United States Patent

Ames

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[54] **TUBE EXPANSION APPARATUS**

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[51] **Int. Cl.**.....**B21j 7/26,** B21d 45/00

[58] **Field of Search**.....72/412, 344, 345, 427, 453, 72/22; 29/202 D

[56] **References Cited**

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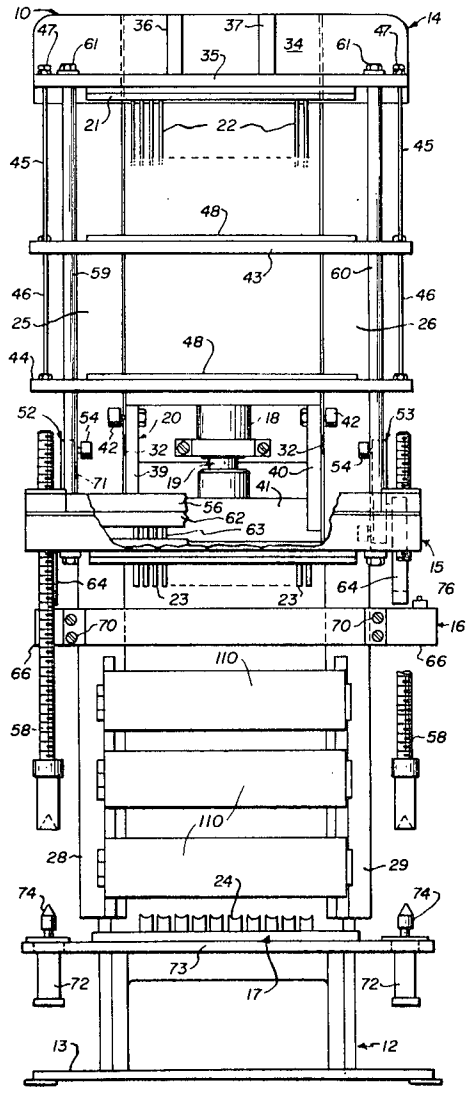
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Assistant Examiner—R. M. Rogers
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[57] **ABSTRACT**

A tube expansion apparatus which includes a vertically supported frame, a main ram and a main cylinder which is affixed to the frame and has a piston which is affixed to a main ram guide carriage and reciprocally drives the latter and hence the main ram. The main cylinder is disposed such that its piston, upon being extended, moves vertically downwardly. This piston rather than being affixed to the main ram is affixed to main ram guide carriage to forcibly urge it and the main ram downwardly, the arrangement being such that the height of the tube expansion apparatus can be substantially reduced in comparison to that of a conventional vertical tube expander.

13 Claims, 7 Drawing Figures



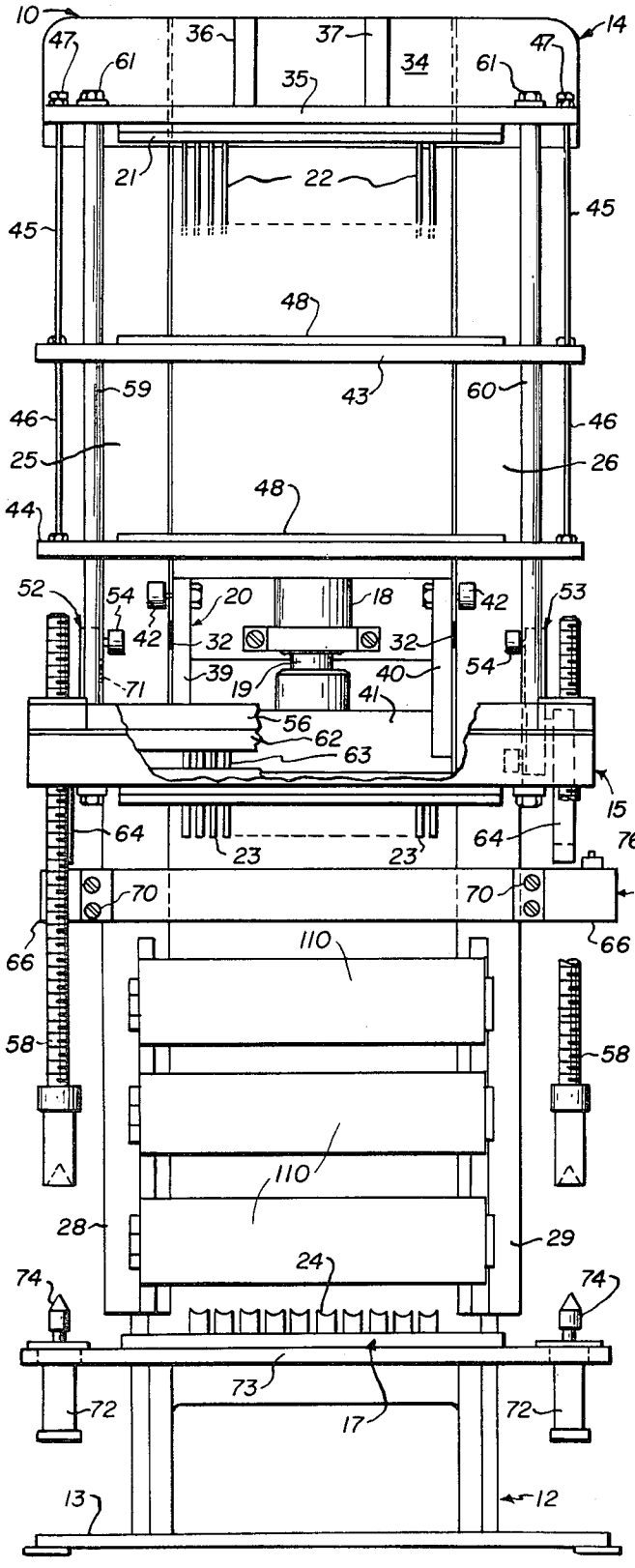


FIG. 1

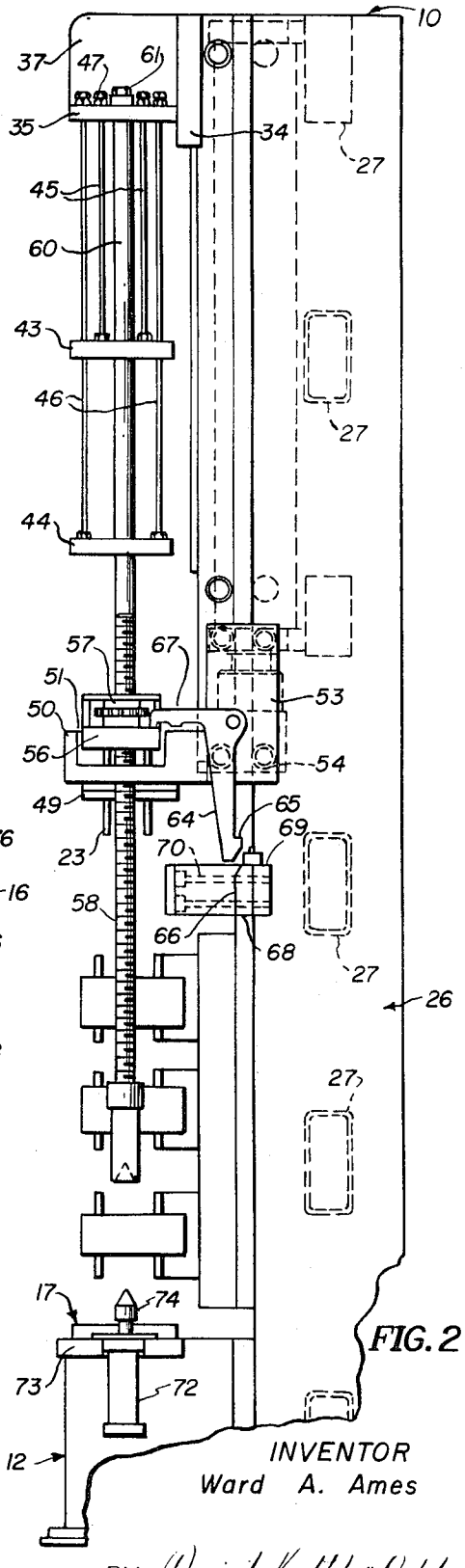


FIG. 2

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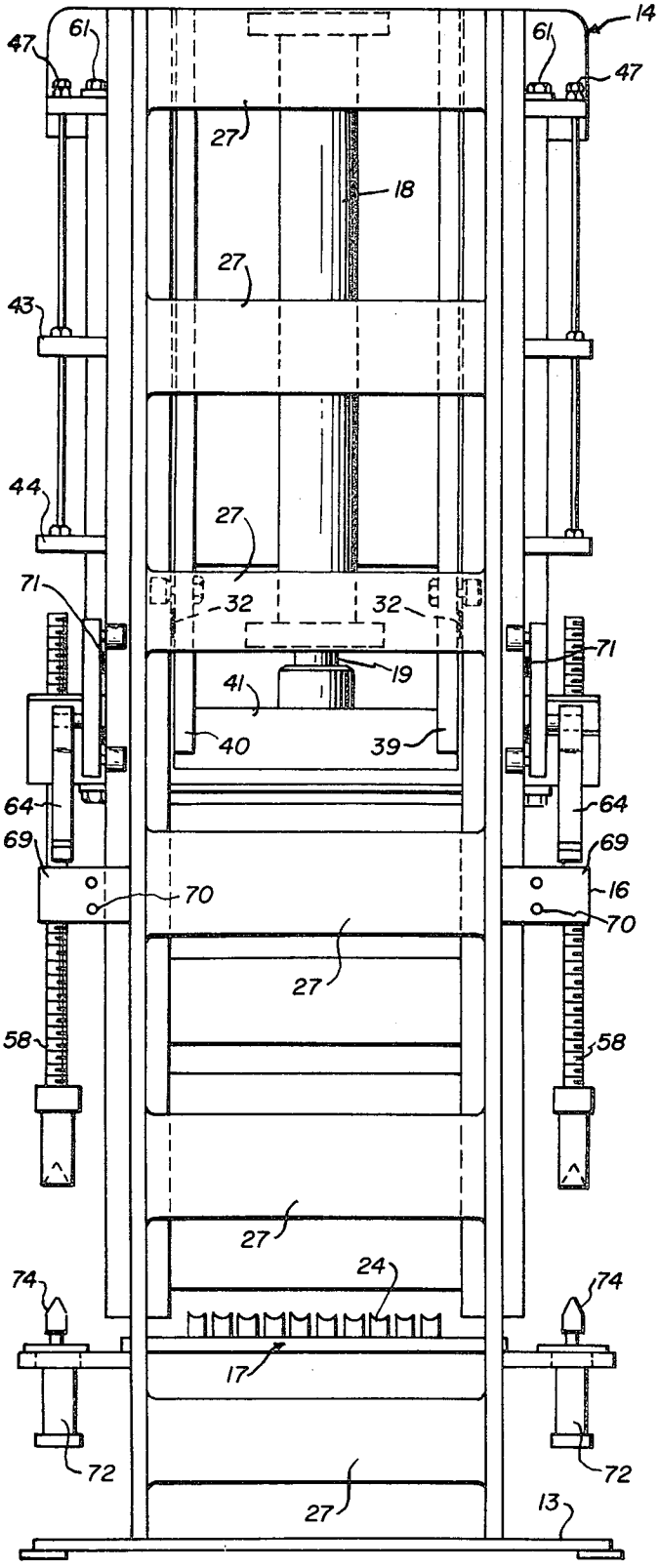
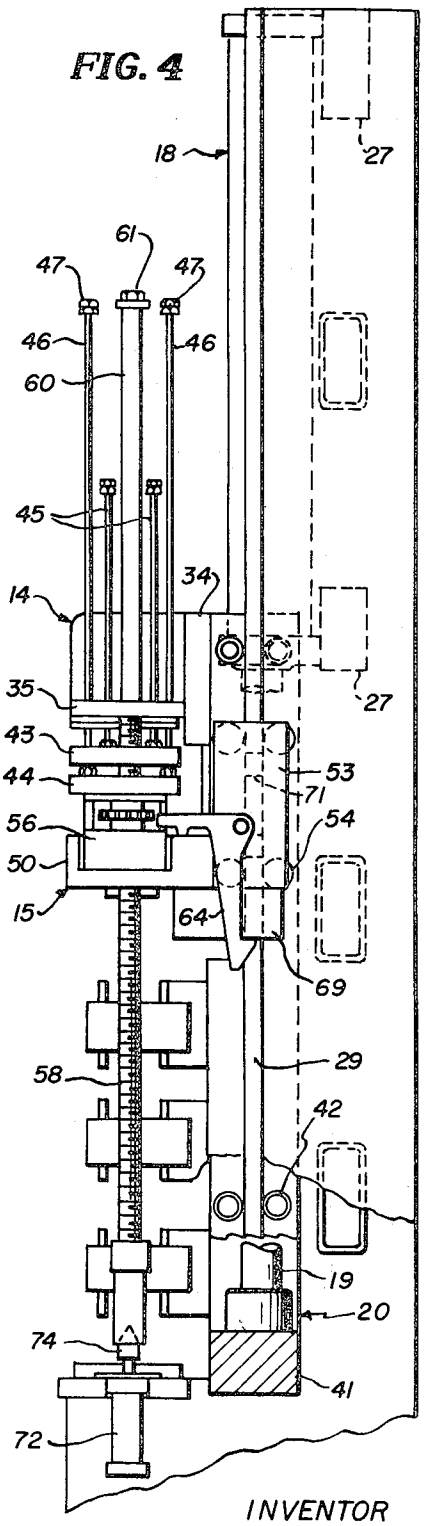


FIG. 3

FIG. 4



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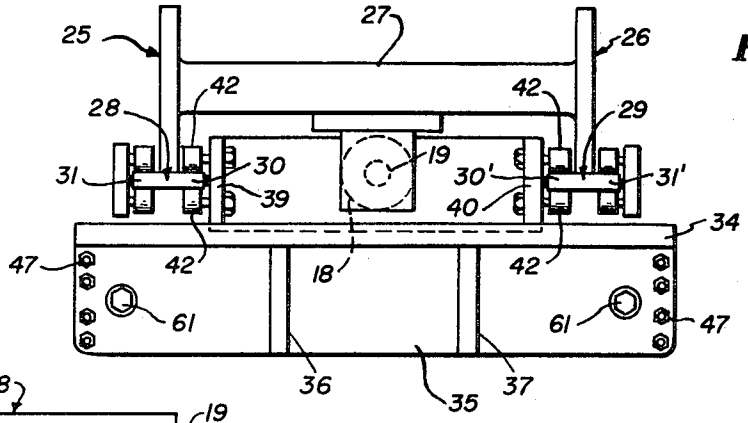


FIG. 5

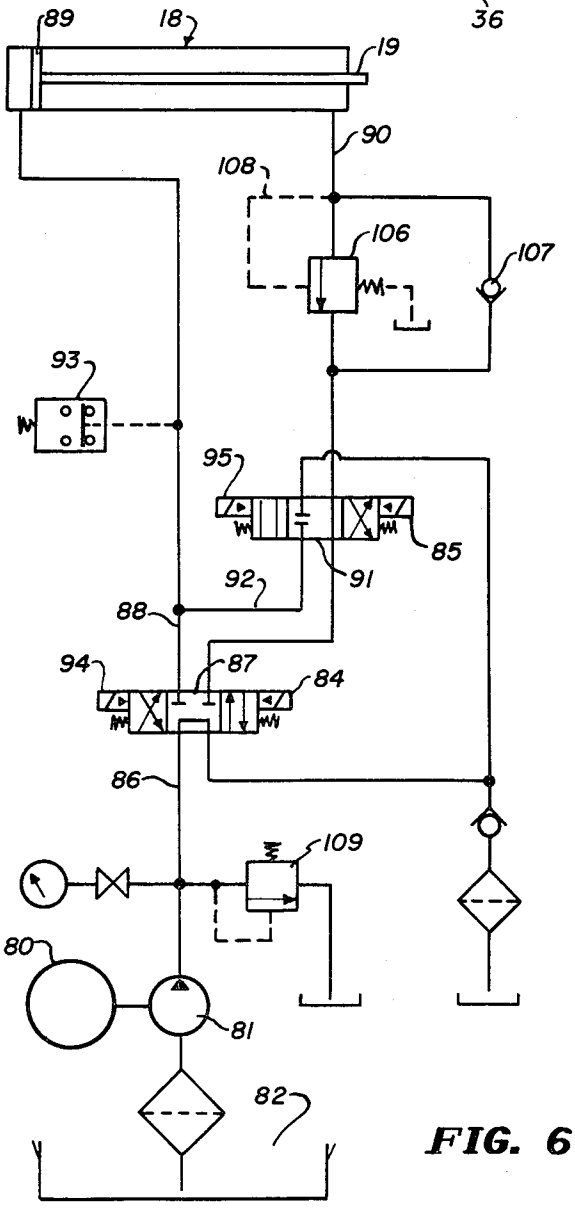


FIG. 6

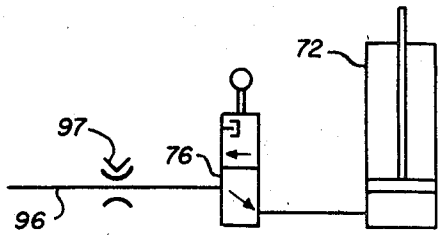


FIG. 7

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TUBE EXPANSION APPARATUS

This invention relates to an improved tube expansion apparatus for radially expanding a portion of a tubular member for the purpose of uniting it with a structural part having a performed aperture for receiving the tubular member.

Tube expansion apparatus of the above type generally are simply referred to as expanders, and are used to form plate-fin heat exchangers for air conditioners, refrigeration equipment and other heat exchange equipment. These plate-fin heat exchangers will hereinafter be referred to as coils. Most expanders are of the vertical type, however, some are horizontal.

The height of a vertical expander, or the length of a horizontal expander, generally can be determined approximately by multiplying the maximum length of the largest coil to be formed with the expander by a factor of 3, and then adding 7 feet to the result. For example, if the largest coil to be formed has a length of 48 inches, using the above rule of thumb, it can be determined that the expander will be approximately 19 feet in height, or length.

Most coil fabricators prefer vertical expanders since they require much less floor space than a horizontal expander. If large coils are to be formed, however, the height of the necessary vertical expander can present a problem unless the plant in which the expander is to be set up has exceptionally high ceilings. It is frequently found that a special penthouse has to be constructed to accommodate the vertical expanders.

Accordingly, many manufacturers have been trying to find a way in which to reduce the height, or length, of these expanders. So far, however, those expanders which have been designed are generally unsatisfactory, for one reason or another.

It is therefore an object of the present invention to provide a new and improved expander of a design providing a substantial reduction in height, or length, in comparison to presently available conventional expanders.

Another object is to provide an improved expander of the above type wherein the height, or length, reduction can approximate 30 percent.

Still another object is to provide an improved expander of a reduced height which will allow the use of a vertical expander in applications formerly reserved for horizontal expanders.

A still further object is to provide an improved expander which is substantially reduced in height, or length, in comparison to conventional expanders, and which is of an improved mechanical design which, among other improvements, provides better guiding and alignment of the working surfaces of the expander.

A still further object is to provide an improved expander of a reduced height having a construction such that the same "push type" hydraulic cycle with simple regenerative control used on conventional expanders can be used.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts which will be exmplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a front plan view of an expander exemplary of the invention;

FIG. 2 is a side plan view of the expander of FIG. 1;

FIG. 3 is a rear plan view of the expander of FIGS. 1 and 2;

FIG. 4 is a side plan view of the expander of FIG. 1, illustrating the main ram in its lowered position;

FIG. 5 is a top plan view of the expander of FIG. 1; and

FIGS. 6 and 7 are schematic diagrams of the hydraulic and air systems of the expander.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring now to the drawings, an expander **10** is shown including, generally, a frame **12** which is vertically supported upon a platform base **13**; a main ram **14**, a work sizing head **15** and a stop block **16** which are all slidably affixed to the frame **12**; a nest tooling plate **17** which is affixed to the frame **12**, at a fixed height above the platform base **13**; and a main cylinder **18** which is affixed to the frame **12** and has a piston **19** which is affixed to a main ram guide carriage **20** and reciprocally drives the latter and hence the main ram **14**. The expander **10** further includes hydraulic means and motor means which are shown schematically in FIG. **6**, for operating it in the manner described below.

The frame **12** of the expander **10** is formed of two vertically supported, parallel, spaced-apart frame members **25** and **26** which preferably are heavy steel plates. These frame members **25** and **26** are affixed, as by welding, to the platform base **13**, and are fixed in parallel, spaced apart relationship by means of a number (six, as shown) of heavy gauge steel tubular spacers **27** (FIG. **2**) and two rectangular steel bars which serve as mounting for the main cylinder **18**. As can be best seen in FIGS. **1** and **5**, alignment plates **28** and **29** are integrally fixedly secured to the front edges of these frame members **25** and **26**. The alignment plates **28** and **29** extend from the tops of the frame members **25** and **26** and terminate just above the nest tooling plate **17**, and further extend laterally on each of the opposite sides of the respective frame members so as to form a pair of inner guide tracks **30** and **30'** and a pair of outer guide tracks **31** and **31'**.

The main ram **14**, as can be best seen in FIGS. **1**, **2** and **5**, includes a vertically disposed back plate **34** which has a ram plate **35** secured thereto in a fashion such as to extend horizontally outwardly therefrom. This ram plate **35** is further supported by means of a pair of spaced-apart support plates **36** and **37**. A rod tooling plate **21** supporting a number of expander rods **22** is removably secured to the underside of this ram plate **35**.

The back plate **34** of the main ram **14** forms an integral part of the main ram guide carriage **20** which is generally rectangular-shaped and includes a pair of carriage side frames **39** and **40** which are fixedly secured in parallel, spaced relationship by means of a carriage cross frame **41** and the back plate **34** affixed to the lower and upper ends thereof, respectively. This main ram guide carriage **20**, as can be best seen in FIG. **5**, is

of a width substantially corresponding to the width between the edges of the inner guide tracks **30** and **30'**, and has guide rollers **42** affixed to the carriage side frames **39** and **40** near the upper and lower ends thereof which engage the opposite sides of the inner guide tracks **30** and **30'**. Brass slides **32** are affixed on the outside surfaces of the carriage side frames **39** and **40** adjacent to and slidably bearing against the inner edges of the alignment plates **28** and **29**. There are two brass slides **32**, mounted top and bottom of each of the two carriage side frames **39** and **40**, and these brass slides **32** provide lateral stability and assure alignment of the main ram **14** during its vertical travel. The guide rollers **42** function to align and guide the main ram guide carriage **20** as the latter is reciprocally raised and lowered by the hydraulic cylinder **18**.

The main cylinder **18** is not aligned atop the main ram **14** as it is with most conventional expanders but is, instead, offset therefrom and is disposed between the frame members **25** and **26**. The main cylinder **18** is vertically disposed in a position such that its piston **19**, upon being extended, moves downwardly, and is fixedly secured to and supported by the spacers **27** parallel to and substantially centrally between the frame members **25** and **26**. It will be appreciated that more than one main cylinder can be provided, if the capacity of the expander is such that two or more are necessary for its operation. The piston **19** of the main cylinder **18** rather than being affixed to the main ram **14** is affixed to the carriage cross frame **41**. Accordingly, when the hydraulic cylinder **18** is operated to extend its piston **19**, the latter bears on the carriage cross frame **41** so as to forcibly urge it and hence the main ram guide carriage **20** and the main ram **14** affixed to it downwardly. This arrangement permits the height of the vertical expander **10** to be substantially reduced in comparison to that of a conventional vertical expander, as explained more fully below.

The work sizing head **15**, as can be best seen in FIGS. **1**, **2** and **5**, includes a generally rectangular-shaped stripper plate **50** and a final expander plate **56**. The stripper plate **50** has a rectangular opening in its bottom surface which is covered by a detachable stripper tooling plate **49**. This tooling plate **49** has a number of strippers **23** removably retained therein.

The final expander plate **56** nests within a recessed cavity or channel **51** in the top surface of the stripper plate **50**, and also has a detachable final expander tooling plate **62** on its underside. This tooling plate **38** has a number of final expanders **63** removably retained therein.

Spaced guide roller brackets **52** and **53** are provided at the rear portion of the stripper plate **50**, and each of these guide roller brackets **52** and **53** supports four guide rollers **54** which are positioned to engage the opposite sides of the outer guide tracks **31** and **31'**, to align and to guide the work sizing head **15**. For each set of front and rear guide rollers **54**, there is a brass slide **71** on the inside surface of each guide roller bracket **52** and **53**. These brass slides **71** bear slidably against the outer edges of the alignment plates **28** and **29**, preventing side sway of the work sizing head **15**.

The final expander plate **56** has a pair of sprockets **57** caged atop it, each of which has a hub (not shown) which is keyed into a keyslot (not shown) in respective ones of a pair of coil height adjustment screws **58**. The coil height adjustment screws **58** pass through a clearance hole in the hubs of sprockets **57**. Thus the adjustment screws **58** and the sprockets **57** will rotate together, with the sprockets **57** caged atop the final expander plate **56**. Below the sprockets **57** are brass nuts (not shown) which are recessed into the final expander plate **56**. These nuts are threaded internally and fastened inside a final plate recess. Power is supplied to rotate the sprockets **57** by a reversible motor (not shown), through a drive sprocket and idler sprockets to provide chain guiding for a drive chain which is driven by the motor and coupled to the sprockets. The sprockets **57** rotate the adjustment screws **58**, which in turn raises or lowers the adjustment screws, both by the same increment.

As indicated above, the rod tooling plate **21** which supports a number of expander rods **22** is affixed beneath the ram plate **35**. These expander rods **22** extend vertically downwardly and pass through the final expander plate **56**, the final expander tooling plate **62**, the final expanders **63**, the stripper plate **50**, the stripper tooling plate **49** and the strippers **23**, as the main ram **14** is lowered. These expander rods **22** preferably also are extended through one or more rod alignment tooling plates **48** removably affixed to guide plate holders **43** and **44** which serve to support and to align them. These guide plate holders **43** and **44** are supported by means of support rods **45** and **46**, respectively, which are fixedly secured to them and are extended through apertures (not shown) in the ram plate **35**. The ends of the support rods **45** and **46** have enlarged stop nuts **47** affixed to them which will not pass through the apertures in the ram plate **35** so that the guide plate holders **43** and **44** normally are hangingly supported. When the main ram **14** is lowered, these guide plate holders **43** and **44** stack up atop the final expander plate **56**, as illustrated in FIG. **4**, and the support rods **45** and **46** merely slide or pass through the apertures in the ram plate **35**. When the operation is reversed, the ram plate **35** engages the enlarged stop nuts **47** and raises or lifts the guide plate holders.

A pair of guide rods **59** and **60** are slidably extended through apertures (not shown) in the stripper plate **50**, the guide holder plates **43** and **44**, and the ram plate **35**. The upper and lower ends of these guide rods **59** and **60** have enlarged stop nuts **61** on them which will not pass through the apertures (not shown) in the ram plate **35** and the stripper plate **50** while the final plate **56** is affixed to them such that it is vertically raised and separated from the stripper plate **50** a distance on the order of one inch when the main ram **14** is raised to its upper vertical limit. This vertical movement of the final plate **56** functions to release the stripper plate locks **64** which are pivotally affixed to the stripper plate **50**, on each of the opposite sides thereof. These stripper plate locks **64** normally are biased so that the locking notches **65** thereon will lockingly engage beneath the lower edge of the lateral lock extensions **66** of the stop block **16** when the work sizing head **15** is lowered during the final sizing of the coils being formed. The arrangement further is such that the work sizing head **15** is held locked in its final sizing position until the expander rods **22** and the final expanders **63** are withdrawn from the coils, at which time the final plate

56 is raised by the guide rods 59 and 60. The final plate 56 upon being raised physically engages the arms 67 of the stripper plate locks 64 to pivotally operate them to disengage the locking notches 65 from the lock extensions 66. When the enlarged stop nuts 61 on the lower ends of the guide rods 59 and 60 engage the bottom side of the stripper plate 50, the latter is physically raised and the complete working sizing head is now returned upward.

The stop block 16 is a generally rectangular-shaped block having lateral lock extensions 66 on each of its opposite ends. The stop block 16 is slidably lockably affixed beneath the work sizing head 15, across the front of the alignment plates 28 and 29, by means of friction plate locks 68 which are adapted to be frictionally clamped to the outer guide tracks 31 and 31'. These friction plate locks 68 each include a lock plate 69 which is disposed to engage the back surface of the guide tracks 31 and 31', to frictionally clamp the latter between these lock plates 69 and a rear surface of the stop block 16 as the threaded bolts 70 are tightened, as can be best seen in FIGS. 2 and 3.

The stop block 16, in addition to functioning to lock the work sizing head 15 in its final sizing position while the expander rods 22 are being withdrawn from the coils, functions to set or establish the height of the coils being formed. The stop block 16 also provides a secondary safety feature in that it prevents the work sizing head 15 from accidentally dropping during set up of the expander 10. In each case, it functions in generally the same fashion, by stopping the downward movement of the work sizing head 15.

The coil height adjustment screws 58 function in conjunction with a pair of air cylinders 72 affixed to the nest tooling plate support 73 to initially support the work sizing head 15 as the main ram 14 is being lowered, to prevent premature crushing of the coils being formed. The coil height adjustment screws 58 are adjustably threadably positioned so that the ends thereof seat atop the pistons 74 when the latter are fully retracted and the work sizing head 15 is engaged with the stop block 16. The latter, of course, previously has been adjustably positioned to set or establish the final coil height. These coil height adjustment screws 58, as indicated above, both are simultaneously adjusted by means of a reversible motor which drives a chain that is linked about and rotatably drives the sprockets 57 caged atop the final expander plate 56. This manner of adjusting the coil height adjustment screws 58 is generally well-known, and hence the motor drive and the chain have not been shown.

The air cylinders 72 are normally operated so that their pistons 74 are fully extended, upon initiating a cycle of operation. As the main ram 14 is lowered, the work sizing head 15 likewise is lowered until the ends of the coil height adjustment screws 58 engage and seat atop the new extended pistons 74. The work sizing head 15 is cushioned in this raised position, dropping by a small increment as the guide holder plates 43 and 44 and the rod alignment tooling plates stack on top of it during the main ram 14 descent, until the main ram 14 engages the upper ends of the coil height adjustment screws 58 and forcibly urges them downwardly against the air pressure of the cylinders 72. The work sizing head 15, of course, is moved downwardly along with the coil height adjustment screws 58, and it engages and operates a mechanically operated air valve 76 supported on the stop block 16. This air valve 76 is operative to release the air pressure on the cylinders 72, and the work sizing head 15 is thereby permitted to lower until it engages the stop block 16.

At the bottom of the stroke of the main ram 14, when the adjustment screws 58 are contacted by the main ram, the final expander plate 56 bottoms into the recessed cavity or channel 51 in the stripper plate 50. At this point, the final expander tooling plate 62 extends through the opening in the stripper plate 50 and bottoms against the upper surface of the stripper tooling plate 49. The final expanders 63, like the strippers 23, are sleeves, and these final expanders 63 pass through the strippers 23 as the final expander tooling plate 38 lowers and bottoms against the stripper tooling plate 49. The expander rods 22 likewise pass through the strippers 23, as the main ram 14 is lowered, to physically expand the tubes as they are extended into the coils, in the well-known manner. It is the function of the final expanders 63 to "bell" the ends of the tubes in the coil to an internal diameter as required to receive the return bends (short 180° bends) which are later soldered in place.

The hydraulic system for operating the main cylinder 18 of the expander 10 is illustrated schematically in FIG. 6, and that for the air cylinders 72 is similarly illustrated in FIG. 7. As indicated above, one of the advantages of the design of the expander 10 is that it permits the same "push type" hydraulic cycle with a simple regenerative control presently used with conventional vertical expanders to be used. The expander 10 therefore can operate with a fast main ram velocity, normally 18 to 25 feet per minute, during the major portion of the expansion cycle, and with maximum tonnage during during the final sizing operation when it is required as indicated by a rise in system hydraulic pressure. The piston rod 19 of the main cylinder 18 is of a diameter such that its cross-sectional area is approximately one-half the area of the piston head. This will provide a ram speed on the return stroke approximately equal to the speed of the power stroke on the regenerative cycle as explained below.

The operation may be generally described as follows. When the motor 80 is energized, it operates the pump 81. While idling, the hydraulic fluid pumped from the reservoir 82 is merely coupled through the hydraulic valve 87 back into the reservoir. When the expansion cycle is initiated, solenoids 84 and 85 are energized, and the hydraulic fluid is pumped through the line 86, the valve 87 and the line 88 to the cylinder 18 against the head 89 of the piston 19. Simultaneously, hydraulic fluid below the piston head 89 is caused to flow from the cylinder 18 through the line 90, the valve 91 and the line 92, to the line 88 where it is joined with the hydraulic fluid pumped to the cylinder 18 by the pump 81. A fast main ram velocity is therefore provided, until the main ram 14 engages the ends of the coil height adjustment screws 58, at which time the work sizing head 15 contacts the coil to perform the sizing operation and sizing of the tube ends. An increase in hydraulic pressure is experienced at this time, which is detected by the pressure switch 93. The latter then operates to de-energize the solenoid 85 so that the fluid in line 90 is

directed through the four-way valves **91** and **87** into the reservoir. With solenoid **84** still energized, a slow main ram velocity results, along with maximum tonnage being exerted on the coils by the action of the main cylinder **18**. These valves are spring-centered, so that when neither of the solenoids **85**, **95** or **84**, **94** are energized, the flow will take place through the center set of valve parts.

Upon completion of the final sizing of the coils, the main ram **14** is raised. To raise the latter, the solenoids **94** and **95** are energized so that the hydraulic fluid now flows through line **86**, the valves **87** and **91**, and the line **90** to the cylinder **18** below the piston head **89**. The hydraulic fluid atop the piston head flows through the lines **88** and **92** and the valves **87** and **91** into the reservoir. When the main ram **14** is at its upper vertical limit, all of the solenoids **84**, **85**, **94** and **95** are de-energized. De-energizing Solenoids **84**, **85**, **94** and **95** any time during the cycle will stop ram movement and maintain its position until solenoids are re-energized.

A pilot operated counterbalance valve **106** is provided to prevent the downward creeping of the main ram **14**, the guide plates **43** and **44**, and the work sizing head **15** when the expander **10** is shut down by de-energizing the main ram pump motor **80**, due to the weight of the main ram, the guide plates and the work sizing head and leakage through the hydraulic control valves. The spring force on the counterbalance valve **106** is preset to a value larger than the hydraulic pressure generated by the static weight of the main ram, the guide plates and the work sizing head, and the parts attached thereto. Thus, the spring pressure will offset the pressure in the pilot line **108**, preventing flow through line **90**, the counterbalance valve **106** to the valve **91**. The check valve **107** will also prevent flow around the counterbalance valve **106**, when oil flow is from bottom side of cylinder **18** through line **90**, but will permit flow around the counterbalance valve when flow is from valve **91** to bottom of cylinder **18**.

When the pump **81** is running and flow is established through valves **87** and **91**, the pressure in line **90** will exceed the preset spring pressure of the counterbalance valve **106**, and this pressure is transmitted to pilot the counterbalance valve **106** to the free flow position. Thus, during the expansion cycle, the hydraulic oil in line **90** returning from the lower side of the piston head **89** of main cylinder **18** pilots the counterbalance valve **106** to the open position. On the return stroke, flow is established through the check valve **107**, applying pressure to the pilot line **108**, also opening the counterbalance valve **106** to flow, and flow takes place through both the check valve **107** and the counterbalance valve **106**.

A pilot operated bypass valve **109** also is provided to limit the maximum pump head pressure, by diverting flow back to the tank when the hydraulic pressure rises to its setting.

The operation of the air cylinders **72** can be seen in FIG. **7**, wherein the mechanically actuated air valve **76** simply controls the supply of air thereto, from an air supply **96** which provides air at approximately 100 psi. A manually adjustable pressure regulator **97** also is provided, to permit the air pressure supplied to the cylinders to be adjusted to a desired operating level.

Having now described the construction of the expander **10**, its operation can be generally described as follows. In setting up the expander **10**, the stop block **16** is slidably adjustably positioned to establish or set the height of the coils to be formed. This is accomplished by lowering the work sizing head **15** so that it is seated atop the stop block **16**, and the stripper plate locks **64** are lockingly engaged with the lock extensions **66**. The threaded screws **58** should be raised at this time, so as not to interfere with the lowering of the work sizing head **15**. With the stripper plate locks **64** engaged, the threaded screws **70** can be loosened to release the friction plate locks **68**. If the stop block **16** is to be lowered, the final plate **15** is lowered so as to forcibly urge the stop block **16** to the desired position and the threaded screws **70** tightened to again engage the friction plate locks **68** with the outer guide tracks **31** and **31'**.

If the stop block **16** is to be raised, the main ram **14** is driven to its bottom position with the adjustment screws **58** bottomed against the rod ends of the air cylinders **72**. On the work sizing head **15**, the final expander plate **56** now nests into the recessed cavity or channel **51** in the stripper plate **50**, bottoming against the upper surface of the latter. Approximately 1 inch of guide rods **59** and **60** will now be exposed between the enlarged stop nuts **61** and its lower surface of the stripper plate **50**. The stripper plate locks **64** engage with the lateral lock extensions of the stop block **16**. A wedge tool (not shown) then is fitted about the guide rods **59** and **60**, between the stripper plate **50** and the enlarged stop nuts **61**. These wedge tools prevent the guide rods **59** and **60** from passing through the stripper plate **50** and raising the final expander plate **56**. The latter therefore will not engage and release the stripper plate locks **64**. Accordingly, when the stripper plate **50** is raised, the stop block **16** is simultaneously raised since it is locked to the stripper plate **50** by the stripper plate locks **64**. When raised to the desired position, the threaded screws **70** are tightened to engage the friction plate locks **68**, to lock the stop block **16** in this position. The wedge tools are removed, and the stripper plate locks **64** are released when engaged by the final expander plate **56**.

The air cylinders **72** are extended by the action of the mechanically actuated air valve **76**, as soon as the stripper plate locks **64** are disengaged. The threaded screws **58** then are threadably raised or lowered by a measured amount exactly equal to the raising or lowering of stop block **16** so that the ends thereof will seat atop the pistons **74**, and the work sizing head **15** is supported in spaced relationship from the top of the coils stacked on the nest tooling plate **17**, to prevent the coils from being prematurely sized.

Next, tooling parts corresponding in number and pattern to the coils to be formed are assembled with their respective retainer plates. For example, hairpin nests **24** are placed in the nest retainer plate **17**, final expanders **63** are affixed with the final expander tooling plate **38**, expander rods **22** are affixed within the rod tooling plate **21**, and strippers **23** are affixed within the stripper tooling plate **49**.

In addition, coil retaining and reinforcing fixtures are removably attached to the expander frame. A row of shoulder bolts arranged vertically and equally spaced

into a pair of plates affixed to the front faces of alignment plates **28** and **29** serve to retain these fixtures. Each fixture is hooked over a pair of bolt heads. The number and dimensions of these backup fixtures is governed by the capacity of the expander **10**. One or more fixtures is employed dependent upon the dimensions of the coil to be expanded. Each fixture has a hinged "door" **110** so that a coil may be rapidly inserted and removed.

Each of these fixtures also has an adjustment allowing for different front-to-back (fin depth) dimensions in addition to adjustable side supports for coil width.

For a coil of given dimensions, it is pre-determined the quantity and size of fixture (or fixtures) to employ as determined by the height of the coil. The fixture is located on the expander's frame as required and the depth and width adjustments are made to the fixture (or fixtures) as the corresponding dimensions of the coil dictate.

Following installation of the proper quantity and pattern of tooling parts and installation and adjustment of the coil backup fixtures, the coil is placed into the expander **10** with the backup fixture door **110** open. It is nested firmly into the nests **24** and the backup fixture doors **110** are then closed.

Upon operating the main cylinder **18**, its piston **19** is extended which action, in turn, lowers the main ram guide carriage **20**. The latter is guided by means of the guide rollers **42** and the inner guide tracks **30** and **30'** on the frame members **25** and **26**. The main ram **14** being integrally affixed to the main ram guide carriage **20** likewise is lowered, and the expander rods **22** slidably pass through the rod alignment tooling plates **48**, the final expander plate **56**, the final expander tooling plate **62**, the final expanders **63**, the stripper plate **50**, the stripper tooling plate **49** and the strippers **23**, into the ends of the tubular members of the coils. As the expander rods **22** are forced into and through the tubular members, the latter are radially expanded by balls or bullet-shaped tips affixed to the ends of the expander rods **22** to unite them with the fins of the coils, in the generally well-known manner. As indicated above, the main cylinder **18** is operated with a "push-type" hydraulic cylinder action and a regenerative control to achieve maximum ram speed during the major portion of the ram cylinder stroke.

As the main ram guide carriage **20** and the main ram **14** are lowered, the rod alignment plates **43** and **44** stack up atop the work sizing head **15**, as illustrated in FIG. 4. The support rods **45** and **46** which normally support them merely slide through these plates and extend vertically upwardly, as illustrated.

As the main ram **14** starts to lower, the work sizing head **15** also is lowered until the ends of the threaded screws **58** seat atop the pistons **74**. These pistons **74** support the work sizing head **15**, while the tubular members of the coil are being expanded by the expander rods **22**. At the end of the stroke of the main ram **14**, the ram plate **35** of the main ram **14** engages the tops of the height adjustment screws **58** and forces work sizing head **15** down, overcoming the air pressure of cylinders **72** until the final expanders **63** come in contact with the tube ends of the tubular members of the coil. The combined resistance caused by sizing of the tube ends of the tubular members by the final expanders **63** and the coil length sizing by the strippers **23** causes an increase in hydraulic pressure in line **88** to the main ram cylinder **18**. This increase is detected by the pressure switch **93** which then switches the hydraulic cycle to a non-regenerative cycle so that maximum tonnage is exerted.

When the threaded screws **58** are forcibly urged downwardly to the point that the work sizing head **15** engages and operates the mechanically operated air valve **76**, the air cylinders **72** are operated to retract their pistons **74**. The work sizing head **15** now is lowered without the resistance previously provided by the air cylinders **72**, to engage the strippers **23** with the coil being formed, and the final expanders **63** with the tube ends so as to "bell" these ends and perform the final coil length sizing operation. When the work sizing head **15** seats atop the stop block **16**, the sizing operation is completed, and the operation of the main cylinder **18** is reversed so as to retract its piston **19**.

At the time that the work sizing head **15** seats atop the stop block **16**, the stripper plate locks **64** are engaged. The work sizing head **15** therefore is locked and held in the final sizing position until the expander rods **22** are withdrawn from the tubular members of the coils. At this time, the ram plate **35** of the main ram **14** engages the enlarged stop nuts **61** on the upper ends of the guide rods **59** and **60**. These shafts then are physically raised which action, in turn, raises the final expander plate **56** which is affixed to them. The final expander plate **56** upon being raised, engages and releases the stripper plate locks **64**. When the enlarged stop nuts **61** on the lower ends of the guide rods **59** and **60** engage the stripper plate **50** of the work sizing head **15**, the whole work sizing head is raised. When the main ram reaches its vertical upper limit, as determined by a limit switch (not shown) which is actuated when the work sizing head is raised a set distance above the stop block **16**, the cycle is completed, and the formed coil can be removed.

From the above description, it can be seen that the construction and operation of the expander **10** is such that its overall height can be substantially reduced, in comparison to conventional vertical expanders of the same capacity. This reduction approaches a 30 percent reduction, and results primarily from the fact that the main cylinder **18** is offset from the main ram **14**, rather than being aligned atop the main ram as has been the standard practice in the past. This offset relationship is accomplished by affixing the main ram **14** to the upper end of a main ram guide carriage which is slidably engaged and guided between the two alignment plates **28** and **29** of the expander **10**, and by affixing the piston **19** of the main cylinder **18** to the carriage cross frame **41** as the lower end of the main ram guide carriage **20**. The length of the main ram guide carriage **20** is substantially equal to the length of the piston **19** of the main cylinder **18**, so that the main ram **14** is vertically lowered the same distance it would be lowered if the main cylinder is affixed atop the main ram. Therefore, the height of the vertical expander **10** can be reduced an amount substantially corresponding to the length of its main cylinder or piston.

This construction and operation furthermore permits the main cylinder **18** to be vertically mounted in a fashion such that a "push-type" hydraulic cycle with a

regenerative control on the initial portion of the expander cycle can be used, thus operating with a faster main ram velocity, as previously explained. This construction, with the "push-type" hydraulic cycle will also generate greater tonnage on the power stroke than a "pull-type" hydraulic cycle, with the same cylinder bore and system pressure since the piston rod area does not subtract from the piston area.

The mechanical design of the expander **10** also provides a substantial improvement over most vertical expanders. The main ram guide carriage **20**, the work sizing head **15** and the stop block **16** all being carried by the vertical frame members **25** and **26** provides for better guiding and alignment of the working surfaces of the expander **10**.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and certain changes may be made in the above construction. Accordingly, 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.

Now that the invention has been described, what is claimed as new and desired to be secured by Letters Patent is:

1. Tube expansion apparatus for forming articles such as cooling coils and the like for air conditioners and other heat exchange apparatus of expansion rods for radially expanding the tubular members thereof, a work sizing head including a final plate supporting a plurality of final expanders for finally sizing said articles, and a stripper support member supporting a plurality of strippers to hold said coil while retracting said expansion rods, and a main cylinder having a piston for raising and lowering said main ram, said final plate and said stripper support member to extend said expansion rods into said tubular members to radially expand them and to engage said final expanders with said articles to size said articles and to engage said strippers for retracting said expansion rods, the improvement comprising a pair of parallel, spaced-apart frame members, a main ram guide carriage of a length substantially corresponding to that of said main cylinder slidably disposed between and guided by said frame members as it is raised and lowered, said main ram being fixedly secured to the upper end of said main ram guide carriage, said main cylinder being vertically supported between said frame members rearwardly of said main ram with its piston extending downwardly and affixed to the lower end of said main ram guide carriage, said piston upon being extended from said main cylinder lowering said main ram guide carriage and hence said main ram affixed to it, said final plate and said stripper support member being slidably supported upon said frame members beneath said main ram and raised and lowered by said main ram as it is raised and lowered.

2. The tube expansion apparatus of claim **1**, further including a push-type hydraulic cycle with a regenerative control for said main cylinder.

3. The tube expansion apparatus of claim **1**, wherein said pair of frame members have inner guide tracks, said main ram guide carriage being slidably engaged with said inner guide tracks so as to be guided and aligned thereby.

4. The tube expansion apparatus of claim **3**, wherein said main ram guide carriage has roller guide means at the upper and lower ends thereof which engage the opposite sides of said inner guide tracks to guide and align said main ram guide carriage.

5. The tube expansion apparatus of claim **3**, wherein said main ram guide carriage further has brass slide pads at the upper and lower ends thereof which engage the inward edges of said inner guide tracks to guide and align said main ram carriage.

6. The tube expansion apparatus of claim **3**, wherein said pair of frame members further have outer guide tracks, said final plate and said stripper support member being slidably engaged with said outer guide tracks so as to be guided and aligned thereby.

7. The tube expansion apparatus of claim **6**, wherein said final plate and said stripper support member have roller guide means thereon which engage the opposite sides of said outer guide tracks and brass slides thereon to engage the outward edges of said outer guide tracks to guide and align said final plate and said stripper support member.

8. The tube expansion apparatus of claim **1**, further including a pair of air cylinders having pistons, a pair of coil height adjustment screws coupled to said final plate and vertically disposed so that the lower ends thereof are engageable with respective ones of said pistons, said pistons normally being extended and engaged by the ends of said coil height adjustment screws to support said final plate and said stripper support member to prevent the final plate from engaging said articles and prematurely sizing them and to prevent said stripper support member from engaging and crushing said coil.

9. The tube expansion apparatus of claim **8**, further including control means for operating said air cylinders to retract their pistons when said final plate is forcibly urged downwardly by said main ram to a predetermined position.

10. The tube expansion apparatus of claim **9**, wherein said control means comprises mechanical air valve means physically operated by said final plate.

11. The tube expansion apparatus of claim **1**, further including a stop block which is releasably locked to said pair of frame members beneath said work sizing head, said work sizing head having a final plate lock on each of the opposite sides thereof which lockingly engage with said stop block when said work sizing head is seatingly engaged atop said stop block, said final plate locks preventing said work sizing head from being raised before said expansion rods are withdrawn from said tubular members, and lock release means for releasing said final plate locks when said expansion rods have been withdrawn.

12. The tube expansion apparatus of claim **11**, wherein said lock release means are coupled to and operated by said main ram to physically engage and to release said final plate locks when said main ram is vertically raised to a position where said expander rods are withdrawn from said tubular members.

13. The tube expansion apparatus of claim **11**, further including a pair of guide rods affixed to said main ram and to said work sizing head, said work sizing head normally being hangingly supported by said main ram by means of said guide rods said lock release

means being fixedly secured to said guide, rods and operated thereby to release said final plate locks when said guide rods are physically raised by said main ram.

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Disclaimer and Dedication

3,688,533.—*Ward A. Ames*, Danville, Ill. TUBE EXPANSION APPARATUS. Patent dated Sept. 5, 1972. Disclaimer and dedication filed Jan. 2, 1975, by the assignee, *Tridan Tool & Machine, Inc.*

Hereby disclaims and dedicates the entire remaining term of said patent to the People of the United States.

[*Official Gazette April 8, 1975.*]