Sept. 21, 1965 A. J. NIEBER, JR., ETAL 3,207,829

MEANS AND METHOD FOR TENSIONING WIRE

Filed Feb. 2, 1961 6 Sheets-Sheet 1

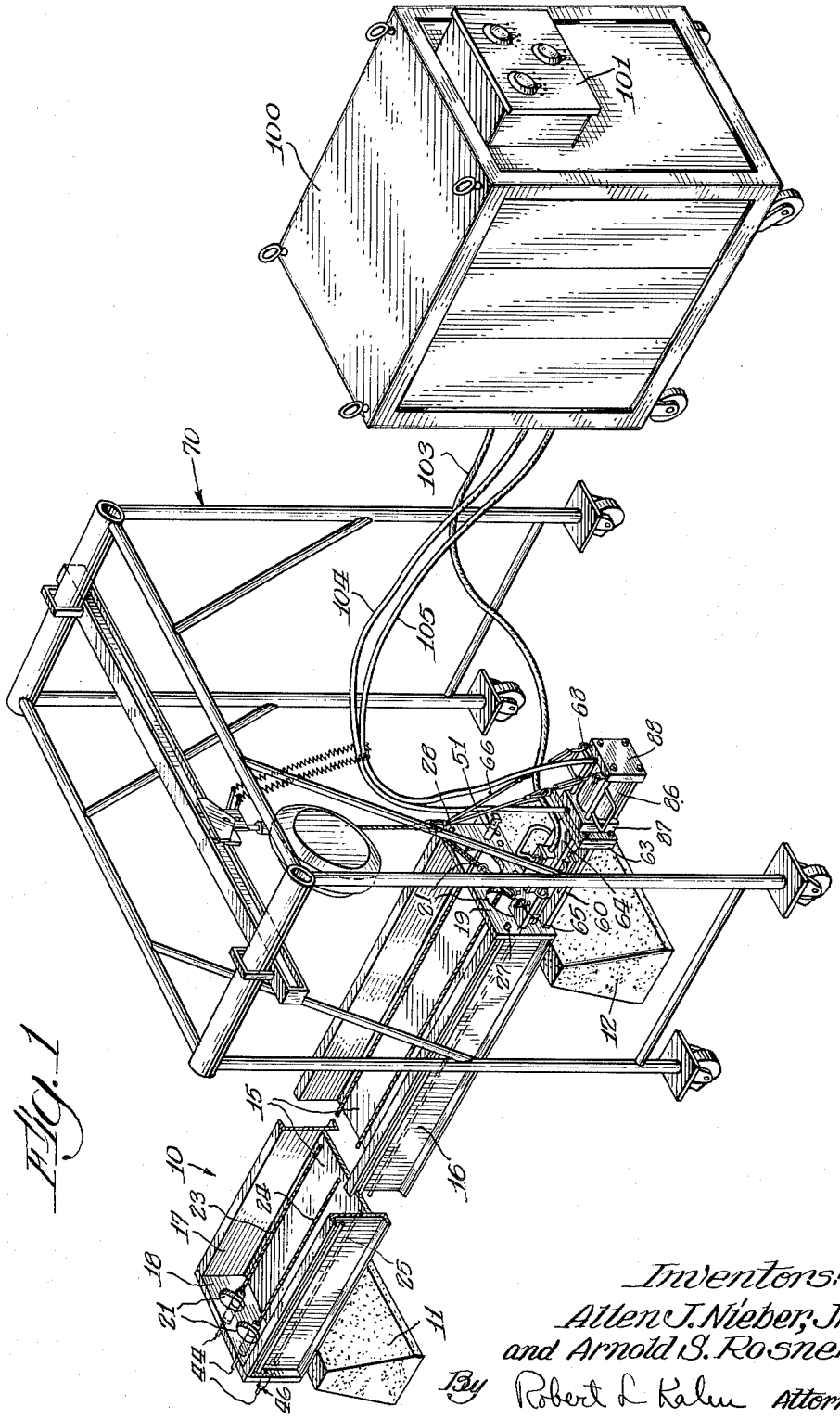


Fig. 1

Inventors:
Allen J. Nieber, Jr.
and Arnold S. Rosner
By Robert L. Kahn Attorney

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MEANS AND METHOD FOR TENSIONING WIRE

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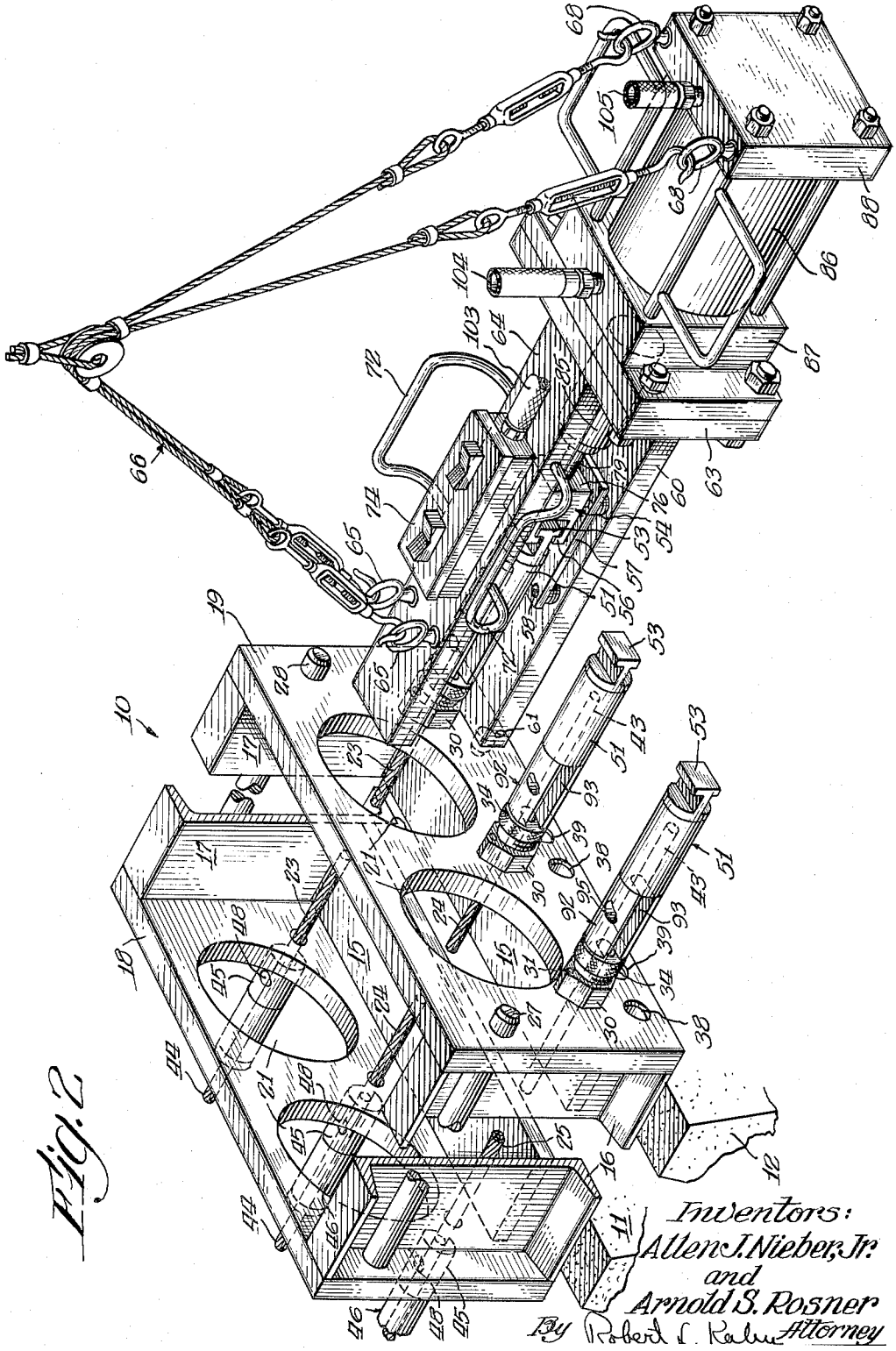


Fig. 2

Inventors:
Allen J. Nieber, Jr.
and
Arnold S. Rosner
By Robert L. Kahn Attorney

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MEANS AND METHOD FOR TENSIONING WIRE

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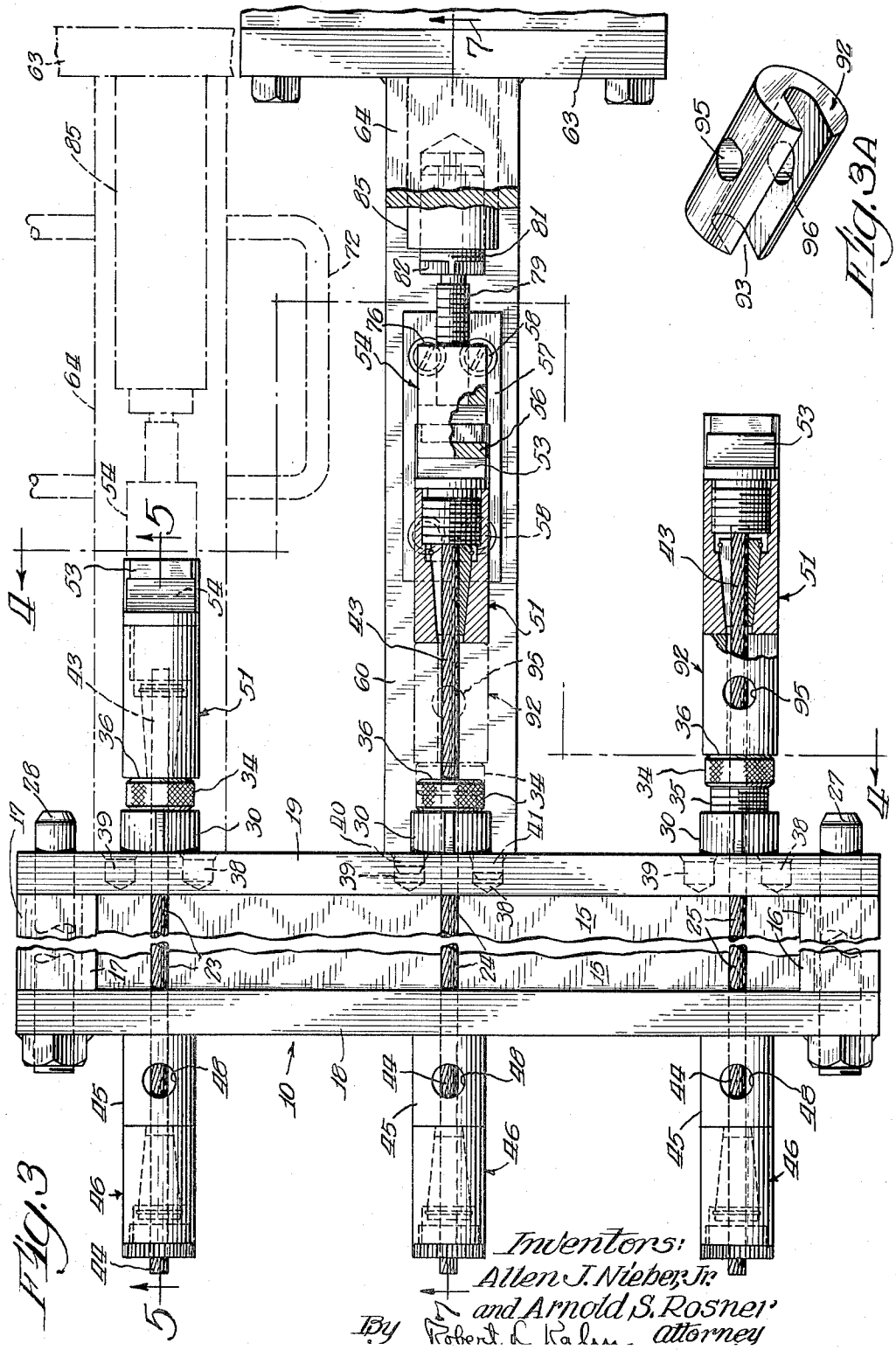


FIG. 3

FIG. 3A

Inventors:
Allen J. Nieber, Jr.
and Arnold S. Rosner
By Robert L. Kalan attorney

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MEANS AND METHOD FOR TENSIONING WIRE

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Fig. 10

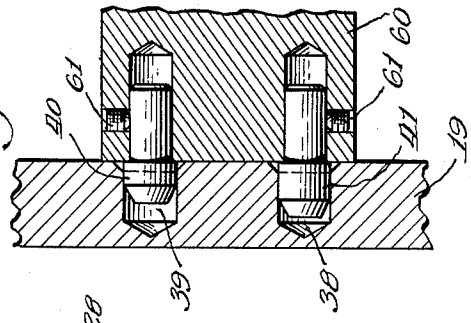


Fig. 9

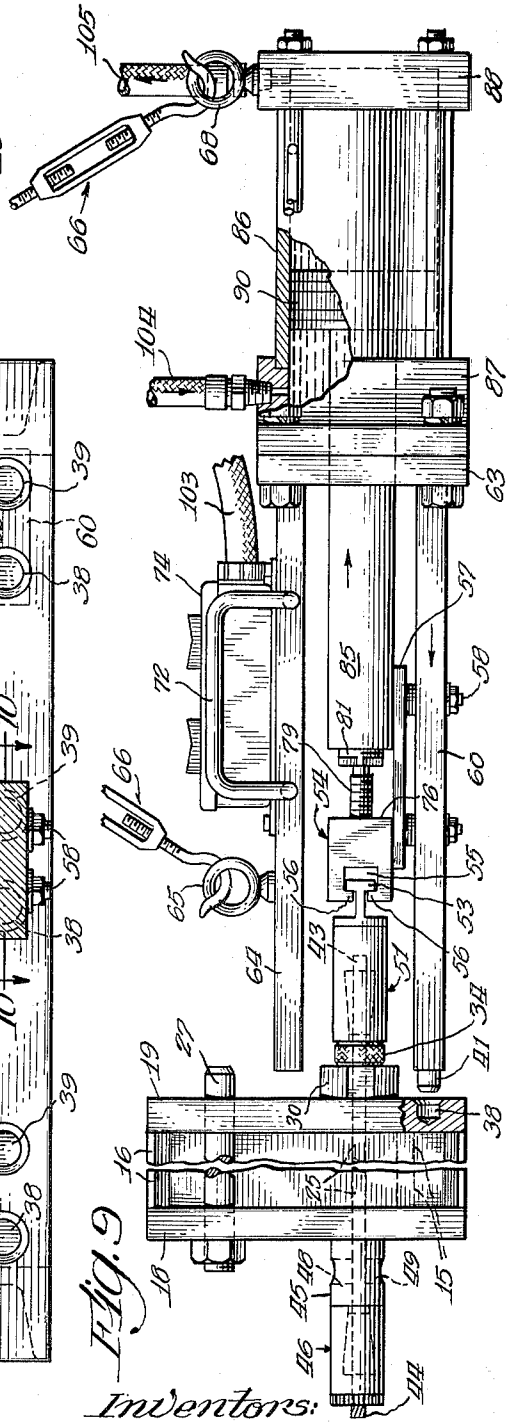
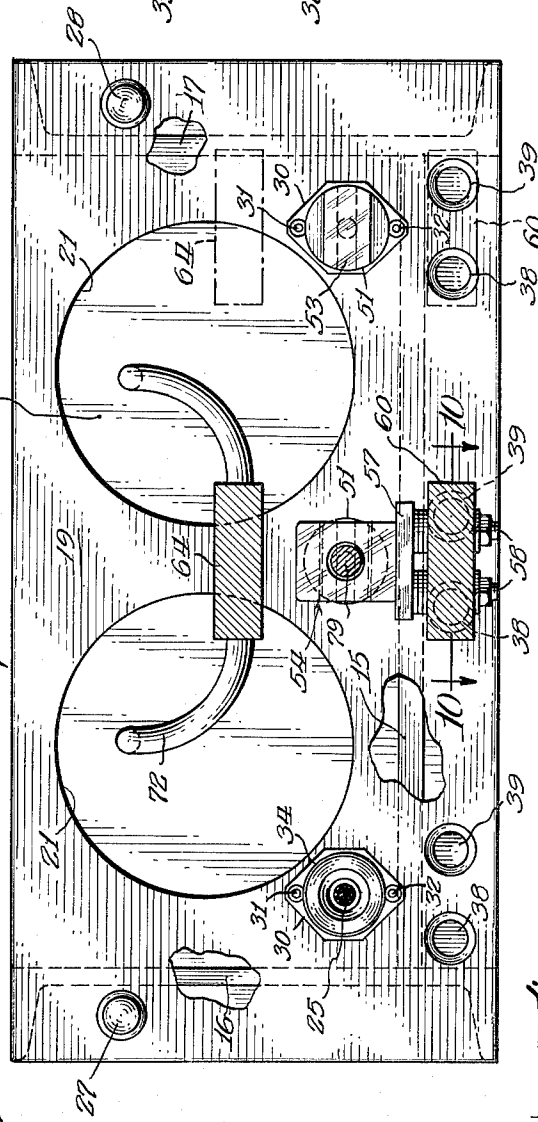


Fig. 11



Inventors:
Allen J. Nieber, Jr.
and Arnold S. Rosner
By Robert P. Kahn Attorney

Sept. 21, 1965 A. J. NIEBER, JR., ETAL 3,207,829

MEANS AND METHOD FOR TENSIONING WIRE

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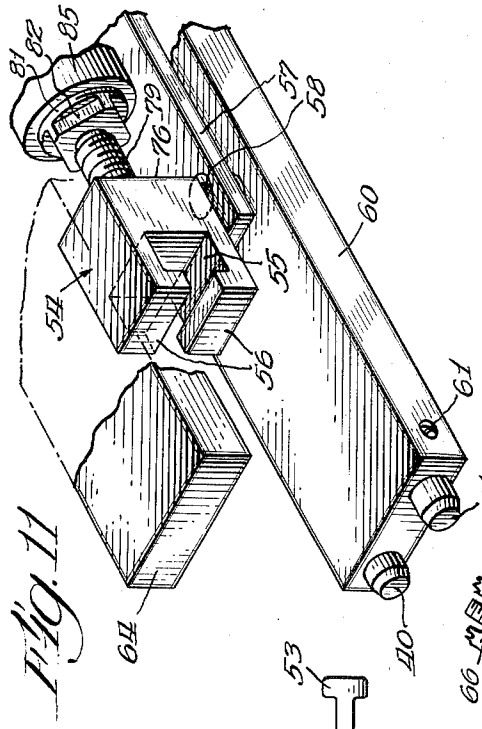


Fig. 11

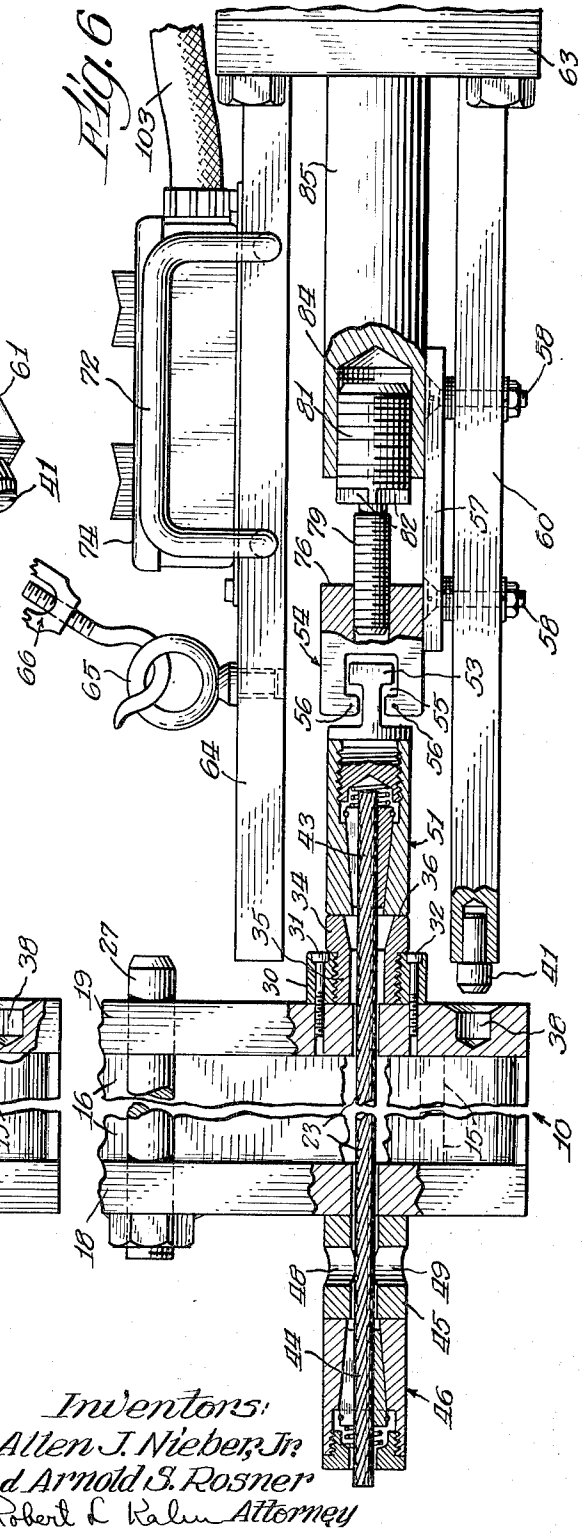


Fig. 6

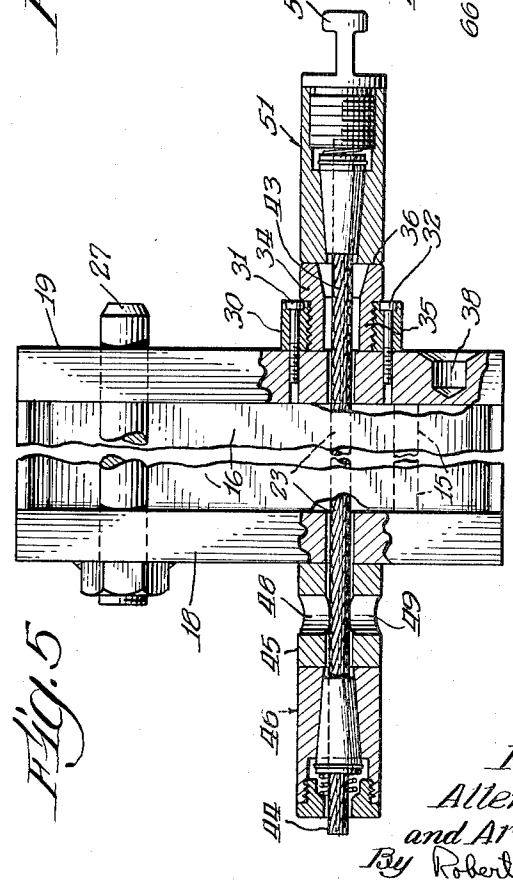


Fig. 5

Inventors:
Allen J. Nieber, Jr.
and Arnold S. Rosner
By Robert L. Kalen Attorney

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MEANS AND METHOD FOR TENSIONING WIRE

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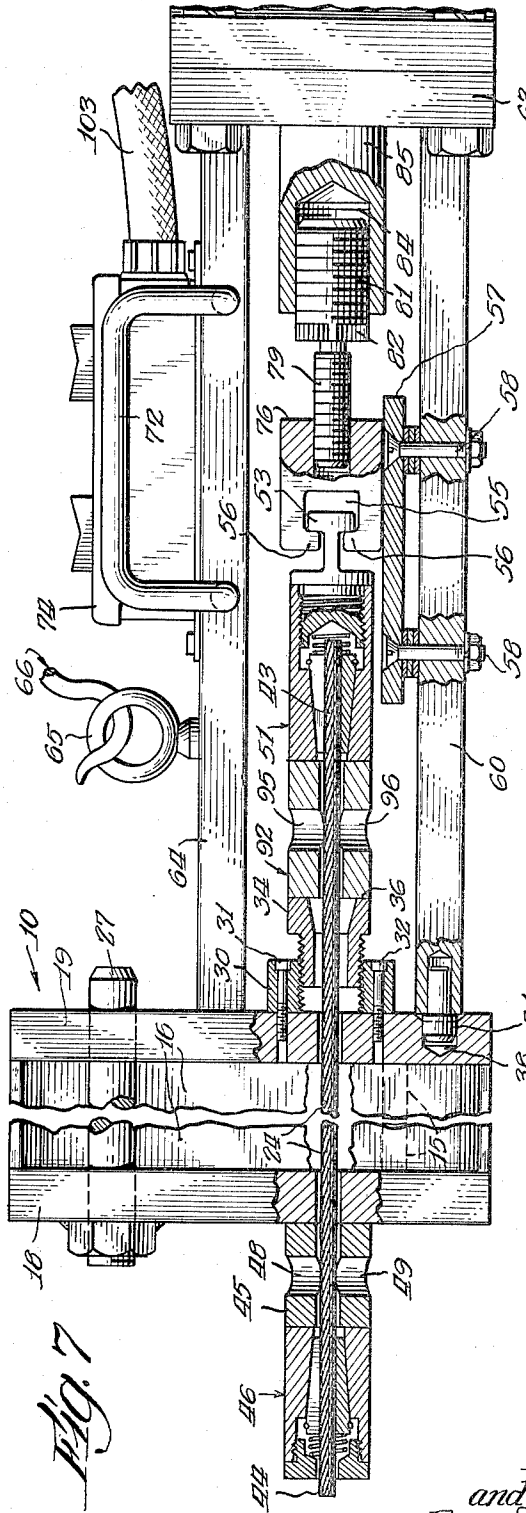


Fig. 7

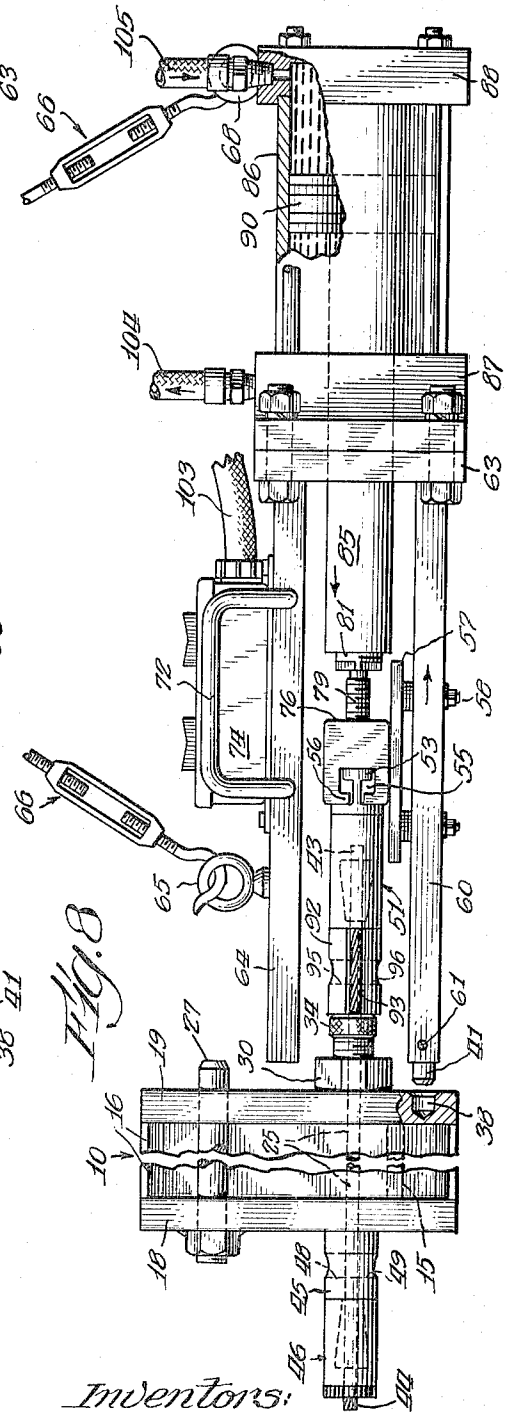


Fig. 8

Inventors:
Allen J. Nieber, Jr.
and Arnold S. Rosner
By Robert L. Kahn Attorney

United States Patent Office 3,207,829 Patented Sept. 21, 1965

3,207,829

MEANS AND METHOD FOR TENSIONING WIRE

Allen J. Nieber, Jr., Livonia, Mich., and Arnold S. Rosner, Chicago, Ill., assignors to The Flexicore Co., Inc., Dayton, Ohio, a corporation of New York

Filed Feb. 2, 1961, Ser. No. 86,689
3 Claims. (Cl. 264—228)

This invention relates to a means and method for tensioning wire and more particularly for tensioning wire during the manufacture of a prestressed slab of concrete or the like.

Longitudinally reinforced slabs of concrete are widely used and an example of a slab of this character is illustrated in United States Patent No. 2,299,070, issued October 20, 1942. Slabs of this general type are made in various widths, heights and thicknesses and lengths of as much as 30' or 40'. A common size of such slab in wide use is 8" x 16". Such slabs are provided with longitudinal steel reinforcement in the form of simple wire or rod or stranded wire as desired. For convenience, these reinforcing elements will be referred to as wires. Certain of the wires, if not all, are tensioned and the tension must be maintained by external means until the cast slab is completed and cured, after which the bond of the concrete to the steel will maintain the tension for the life of the slab.

Prestressed slabs are generally disposed in side by side relation. It is important that slabs have similar deflection characteristics when laid in side by side relation. A slab which is ¼" out of a line transverse to a number of slabs is objectionable and results in extra work and expense. An important factor in the design of a slab is camber and a major factor in camber is the tension in the prestressing wires. It is therefore very important in the manufacture of slabs to control the tension in prestressing wires at all times until the concrete is cured. In theory, the tolerance on wire tension should be very small, no more than about 1%. In practice, it is difficult to hold this limit, without great expense, and as a result tolerances up to 5% are common. To a large degree, this tolerance range is a result of conventional methods of manufacture.

In general, the elongation of a prestressing wire is used, during slab manufacture, as a control factor on the assumption that elongation and wire tension are related to each other in a simple relationship. This assumption does not work out in practice for a number of reasons. One is that wire diameter will vary as much as 5% and in stranded wire, such a cumulative change could result in an effective change in wire diameter of much greater than 5%. Another reason is that the modulus of elasticity may vary from one wire roll to another by 5% or more. In the case of stranded wire the tendency of the wires to alter their twist pitch makes for a much greater than 5% variation in the stress-strain relation. This untwisting tendency is particularly noticeable if high stresses are used.

To stress steel to just below its elastic limit when used in concrete results in the most efficient utilization of the steel. However, it is clear from the above considerations that the elongation control for steel wire is so inaccurate as to make it impossible to manufacture slabs with steel stressed close to the elastic limit. As a result, it has been impossible to use steel most efficiently in conventional manufacturing methods. In addition, it is not easy to compensate for slight dimensional changes in the casting forms due to wear and tear, as well as the various lengths to which slabs are cast.

Slabs may be cast in molds or forms such as disclosed

in the patent referred to above. In such case, a cast slab will have the desired length.

After a mold is set up with tensioned wires and tubes properly inflated for providing longitudinal passages in a slab, the mold is filled with a concrete mix, tamped in suitable fashion and transported to a steam curing room. Setting up the reinforcing wires to a suitable tension has been time consuming and has constituted a rather expensive step in the entire procedure for manufacturing prestressed slabs.

Various attempts have been made to speed the tensioning steps with indifferent success. As a rule, individual wires are handled separately. Except where nuts are used on threaded end portions of tensioned wires, the tension generating means is usually separate from the tension holding means. Attempts to speed up the tensioning of such wires or rods has generally resulted in inferior products.

Another serious drawback has been due to the fact that after a desired tension in a wire has been obtained by a tensioning means, the transfer of tension to a holding means has invariably resulted in a marked decrease in tension generally called slip loss. Thus if a wire has a yield point of 190,000 p.s.i., it would be desirable to tension this wire to 170,000 or 180,000 p.s.i. With tensioning means heretofore available, it has been practically impossible to maintain this value accurately when the tension creating means is replaced by a simple tension holding means. As a rule, the action of tension holding means has involved some wire slippage while the holding means takes a grip on the wire upon the transfer of the tension from the tension creating means to the tension holding means. Such slippage has permitted the wire to shorten enough so that in the slab lengths being handled, a serious reduction in tension has resulted. This reduction in tension is not sufficiently constant to be a reliable factor. Even if such reduction were relied upon, it might be necessary to overstress the wire to compensate for the drop in tension or use the wire less efficiently.

In the new system disclosed herein, the accuracy of stress maintenance during the transition when the stress creating means is disconnected from the tensioned wire is very high and for all practical purposes there is no significant change in the stress of the wire during this transition. In addition, the invention makes it unnecessary to change anything to take account of different slab lengths.

For a complete disclosure of the invention, reference will now be made to the drawings wherein:

FIGURE 1 is a perspective view of the wire tensioning system applied to a wire in a casting form.

FIGURE 2 is a perspective view on an enlarged scale of the tensioning jack applied to one wire in a casting form, the drawing also showing two other wires which have previously been tensioned.

FIGURE 3 is a plan view illustrating various steps in connection with tensioning wires in a casting form.

FIGURE 3A is a perspective detail of a slack take-up block for use in maintaining tension until the concrete has set.

FIGURE 4 is a view on broken line 4—4 of FIGURE 3, showing a wire ready for tensioning.

FIGURE 5 is a section on line 5—5 of FIGURE 3.

FIGURE 6 is an elevation partly in section showing the tension jack hooked on for operating on a wire.

FIGURE 7 is a section on broken line 7—7 of FIGURE 3, showing the wire after tensioning; FIGURE 7, however, showing the take-up block positioned on the wire and adjustable spacer sleeve taking up excess wire length.

FIGURE 8 shows the parts of FIGURE 7 with the jack being removed from a tensioned wire.

FIGURE 9 shows the jack in preparation for hooking on to a wire prior to tensioning, this view being similar to FIGURE 6 but showing the hydraulic cylinder in detail.

FIGURE 10 is a sectional detail showing the jack locating pins in recesses in the live bulkhead.

FIGURE 11 is a perspective detail showing the jack base and the detachable coupling yoke.

Referring first to FIGURE 1, a steel casting form, generally indicated by **10**, rests upon suitable supports such as, for example, blocks **11** and **12**. Casting form **10** may be constructed in a number of ways, one of which is more fully disclosed in the aforementioned patent. Inasmuch as the details of the casting form are not important for the present invention, except at the bulkheads, a detailed description will not be given. Instead, a simple casting form is ilustrated having bottom **15**, sides **16** and **17** and bulkheads **18** and **19**. As a rule, one of the bulkheads, such as **18**, may be made adjustable insofar as location along the casting form is concerned so that slabs having any desired length up to the maximum may be cast. For convenience, bulkhead **18** will be referred to as the dead end.

Bulkhead **19**, which may be considered as a live bulkhead, is generally similar to bulkhead **18** in many respects. Thus the two bulkheads have openings **21** for accommodating inflatable tubes to provide longitudinal passages in the slabs. Both bulkheads also have openings for accommodating longitudinal prestressing wires, of which three are shown by way of example. These three wires **23**, **24** and **25** are here illustrated as being disposed near the bottom of the slab. It will be understood, however, that the location of the prestressing wires is immaterial insofar as the present invention is concerned.

Sides **16** and **17** of the casting form carry guide pins **27** and **28** at opposite sides near the top to cooperate with registering openings in the bulkheads for insuring correct position of the bulkheads.

Bulkhead **19** carries adjustable spacer sleeves on the outside thereof through which the tensioning wires will pass. Referring particularly to FIGURES 2 to 8 inclusive, bulkhead **19** has rigidly attached thereto, at each opening for a wire, nut member **30**. Each nut member **30** is attached to the bulkhead by bolts **31** and **32** passing through the nut and threaded into the bulkhead. Each nut member **30** is generally concentric with the wire opening through the bulkhead insofar as the threaded nut portion is concerned. Cooperating with each nut member **30** is spacer sleeve **34** having portion **35** externally threaded to extend within and cooperate with the thread in member **30**. Spacer sleeve **34** has active end portion **36** presenting a smooth annular bearing surface. Sleeve member **34** may be knurled on the outside or may have a hexagon or similar shape for taking a wrench. However, as a rule, nut member **30** will be adjusted easily by an operator and the nut member can turn freely enough so that no wrench will be required. Nut member **30** and sleeve **34** together form an adjustable spacer assembly.

In addition to the adjustable spacer assemblies carried by live bulkhead **19**, the live bulkhead is also provided with recesses **38** and **39** for each adjustable assembly. Bulkhead recesses **38** and **39** accommodate locating pins **40** and **41** of a jack, to be later described.

A prestressing wire will have one free end portion **43** extending for a few inches beyond live bulkhead **19**. The prestressing wire also extends beyond dead bulkhead **18** for a few inches. Thus the prestressing wire has dead end portion **44** passing through dead spacer sleeve **45** and through wire grip **46**. Dead spacer sleeve **45** may consist of a short length of heavy pipe having transverse aligned openings **48** and **49** extending through the pipe wall. Openings **48** and **49** are large enough to permit applying a torch to the wire for burning off end portion **44** from the body of the wire between the bulkheads. This burning will be accomplished after the tensioned wire has been solidly anchored to the concrete after curing of the concrete.

Wire grip **46** may consist of any one of a number of devices available on the market for tightly gripping a wire. Such devices usually have tapered jaws which are pulled toward each other to grip a wire as the wire is tensioned. Such wire grip devices are usually available as strand chucks. Since they are well known, no detailed description will be given.

Referring now to wire end portion **43** beyond the live bulkhead, this end portion is also gripped by wire grip **51**, which may have the same general construction as dead end wire grip **46**. However, live end wire grip **51** has rigidly attached thereto in any suitable fashion a generally T-shaped yoke anchor **53** extending away from the wire receiving end of grip **51**. It will be noted that wire grip **51** has a blind chamber for receiving wire portion **43**, anchor **53** terminating the chamber. In the case of dead end wire grip **46**, wire portion **44** can pass through the wire grip and project beyond. This will permit any excess wire length to be easily accommodated, although as will be apparent later, changes in wire length will be accommodated at the live end of the bulkhead.

Yoke anchor **53** cooperates with yoke **54** having transverse passage **55** therethrough and jaws **56** accommodating the head of anchor **53**. Passage **55** is large enough to permit the head of anchor **53** substantial longitudinal play. Yoke **54** is slidingly disposed upon guide plate **57** which is adjustably supported by bolts **58** on jack base **60**. Jack base **60** is a flat steel plate having locating pins **40** and **41** locked in recesses within the edge of the base by set screws **61**. Jack base **60** has, at the end remote from the locating pins, rigidly attached thereto end plate **63**. End plate **63** carries jack top plate **64** disposed above in the normal position of the jack and generally parallel to base **60**. Top plate **64** has a number of eye bolts **65** which may be used in connection with jack supporting harness **66**. Supporting harness **66** also engages eye bolts **68** at the cylinder end of the jack, to be described later. Harness **66** is supported from a portable harness frame **70** which may be provided with casters for easy movement. The harness frame is of conventional construction and, as illustrated in FIGURE 1, is made from lengths of pipe and cross bars.

Jack top plate **64** also has handles **72** extending on opposite sides of manual control box **74**. The control box contains some electric switches, which will be described in detail later.

Referring back to yoke **54**, head portion **76** of the yoke is recessed and tapped to accommodate bolt **79**. Bolt **79** is part of a differentially threaded bolt portion **81** having the exterior thereof threaded. Bolt portion **81** is larger in diameter than bolt portion **79** and has a finer thread than has portion **79**.

Hexagonal portion **82** will accommodate a wrench. The two threads have slightly different pitches and may be both right handed. Thus one turn of the differential bolt will result in a slight movement between yoke **54** and a ram to be described.

Bolt portion **81** cooperates with threaded recess **84** at the end of ram **85**. Rigidly supported from jack plate **63** is hydraulic cylinder **86** having end plates **87** and **88** respectively. End plate **87** of the cylinder is rigidly attached to jack plate **63** and these two plates are provided with openings through which ram **85** may pass. It is understood that ram **85** is a piston rod and is slidable into and out of cylinder **86** through suitable glands for providing a fluid tight seal. End plates **87** and **88** have suitable couplings to permit the introduction of fluid or liquid into the cylinder. Coupled to ram **85** is piston **90** which can operate within cylinder **86**. Pressure on one side or the other side of piston **90** will result in movement of the piston and consequent movement of the ram and coupled attachments.

A brief description of the steps in tensioning a wire

will now be given. Assuming that the casting form is set up as illustrated, for example, in FIGURE 1 and assuming that the prestressing wires are disposed within the casting form, the ends of each length of prestressing wire beyond the bulkheads will be prepared so that they are in the condition illustrated in FIGURE 4, for example. Dead end **44** of the wire will have dead spacer sleeve **45** and will have wire grip **46**. Live end **43** of the wire will pass through the adjustable spacer sleeve assembly consisting of members **33** and **34** and will extend into and be caught by live end wire grip **51**. Part **34** will be turned to its innermost position as seen in FIGURE 5. Live end wire grip **51** will have attached thereto yoke anchor **53**.

It is understood that in practice, the prestressing wire may be pulled from a reel and first passed through dead end bulkhead **18** and then successively passed through the various parts until the forward end of the wire is in wire grip **51**. While the wire is still on the reel and after cutting off the length to be used, the dead end wire grip can be put on and moved up by hand snugly against dead spacer sleeve **45**. Then the main wire supply from the reel can be cut off to the left of dead end wire grip **46**, as seen for example in FIGURE 5, so that the various parts extend straight out as illustrated, for example, in FIGURE 5.

The jack is now moved into position. First the jack is maneuvered so that yoke anchor **53** can be fitted into space **55** between yoke jaws **56**. When this has been accomplished, the jack is lined up so that pins **40** and **41** fit into the appropriate recesses in live bulkhead **19**. It is understood that piston **90** in cylinder **86** will generally be in the position where it is near end plate **87**.

It is obvious from FIGURE 9 that if piston **90** moves to the left, the yoke at the end of the piston rod will be moved toward the live bulkhead. If piston **90** is moved in the other direction, then the reverse will be true. The buttons on manual control box **74** are provided for the purpose of controlling the direction of movement of the piston. By thus controlling the position of piston **90** in cylinder **86**, it will be possible to move the jack into position as shown in FIGURE 2, for example, so that the system is ready to begin tensioning the wire. In this position, the locating pins on the jack base engage the recesses in the live bulkhead. Slack between the yoke jaws and the yoke anchor has been taken up. The differential screw coupling between the yoke and ram can be adjusted so that when the hydraulic system is in normal starting position all lost motion will have been taken up.

The jack is now ready to tension the wire, and accordingly, the appropriate button in control box **74** is kept down. Pressure within cylinder **86** forces piston **90** to the right, as seen in FIGURE 9 for example. The hydraulic system is provided with suitable means so that the desired tension in the wire is obtained smoothly and quickly. Assuming that the desired tension has been obtained, live wire grip **51** will be pulled to the right, as seen in FIGURES 6 and 9 for example, creating a space between wire grip **51** and part **34** of the adjustable spacer assembly.

As a rule, the amount of stretch of the wire for a given length will lie between certain limits for a certain desired tension in the wire. Slack take-up block **92** shown in FIGURE 3A, suitable for the desired stretch, can be used. Take-up block **92** is slotted at **93** to permit the block to be slipped over the wire. Take-up block **92** is provided with alined windows or apertures **95** and **96** extending transversely of the block to provide access for a torch to burn the wire after the slab has been cured.

With the wire stretched to a suitable value, slack take-up block **92** is slipped over the wire and adjustable spacer sleeve **34** is screwed out to take up excess wire length. The wire is now tensioned to the desired value with the wire grips at both ends of the wire in biting or operating position. With all excess space around the wire between the two grips fully taken up, it is now possible to relax the jack. This is accomplished by reversing the hydraulic system so that piston **90** moves to the left toward the live bulkhead. This motion is enough to cause the yoke to move to the left as seen in FIGURE 6, for example, while the yoke anchor remains stationary.

Space **55** within the yoke will be large enough so that sufficient clearance will be provided to permit the jack to be pulled away from the bulkhead sufficiently so that the jack may be moved laterally for disengaging the yoke and yoke anchor. The tensioned wire may be left, as illustrated for example in the bottom of FIGURE 3, with assurance that no immediate decrease in tension has occurred. After all of the wires for a casting form have been tensioned to desired values, the entire casting form can be filled with concrete and then moved into a steam room for curing. The only portions of the tensioning system which may remain with the casting form during curing are the wire grips and the dead and adjustable spacer sleeves. After the slab has been properly cured, a torch can be applied through the windows or openings in sleeves **45** and **92** to burn the wire away. Thereupon, the wire grips may be easily separated from the short wire strips and excess wire may be trimmed.

Referring to FIGURE 1, the entire hydraulic system is housed in power cabinet **100** having control panel **101**. The hydraulic system within power cabinet **100** is connected by one electric power cable **103** running to manual control box **74** and by two hydraulic hose **104** and **105** going to end plates **87** and **88**, respectively, of the hydraulic cylinder. It is understood that hose **104** and **105** will be of the type capable of withstanding considerable pressure.

The adjustable take-up member consisting of two telescoping sleeve members are provided with cooperating threads so that the overall length may be adjusted. It is possible to make the take-up sleeves long enough and provide them with a sufficient range of adjustment to make it unnecessary to provide the slotted fixed take-up blocks as illustrated in FIGURE 3A. In such case, the adjustable take-up sleeve can be provided with transverse windows or openings to permit access of a torch to the wire. It is of course possible to make the take-up sleeve of more than two threaded members.

It is also possible to have the fixed take-up block illustrated in FIGURE 3A provided with a threaded end portion for cooperating with threads upon fixed cooperating nut member **30**. In such case, take-up block **92** will function as a readily removable portion of the adjustable take-up means for covering the added length of wire between the live bulkhead and the wire gripper. It is clear that block **92**, if threaded, would not have complete threads around the block due to the slot in the block. It would therefore be necessary to make the adjustable take-up more massive. It is also possible to have a removable portion fill in the slot in the block and complete the threading thus rendering this block readily removable while maintaining its strength.

It is also possible to have one length of wire from the live bulk head extend to the dead bulk head and be looped around hooks and return to the live bulk head, both ends to be tensioned.

What is claimed is:

1. A facility for manufacturing cored prestressed concrete slabs having a length no greater than about 60 feet, each slab having an integral homogeneous mass of concrete within which are individually tensioned steel strands longitudinally of the slabs within the concrete and bonded thereto throughout the length thereof, said facility including a steel casting form structure having a wall portion through which strands to be tensioned extend to provide extra strand length, a sleeve-like strand chuck adapted to be disposed about a strand at the extra strand length, said strand chuck, when installed and gripping said strand, permitting the strand therein to remain straight,

means for engaging said strand chuck and tensioning said extra strand length, said strand chuck moving with strand elongation away from the casting wall portion, and means disposed between said wall portion of said casting form structure and said strand chuck and physically separate from said chuck and having passages therethrough for loosely accommodating a strand to provide incompressible spacing means about said extra strand length between said chuck and wall portion, said incompressible spacing means including sleeve-like cooperatively threaded members adapted to be turned with respect to each other for telescoping action for length adjustment, said incompressible spacing means also including means for exposing part of the extra strand length between said chuck and said wall portion to strand severing means whereby after strand tensioning and elongation and after adjustment of the length of said spacing means and transfer of the strand tensioning force to said spacing means (resulting from the removal of external strand tensioning means), said casting form and associated incompressible spacing means and strand chucks with tensioned strands may be handled for curing of the casting and thereafter permit strand severance at the exposed extra strand length portion to relieve the tension throughout the extra strand length, said threaded length adjusting means requiring adjustment only when said extra strand length is substantially free of tension and obviating the necessity for using considerable turning force at any time.

2. In the manufacture of prestressed concrete slabs having steel strands longitudinally thereof bonded to the concrete and longitudinally tensioned to a sufficiently high degree and the slabs having such a length that a reduction in strand elongation incident to the strand gripping action of a strand chuck of the type having jaws bearing on a straight length of strand results in a significant drop in strand tension, the steps which comprise: disposing a strand longitudinally of a casting form at a desired position in the casting region with said strand extending beyond said casting form through at least one end of the casting form to provide a strand gripping portion externally beyond said one casting form end, anchoring the strand portion adjacent the other casting form end to permit strand tensioning from said external strand gripping portion, applying a strand chuck of the aforementioned type to a part of the strand gripping portion, tensioning said strand to cause strand elongation and movement of said strand chuck away from said one casting form end until a desired strand tension has been obtained, adjusting the overall length between the chuck gripping part and a stationary form part of a substantially incompressible metallic spacing means loosely disposed about the tensioned strand length externally of the casting form to take up all added strand length without changing the strand tension, said adjusting including the step of relatively rotating two, telescoping, cooperatively threaded metal members disposed over tensioned strand and having an open area exposing said strand, freeing said strand chuck from external force generating means used in strand tensioning to transfer the force for maintaining strand tension to said substantially incompressible spacing means, repeating the strand tensioning procedure for desired slab strands, casting the concrete slab in the casting form, said casting including disposing the entire form and associated incompressible spacing means and strand chuck for each tensioned strand in an environment for curing to establish a bond between tensioned strands and concrete, and after curing, severing each tensioned strand through said open area at a region between the strand chuck and said one end of the casting form whereby said strand chuck is re-usable and said cooperatively threaded members may be easily turned with respect to each other for disassembly.

3. In the manufacture of prestressed concrete slabs having steel strands longitudinally thereof bonded to the concrete and longitudinally tensioned to a sufficiently high degree and the slabs having such a length that a reduction in strand elongation incident to the strand gripping action of a strand chuck of the type having jaws bearing on a straight length of strand results in a significant drop in strand tension, the steps which comprise: disposing a strand longitudinally of a casting form at a desired position in the casting region with said strand extending beyond said casting form through at least one end of the casting form to provide a strand gripping portion externally beyond said one casting form end, anchoring the strand portion adjacent the other casting form end to permit strand tensioning from said external strand gripping portion, tensioning said strand by applying force to a chuck of the aforementioned type positioned on said strand gripping portion to cause strand elongation and movement of said strand chuck away from said one casting form end until a desired strand tension has been obtained, adjusting the overall length between the chuck gripping part and a stationary form part of a substantially incompressible metallic spacing means loosely disposed about the tensioned strand length externally of the casting form to take up strand length without changing the strand tension, said adjusting including the step of relatively rotating two, telescoping cooperatively threaded metal members disposed over tensioned strand and having an open area exposing said strand, freeing said strand chuck from external force generating means used in strand tensioning to transfer the force for maintaining strand tension to said substantially incompressible spacing means, repeating the strand tensioning procedure for desired slab strands, casting the concrete slab in the casting form, said casting including disposing the entire form and associated incompressible spacing means and strand chuck for each tensioned strand in an environment for curing to establish a bond between tensioned strands and concrete, and after curing, severing each tensioned strand through said open area at a region between the strand chuck and said one end of the casting form whereby said strand chuck is re-usable and said cooperatively threaded members may be easily turned with respect to each other for disassembly.

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ROBERT F. WHITE, *Primary Examiner.*

MICHAEL V. BRINDISI, *Examiner.*