June 25, 1963 E. W. CLARK, JR., ETAL 3,095,042

SUSPENSION HANGER FOR DEEP WELL TUBING

Filed May 13. 1960

2 Sheets-Sheet 1

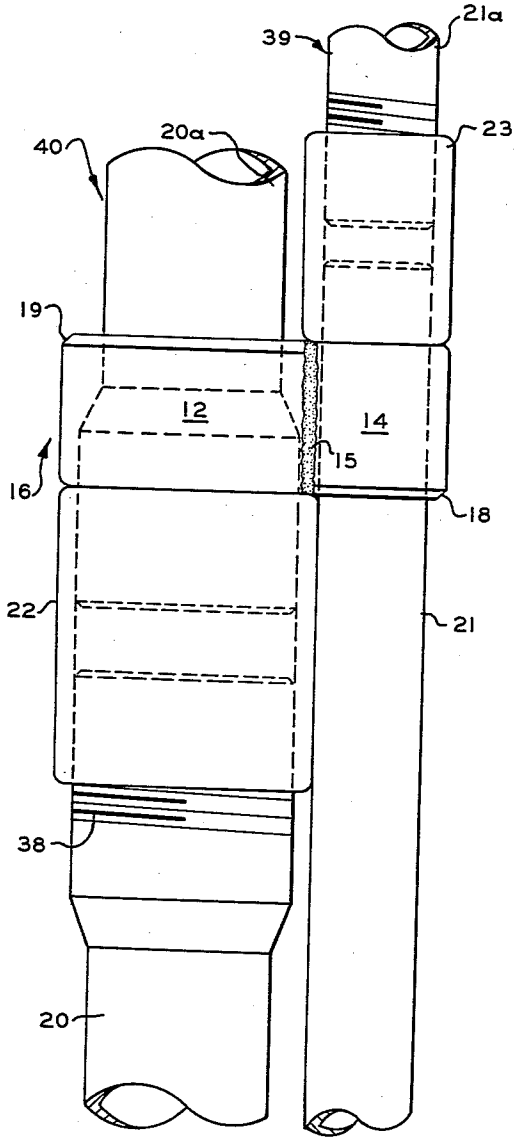


FIG. 3

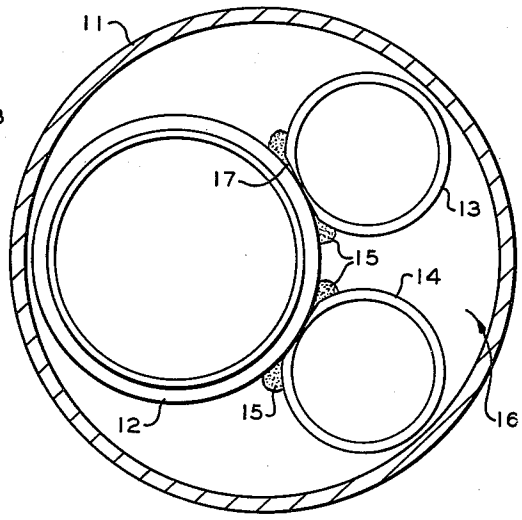


FIG. 1

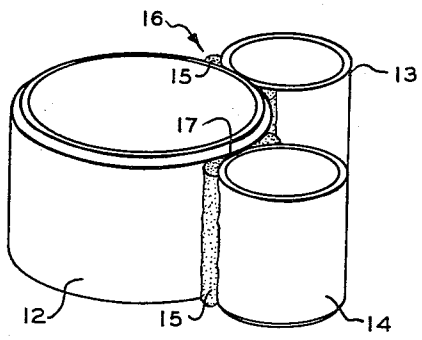


FIG. 2

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2 Sheets-Sheet 2

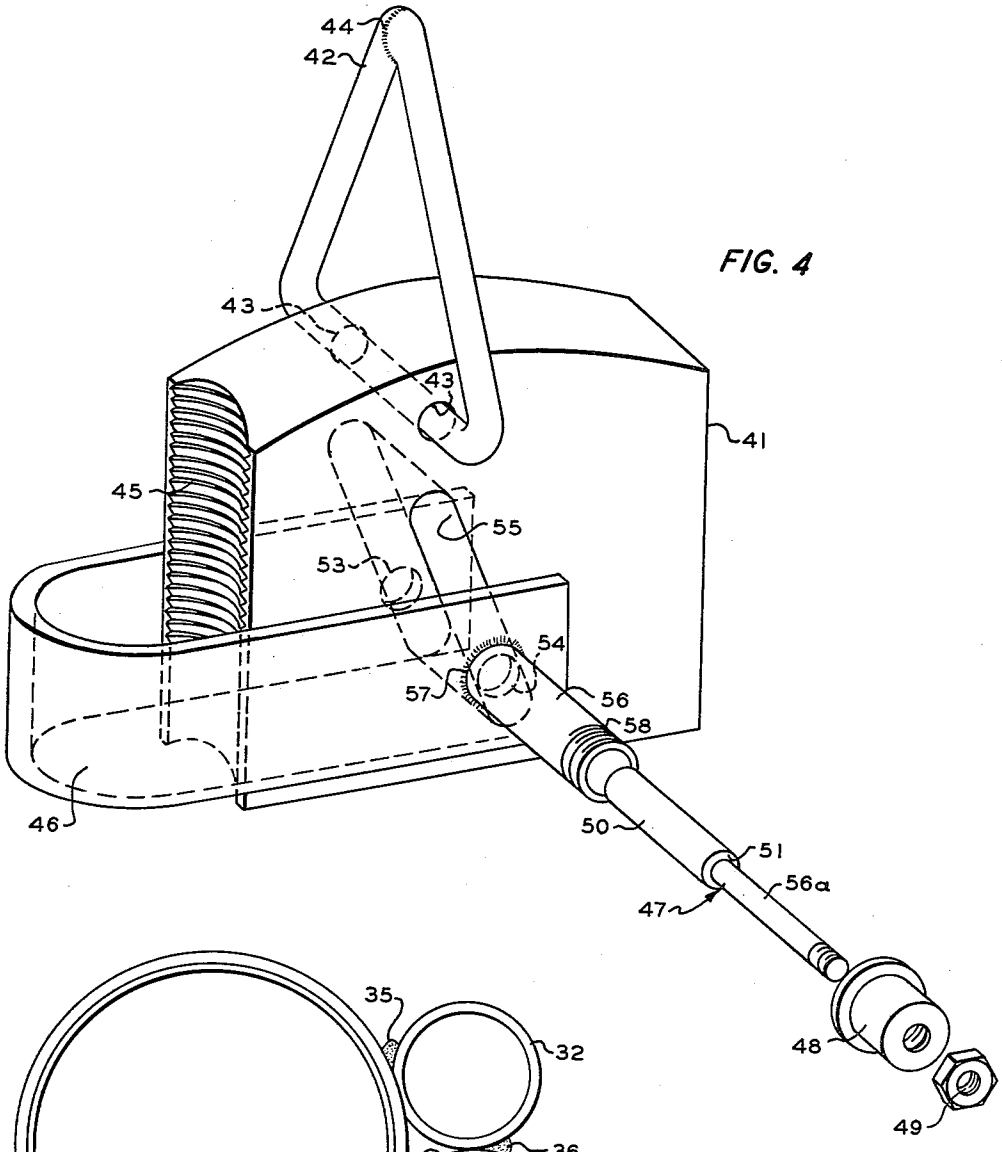


FIG. 4

FIG. 5

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SUSPENSION HANGER FOR DEEP WELL TUBING

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This invention relates to apparatus for hanging one tubing string to another tubing string in a deep well. In one aspect it relates to apparatus for hanging a string of small diameter tubing to a string of large diameter tubing in a deep well so that the large diameter tubing string carries the weight of the small diameter tubing string. In another aspect it relates to apparatus for hanging more than one small diameter tubing string to a large diameter tubing string in a deep well.

As far as we are aware, the only equipment available for attaching a first string of well tubing to a second string of well tubing for supporting the first string is known as tubing clamps. Such equipment, as the name implies, clamps one joint of tubing to another. These clamps contain jaws which are drawn and held together in a clamping action by bolts. The bolts used with such clamps are necessarily small and therefore the clamping force available is small. Accordingly, when using tubing clamps, from one to two clamps are ordinarily required for each joint of tubing to be supported.

An object of this invention is to provide a suspension hanger which does not depend on clamping action. Another object of this invention is to provide a simple tubing support which is relatively easy and inexpensive to manufacture and to install. Still another object of our invention is to provide a tubing support which is free from separable metal parts such as those which are used in ordinary tubing clamps. Yet another object of our invention is to provide a tubing support which, when installed in a well, replaces a relatively large number of conventional tubing clamps. Still other objects and advantages of our invention will be realized upon reading the following description which, taken with the attached drawing, forms a part of this specification.

In the drawing, FIGURE 1 is a plan view of one embodiment of our invention. FIGURE 2 is a perspective of the embodiment illustrated in FIGURE 1. FIGURE 3 is an elevational view of the apparatus of our invention installed to support a small diameter tubing by a large diameter tubing. FIGURE 4 is a perspective view of a lift device employed in installing the apparatus of our invention. FIGURE 5 illustrates another embodiment of apparatus of our invention.

Our device is a tubing support apparatus for use in deep wells in which more than one tubing string is required, such as wells completed as dual production wells. The device is intended for installations consisting of a relatively large diameter supporting string of tubing, and one or more additional supported strings of small diameter tubing. This one or more additional strings of tubing are attached to the supporting string in such a manner that their weight is carried by the supporting string. As is well known, such small diameter well tubing as nonupset 1" or 1¼" I.D. will not support its own weight when run into oil wells of conventional depth. Thus, some type of support device is required at various elevations in the well. For use in a well in which three tubing strings are to be run, the device consists of three hollow cylinders attached together on their peripheries with their axes being mutually parallel. The inside diameters of the support cylinders are sized to fit the outside diameters of the respective tubing sizes directly above or below

collars or couplings. The appropriate cylinder of the support device is placed on the main or support string above a collar and the additional or supported strings are then inserted through their appropriate cylinders. The collar or coupling of each supported string rests upon its support cylinder. The intervals between these support devices are determined by the tensile strength of the small diameter supported tubing. The supported strings are cut to fit the support device spacing as the strings of tubing are run into the well so that the weight transferred to the support by the collar of the supported string will be equal to the weight of the supported strings of tubing between the support being installed and the next lower support. In fabrication of the support device the axial centers of the support cylinders are such as to provide for a minimum diameter of the finished support device. The overall diameter of this support device is not greater and is usually less than the sum of the diameters of the couplings of the large diameter and one small diameter tubing.

Referring to FIGURE 1, reference numeral **11** is a well casing in which a tubing hanger **16** of our invention is placed. This hanger consists of a support tubing sleeve or cylinder **12** which has outside and inside diameters approximately the same as corresponding diameters of a coupling used with the tubing on which sleeve **12** is to be placed. Support tubings are frequently made of external upset end tubings (EUE) so that threads for accommodation of couplings will not reduce the cross sectional area of the tubing. This requirement is preferred because this support tubing must carry not only its own weight but also the weight of the one or more strings of small diameter tubing. Sleeves or cylinders **13** and **14** are for carrying the weight of the supported tubing strings. In FIGURES 1 and 2 are illustrated means for rigidly attaching sleeves **13** and **14** to sleeve **12**. These means are preferably welds **15** at the particular positions illustrated in the drawing. Sleeves **13** and **14** are positioned some little distance apart. In this particular illustration separate lines joining the centers of the sleeves **13** and **14** with the center of the sleeve **12** form an angle of 60 degrees. Some spacing is necessary so that upon installation of sleeve **14**, sleeve **13** can be installed with sufficient room for welding. The upper surface of sleeve **12** is provided with a beveled surface **19**, as illustrated, so that upon lifting this apparatus upward through a casing there will be no tendency to hang up on irregularities along the inner wall of the casing. Similarly, the lower ends of the sleeves **13** and **14** are provided with beveled surfaces **18** so that as the tubings are lowered through the casing there will be no tendency to hang up due to irregularities in the casing.

In order to make certain that this apparatus will have an over-all diameter less than the combined diameters of the couplings of the well tubings involved, we grind off or otherwise remove a portion of the sleeves **13** and **14** throughout the lengths thereof so that the effective diameters of the assembly are reduced. One convenient method of removing such a portion of a wall of the sleeve is merely by grinding on an abrasive wheel. However, the use of a grinding wheel provides a simple method for this operation with the result that a concave surface or an approximate plane surface can be produced. In this manner the curvature of the ground surface can be made approximately the same as the curvature of the outer surface of sleeve **12** and in this manner we believe an excellent fit of one sleeve against the other is obtained.

FIGURE 3 illustrates tube hanger **16** of our invention installed in relation to the support and supported strings of tubing and shows the beveled edges **18** and **19** of sleeves **12** and **13**, respectively. Sleeve **12** is shown as resting upon a coupling **22** of an EUE support tubing.

Reference numerals **20** and **20***a* are the ends of joints of tubing connected by a collar **22**. Sleeve **14** is shown as being positioned immediately below coupling **23** which joins adjacent ends of tubings **21** and **21***a*. These latter tubings are usually NU (non-upset) tubings. The relative position of collar **23** on the supported tubing string **39** is illustrated relative to the position of the support collar **22** on the support tubing string **40**. In this manner collar **23** transmits to sleeve **14** the weight of a portion of the tubing string **39** and this weight, plus the weight of the tubing hanger **16**, is transferred to the support collar **22**.

One method of fabricating a tubing hanger similar to that illustrated in FIGURES 2 and 3 is to turn out or remove the threads from the inside of a coupling fitting the tubing of string **40**. When these interior threads are removed, the coupling then slips over the upset end of the tubing and rests upon coupling **22**. We have found that such a coupling can be cut into two portions to provide a pair of sleeves **12** suitable for producing two hangers. Sleeves **14** can be made by removing the threads from a coupling fitting the tubing of string **39**. If desired, pipe can be used for fabrication of the sleeves **14, 13** and **12** in place of couplings. Beveled surface **19** is preferably produced while the coupling is yet in the lathe at the time of turning out the threads. In case the sleeve is made from pipe, the beveled surface is made prior to cutting off the sleeve **12**. After producing the beveled surfaces **18** and **19** and removal of the threads, the small diameter sleeves are ground to produce the surface **17**. The members are then ready for welding for the production of the finished hanger. Usually a number of these hangers is required for use in a given well. Hangers are assembled on a jig to insure alignment of support rings.

The installation of the hangers in the well or, in other words, running of the several tubing strings with the small diameter tubings to be supported by large diameter tubing is as follows. In the explanation which follows the tubing hangers are placed at approximately 1000-foot intervals. In running the tubings the first joint of small diameter tubing is positioned with respect to the bottom end of the first joint of large diameter tubing so the tubing strings will bottom at the desired elevations for production from separate formations. Such tubing strings are usually tied together at as near their bottom ends as possible by such means as a tubing clamp, well packer, dual production landing nipple or mandrel, or with a pump. The tubing strings are then run in a normal manner to the joint of large diameter tubing nearest the 1000-foot mark. A tubing hanger **16** is placed on the collar at the upper end of the last joint of large diameter tubing and then the lower end of the next joint is inserted through the ring or sleeve **12** and made up with collar **22** as usual. This operation so far has positioned a hanger **16** on its support collar **22**.

This support hanger is intended to carry the weight of the small diameter tubing above the aforementioned tubing tying means. The string of small diameter tubing is run to the extent that the last joint extends through ring or sleeve **14** of the hanger. A special slip, FIGURE 4, is attached to the small diameter tubing string and a lifting pull applied approximately equal to the weight of the 1000 feet of tubing to be supported. As is well known, steel is elastic, and this pull which may be 500 pounds or more, depending on the weight of the tubing, elongates the 1000 feet of tubing at least some inches. The elongated tubing is marked at such a distance above the top surface of sleeve **14** required for threads. The pull on the tubing is slacked and the slip released, then the marked joint of tubing is removed, cut at the mark and threaded. This cut and threaded joint is again made up, the slip attached and the pulling force applied. The tubing is again stretched. The sleeve **14** is placed over the threaded end of the tubing and collar **23** is then made up on the newly cut threads until it rests firmly on the top surface of the sleeve **14**. Then upon releasing the upward pull on the slip, the tubing weight carried by the slip is transferred to sleeve **14** of the hanger.

Upon release of the slip, the installation of the hanger for the first 1000 feet of small diameter tubing is complete. For the next 1000 feet the tubings are run, with the small one being marked, cut and threaded, etc., as hereinbefore explained. Each tubing hanger is intended to support the weight of the small diameter tubing down to the next hanger. The large diameter tubing provides the supports for the hangers and their loads of 1000-foot sections of small diameter tubing.

In one installation from 20 to 30 minutes were required to install a hanger. The time required for such installation depends largely upon the ease with which the small diameter pipe can be threaded. In the installation which required from 20 to 30 minutes to install a hanger, the small diameter pipes threaded relatively easily. The support hangers were spaced at 10-joint intervals of the large diameter tubing; thus the time required for running the tubing averaged from 2 to 3 minutes per joint. Such running time compares favorably with installing two conventional tubing clamps per joint of support tubing.

In another installation standard black iron pipe was used as the small diameter tubing and some little difficulty was encountered in its threading. The result was that from 20 to 45 minutes were required to install a hanger for the support of two strings of the iron pipe on a string of 2-inch support pipe. However, in this case support hangers were installed 15 joints of 2-inch pipe apart and the running time per joint of 2-inch pipe was from about 1½ to 3 minutes per joint. This running time also compares favorably with the running time when using two conventional tubing clamps per joint.

In some cases it may be advisable to use 1-inch, continuous-weld, screw end line pipe for the supported tubings in a well. Such pipe has a free hanging length of approximately 1870 feet with a safety factor of 1.75. In such a case the tubing hangers can be placed approximately 1800 feet apart, which spacing then reduces the number of required support hangers.

Because of the close fit of three strings of tubing in a 5½-inch casing, a 1-inch tubing string cannot wrap around the 2-inch tubing string. Furthermore, this wrapping around is eliminated because the small diameter tubing string is hung under tension in the casing.

In one case in which the tubing support apparatus of this invention was employed, three tubing strings were run in the well in which the support string was a 2-inch EUE tubing and the two supported strings were 1-inch NU tubing. These tubings were run in a 5½-inch, 14-pound casing to 3300 feet. In this case 11 hangers were required and were placed at 300-foot intervals. In this same installation, when using conventional clamps, 220 clamps would have been required. The total cost at prevailing prices of this number of clamps was $517 in contrast to $44 for 11 tubing hangers. Thus a marked savings was realized. The running time using the tubing hangers was approximately the same as would have been required if the conventional clamps had been used.

Had sufficiently strong 1-inch pipe been used for the above-mentioned installation, only three support hangers of our invention would have been required when run at 1000-foot spacing. At $4.40 per hanger only $13.20 worth of hangers would have been required. Many advantages are realized when using the tubing hangers of our invention. One advantage is that the outside diameter of the tubing bundle, as illustrated in the drawing, is reduced to a minimum and is obviously less than that realized when using conventional bolted clamps. A second advantage is that it eliminates the problem of drop-

ping loose pieces of metal down the casing or hole because of clamp breakage as is associated with the use of conventional bolted clamps. Furthermore, the supported tubing is in tension and bending forces due to compression are thus eliminated. Also, the number of supports required is much less than when bolted clamps are used; hence, the cost per installation is markedly reduced. Other advantages will be realized by those skilled in the art upon fabricating and using the tubing supports herein disclosed.

Another embodiment of support is illustrated in FIGURE 5. This embodiment is, broadly, the same as that illustrated in FIGURE 1 with only a minor difference. Support sleeve **30** is the large diameter sleeve and sleeve **31** is a small diameter sleeve such as illustrated in FIGURE 1. In this embodiment sleeve **31** is welded at welds **33** and **34** to the exterior surface of sleeve **30**. After completing these welds, sleeve **32** is welded at weld **35** to sleeve **30** and at weld **36** to sleeve **31**. This embodiment shows the use of two small diameter sleeves **31** and **32** of unlike diameters to accommodate supported tubings of unlike sizes. In some three-tubing installations the two supported tubing strings required have different sizes and accordingly such a support hanger as illustrated in FIGURE 5 is used. However, even when using sleeves **31** and **32** of different sizes the method of construction as illustrated in FIGURE 1 can be used, that is, the two sleeves can be welded to the large diameter sleeve only.

We have provided a special slip type elevator for lifting and for stretching the small diameter tubings while running the several tubing strings in the well. This apparatus is illustrated in FIGURE 4. This apparatus comprises a body member which is actually a single slip member **41** provided with teeth **45** as illustrated. These teeth are rounded in form to fit approximately the tubings with which the apparatus is to be used. A bail or clevis **42** is placed through opening **43** in body **41**. At the extremities of opening **43** the ends of this bail member, in its construction, are bent upward and fastened together at weld **44**. This member then forms a very strong member with which to pull the apparatus and attached tubing. A U-shaped strap **46** is provided with a pair of openings **53**, **54** through which the large diameter end **50** of a pin **47** extends. A sleeve **56** is welded to the U-shaped strap at the outer end of one of the openings to provide a conduit through which a small diameter end **56***a* of the pin extends. The large diameter end **50** of pin **47** terminates as a shoulder **51**, as illustrated. The outer end of sleeve **56** is threaded to accommodate a cap **48** which is provided with an opening sufficiently large to accommodate the small diameter end **56***a* of the pin **47**. The end of the small diameter portion of pin **47** is threaded to accommodate a nut **49**. This nut prevents the pin from being removed from one side of the apparatus while the shoulder **51** prevents the pin from being removed through the cap **49** since the shoulder **51** has a greater diameter than the opening in the cap. This shoulder **51** is so positioned on the pin that the pin can be withdrawn through the sleeve such a distance that the U-shaped strap can be assembled in operative position on body member **41** or removed therefrom. The strap is so constructed that when in operative position the strap holds the tubing tightly against the teeth of the slip. A slot is provided in body **41** as illustrated. The upright axis of this slot **55** makes a slight angle with the vertical in such a direction that as the force of gravity pulls the U-shaped strap and the pin **47** downward, the strap holds a tubing firmly against the teeth **45**. This angle of slope is illustrated in FIGURE 4, and in one case was 14° from vertical.

In a second installation the hanger apparatus illustrated in FIGURE 1 was fabricated from one-half of a 2-inch EUE coupling, a short section of 1¼-inch line pipe to hang a 1-inch I.D. pipe and from a short section of 1-inch I.D. line pipe to hang a ¾-inch I.D. pipe. The sleeves made from the 1¼-inch and the 1-inch pipes had to be reamed a slight extent to accommodate the 1-inch and the ¾-inch pipes. This embodiment of the hanger as fabricated cleared a 4.62-inch inside diameter casing. When using such a tubing hanger in a well spaced at intervals of 15 joints of the 2-inch support tubing, this installation would have required 440 conventional clamps at a cost of $1,034 in contrast to 15 hangers at a total cost of $67.50. This difference is a material difference. The well service time was approximately the same as it would have been if conventional clamps had been used.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto.

That which is claimed is:

1. In a deep well a production tubing assembly comprising a first tubing string, said first tubing string comprising first and second joints of tubing, a first coupling joining said first and second joints of tubing, a second tubing string, said second tubing string comprising third and fourth joints of tubing, a second coupling joining said third and fourth joints of tubing, a first hollow cylindrical member around said second joint of tubing, said first hollow cylindrical member having approximately the same inner and outer diameters as the corresponding diameters of said first coupling and being positioned immediately below said first coupling, a second hollow cylindrical member around said third joint of tubing immediately above said second coupling and having approximately the same inner and outer diameters as the corresponding diameters of said second coupling, said first and second cylindrical members being positioned at the same level and rigidly attached to each other whereby said first cylindrical member supports said first coupling and at least a portion of said first tubing string, said second coupling and the portion of said second tubing string above said second coupling supporting said first and second cylindrical members and said portion of said first tubing string, and the end surface of said first cylindrical member in contact with said first coupling and the end surface of said second cylindrical member in contact with said second coupling being flat surfaces.

2. An apparatus for hanging first and second well tubing strings to a third well tubing string in a deep well comprising hollow cylindrical first and second members having approximately the same inner and outer diameters as the corresponding diameters of couplings fitting the tubings of the first and second well tubing strings, respectively, the upper end surfaces of the first and second hollow cylindrical members being flat when the apparatus is oriented in its operable position, the flat surfaces supporting couplings of vertically positioned first and second tubing strings, a third hollow cylindrical member having approximately the inner and outer diameters as the corresponding diameters of a coupling fitting said third well tubing string, the lower end surface of said third hollow cylindrical member being flat when said apparatus is oriented in its operable position, the flat surface of the third cylindrical member resting on a coupling fitting said third tubing string, the cylindrical members being positioned with their longitudinal axes mutually parallel, each of said first and second cylindrical members having a portion of their wall removed in such a manner that the wall remaining comprises a flattened surface the axis of which is parallel to the longitudinal axes of said first and second cylindrical members, each of the first and second cylindrical members being rigidly joined to the exterior surface of said third cylindrical member along each flattened surface in such a manner that the longitudinal axes of the three cylindrical members are mutually parallel, whereby the distances, measured along separate straight lines normal to and through the longitudinal axes of said first and third members, and through the longitudinal axes of said second and

third members from the outer edges of the first and second cylindrical members opposite the corresponding axes to the edge of the third cylindrical member opposite the corresponding axes are less than the combined outer diameters of said first and third members and less than the combined outer diameters of said second and third members, these diameters as combined being taken separately in directions normal to the directions of the corresponding lines, and said tubing strings being so positioned with respect to each other that points of intersection of the axis of each tubing string with a plane normal to the axes define the corners of a triangle.

References Cited in the file of this patent

UNITED STATES PATENTS

927,854	Hendershot	July 13, 1909
1,254,822	Mannheimer	Jan. 29, 1918
1,798,167	Parker	Mar. 31, 1931
1,806,176	Owens	May 19, 1931
1,852,279	Armacost et al.	Apr. 5, 1932
1,892,781	Hoenstine	Jan. 3, 1933
2,714,496	Doyle	Aug. 2, 1955

OTHER REFERENCES

"Parallel Macaroni String Cuts Well Costs," The Petroleum Engineer, January 1957, pages B–38 to B-44.