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[54] **TUBULAR CONNECTION**

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Related U.S. Patent Documents

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Filed: **Apr. 23, 1975**

[51] **Int. Cl.**3 .... **F16L 15/00**

[52] **U.S. Cl.** **285/332.2**; 285/334; 403/343

[58] **Field of Search** 285/334, 333, 355, 390, 285/332.2, 332.3; 403/343, 118; 85/46

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[57] **ABSTRACT**

A pipe joint includes pin and box members having interengaged threads characterized as producing hoop tension in the pin member and hoop compression in the box members.

61 Claims, 9 Drawing Figures

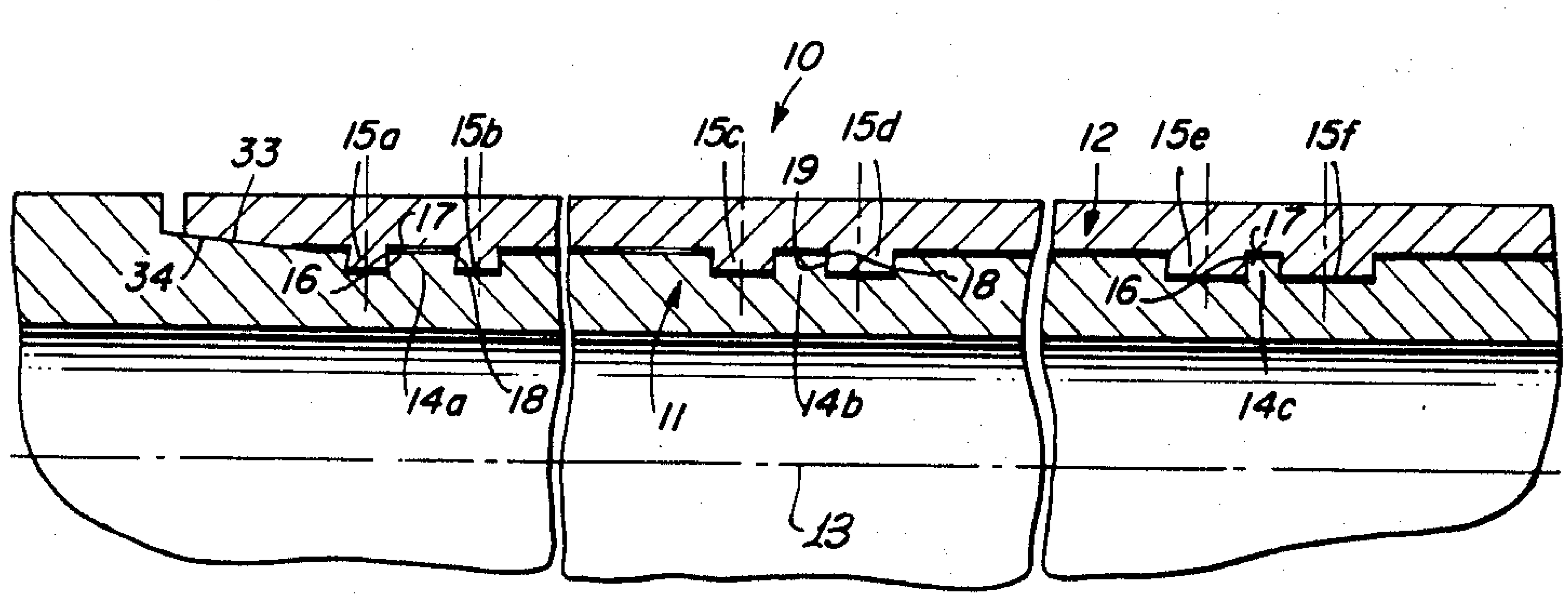


FIG. 1.

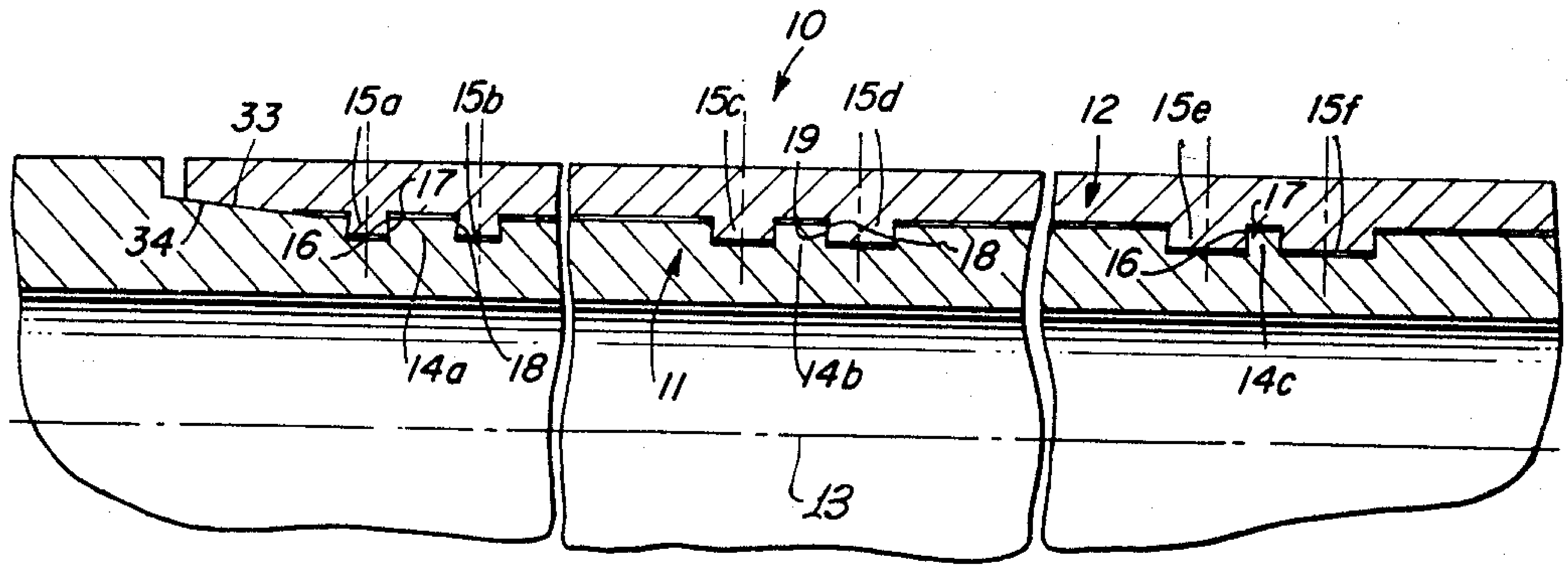


FIG. 2.

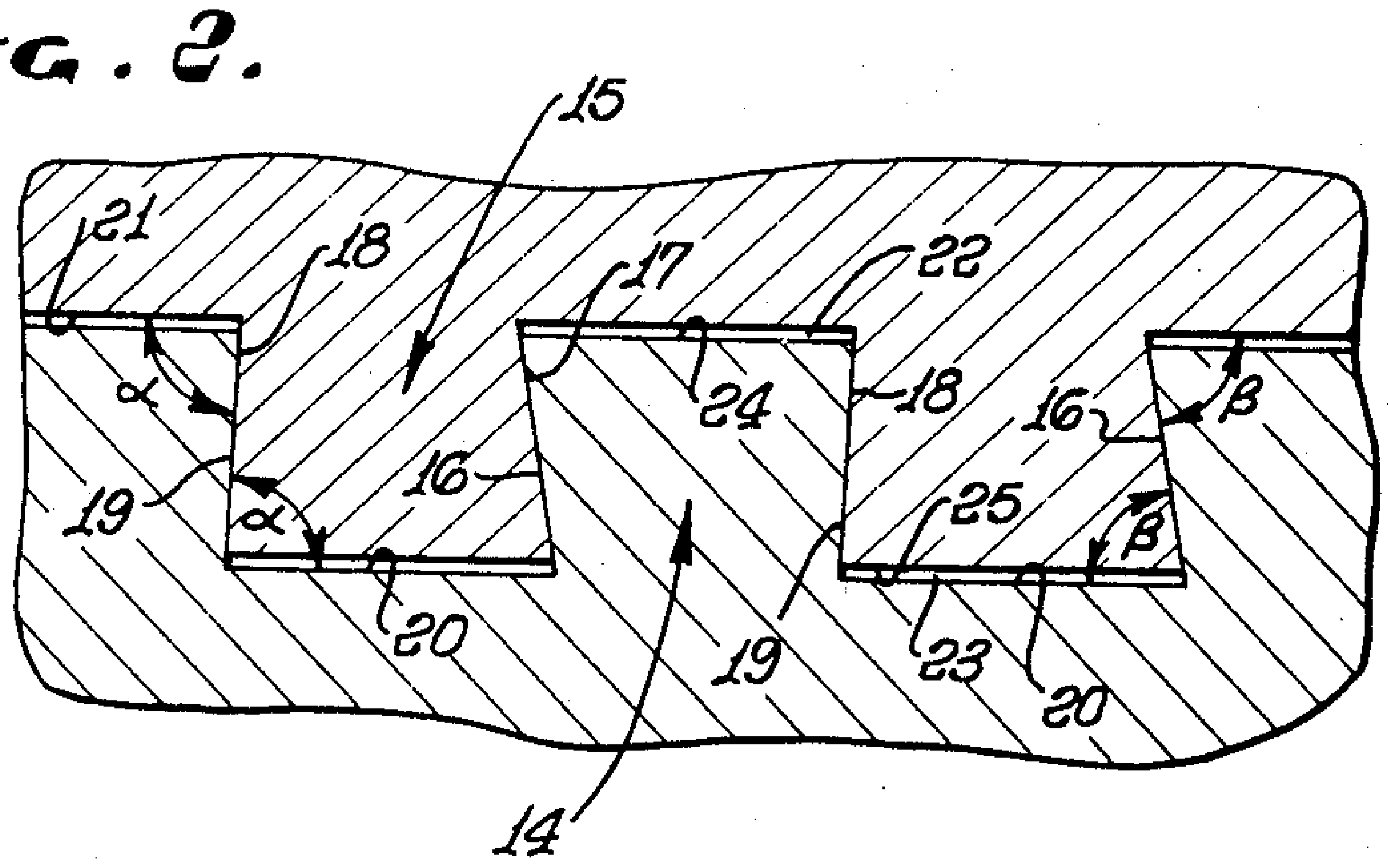


FIG. 3.

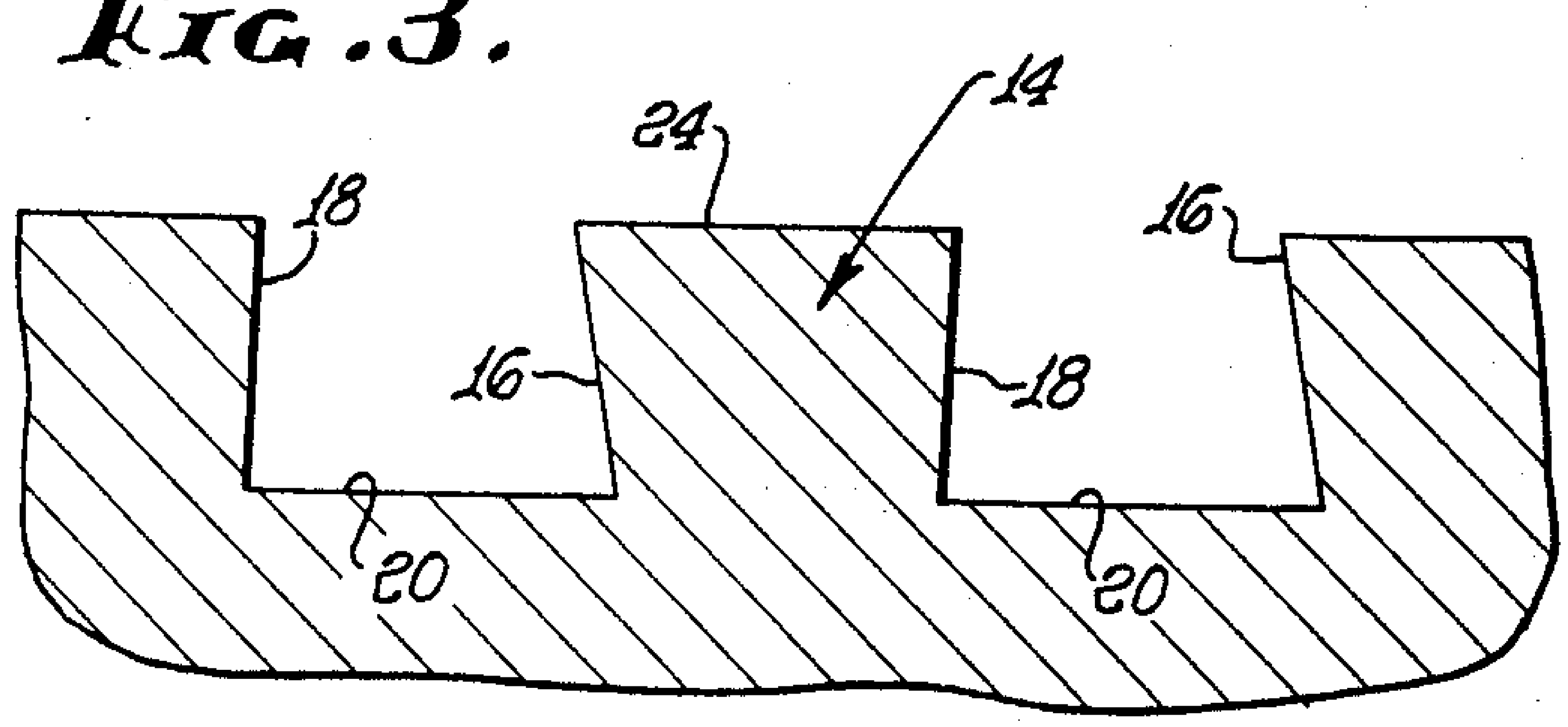


FIG. 4.

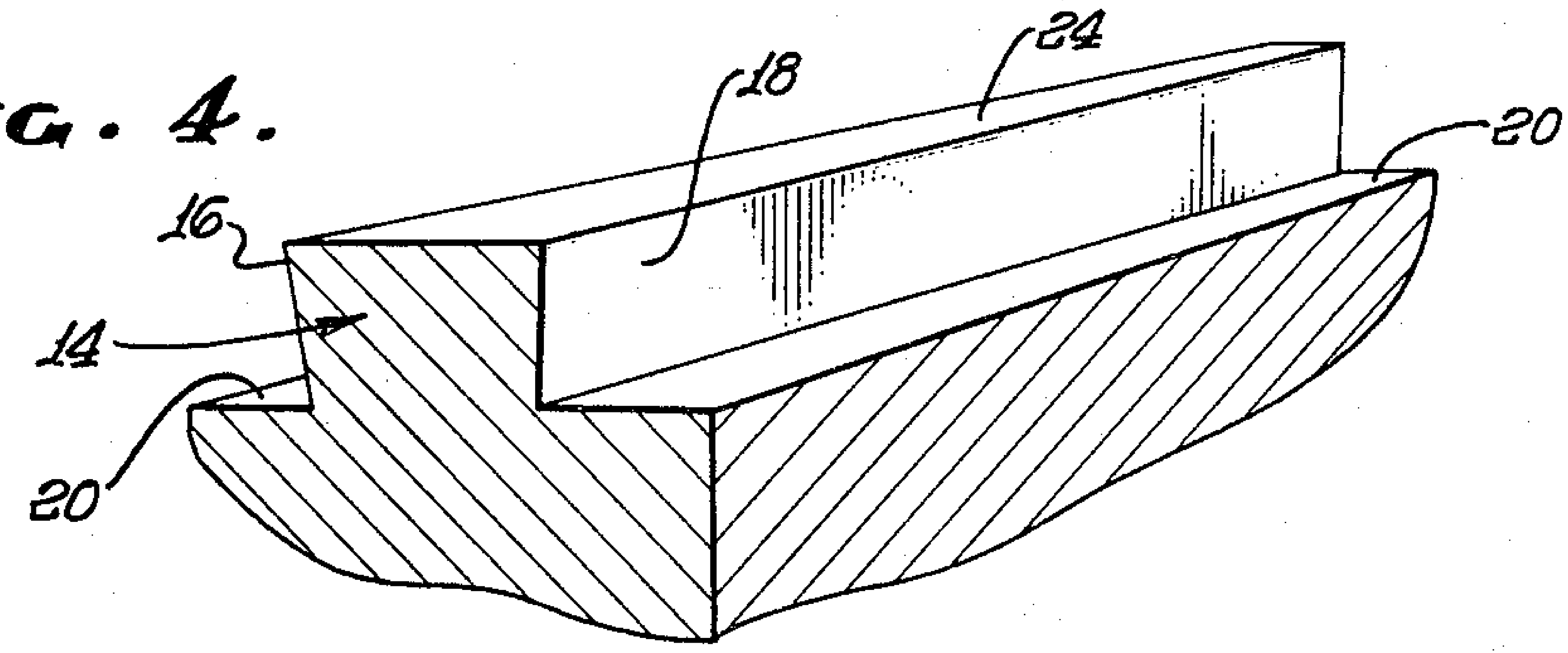


FIG. 5.

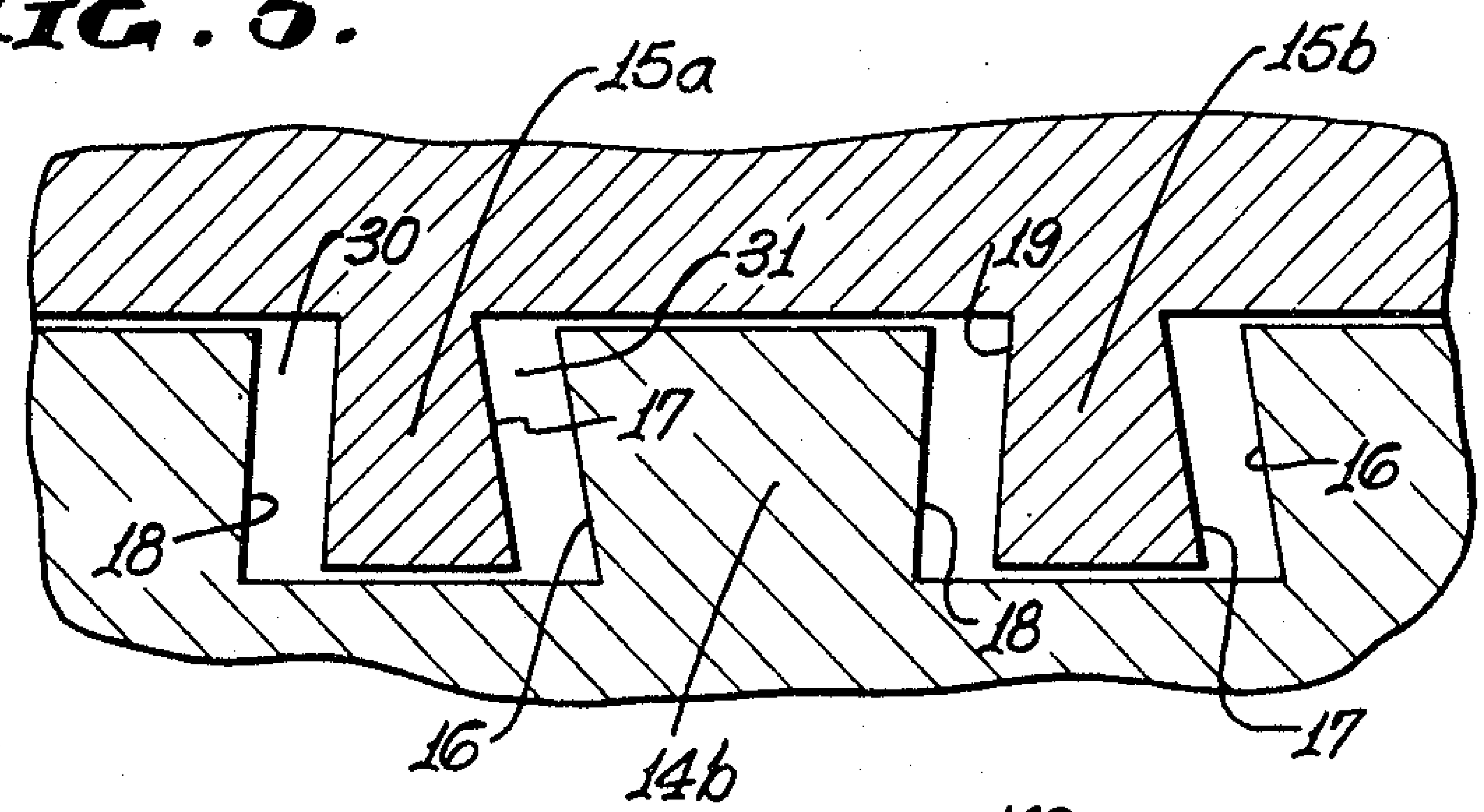


FIG. 6a.

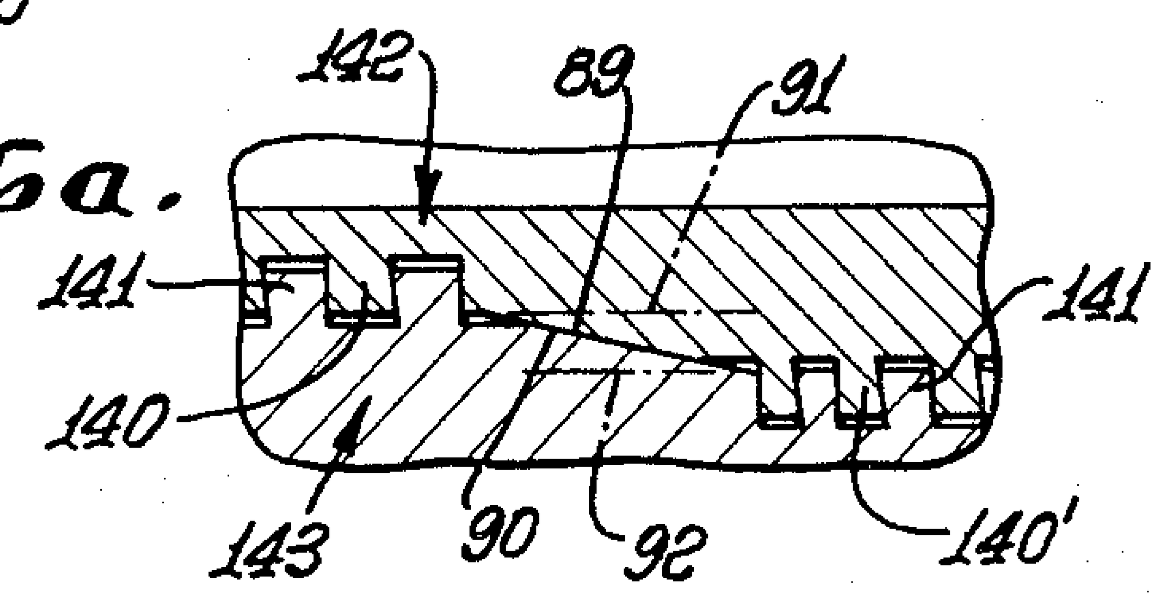


FIG. 6.

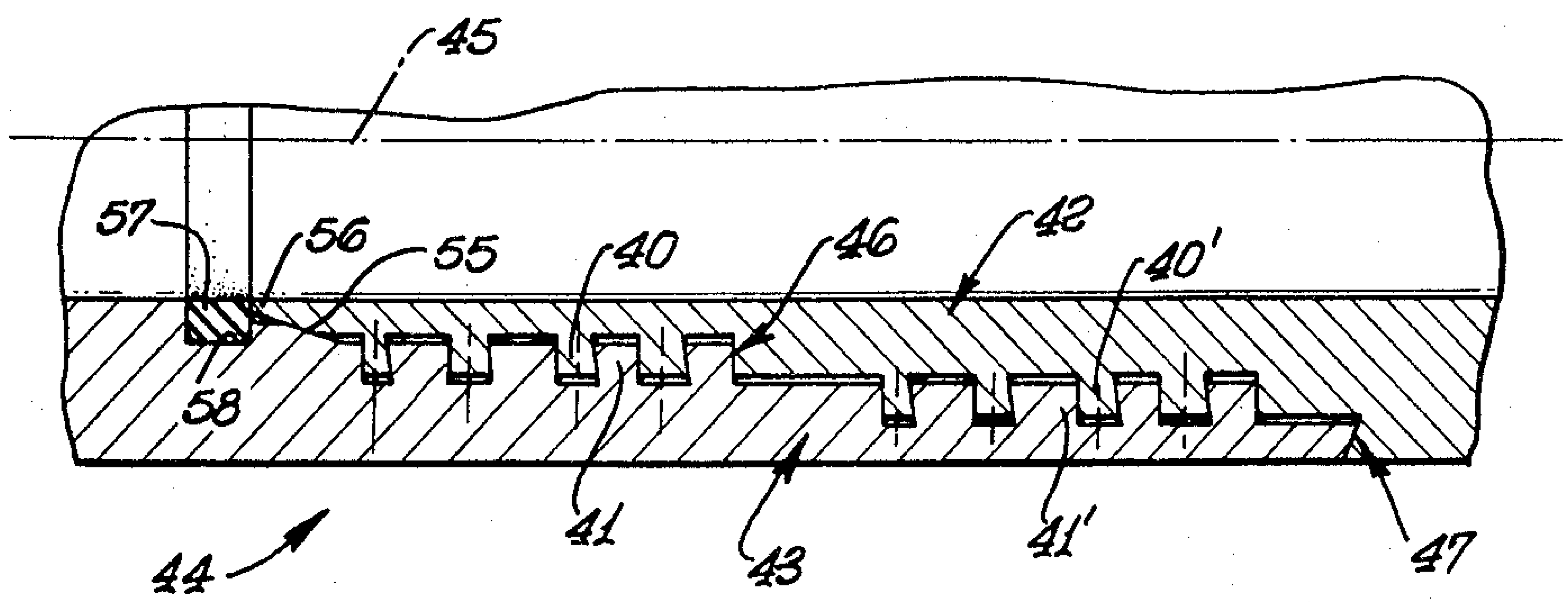


FIG. 7.

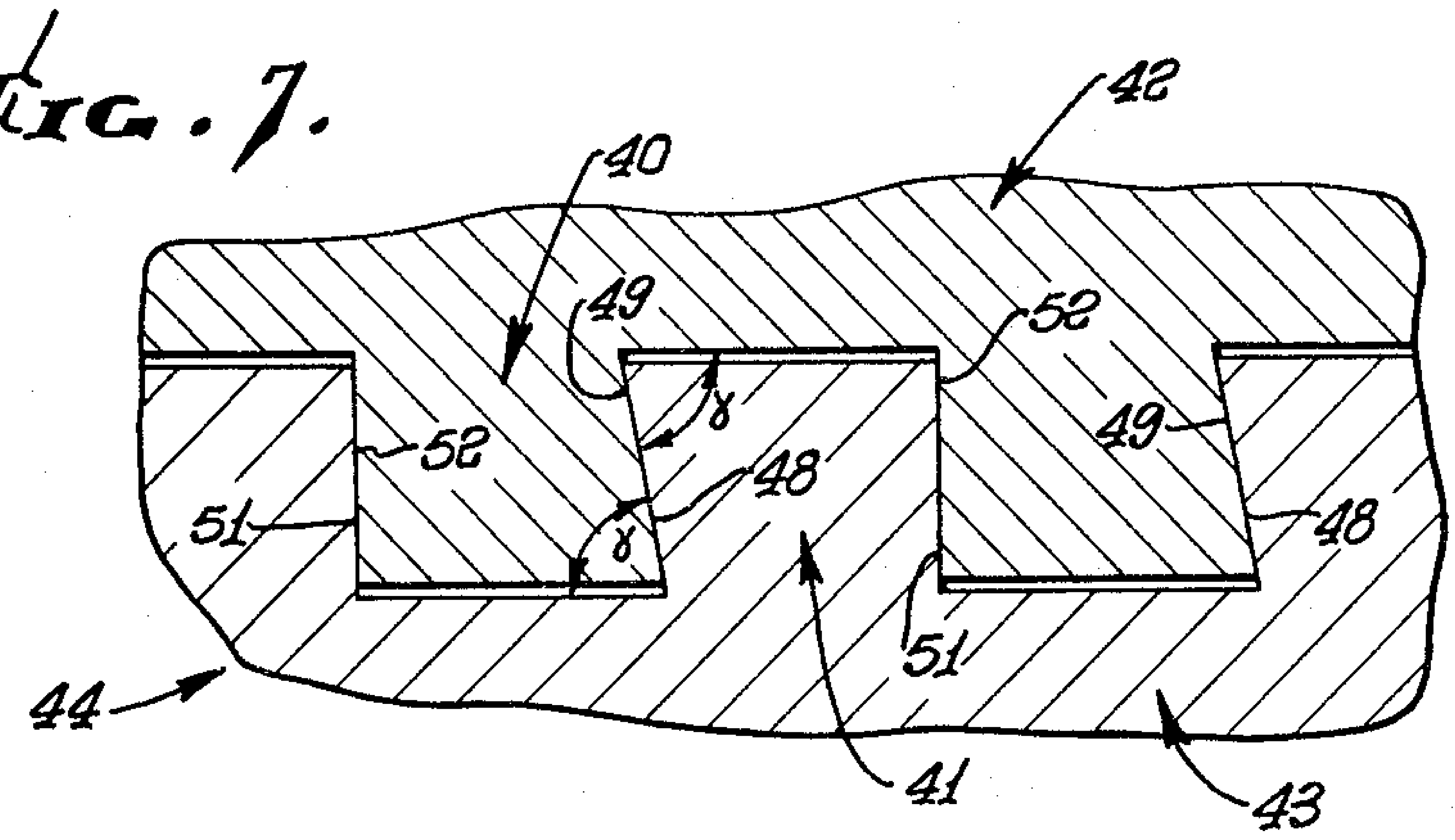


FIG. 8.

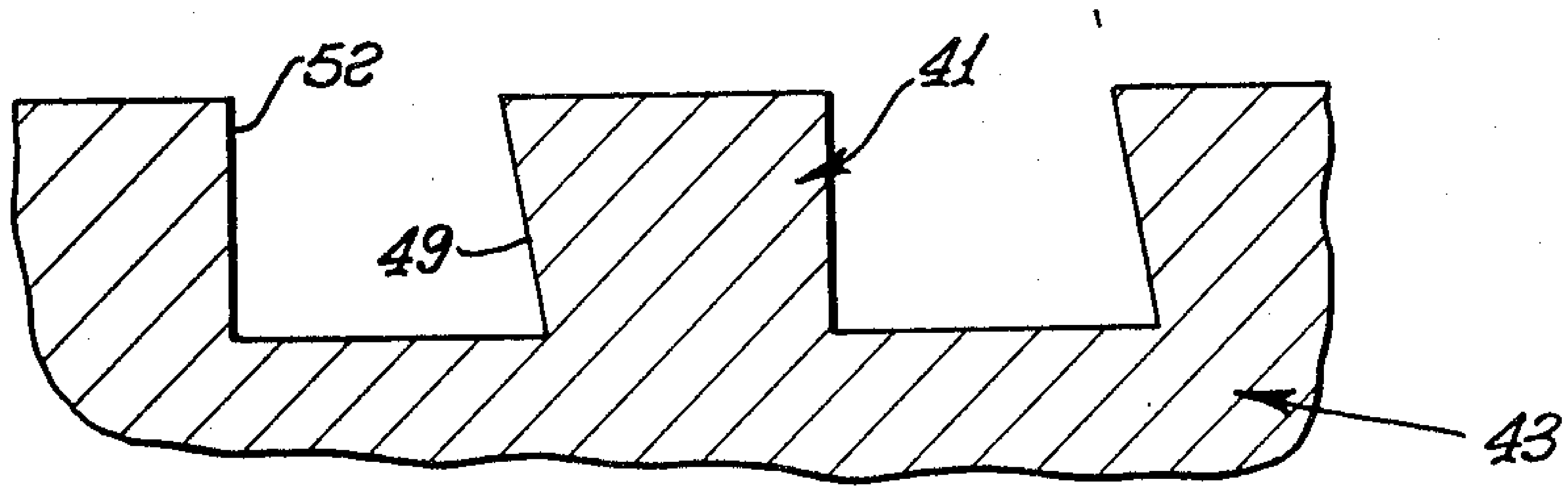
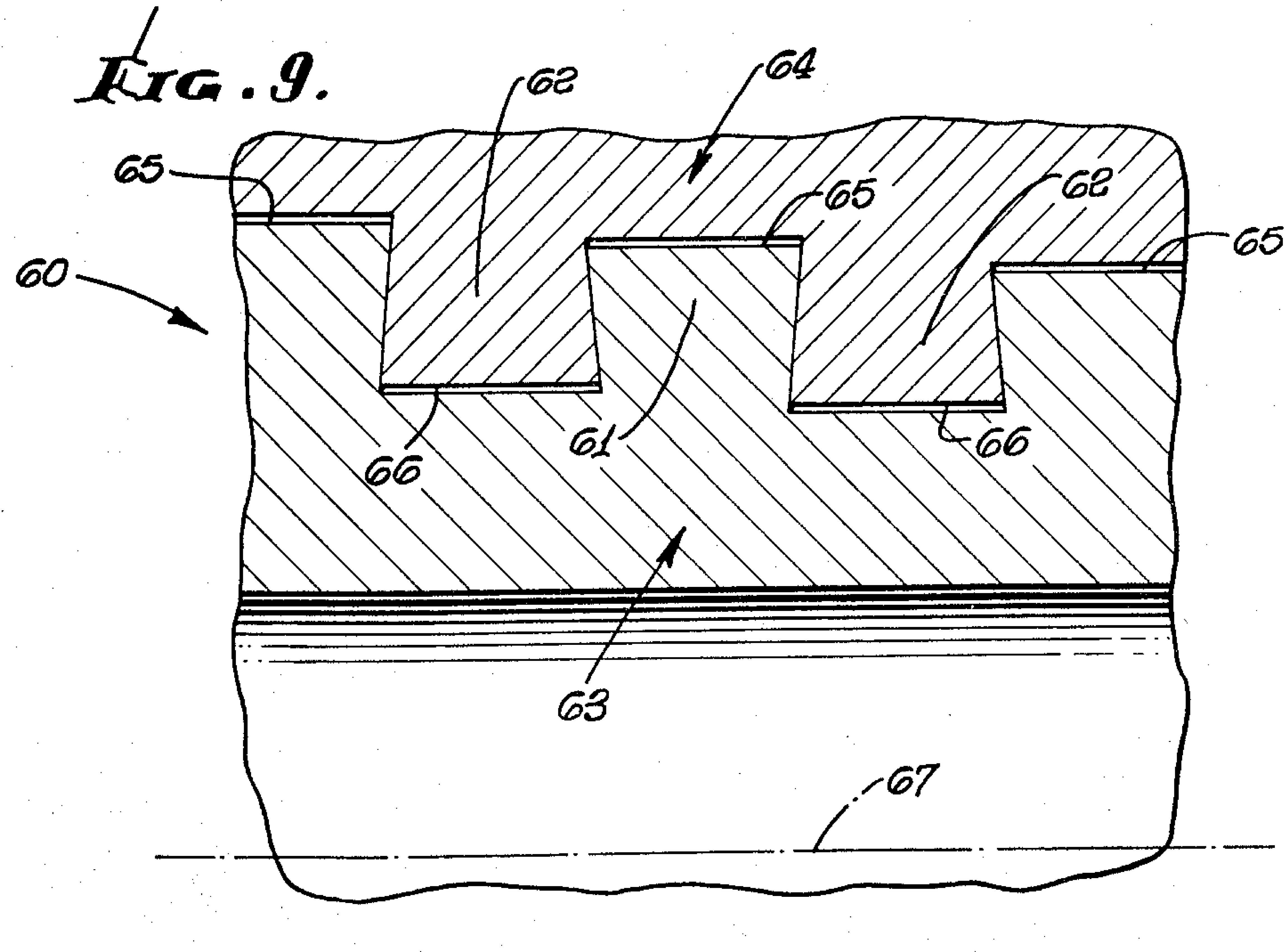


FIG. 9.



TUBULAR CONNECTION

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

This invention relates generally to thread connected joints as usable in oil well tubing, casing, line pipe and drill pipe (all of which will be referred to as pipe, for convenience). More particularly, it concerns a means for connecting joint pin and box members in a manner to provide minimal hoop, radial or axial stresses induced by assembly or applied torque.

With increased concern for protection of our environment, it is becoming more important that tubular joint connections used in oil industry be capable of performing with maximum security under all conditions characteristic of the operating tasks they are relied upon to fulfill. Basic fundamental technology required to meet these performances must be satisfied through all operating stress or strain levels. Today there are no tubular connections produced anywhere in the world which will meet these requirements through all operating stress or strain conditions characteristic of services to which they may be exposed. In most cases, margins of safety are inherently smaller as severity of performance increases. There is a need for a connection that will have mechanical integrity which will not be weakened by load stresses or strains induced by tension, compression, internal pressure, external pressure, torsion, bending, thermal variances, or any combination of these until the material itself has failed by limitations of metallurgical properties in rupture or fracture.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide a pipe joint meeting the above need. Basically, the joint comprises interengaged thread means on pin and box members for producing hoop tension in the pin member and hoop compression in the box member in response to forcible make-up of the members, the thread means having a dove-tail interfit. As will appear, the thread means includes helical threading on each of the pin and box members, with greater pitch distance at the thread tip than at the thread root. Also, the threading typically has progressively reducing axial width along its helical length, so that the conditions of hoop tension and compression as described will be created upon final make-up, at which time the interengaged threads preferably having wedging flank interfit to limit such make-up.

As will appear, the dove-tail (semi or full) thread flanks will interlock the elements of the connection. When torque is applied to assemble the connection, rotational movement between elements will stop when the wedges (threads) are made up on the flanks of the groove between the threads. Since the threads are wedge type and interlocked by a negative face angle on the back flank and the crests and roots are parallel, the strain reactions to applied torque are primarily axial in direction. Torque is resisted by the axial "squeezing" of the threads. Since back flank is intended to always be negative (back flank to the root plane will be less than 90°), thread strain reactions against this surface will cause the box member to be pulled radially inward and the pin member to be pulled radially outward. Therefore, the box member attains a condition of hoop compression while the pin will be in hoop tension. Excessive torque will only result in high axial squeezing forces on the threads and have very little effect in inducing other extraneous stresses other than some minor degree of bending of end threads.

Further, the threads are so designed that possible clearances between mating crests and roots will be minimal while flanks will be in wedging interference. In this manner the threads will be functionally leak resistant. The primary resistance to leakage through this connection will typically be accomplished by a separately functional metal to metal seal. One or more such seals may be incorporated for this requirement. In any case, the seals will be located adjacent to or within the thread areas so that they can receive the benefits of the interlocking threads. When properly located and suitable interference (radial) established, the leak resistance of the connection will not be affected by torque, tension, internal or external pressures, bending axial compression, or radical thermal changes in response to internal or externally applied termperature differences.

It is another object of the invention to provide a pin and box connection employing thread means as described which will interlock in such manner as to prevent opening up of a seal between the members in response to fluid pressure (internal or external) application to the seal zone; further, it is an object to provide the interlock at axially opposite sides of the seal zone so that the pin and box members are clamped against relative radial separation at opposite ends of the seal zone, preventing opening up of the latter in response to fluid pressure application.

Accordingly important objects and benefits to be obtained from a tubular connection constructed as described are:

1. To offer torsional strength equivalent to that of the full pipe body, without the use of either an internal or an external shoulder.
2. To obtain a joint strength in either tension or compression equivalent to the strength of the full pipe body.
3. To resist radial strain differentials caused by the application of either external or internal pressures which normally reduce the effective interferences between sealing elements.
4. To mechanically interlock the two joint elements so that high bending stresses will be ineffective to the leak resistant integrity of the connection.
5. To produce a connection or non-upset pipe that will have full performance properties comparable to those of integral upset products.
6. To make it possible to recover used or damaged upset pipe by cutting off the upset ends and apply the new connection as threaded and coupled, with performance capabilities comparable to new integral upset end connections.
7. To make a connection for line pipe that will be virtually self-locking with high resistance to unscrewing.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following description and drawings, in which:

DRAWING DESCRIPTION

FIG. 1 is a section in an axial radial plane through a pipe joint embodying the invention;

FIG. 2 is an enlarged view of made-up threading (full dove-tail) in the FIG. 1 joint;

FIG. 3 is an enlarged view of pin or box member threading as seen in FIG. 2;

FIG. 4 is a perspective showing of a projected thread as seen in FIG. 3;

FIG. 5 is a view like FIG. 2, but showing the threading prior to completion to make-up;

FIG. 6 is a section in an axial radial plane through a two-step pipe joint embodying the invention;

FIG. 6a is a view like FIG. 6 showing a variation; FIG. 7 is an enlarged view of made-up threading (semi-dove-tail) in the FIG. 6 joint;

FIG. 8 is an enlarged view of pin or box member threading as seen in FIG. 7; and

FIG. 9 is a view like FIG. 2 but showing axially tapering threading.

DETAILED DESCRIPTION

Referring first to FIGS. 1–5, a pipe joint **10** includes pin and box members **11** and **12**, the joint defining an axis **13**. Interengaged thread means on the members include helical threading or threads **14** and **15** characterized as producing hoop tension in the pin member, and hoop compression in the box member in response to forcible make-up of the members. As such time, the threads **14** and **15** have dove-tail interfit as at flank **16** on thread **14** engaged with flank **17** on thread **15**, and opposite flank **18** on thread **14** engaged with flank **19** on thread **15**. In other words, the angles α and β as shown are acute, angle α formed between flank **18** and root wall **20** of thread **14** (or between flank **19** and root wall **21** of thread **15**); and the angle β formed between flank **16** and root wall **20** (or between flank **17** and root wall **21**). Walls **20** and **21** are cylindrical, and parallel to axis **13**. Note the clearances at **22** and **23** between those root walls and the cylindrical tips **24** and **25** of the threads **14** and **15**, respectively. Further, flanks **16** and **18** on thread **14** flare toward the thread lips **24**, and flanks **17** and **19** flare toward thread tip **25**. Thus threads **14** and **15** define full dove-tail.

It will be noted the helical thread **14** has greater pitch distance (i.e. in an axial direction) between flanks **16** and **18** at the thread tip than at the thread root; likewise, helical thread **15** has greater axial pitch distance between flanks **17** and **19** at the thread tip than at the thread root. Further, each thread **14** and **15** has progressively reducing width, or pitch distance, along the helical length thereof. This is clear from FIG. **1** by comparison of the widths of the thread **15** at locations **15a** . . . **15f**, and of the widths of the thread **14** at axially spaced locations **14a** . . . **14c**. The linear projection of thread **14** in FIG. 4 clearly shows progressive width decrease along the thread length. At the same time, the pitch distance between corresponding points on successive thread turns, in axial radial planes, is the same as is clear from comparison of FIGS. 2 and 5.

It is a further clear from FIGS. **1** and **2** that the threads **14** and **15** have vertically wedging interfit to limit make-up. Prior to completion of such make-up, i.e. in partialy made-up condition, there are gaps between the threads **14** and **15**, as is clear from FIG. 5. The latter may, for exmaple, illustrate the position of thread section **15a**, as it is rotated past section **14b**, such section also being indentified in FIG. **1**. Note gaps **30** and **31** in FIG. 5.

The angles α and β should be less than about 85° to enable the interengaged flanks to resist unscrewing or disassembly of the joint. When the connection is assembled power tight, the sealing surfaces will be locked together because of the thread from which secures the two joint elements in intimate contact through any degree of, or direction of, radial strain. Maximum load stresses can be transmitted through the connection in any direction (radial or axial) without disengagement of the two mating elements. Multi-directional stresses may be applied without decreasing performance capabilities of the connection. The wedging action of the front and back flanks of made up threads not only offers a positive stop for make-up without the use of an auxiliary shoulder but offers maximum attainable resistance to torque, tension, compression, or any other induced load condition without resulting in detrimental strain reaction to the sealing qualities of the joint. This flank wedging action also prevents the normal tendency of threads to bend or deflect under high axial load conditions which normally lead to possible "pullout" or joint separation followed by leakage, or telescoping from compressive loads. The connection is securely interlocked in a manner which resists strain differentials between the two joint elements when subjected to load stresses in any direction or from any operational cause.

FIG. **1** also shows the provision of annular beveled shoulders **33** and **34** on the respective members **11** and **12**, and having metal-to-metal sealing interfit in response to joint make-up. In addition, the interengaged flanks **16** and **17**, and **18** and **19**, provide metal-to-metal seals along the thread length.

FIGS. **6–8** illustrate another form of the invention, wherein semi dove-tail threads **40** and **41** are formed on pin and box members **42** and **43** forming joint **44**. The latter is shown in the form of a two step thread, with a second pair of threads **40'** and **41'** (corresponding to threads **40** and **41**) at a greater radius from the center line or axis **45** than threads **40** and **41**. Note metal-to-metal annular seals which are established at locations **46** and **47** upon full make-up of the joint.

In FIG. 7, the angularity γ of interengaged flanks **48** and **49** (of respective threads **40** and **41**) from the direction of the axis **45** should be less than about 85°, but greater than zero, in a manner similar to angles α and β in FIG. 2; on the other hand, interengaged flanks **51** and **52** on threads **40** and **41** extend radially, in axial radial planes.

Referring back to FIG. 6, a tapered metal-to-metal annular seal is formed at **55** between the pin and box members; also, the nose **56** the pin **42** annularly engages a non-metallic (as for example molded tetrafluoroethylene) seal ring **57** received in an annular recess **58** in the box member **43** to block leakage of corrosive well fluid to the interengaged threads.

FIG. 9 illustrates an application of the invention to a joint **60** wherein threads **61** and **62** on pin and box members **63** and **64** taper, axially. Note the fully dove-tailed threading of the type seen in FIG. 2; however the tips **65** and **66** of the threads progress toward axis **67** along the thread lengths.

FIG. **6a** is like FIG. **6**, but varies in that annular shoulders are provided on the members at **89** and **90**, these being axially tapered as shown. Such shoulders come into pressural interengagement upon make-up of the members, and have sealing interfit in a zone between axial cylinders indicated at **91** and **92**. Cylinder **91** is defined by the crests of threads **140** (corresponding to threads **40** in FIG. **6**) which mesh with threads **141** (corresponding to threads **41** in FIG. **6**), and cylinder **92** is defined by the crests of threads **141'** (corresponding to threads **41'** in FIG. **6**) meshing with threads **140'** (corresponding to threads **40'** in FIG. **6**). The interengaged threads at the two steps serve to positively lock or clamp the pin and box members **142** and **143** together against relative radial separation, at or proximate opposite ends of the sealing interfit shoulders **89** and **90**, whereby the latter cannot open up to leak fluid pressure therebetween. All of this may be provided in a non-upset joint, or in an upset joint, as desired. Fracture of the joint cannot occur at the seal zone because strain is minimized or non-existent in the members defining the seal zone, due to the positive interlock provided by the interlocked threads.

Finally, the thread elements of the connection may be either single or multiple pitch. The variance in pitch between joints will be related to product requirements of performance rather than size or other physical dimensions.

I claim:

1. In a pipe joint including pin and box members, the joint having an axis,

a. a pair of interengaged threads on said members for producing hoop tension in the pin member and hoop compression in the box member in response to forcible make-up of said members,

b. the threads on said members having dove-tail interfit,

c. said thread on each member having progressively changing axial width along substantially the entire helical length thereof and at selected radical distance from said axis, whereby upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge the members radially together.

2. The joint of claim **1** wherein each thread has greater pitch width at the thread tip than at the thread root.

3. The joint of claim **2** wherein each thread has opposite flanks one of which in axial radial planes extends radially.

4. The joint of claim **3** wherein the other flank flares toward the thread outer extent relative to said one flank in axial radial planes.

5. The joint of claim **2** wherein each thread has opposite flanks both of which flare toward the outer extent of the thread in axial radial planes.

6. The joint of claim **2** wherein said threads have opposed tips and root walls with clearances formed therebetween, thread flanks forming angles with said thread tips and root walls in axial radial planes, said angles being less than about 85°.

7. The joint of claim **2** wherein the threads on said members in fully made up condition have mutually wedging interfit to limit said make-up.

8. The joint of claim **2** including annular shoulders on said members having sealing interfit in response to said make-up.

9. The joint of claim **8** wherein both of said shoulders are metallic.

10. The joint of claim **8** wherein at least one of said shoulders is non-metallic.

11. The joint of claim **1** including a second pair of interengaged threads like said first pair, said two pairs defining a multiple-step thread.

12. The joint of claim **1** wherein said threads are axially tapered.

13. The joint of claim **11** including annular shoulders on said members having sealing interfit between two of the thread steps.

14. The joint of claim **13** wherein said sealing interfit shoulders taper axially, the interengaged threads at said two steps locking the pin and box members together against relative radial separation at opposite ends of said sealing interfit shoulders.

15. In a pipe joint including pin and box members, the joint having an axis,

a. annular shoulders on the members having sealing interfit, and

b. first and second interengaged threads on the respective members, the threads having dovetail interfit and locking the members together against relative separation proximate one axial side of said annular shoulders, each thread having progressively changing axial width along substantially the entire helical length thereof at selected radial distance from said axis, whereby upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge the members radially together.

16. The pipe joint of claim **15** including third and fourth interengaged threads on the respective members, the third and fourth threads having dovetail interfit and locking the members together against relative separation proximate the other axial side of said annular shoulders, each of the third and fourth threads having progressively changing axial width along substantially the entire helical length thereof at selected radial distance from said axis.

17. In a joint including pin and box members, the joint having an axis,

a. a pair of interengaged threads on said members for producing circumferential tension in the pin member and circumferential compression in the box member in response to forcible make-up of said members,

b. the threads on said members having dove-tail interfit,

c. said thread on each member having progressively changing axial width along substantially the entire helical length thereof and at selected radial distance from said axis, whereby upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge the members radially together.

18. The joint of claim **17** wherein each thread has greater pitch width at the thread tip than at the thread root.

19. The joint of claim **18** wherein each thread has opposite flanks, one of which in axial radial planes extends radially.

20. The joint of claim **19** wherein the other flank flares toward the thread outer extent relative to said one flank in axial radial planes.

21. The joint of claim **18** wherein each thread has opposite flanks both of which flare toward the outer extent of the thread in axial radial planes.

22. The joint of claim **18** wherein said threads have opposed tips and root walls with clearances formed therebetween, thread flanks forming angles with said thread tips and root walls in axial radial planes, said angles, being less than about 85°.

23. The joint of claim **18** wherein said threads on said members in fully made up condition have mutually wedging interfit to limit said make-up.

24. The joint of claim **18** including annular shoulders on said members having sealing interfit in response to said make-up.

25. The joint of claim **24** wherein both of said shoulders are metallic.

26. The joint of claim **24** wherein at least one of said shoulders is non-metallic.

27. The joint of claim **17** including a second pair of interengaged threads like said first pair, said two pairs defining a multiple-step thread.

28. The joint of claim **17** wherein said threads are axially tapered.

29. The joint of claim **24** wherein said sealing interfit shoulders taper axially, the interengaged threads locking the pin and box members together against relative radial separation at opposite ends of said sealing interfit shoulders.

30. A thread structure for a pin member adapted for use in a pipe joint, said pin member having an axis and adapted to be made-up with a mating box member having a complementary thread structure, said thread structure for said pin member comprising:

a helical pin thread structure having at least one dove-tail flank adapted for interfitting with a complementary helical thread flank on a mating box member for producing hoop tension in said pin member and hoop compression in such box member in response to forcible make-up of said pin member with such box member to form a joint;

said helical pin thread structure having progressively changing axial width along substantially the entire helical length thereof and at selected radial distance from the axis, whereby upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge said pin member radially toward such box member;

said pin member including a second pin thread like said first pin thread, said two threads defining a multiple step thread; and

said pin member, including an annular seal shoulder on said pin member between said thread steps adapted for sealing interfit with such box member.

31. The pin member of claim 30, wherein said annular seal shoulder tapers axially, the pin threads at said two steps adapted for locking the pin and box members together against relative radial separation at opposite ends of said seal shoulder.

32. A thread and seal structure for a pin member adapted for use in a pipe joint, said pin member having an axis and adapted to be made-up with a mating box member having a complementary thread structure to form the joint, said thread and seal structure for said pin member comprising:

an annular seal shoulder formed on said pin member adapted for sealing interfit with such box member upon make-up of the joint;

a first helical pin thread structure on said pin member adapted for interengagement with a complementary helical thread structure on such box member upon make-up of the joint;

said first pin thread structure having a flank adapted to have a dove-tail interfit with such thread flank on such box member for locking the pin member and box member together against relative separation proximate one axial side of said annular seal shoulder upon make-up of the joint; and

said first pin thread structure having progressively changing axial width along substantially the entire helical length thereof at selected radial distance from the axis wherein upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge said pin member and such box member radially together.

33. A thread structure for a pin member adapted for use in a joint, said pin member having an axis and adapted to form a joint upon make-up with a mating box member having a complementary thread structure, said thread structure for said pin member comprising:

a helical pin thread structure on said pin member adapted for producing circumferential tension in said pin member and circumferential compression in such box member in response to forcible make-up with such box member to form the joint;

said helical pin thread structure having a dove-tail flank; and

said helical pin thread structure on said pin member having progressively changing axial width along substantially the entire helical length of said pin thread structure and at a selected radial distance from said axis, whereby upon complete make-up of the joint the thread flanks produce forces tending to urge said pin member radially together with such box member.

34. The pin member of claim 33, wherein said pin thread structure has greater pitch width at the thread tip than at the thread root.

35. The pin member of claim 34, wherein said pin thread structure has opposite flanks, one of which in axial radial planes extends radially.

36. The pin member of claim 35, wherein the other flank flares toward the thread outer extent relative to said one flank in axial radial planes.

37. The pin member of claim 34, wherein said pin thread structure has opposite flanks both of which flare toward the outer extent of the thread in axial radial planes.

38. The pin member of claim 34, wherein said pin thread flank forms an angle with said thread tips and root walls in axial cylindrical planes, said angle being less than about 85°.

39. The pin member of claim 34, wherein the thread structure on said pin member is adapted in fully made-up condition to have mutually wedging interfit with such box member having complementary thread structure to limit said make-up.

40. The pin member of claim 34, including an annular shoulder on said member adapted for sealing interfit with a complementary shoulder on such box member in response to said make-up.

41. The pin member of claim 40, wherein said pin member annular shoulder is metallic.

42. The pin member of claim 40, wherein said pin member annular shoulder is non-metallic.

43. The pin member of claim 33, including a second thread structure like said first thread structure, said pair defining a multiple-step thread structure.

44. The pin member of claim 33, wherein said thread structure is axially tapered.

45. The pin member of claim 40, wherein said annular shoulder tapers axially.

46. A thread structure for a box member adapted for use in a pipe joint, said box member having a complementary *thread structure, said thread structure for said box member comprising:*

a helical box thread structure having at least one dovetail flank adapted for interfitting with a complementary helical thread flank on a mating pin member for producing hoop compression in said box member and hoop tension in such pin member in response to forcible make-up of said box member with such pin member to form a joint;

said helical box thread structure having progressively changing axial width along substantially the entire helical length thereof and at selected radial distance from the axis, whereby upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge said box member radially towards such pin member;

said box member including a second box thread like said first box thread, said two box threads defining a multiple step thread; and

said box member including an annular seal shoulder on said box member between said thread steps adapted for sealing interfit with such pin member.

47. The box member of claim 46, wherein said annular seal shoulder tapers axially, the box threads at said two steps adapted for locking the pin and box members together against relative radial separation at opposite ends of said shoulder.

48. A thread structure and seal for a box member adapted for use in a pipe joint, said box member having an axis and adapted to be made-up with a mating pin member having a complementary thread structure to form the joint, said thread structure and seal for said box member comprising:

an annular seal shoulder formed on said box member adapted for sealing interfit with such pin member upon make-up of the joint;

a first helical box thread structure on said box member adapted for interengagement with a complementary helical thread structure on such pin member upon make-up of the joint;

said first box thread structure having a flank adapted to have a dove-tail interfit with such thread flank on such pin member for locking the box member and pin member together against relative separation proximate one axial side of said annular seal shoulder upon make-up of the joint; and

said first box thread structure having progressively changing axial width along substantially the entire helical length thereof at selected radial distance from the axis wherein upon complete make-up of the joint the interengaged thread flanks produce forces tending to urge said box member and such pin member radially together.

49. A thread structure for a box member adapted for use in a joint, said box member having an axis and adapted to be made-up with a mating pin member having a complementary thread structure, said thread structure for said box member comprising:

a helical box thread structure on said box member adapted for producing circumferential compression in said box member and circumferential tension in such pin member in response to forcible make-up with such pin member;

said helical box thread structure having a dove-tail flank; and

said helical box thread structure having progressively changing axial width along substantially the entire helical length of said box thread structure and at a selected radial distance from said axis, whereby upon complete make-up of the joint the thread flanks produce forces tending to urge said box member radially together with such pin member.

50. The box member of claim 49, wherein said box thread structure has greater pitch width at the thread tip than at the thread root.

51. The box member of claim 50, wherein said box thread structure has opposite flanks, one of which in axial radial planes extends radially.

52. The box member of claim 51, wherein the other flank flares toward the thread outer extent relative to said one flank in axial radial planes.

53. The box member of claim 50, wherein said box thread structure has opposite flanks both of which flare toward the outer extent of the thread in axial radial planes.

54. The box member of claim 50, wherein said box thread flank forms an angle with said thread tips and root walls in axial cylindrical planes, said angle being less than about 85°.

55. The box member of claim 50, wherein the thread structure on said box member is adapted in fully made-up condition to have mutually wedging interfit with such pin member having complementary thread structure to limit said make-up.

56. The box member of claim 50, including an annular shoulder on said member adapted for sealing interfit with a complementary annular shoulder on such pin member in response to said make-up.

57. The box member of claim 56, wherein said box member annular shoulder is metallic.

58. The box member of claim 56, wherein said box member annular shoulder is non-metallic.

59. The box member of claim 49, including a second thread structure like said first thread structure, said pair defining a multiple step thread structure.

60. The box member of claim 49, wherein said thread structure is axially tapered.

61. The box member of claim 56, wherein said annular shoulder tapers axially.

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