive means may be utilized. For example, the cylinders may be air-oil combinations; some form of worm gear drive; or rack and pinion drive mechanisms. While hand loading the magazine **6** is accomplished easily, means may be provided for automatic feed to the magazine. It will be apparent, to those skilled in the art, that any size cell may be manufactured by merely adjusting the distance of travel of the insertion mechanism **5.** Likewise, the magazine tube size may be adjusted merely by moving the tube supports **107** as described above. Where plate size or hole pattern is varied, the various guides and plates may be made adjustable. Adjustment may be in the form of plates with new hole patterns or certain of the plates may be provided with grooves and releasable fittings which may be adjusted to a new hole pattern. The design of the stop assembly **83** may be varied. Such variations are intended to be encompassed by the scope of the appended claims, provided that the stop assembly **83** is released so that expansion of the tubes progresses toward the free end of the tubes. These variations are merely illustrative.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. An insertion apparatus for inserting and expanding tubular bodies comprising:

a supporting structure;

an insertion mechanism mounted on said supporting structure and movable longitudinally along said supporting structure between at least a first position and a second position; and

a tube magazine for storing a plurality of tubes mounted to said supporting structure and aligned axially with said insertion mechanism whereby said insertion mechanism drives at least one tube from said tube magazine to a second area longitudinally removed from said tube magazine as said insertion mechanism moves from said first position to said second position.

2. The insertion apparatus of claim **1** wherein said insertion mechanism includes a plurality of pusher rods having first and second ends, said first end being attached to a movable part of said insertion mechanism and movable therewith, and further characterized by expanding means mounted to said second end of said pusher rods.

3. The insertion apparatus of claim **2** wherein said insertion mechanism is further characterized by a load cell operatively connected to said pusher rods, said load cell comprising a body defining a chamber, an electrical conductor carried in said chamber, means for operatively connecting at least one pusher rod to said electrical conductor, means for biasing said connecting means so that said connecting means and said electrical conductor are disconnected electrically in normal operation of said pusher rod and connected electrically in abnormal operation of said pusher rod.

4. The insertion apparatus of claim **3** wherein said biasing means comprises a spring arranged so as to exert a force acting to disconnect electrically said connecting means and said electrical conductor.

5. The apparatus of claim **3** wherein said tube magazine includes at least a first plate mounted to said supporting structure, a second plate mounted to said supporting structure and spaced from said first plate, each of said first and said second plates having a plurality of slots in them adapted for storing a plurality of tubes, said slots having bottoms aligned with said pusher rods, said slot bottoms adapted to permit axial passage of said expanding means and said pusher rods as said insertion mechanism moves from said first position to said second position.

6. The apparatus of claim **5** wherein each of said slots extend through respective ones of said first and said second plates.

7. The apparatus of claim **6** wherein each of said first and said second plates are rectangular in plan, said tube magazine being further characterized by a cover part enclosing three sides of said plate.

8. The apparatus of claim **7** wherein said tube magazine is further characterized by a base plate, a pair of rails mounted on said base plate, said rails being parallel to and spaced from one another; a first cross brace slidably mounted on said rails, and a second cross brace slidably mounted on said rails, said cross braces having respective ones of said first and said second plates mounted thereto.

9. The apparatus of claim **8** wherein each of said first and said second plates are movably mounted on respective ones of said first and said second cross braces.

10. The apparatus of claim **5** wherein said second area axially removed from said tube magazine comprises a cell assembly area along said supporting structure, said cell assembly area having a first end and a second end, said first end being adjacent said tube magazine and said second end being longitudinally remote therefrom, said apparatus being further characterized by at least one tube stop mounted along said second end of said cell assembly area, said tube stop being movable between at least a first and a second position, and drive means for moving said tube stops, mounted to said supporting structure.

11. The apparatus of claim **10** wherein said tube stop includes a tubular structure having a flaired end.

12. In an insertion device for inserting a plurality of tubular structures into a plurality of cell plates for a cell assembly including drive means and at least one pusher rod operatively connected to said drive means the improvement which comprises safety shut off means including a load cell connected to said drive means, said load cell including an electrical switch and bias means

adapted for opening said switch, and an electrical conductor carrying electrical energy to said switch, said bias means being responsive to forces exerted by said drive means such that excessive force overcomes said bias means, closing said switch.

13. The improvement of claim **12** wherein each of said load cells have a pair of pusher rods operatively connected to it.

14. In an insertion device for inserting a plurality of tubular structures into a plurality of parallel plates having openings in them for receiving said tubular structures, the improvement which comprises means for sequentially and continuously pushing said tubular structures through said openings in said plates and expanding said tubular structures into fixed contact with alternate ones of said plates.

15. In an insertion device for inserting a plurality of tubular structure into a plurality of plates having openings in them for receiving said tubular structures including means for inserting a plurality of tubular structures through said openings, each of said tubular structures having a first end and a second end, and means for expanding said tubular structures so as to interconnect said plurality of plates with said tubular structures, said expanding means being inserted through said tubular structures from said first end of said tubular structures, the improvement which comprises movable stop means at the second end of said tubular structures, said stop means being movable between at least a first and a second position, one of said first and said second positions being adapted to prevent further tubular structure travel by engaging said tubular structures at said second end, and means for repositioning said stop means to the other of said first and said second position after tubular structure expansion progresses a predetermined distance along said first end of said tubular structures.

16. An insertion apparatus for inserting and expanding tubular structures in a cell assembly including a plurality of plates having openings in them for receiving said tubular structures comprising:

a supporting structure having a first end and a second end, said second end defining a cell assembly area;

an insertion mechanism mounted to said supporting structure near said first end and movable reciprocally between at least a first position and a second position; and

a magazine for loading a plurality of said tubular structures mounted to said supporting structure and aligned axially with said insertion mechanism, said tube magazine having at least one opening in it permitting passage of at least a portion of said insertion mechanism as said insertion mechanism moves between said first and said second position.

17. The apparatus of claim **16** wherein said insertion mechanism comprises:

a first stationary plate mounted to said supporting structure near said first end;

a second stationary plate mounted to said supporting structure and spaced axially from said first plate;

a first guide rod mounted between said first and said second stationary plates;

a third plate movably mounted on said first guide rod;

a fourth plate movably mounted to said third plate and supported by said fourth and said second plates;

first drive means operatively connected to said fourth plate; and

second drive means operatively connected to said third plate.

18. The apparatus of claim **17** further characterized by tube stop means mounted near said second end of said supporting structure, said tube stop means including a tube stop and means for defining a first and a second position for said tube stop.

19. The apparatus of claim **18** wherein said magazine comprises a first guide means mounted to said supporting structure, a second guide means mounted to said supporting structure spaced axially from said first guide means, said first and said second guide means including at least one plate respectively which extends upwardly from said supporting structure, each of said respective plates having at least one opening through them which openings may be aligned axially, and a groove in each of said respective plates extending from the opening in each of said respective plates and sized to permit insertion of tubular structures in said groove so that said tubular structure extends between said first and said second plates, whereby said tubular structures may gravity feed into position between the opening in each of said respective plates.

20. The apparatus of claim **19** wherein said magazine is further characterized by a base mounted to said support structure, said base having a pair of spaced rails disposed axially along an upper surface thereof, and a pair of cross braces movably mounted to said base and slidable along said rails, said first and said second guide means being mounted to respective ones of said cross braces.

21. The apparatus of claim **20** wherein said first and said second guide means are movably mounted on said cross braces.

22. A stopping means comprising:

a holder structure, said structure having at least one opening in it;

a tube stop having a first and a second end movably mounted to said holder structure along said first end of said tube stop, through said opening;

a mounting structure mounted to said second end of said tube stop;

a spacer operatively connected to said tube stop through said mounting structure; and

means for biasing said spacer toward at least one direction of movement.

23. The device of claim **22** wherein said tube stop is a tubular structure having a flaired opening along its first end.

24. In an insertion device for inserting a plurality of tubular structure into a plurality of arranged plates, said plates having openings in them for receiving said tubular structures, the improvement which comprises means for sequentially and continuously pushing said tubular structures through said openings of said plates and expanding said tubular structure into fixed contact with at least alternate ones of said plates.

25. An insertion apparatus for inserting and expanding a tubular body, comprising:

a supporting structure;

an insertion mechanism mounted on said supporting structure movable between at least a first position

and a second position, said inserting mechanism including at least one pusher rod having a first end and a second end, one of said first and said second ends being attached to a movable part of said insertion mechanism and being movable therewith;

means for detecting abnormal operation of said pusher rod operatively connected to said pusher rod and a source of power for said apparatus; and

means for stopping movement of said tubular body as said insertion mechanism moves between said first and said second position, said stopping means being movable between a first stopping position abutting said tubular body and a second disengaged position remote from said tubular body, movement of said stopping means occuring predeterminedly as said insertion mechanism moves between said first and said second positions.

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