United States Patent [19]

Hedefine et al.

[11] **3,864,776**

[45] **Feb. 11, 1975**

[54] **PRESTRESSED POST TENSION SUSPENSION BRIDGE CABLE ANCHORAGE**

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[22] Filed: **Nov. 15, 1973**

[21] Appl. No.: **416,092**

[52] **U.S. Cl.** **14/21**

[51] **Int. Cl.** **E01d 11/00**

[58] **Field of Search** 14/21, 18, 23

[56] **References Cited**

UNITED STATES PATENTS

1,299,049	4/1919	Sopwith	14/21 X
2,132,269	10/1938	McHugh	14/21
2,914,783	12/1959	Hoyden	14/21
3,475,777	11/1969	Robinson	14/21
3,548,432	12/1970	Durkee	14/21

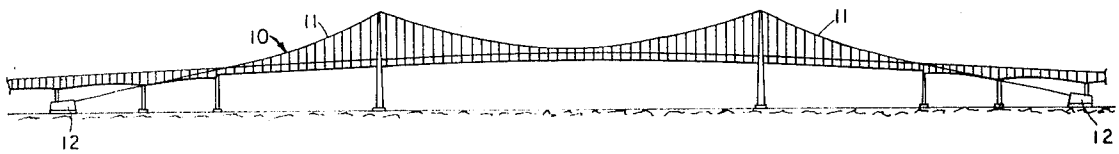
Primary Examiner—Nile C. Byers, Jr.

Attorney, Agent, or Firm—Auslander & Thomas

[57] **ABSTRACT**

By prestressing a suspension bridge cable anchorage at a bearing plate and tensioning the cable strands at different points on the bearing plate, savings in the mass of concrete or scope of anchor rod in rock is obtained, saving labor and material. The anchorage is adapted to different cable strand configurations and facilitates suspension bridge construction and cable anchorage.

34 Claims, 18 Drawing Figures



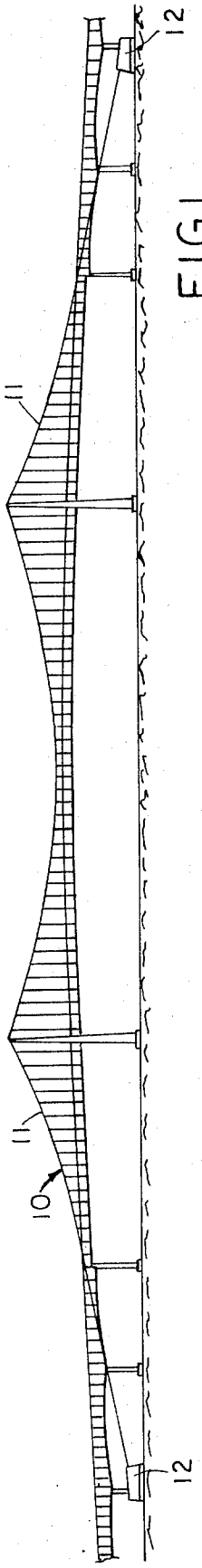


FIG. 1

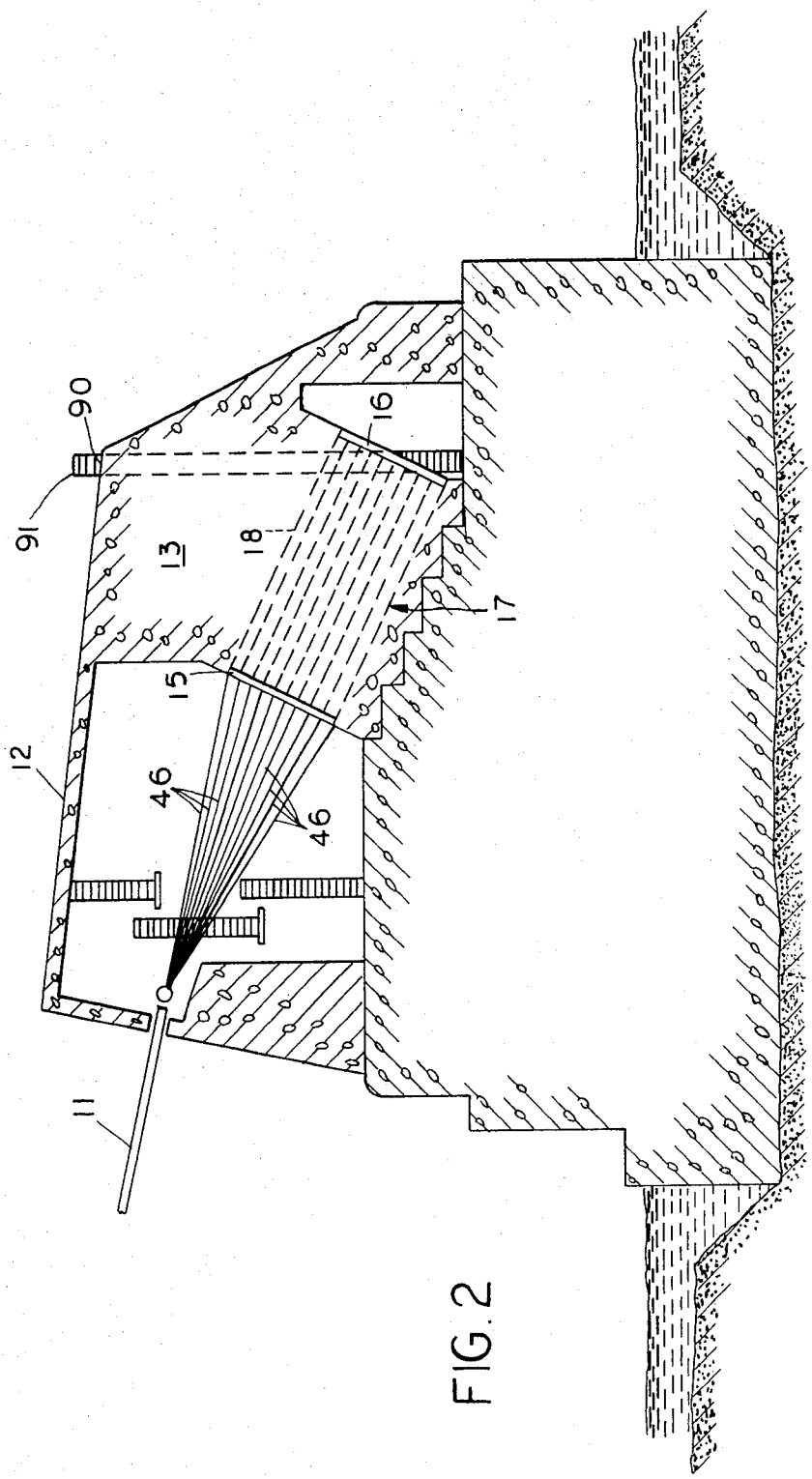


FIG. 2

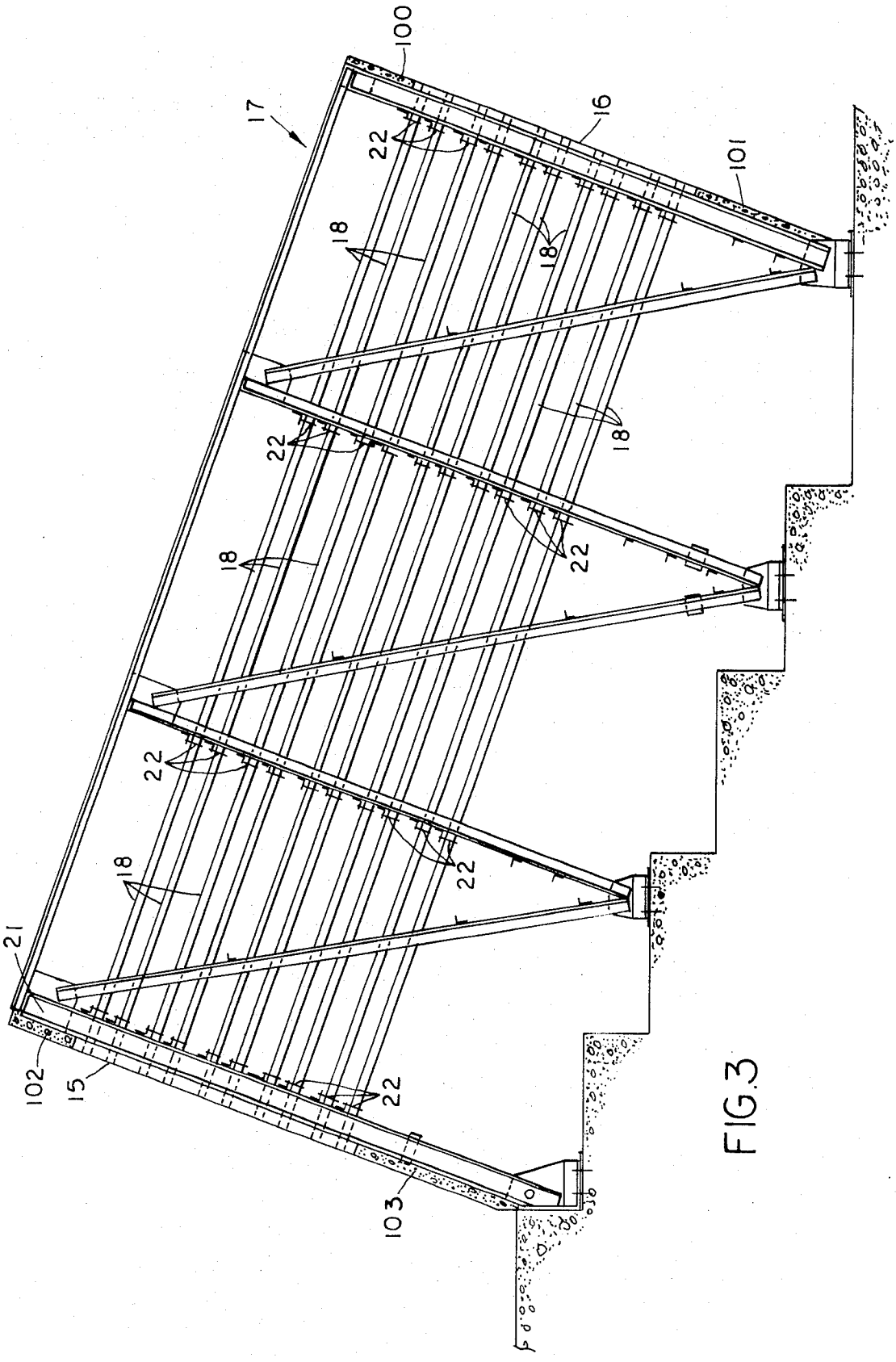


FIG. 3

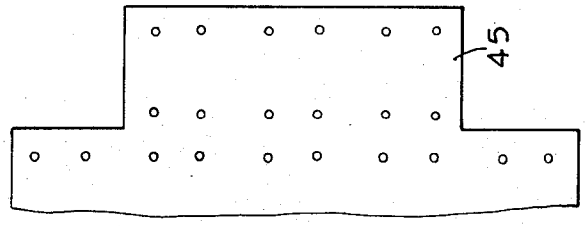


FIG. 8A

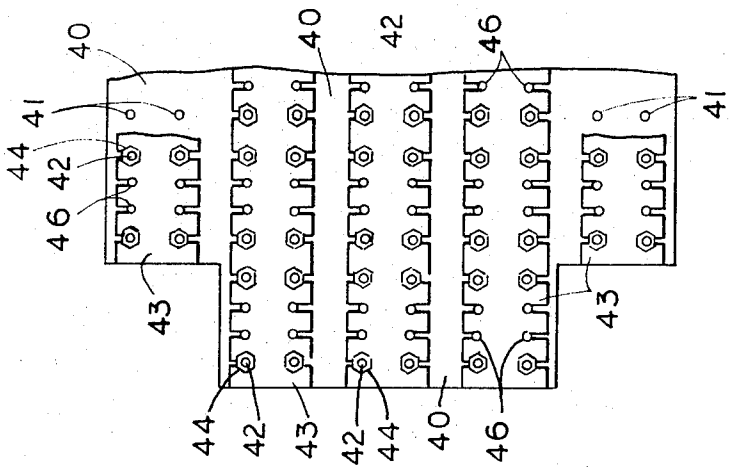


FIG. 8

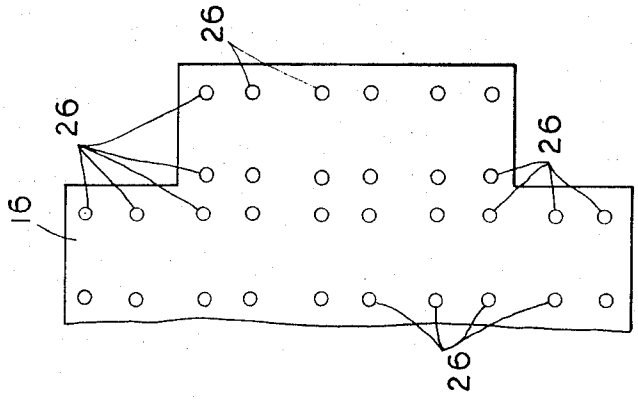


FIG 4A

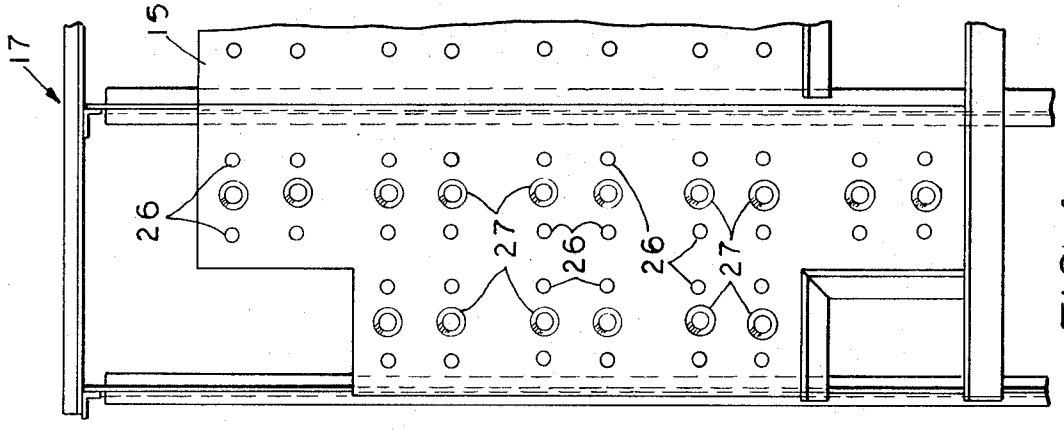


FIG. 4

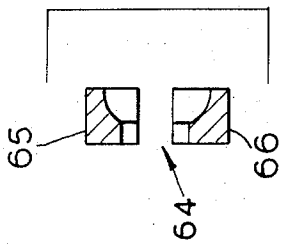


FIG. 11A

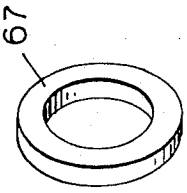


FIG. 11B

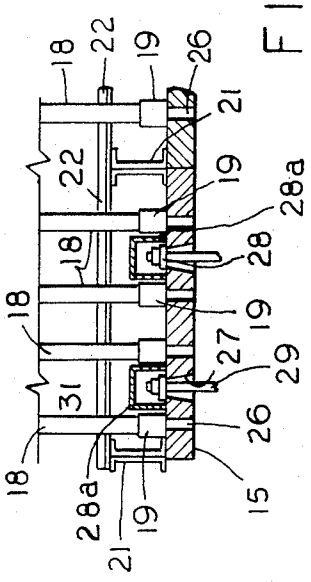


FIG. 5

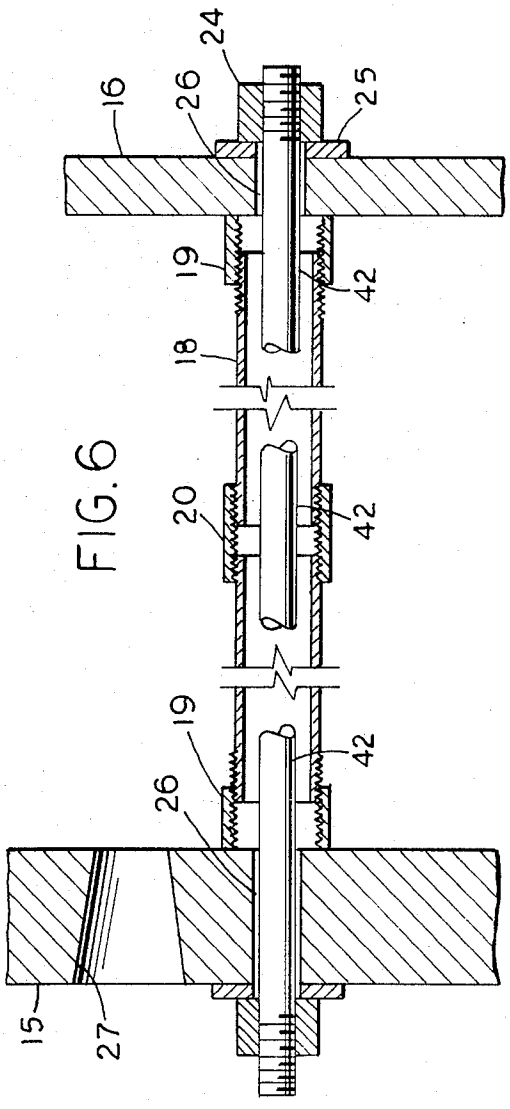


FIG. 6

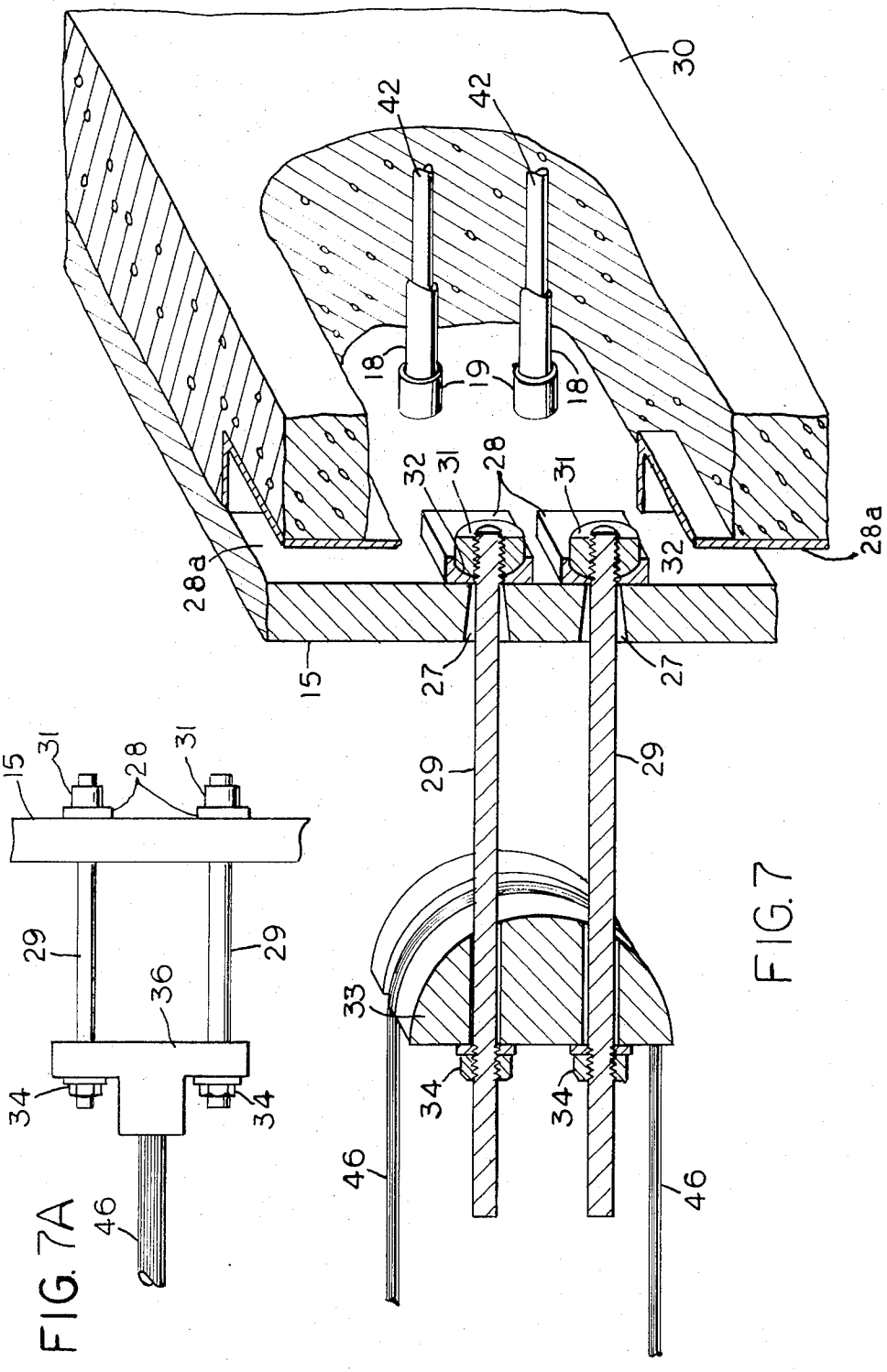

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FIG. 7

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FIG. 7A

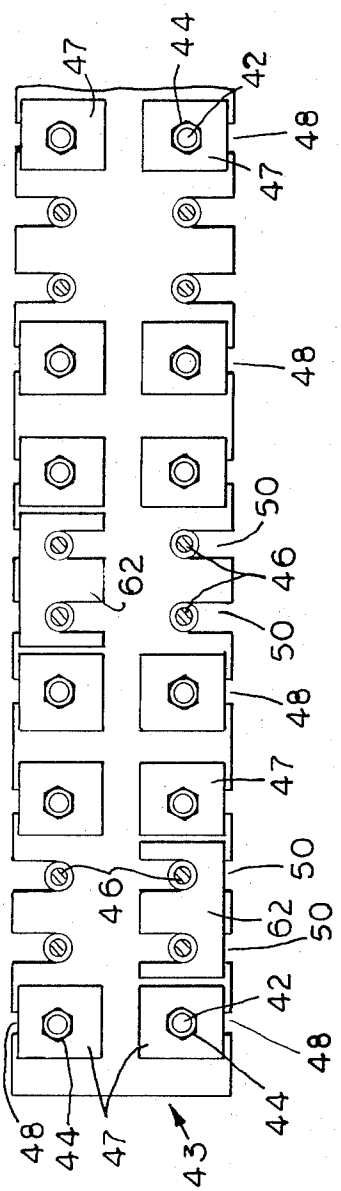

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FIG.9

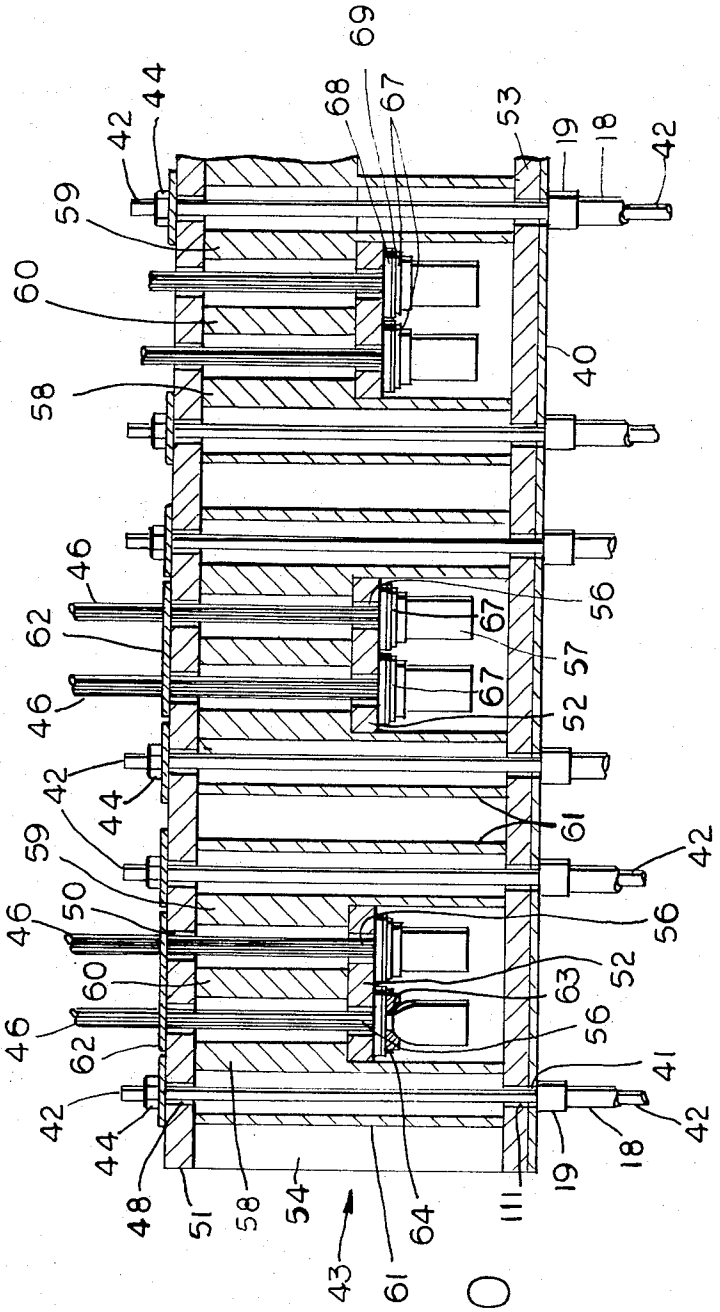

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FIG.10

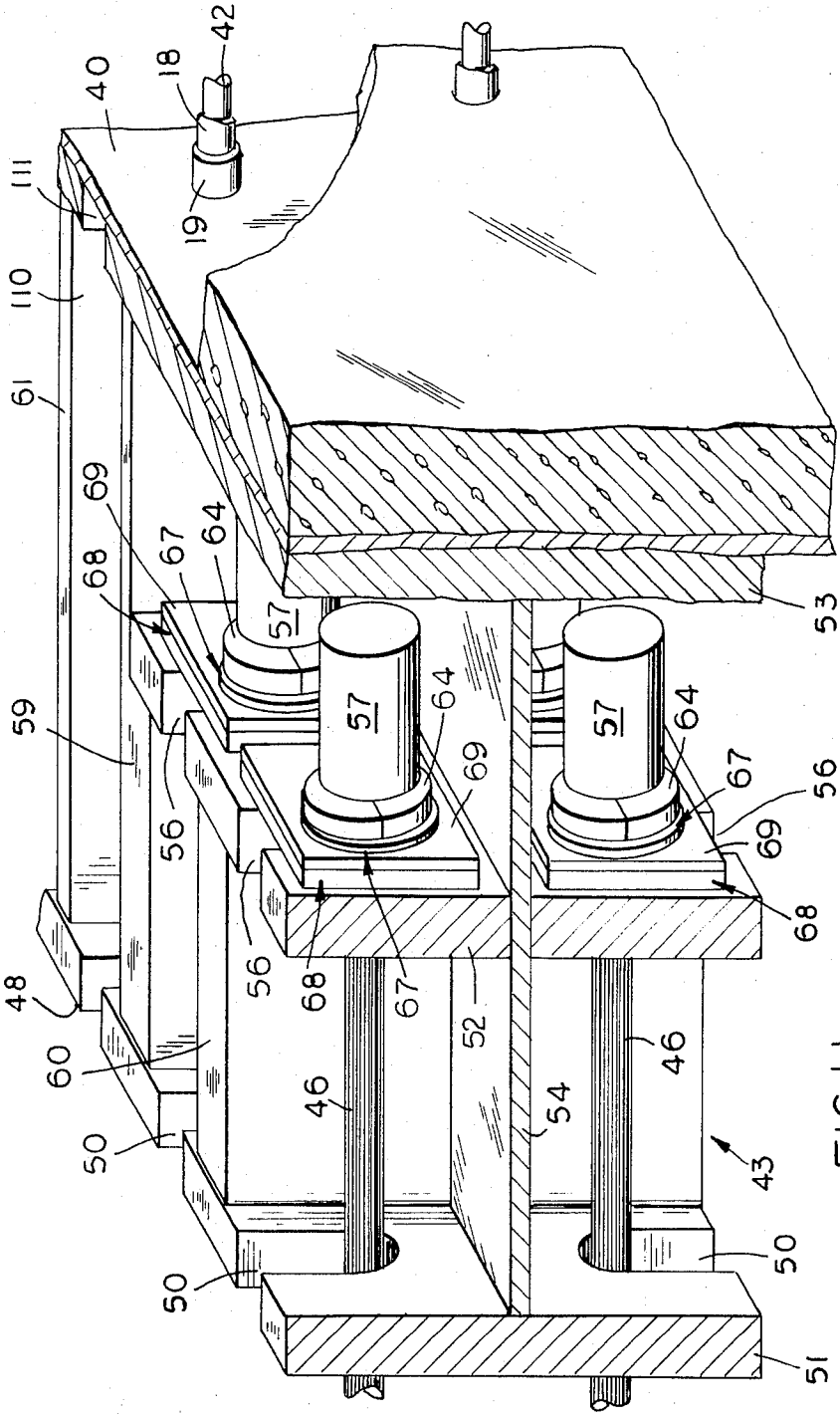


FIG. 11

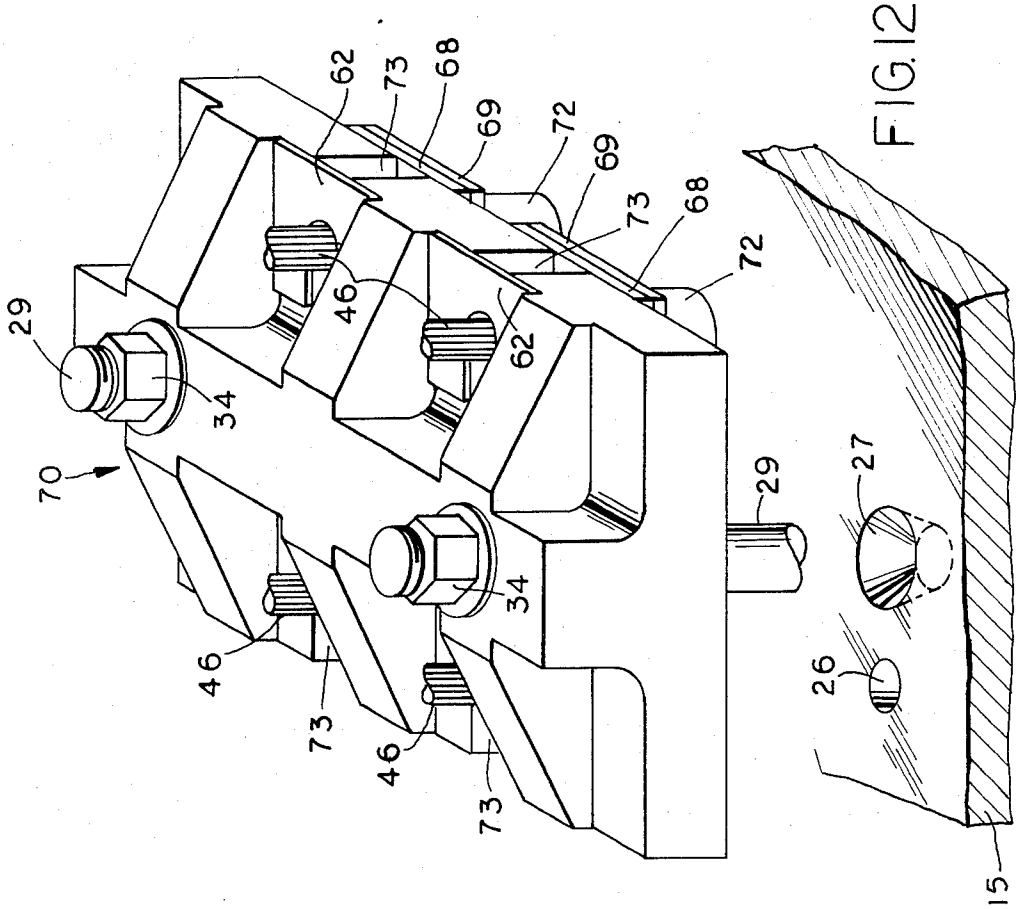

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FIG. 12

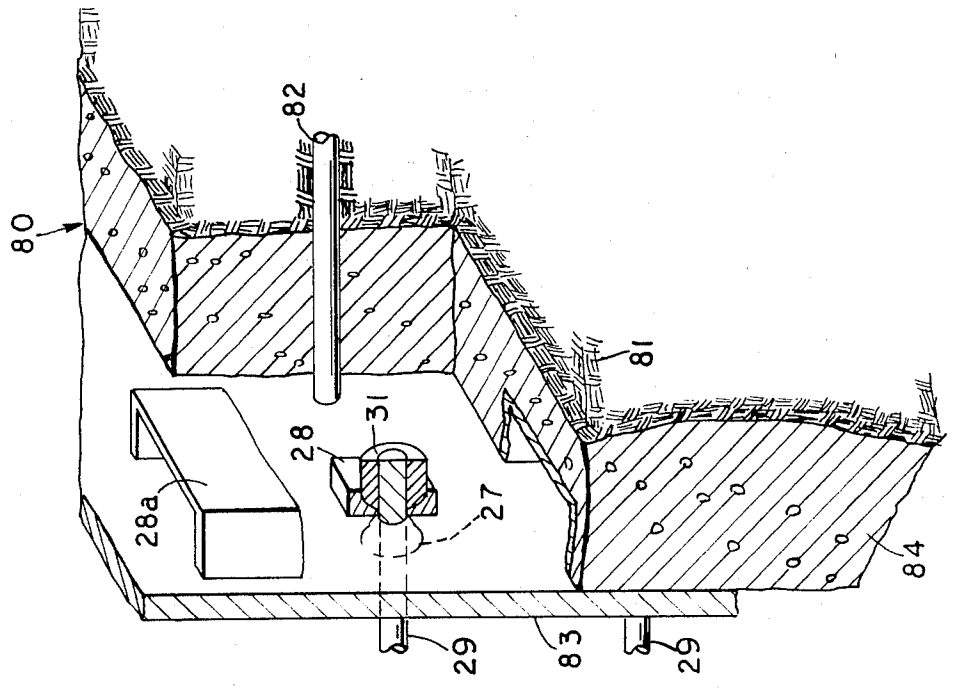

82
80
81
31
28
28a
27
84
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83
29

FIG. 13

PRESTRESSED POST TENSION SUSPENSION BRIDGE CABLE ANCHORAGE

The present invention relates to a prestressed post tension suspension bridge cable anchorage.

In the past, many efforts have been made to reduce the cost of both labor and material in the construction of suspension bridges without sacrificing structural strength.

The main cables of suspension bridges built since the beginning of the industrial era have been of three types: chains, eyebar and wire. Since the late 1920's important suspension bridges have used wire cables, which in turn have been of two types: parallel wire cables and helical wire strand cables.

From the bridge designer's point of view, parallel wire cables are superior to cables made of helical wire strands. This is because straight, parallel laid wires deliver the full strength and modulus of elasticity of the steel, whereas strength and modulus are both reduced as a result of the helical placement of wires in conventional strands. Consequently, bridge cables of helical strand construction must have significantly greater cross-sectional area than those of parallel wire construction.

On the other hand, from the bridge erector's standpoint, strand-type cables are superior to the parallel wire type. Strands are readily erected and adjusted, with minimum equipment and manpower. But "aerial spinning" of individual wires, the standard erection procedure for parallel wire cables, is a long, tedious and complex operation, requiring expensive and complicated equipment. For this reason, helical strand cables can be used economically on small to medium-size suspension bridges, in spite of the resulting increased quantity of permanent material.

Parallel wires, rather than helical wires, could be shop manufactured and socketed, and properly packaged for shipment, then it would be possible to construct parallel wire bridge cables using the simple erection techniques applicable to strand-type cables. A cable made of shop-built parallel wire strands would combine all of the erection advantages of strand-type cables with the superior in-place characteristics of parallel wire cables.

Whether the cable was spun, parallel or helical, the cable required an anchorage.

The larger the bridge, the heavier the anchorage mass that was required to hold the cable and cable strands securely, and further be able to withstand the stress and strain of the suspension bridge under use and weather conditions.

Anchorages usually were in concrete anchorage foundations, in or out of the water, or in bed rock. In either case, the amount of concrete required for the anchorage foundation in or out of water was dictated by the load calculated for the suspension bridge or the depth of anchorage foundation in bed rock was dictated by the same consideration.

According to the present invention, an anchorage foundation of concrete or in bed rock is provided, that enables a suspension bridge cable to be anchored using a minimum requirement of concrete or a minimum depth or lesser depth of anchorage in bed rock, size for size and stress for stress, of comparable bridges constructed in the past with a saving of time and labor because of ease of construction.

The present invention is at the same time adapted for use with parallel spun cable strands, or helical cable strands, or prefabricated parallel wire or strands.

As an incident to the present invention, some applications of the present invention enable faster anchorage of the strands and free inspectability of the cable anchorage, the bearing plates and the strands and easy alignment of the strands with a minimum of adjustment or precalculation.

Anchorages of the past have used frames similar to that of the present invention. By so doing, the difficult task of aligning the strand splay to the anchorage was made less difficult and a solid anchorage was made at a rear bearing plate such as shown in U.S. Pat. No. 3,548,432 to Durkee, U.S. Pat. No. 3,475,777 to Robinson even provided anchor rods through the anchor block which wire tensioned the bearing plate and somewhat made alignment of the strands and rods easier.

Now according to the present invention alignment is made even simpler and prestressing by post tensioning of the bearing plates may be used to the point of reducing the amount of concrete necessary to go into the anchorage necessary to support the weight and stress of the suspension bridge and the strands substantially self aligned to the splay in a compact construction which in itself may save concrete.

Although such novel feature or features believed to be characteristic of the invention are pointed out in the claims, the invention and the manner in which it may be carried out may be further understood by reference to the description following and the accompanying drawings.

FIG. **1** is a typical suspension bridge with cable anchorage in the water.

FIG. **2** is a section of a concrete anchorage in water.

FIG. **3** is a frame of anchor cylinders free of concrete.

FIG. **4** is a partial front elevation of the front bearing plate of FIG. **3.**

FIG. **4***a* is a reduced partial elevation of the rear bearing plate of FIG. **3.**

FIG. **5** is a partial sectional plan view of a bearing plate such as exemplified in FIG. **4** including cylinders and structure.

FIG. **6** is a cut-away view of the front and rear bearing plates, an anchor cylinder and a tensioning rod.

FIG. **7** is a cut-away view behind the bearing plate showing a strand shoe and tension rods.

FIG. **7***a* is a fitting for FIG. **7** for a prefabricated strand anchorage.

FIG. **8** is a partial front elevation of a bearing plate and beams for a prefabricated strand anchorage and tension rods.

FIG. **8***a* is a partial elevation of the rear bearing plate of FIG. **8.**

FIG. **9** is a detail of a bearing plate beam, the rod and strands shimmed.

FIG. **10** is a partial plan section of a beam with details of tension rods and attached strands.

FIG. **11** is an isometric cut-away view of a base, connected strands and bearing plate against the concrete anchorage.

FIG. **11***a* is an exploded section view of a socket anchor of FIG. **11.**

FIG. **11***b* is a closure ring for the socket anchor of FIGS. **10** and **11.**

FIG. 12 is a perspective view of an alternate strand shoe for prefabricated strands such as may be used with the bearing plate of FIG. 7.

FIG. 13 is a partial section of a bearing plate and rock anchorage of the present invention.

Referring now to the figures in greater detail, where like reference numbers denote like parts in the various figures.

The suspension bridge **10** as shown in FIG. 1 is suspended by cable **11** anchored in concrete anchorages **12** in the mass of anchor blocks **13.**

The strands **46** of the cable **11** are fastened to a bearing plate **15,** such as shown in FIG. **4,** at one end of an anchor block **13.**

A rear bearing plate **16** is shown reduced and cut away in FIG. **4***a*, which is at the other end of the anchor block **13.**

The bearing plates **15, 16** are usually part of a frame **17** which supports the anchor cylinders **18.** As can be seen in FIG. **6** a cylinder **18** is preferably held to the bearing plates **15, 16** by threading sleeves **19** extending from the bearing plates **15, 16.**

The enormity of dimension of parts may be hard to conceive from the drawings.

It is oftentimes necessary to couple the anchor cylinders **18** in order to achieve sufficient length by a coupling sleeve **20** as shown in FIG. **6.**

The frame **17** is provided with, among other things, channel irons **21** and cylinder supports **22** to hold the anchor cylinders **18** in proper position.

Rods **42** are set up in the anchor cylinders **18** and ultimately tightened against the bearing plates **15, 16** held by nuts **24,** usually with washers **25** between the nuts **24** and bearing plates **15, 16,** although on occasion shims may be used.

The front bearing plate **15,** as seen in FIG, **4** and **5** includes a series of spaced openings **26** through which the rods **42** may pass as shown in FIG. **6.** The rear bearing plate **16** includes a counterpart of the openings **26** in front bearing plate **15.**

The front bearing plate **15** includes a secondary system of openings **27** which have a regular flare tapering to a greater width at the front of the front bearing plate **15.**

In FIG. **5,** washers **28** having rounded concavities **32** are provided behind the flared openings **27** to receive stud bolts **29** as shown in FIG. **7.** In FIG. **7,** some concrete **30** is shown, as will be more fully discussed later.

In FIG. **7** the stud bolts **29** are held by rounded nuts **31** which coincide with a concavity **32** in the washers **28.** The stud bolts **29** extend through a shoe **33** shown in section in FIG. **7.** The stud bolts **29** are held to the shoe **33** by nuts **34.** In FIG. **5,** covers **28***a* for the washers **28** and nuts **31** are shown.

The shoe **33** as shown in FIG. **7** is a section of a double shoe capable of holding one strand **46** of cable **11** wire on each side of the bolts **29.** Each strand **46** is made up of several wires.

The shoe **33** is similar to the structure used in the construction of "spun" strands.

A cover **28***a*, as shown in FIG. **7,** normally protects the nuts **31** and bolts **29** and round washers **28** from poured concrete **30.** The covers **28***a* may be grouted upon completion of the bridge **10.**

In FIG. **7***a* an alternate construction of strand socket **36** is shown. The construction of the socket **36** is one form of socket useable with prefabricated strands which do not have to be spun. The socket **36** may be used with the bearing plate **15.**

As shown in FIG. **8,** a bearing plate **40** has a series of openings **41** adapted to receive rods **42** which are shown held to the beams **43** by nuts **44.** The other ends of the rods are held to the rear bearing plate **45** in the same manner as shown in FIG. **6.** The strands **46** are only shown in section in FIGS. **8** and **9.**

In FIG. **9** a detail of a beam **43** is shown. Washer plate **47** closes the U channels **48** and held by the nuts **44.**

The strands **46** pass through the U channels **50** and as can be seen in FIGS. **10** and **11,** are locked into the beams **43.** The rods **42** pass through the beam **43,** the washer plate **47** and the bearing plate **40** and are fastened to the front of the beam **43.**

The beam **43** as shown in FIGS. **10** and **11** has a heavy forward flange **51,** a middle flange **52,** a rear flange **53,** all of which may be joined by an intermediate webbing **54.** The middle supports **52** are heavy to stand great stress and include U channels **56** into which the strands **46** with sockets **57** are held.

The beam **43** also includes two support walls **58, 59** which brace the middle flange **52** crossing beam **43** with part of its thickness to brace the rear flange **53.** A central support wall **60** also braces the middle flange **52.**

Thinner cross walls **61** span the beam **43** from the forward flange **51** to the rear flange **53** and serve as a channel for the rods **42** which pass between the walls **61** and **58, 59.**

The strands **46** may be held by a keeper **62** as shown in FIG. **9.**

The rods **42** pass through anchor cylinders **18** which are held to the bearing plate **40** by threaded sleeves **19.** While not shown, the anchor cylinders **18** are also held by threaded sleeves **19** at the rear bearing plate **45.**

The sockets **57** round ends **63** are preferably rounded as shown cut away in FIG. **10.**

Engaging a strand in a beam **43** is easily effected by just placing the strand **46** and socket **57** through the U channels **50, 56.** A split washer **64** having half sections **65, 66** is then placed about the rounded end **63** of the socket **57** and held in position by a keeper ring **67** as shown in FIGS. **11, 11***a* and **11***b*. Adjustment of the strands **46** is effected by the use of fills **68** and shims **69.** The use of fills **68** and shims **69** is illustrated in FIG. **11.**

In FIG. **12** a strand shoe **70** is shown. The strand shoe **70** is particularly adaptable for use with bearing plate **15** of FIG. **4.** Stud bolts **29** extend from the bearing plate **15** and hold the strand shoe **7** with the nuts **34.**

Prefabricated strands **46** with their sockets **72** are engaged in the U channels **73** and tightened by use of the nuts **34** to take up any slack.

The cable anchorage **80,** as shown in FIG. **13,** is an anchorage to the mass of bed rock **81.** Rods **82** are anchored deep into bed rock **81** mass by means well known in the art. The rods pass through the bearing plate **83** which is grouted with concrete **84** so that the interface between the bearing plate **83** and rock **81** and concrete **84** is smooth.

The rear of the bearing plate **83** is preferably provided with cover **28a** to protect the stud bolts **29,** washer **28** and round nut **31** so that they can be properly adjusted.

Thus far, the hardware has been described in its physical detail. Much of it is old in the art and might not show any significance.

In suspension bridges the old method of spinning cable is not entirely abandoned even though it is generally slow and the labor is expensive.

Great savings in labor and money have been made by erecting suspension bridges by unrolling and setting prefabricated cable strands.

The present invention adds a new dimension to suspension bridge building by adapting a new advantage to the construction of the cable anchorage whether in rock or concrete with old-fashioned spun cable or with the newer prefabricated cable.

The frame **17** with its anchor cylinder **18** and bearing plates **15, 16** is encased in concrete as can be seen in FIG. **1**, where the anchor block **13** has hardened to concrete.

After the concrete has fully hardened, the rods **42** are tightened against the bearing plates **15, 16** with the nuts **24** bearing on the bearing plates **15, 16** and are prestressed to a stress about a third greater than the tension the cable **11** and strands **46** are expected to have to bear.

The strands **46** then are anchored to the front bearing plates **15, 40. 83** by various means such as shown in FIGS. **5, 7, 7a, 9, 10, 11, 12** and **13.**

In the completed suspension bridge **10,** usually a smaller amount of concrete block **13** is required to form the cable anchorage **12.** The post tensioning of the anchor block **13** is effected by tensioning the bearing plates **15, 16** by tightening the nuts **24** on the rods **42** against the bearing plates **15, 16,** such as shown in FIGS. **6, 7, 10** and **11.** When the strands **46** are in place the resultant stress on the anchor block **13** is the differential of the normal tension from the cable **11,** strands **46** and the stress of post tensioning, thus relieving the anchor block **13** of most of the post tensioning stresses. With the present invention, the rods **42** and cylinders **18** may be closely set, saving space and concrete. The strands **46** are quickly and easily mounted. The prestressing by post tensioning of the anchor block **13** is made simple, saving labor and time.

In the past, such as shown in U.S. Pat. No. 3,475,777, some ease of construction was achieved by attaching the strands to a post-tensioned rod, post tensioned to the anchor block. Such expedient and the coupling means may have facilitated the building of suspension bridges but it has the complications of bore-sight alignment and it overlooked the importance of pretensioning the concrete block before attaching the strands **46.** All the tensions of each strand of the U.S. Pat. No. 3,475,777 depend directly upon each of the individual, post-tensioning rods **42, 82.**

The strands **46** of the present invention are each directly or indirectly connected to the front bearing plates **15, 40, 83** or bear upon it in some way as are the rods **42, 82,** thus any stress on strands **46** or rod **42, 82** bears on the entire bearing plate **15, 40, 83** rather than on any one particular rod **42.** The massiveness of the bearing plate **15, 40, 83** is better able to distribute a particular stress than a particular rod.

The concrete anchorage **12,** as shown in FIG. **2** usually has a manhole **90** and ladder **91** for access to the bearing plate **16.** Inspection and maintenance is facilitated by this. If the rods **42** are ungrouted as yet, or ungrouted, repair may be facilitated.

In FIG. **3,** parts of the frame **17** are shown with the concrete faces **100, 101, 102, 103,** ultimately to form the concrete block **13** flush with the bearing plates **15,** 16. In FIG. **4,** the openings **26** in the bearing plate **15** are for the rods **42** to protrude through. As seen in FIG. **6,** a rod **42** is shown in the bearing plates **15, 16** held by washers **25** against the bearing plates **15, 16** and tightened by nuts **24.**

Inside the bearing plates **15, 16** are threaded sleeves **19** which are anchor cylinder **18** may be screwed into to join the front and rear bearing plates **15, 16.** A coupling sleeve **20** may join parts of the anchor cylinder **18** when it is in more than one piece.

The openings **27** are flared wider toward the front of the bearing plate **15.**

As can be seen in FIG. **7,** a washer **28** with a concavity **32** and a nut **31** is inside the bearing plate **15** where stud bolts **29** are held by rounded nuts **31.** The inside of the bearing plate **15** of the stud bolt **29** construction is protected by a cover **28a** so that when the concrete block **13** is poured, this portion will be free to manipulate.

When the bearing plate **15** is set up; it is preferable to install the studs **29** and nuts **31** in the washers **28** so that the strands **46** may be attached after the concrete has been poured over the frame **17** and the anchor block **13** has been prestressed.

The alignment and adjustment of the sockets **36** or shoes **33, 70** to get proper splay, is easily done from a flat bearing plate **15** by the latitude of movement the studs **29** have in the flared openings **27** in the bearing plate **15** which appose the cable **11** and the splay of the strand **46.**

Socket covers **28a,** as shown in FIG. **5,** may cover the stud **29,** washer **28,** but **31** construction. The socket covers ***28a*** may be used whether or not the open area of the socket cover ***28a*** is grouted when the strands **46** are fully placed and adjusted.

The bearing plate **40** is relatively thin. The support for prestressing and post tensioning is found primarily in the beams **43.**

Rods **42** pass through the bearing plate **40** openings **41** through the channels **110** in the beam **43** passing through a U channel **111** at the bearing plate **40** and U channel **48** at the front of the beam **43.**

The prestressing is done by tightening the nuts **44** on the rods **42** in the front of the beam and nuts (not shown) on the bearing plate **45,** or otherwise gripping the rods **42** by means known in the art.

Easy adjustment of tension and slack on the rods **42** and beam **43** is taken care of by tightening the nut **44** down on the washer **47** shown in FIG. **9.**

Prefabricated strands **46** with sockets **57** are easily placed through the U channels **50, 56** behind the middle flange **52,** which is in an intermediate position in the beam **43,** where they can be set so their round bottoms **63** fit into the rounded split washers **64,** held in place by the keeper ring **67** and adjusted fills **68** and shims **69.**

The stresses of post tensioning of the rods **42** and tensioning of the strands **46** are again divided to the beam **43** and the bearing plate **40.**

Adjustment of the strands **46** under construction and in final use is facilitated by the ability of the socket **57** to move in the split washer and orient the strand **46** with room for movement provided by the U channels

50 which easily adjust for splay just as the flaring of the opening 27 permits the same type of adjustment.

In FIG. 12, the strand shoe 70 is another fitting useable with the bearing plate 13 of FIG. 7. The bearing plate 15 is prestressed as heretofore discussed. The shoe 70 is held by studs 29 and nuts 34. The strands 46 are placed in the U channels 73 held in place by keeper plates 62, adjusted for splay and adjusted for length by tightening the nuts 34 and using shims 69, or by using means disclosed or known in the art.

Where solid bed rock is available for a cable anchorage, the advantages of the present invention are also available.

As is well known in the art, cable strands may be anchored to bed rock 81.

When rock is not solid, a concrete anchorage may be carved out of rock and filled with concrete. In such case, the teachings of the present invention may be applied.

Where bed rock 81 is available as shown in FIG. 13, the anchorage is to actual rock as distinguished from concrete. The techniques known in the art provide for drilling suitable holes in the rock 81, then securing rods 82.

According to the present invention, savings in labor and/or material and time may be achieved in the case of rock formations. It saves excavation and allows anchorage of the rods 82 more easily, often with less rods 82 or shorter rods 82, with less grouting in a rock mass capable of supporting the particular bridge being built.

As shown in FIG. 13, a rod 82 is secured by means known in the art. A bearing plate 83 rests flat against the jagged surface spaced by grout 84 between the rock 81 and plate 83.

A rounded washer 28, stud bolt 29 and round nut 31 allow the stud bolt 29 to be attached to a strand fitting. The rod 82 and other rods 82 (not shown) are stressed between the bearing plate 83 and the anchorage of the rod 82; the strands are tensioned as stated before, leaving greater stress on the rods 82.

The stresses are then balanced, with greater stress on the rock anchor and counterbalanced by the cable strand tensioning. Stresses are distributed throughout the bearing plate 83.

The cover 28*a* is for access. It may be left open or grouted when construction is complete.

Overall, when prestressing and post tensioning in concrete, according to the present invention, there is a good saving of concrete required to anchor the cable and a concommitant material cost and saving of labor because the anchorage 13 is constructable is a very compact space.

According to the present invention, the compactness of the anchorage 12 usually obviates the use of more concrete than is necessary to support the weight of the bridge 10 with a concommitant saving of labor.

By the same token, according to the present invention, when anchoring in bed rock 81, the savings comes in the rock excavation and material and labor, because of the simplicity of installation.

Whenever used herein, the phrase "U-shaped channel" refers to a slot, whether of parallel sides of angulated sides, shaped to receive its selected rod or strand. The bottom portion of said U-shaped channel does not necessarily have to be round.

Unless otherwise specified, specific shapes are not of the essence, where round, square or other shapes serve the same functional purposes.

The terms and expression which are employed are used as terms of description; it is recognized, though, that various modifications are possible.

Having thus described certain forms of the invention in some detail, what is claimed is:

1. In a suspension bridge a cable anchorage construction comprising an anchorage mass, a cable, said cable including at least one cable strand, a bearing plate apposed to said cable, at least one rod opening in said bearing plate, at least one rod, said at least one rod gripped at least at one of its ends remote from said bearing plate, the other end of said at least one rod extending through at least one bearing plate opening, means to fasten said at least one extending rod held bearing upon said bearing plate, means bearing upon said bearing plate to hold said at least one said cable strand, tightening means including said bearing plate and said at least one rod to stress said cable anchor mass, means clear of said at least one rod held bearing upon said bearing plate to retain at least one cable strand, and means to tension said at least one cable strand against said anchorage mass's stress.

2. The invention of claim 1 wherein said anchorage mass is bedrock.

3. The invention of claim 2 wherein said at least one rod is held fastened in said bedrock.

4. The invention of claim 3 wherein said bedrock is stressed by tightening said at least one rod against said bearing plate.

5. The invention of claim 4 wherein said means to hold said cable strand includes means to orient said holding means to the splay of said at least one cable strand.

6. The invention of claim 5 wherein said means to hold said cable strand includes a protective cover.

7. The invention of claim 1 wherein said anchorage mass is substantially concrete.

8. The invention of claim 7 including a frame, a front bearing plate, a rear bearing plate, at least one anchor cylinder and at least one held rod bearing upon said front and rear bearing plate.

9. The invention of claim 8 wherein said front and rear bearing plates include at least one sleeve, said at least one anchor cylinder held by said sleeve.

10. The invention of claim 9 wherein said sleeve and at least one anchor cylinder are threaded.

11. The invention of claim 10 wherein said rear bearing plate includes at least one opening for at least one rod, said front bearing plate includes at least one opening for at least one rod and at least another opening for means to hold at least one cable strand.

12. The invention of claim 11 wherein said concrete mass is stressed by tightening said at least one rod against said concrete mass between said front and rear bearing plates.

13. The invention of claim 12 wherein said at least one cable strand is spun on a shoe, said shoe held to said front bearing plate by at least one stud bolt.

14. The invention of claim 13 wherein said at least one stud bolt is held to said front bearing plate by a rounded bottom nut.

15. The invention of claim 14 wherein said nut rests in a rounded washer.

16. The invention of claim 15 wherein said opening in said bearing plate for said cable strand holding means is flared outward to the face of said front bearing plate.

17. The invention of claim 12 wherein said at least one cable is prefabricated and includes a socket.

18. The invention of claim 17 wherein said socket is held by at least one stud bolt.

19. The invention of claim 18 wherein said at least one stud bolt is held to said front bearing plate by a rounded bottom nut.

20. The invention of claim 19 wherein said nut rests in a rounded washer.

21. The invention of claim 20 wherein said opening in said bearing plate for said cable strand holding means is flared outward to the face of said front bearing plate.

22. The invention of claim 17 wherein said socket is T shaped.

23. The invention of claim 17 including a shoe having at least one U-shaped channel wider than said strand and having a socket wider than said U-shaped channel.

24. The invention of claim 8 wherein said bearing plate includes at least one beam adapted to interact with said bearing plate.

25. The invention of claim 24 wherein said beam includes a front flange and a rear flange and support means, at least one U channel in its front and rear flanges adapted to receive at least one rod at said front flange, means to hold said at least one rod on said front flange, at least one intermediate flange having a U channel apposed to a U channel in said front flange, and at least one cable strand narrower than said U channel with a socket wider than said U channel.

26. The invention of claim 25 wherein said means to hold said at least one rod includes at least one fill.

27. The invention of claim 26 further including at least one shim.

28. The invention of claim 27 wherein said at least one shim includes a U channel.

29. The invention of claim 28 wherein said at least one cable strand is prefabricated.

30. The invention of claim 29 wherein said cable strand includes at least one socket having a rounded portion facing the length of said strand.

31. The invention of claim 29 wherein said at least one socket is mounted in a rounded washer.

32. The invention of claim 31 wherein said rounded washer is split into more than one piece and adapted to be held together by a keeper.

33. The invention of claim 23 wherein said socket mounting includes at least one fill.

34. The invention of claim 33 further including at least one shim.

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