March 29, 1932. P. J. McCULLOUGH 1,851,714

SUCKER ROD CONNECTION

Filed Aug. 29, 1929 2 Sheets-Sheet 1

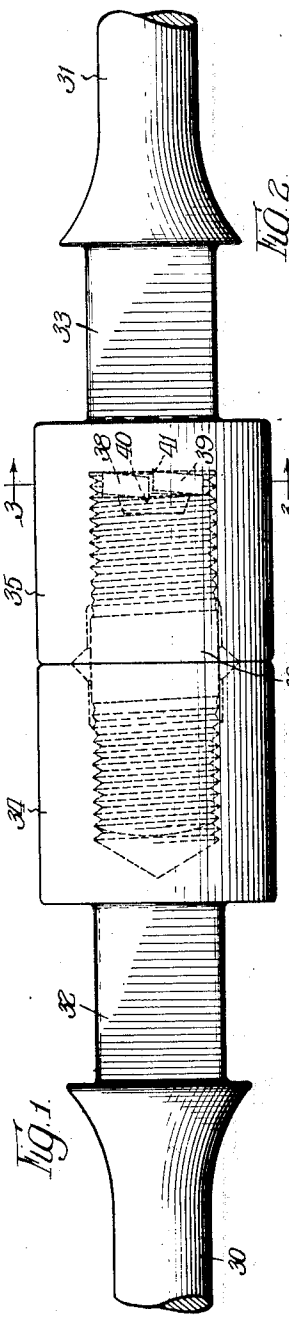

Fig. 1.

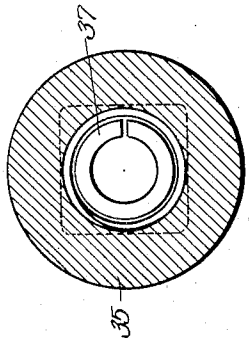

Fig. 2.

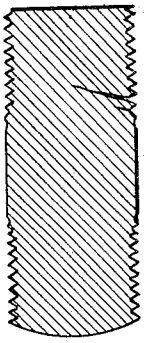

Fig. 7.

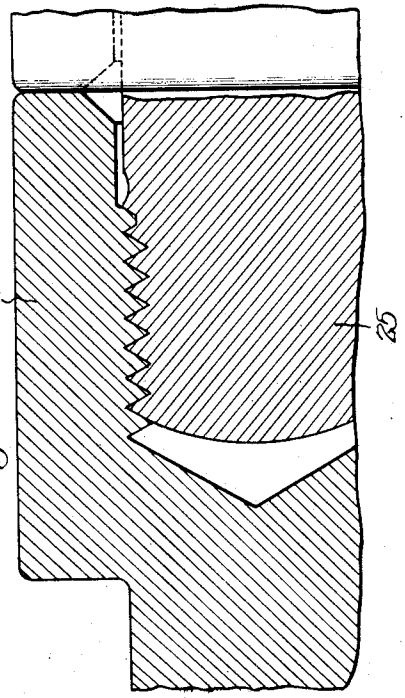

Fig. 4.

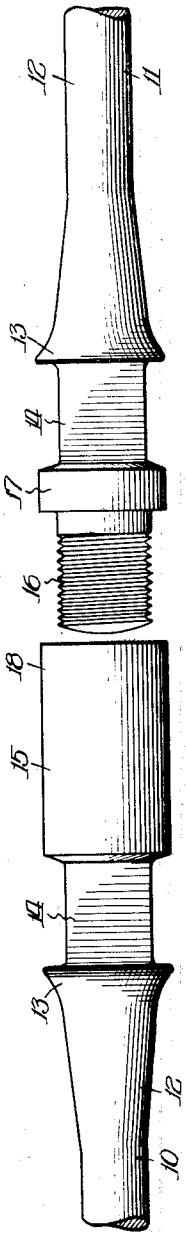

Fig. 3.

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SUCKER ROD CONNECTION

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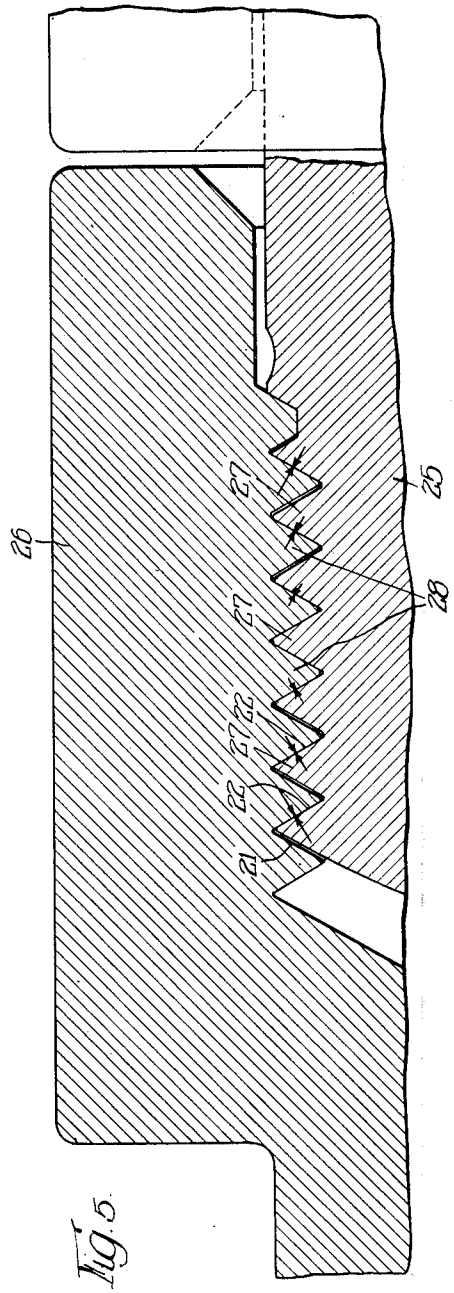

Fig. 5

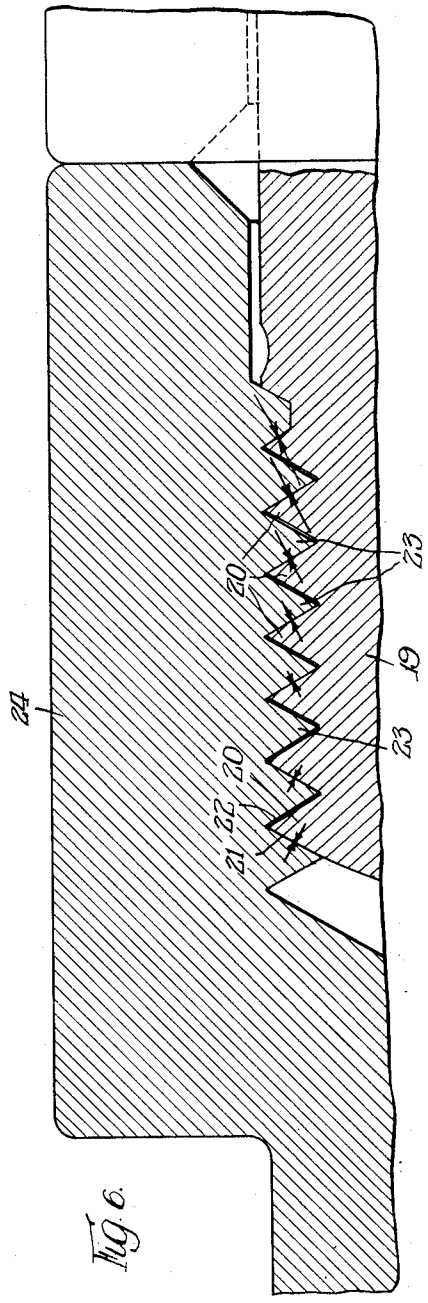

Fig. 6

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UNITED STATES PATENT OFFICE

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SUCKER ROD CONNECTION

Application filed August 29, 1929. Serial No. 389,138.

This invention relates to improvements in sucker rod connections, particularly for use in connection with oil wells.

It is common practice to insert lengths of tubing or piping about 2½ inches in diameter after the well is drilled and to operate a pump at the lower end of the tubing in order to suck the oil from the well. A plunger is connected with the operating mechanism at the top of the well by connected sections of sucker rods, each section of which is about 25 feet in length. In operation the connected sucker rods move about 18 to 24 strokes per minute, each stroke being a movement of about 4 to 5 feet. It is evident that when the well reaches 5,000 or more feet in depth that there is a heavy load upon the connections. Thus the weight of the rods and connections when in operation may be from 5,000 to 15,000 pounds. The American Petroleum Institute has adopted certain standards relative to the dimensions of sucker rods and it is the intention of the present invention to provide improvements which will conform to the A. P. I. standards. In general a sucker rod is formed either with an integral threaded pin at one end which screws into a threaded socket of an adjoining sucker rod or both ends of the adjoining sucker rods may be provided with integral threaded pins which engage a separable coupling member. The connections must be such that the sections of the rods may be readily connected and disconnected when inserting or removing a complete string. The rods have to be pulled up at times to renew the pump parts. In the standard form of connections the coupling or socket member will abut against a shoulder of the rod and will be placed under compression when tightened whereas the pin will be placed under tension.

The loading upon tightening the connections will result in compression of the socket or coupling member and stretching of the pin. Thus when standard internal and external threads are used the final connection will not result in a uniform loading upon each of the threads, instead it has been found that the last thread from the end of the pin will receive a greater load than the first thread. It is due to this condition that breaks in the pins occur in use from fatigue cracks which start at the root of the last thread. Tests have been carried out upon connected strings in which the rods were ¾″ in diameter and provided with $1\frac{1}{16}$″ diameter threaded pins. It was found that the pins would break at the root of the last thread while the smooth ¾″ section of the rods would not fail. The generally accepted theory is that a bar or rod when threaded must be increased to four times its cross-sectional area to withstand the same amount of fatigue, but due to the limitations of the standard dimensions it is not possible to increase the size of the pins to withstand breakage from fatigue.

According to my invention, proceeding from the tests which established the reason for the failure of the pins at a particular section, it is proposed to design the threads upon one of the connected members with a suitable variation in pitch from that of the other such that the loading upon each thread after the pin is stretched and the coupling compressed will be more nearly uniform.

Thus the object of my invention is to provide improved sucker rod connections which will give a longer life in service, since fatigue failures will not occur due to substantially uniform loading throughout the connections.

It is further an object of my invention to provide a sucker rod connection in which the threaded pin has a slightly greater number of threads per inch than the threaded socket with which it engages whereby upon making a tight connection the increased number of threads will compensate for the stretching of the pin and the compression of the socket and the number of threads per inch of the pin and socket will then be found to be substantially equal.

An additional object of the present invention consists in a construction in which the opposite ends of the connected sections of sucker rods are formed with internally threaded sockets and a double threaded pin is used to form the connections between the rods; the pin being substantially permanently secured to the socket of one rod by insert-

ing a lock washer in one socket which engages against the end of the threaded pin. This form of construction permits of the use of a special alloy steel for the pin while the rods themselves may be formed of the usual high carbon steel.

In the drawings:—

Figure 1 is a longitudinal elevation of an improved sucker rod connection.

Figure 2 is a transverse section on plane indicated by 2—2 in section 1 illustrating locking means for the connection pin.

Figure 3 is a separated view of the end portions of a pair of adjoining sucker rods illustrating a standard form of sucker rod connection.

Figure 4 is a longitudinal section of a portion of the sucker rod connection illustrated in Figure 1 when drawn up tight.

Figure 5 is an enlarged and somewhat exaggerated diagram illustrating a section through the sucker rod connection after the pin has been partially threaded in place.

Figure 6 is a similar enlarged and somewhat exaggerated diagram illustrating a section through a sucker rod connection which has been drawn up tight and in which standard threads have been used.

Figure 7 is a longitudinal section through a connecting pin which has been subjected to fatigue tests and illustrates the fracture which occurs when a standard thread is used.

A standard arrangement of sucker rod connections is illustrated in Figure 3 in which 10 is a sucker rod adapted to be connected to an adjacent sucker rod 11. Each of the rods is provided with a relatively long cylindrical shank 12, which is enlarged adjacent its ends to form a shoulder 13. Adjacent to the shoulder 13 is a squared section 14 adapted to receive a tool in order to tighten the connection. The rod 10 is provided with an enlarged cylindrical socket 15 adjacent the squared section 14, the socket being internally threaded to receive a threaded pin 16. The pin 16 constitutes a reduced extension from a cylindrical shoulder 17 which is formed adjacent the squared section 14 of the rod 11. It will be apparent that when the connection is made and drawn up tight that the end 18 of the socket 15 will abut against the shoulder 17 and thereby place the cylindrical wall of the socket under compression while the pin 16 will be placed under tension. It is usually desirable to draw the connection tight with a force substantially equal or greater than the maximum load which will be imposed upon the sucker rod connection so as to prevent any separation between the socket 15 and shoulder 17 which might result in a loosening of the joint. If the internal and external threads were formed exactly true and there were no compression in the couplings or stretching of the pin it is apparent that the loading would be equally distributed on the trailing faces of the external teeth. If such were possible it is apparent that at a section through the pin at the root of one of the last threads to enter the socket there would be the maximum tensile stress but there would be no tendency for a failure or a crack to start at the root of one of the last threads due to an excessive loading on the last threads relative to the first threads. However, in actual practice this condition will not occur since there will be a stretching of the pin and a compression of the coupling resulting in a non-uniform loading on the faces of the individual teeth.

This condition has been illustrated in an enlarged and exaggerated manner in Figure 6. In this figure 19 is a pin provided with the external threads 20. The leading face of each external thread 20 is indicated 21 and the trailing face 22. The teeth 20 of the pin cooperate with teeth 23 of the socket or box 24 of the connected sucker rod. The initial pressures upon the cooperating teeth when making the connections will be borne by the trailing faces 22 and be uniformly distributed but as the connection is tightened it will be apparent that stretching of the pin at the first tooth will result in relieving the pressure on the trailing face. The stretching will proceed through each of the teeth towards the last tooth to enter the socket and thus it will be obvious that the end of the pin 19 and therefore the first tooth 20 will have a maximum stretch equivalent to the accumulation of the individual stretches along the length of the pin relative to the teeth of the box section while in a similar manner the first tooth at the outer end of the box section will be compressed to a greater extent than the last tooth at the interior of the socket. This condition results in a greater pitch or a coarser thread on the pin while there will be a smaller pitch or a finer thread upon the interior of the socket. It is of course to be understood that the stretching and compression of the connected members is relatively so small that it is difficult to determine that this condition actually exists but if a connection is longitudinally cut and the surfaces polished it will be found that the leading faces 21 of the last few teeth of the pin to enter the socket are slightly separated from the cooperating faces of the teeth of the socket while at the end of the pin the load has actually been changed from the trailing faces 22 of the teeth to the leading face 21. The arrows in Figure 6 normal to the faces of the cooperating teeth illustrate by their length the approximate pressures which the individual teeth bear and it will be seen that the last teeth of the pin to enter the box section are bearing a much greater portion of the tensile load. It is due to this condition and especially because of the impulsive loadings to which the sucker rod

connections are subjected in use that failures or cracks are liable to start at the roots of the last teeth of the pin. These failures caused by the fatigue of the metal finally result in breakage of the pin adjacent the end of the threaded portion.

In Figure 7 there is shown a section of a double threaded pin after being subjected to test by the application of impulsive loads. The right hand end was formed with the standard thread and screwed into a standard socket. It will be noted that fatigue failures have started by the opening up of the metal at the roots of the last teeth. The failures finally result in complete breakage of the pin and consequent inconvenience and relay in fishing for the broken section of a string and making repairs. A large proportion of the breaks in sucker rod strings may be traced to this cause.

According to the present invention it is proposed to form a thread upon one of the connected members which is so designed that it will compensate for the stretching of the pin and the compression of the coupling socket. A preferred manner of attaining this result consists in making a slightly finer thread on the pin; that is a thread with a slightly smaller pitch than the standard thread on the interior of the cooperating socket. In Figure 5, 25 is a pin formed in this manner cooperating with the socket 26. The teeth of the pin are indicated at 27 cooperating with the teeth 28 of the socket. This figure illustrates the condition after the pin is threaded into the socket and before a load has been applied by the tightening of the joint until the shoulder of the socket engages the shoulder of a connected rod. It should be clearly understood that the change in the pitch of the threads upon the pin is not sufficiently great to prevent the threading of the pin into the socket and it is not intended to have a difference in pitches between the internal and external teeth such that locking or wedging of the pin in the socket may result. Instead, if the threads on the socket are the standard ten to the inch thread the thread upon the pin may comprise 10.073 threads to the inch. A manner of determining a desirable pitch for the special thread will be hereinafter described since it will depend upon the loads to which the connection will be subjected in use, the length of the pin and the modulus of elasticity of the metal which has been used in the coupling and pin. The arrows normal to the tooth faces in Figure 5 illustrate the pressures after the pin is threaded into the socket but as previously described the pressures are not sufficient to prevent the turning movement of the pin to its final position. As soon as the shoulder of the socket comes into abutting relation with the shoulder of the pin, the loading applied will result in a stretching of the pin and a compression of the coupling as previously described. It is apparent that initially the last teeth of the pin to enter the socket are bearing on their leading faces instead of on their trailing faces as in the former condition. The first threads of the pin to enter the socket are bearing the tensile pressure and after the connection is tightened and the pin stretches the load will be uniformly distributed on the trailing faces of the teeth on the pin from the first thread back towards the last threads of the pin. In the theoretically desirable condition, loadings upon each thread should be uniform but since these connections will be made by workmen who will not always tighten the connections to the exact amount the special thread is so designed that the error, if any, will be on the safe side; that is, that the last threads on the pin will never receive excessive loadings relative to the other threads. Another manner of stating the condition which is desired to be obtained is that the pitch of the threads on the pin which is initially smaller than the standard pitch of the threads in the socket will be increased during the tightening of the connection and become more nearly equal to the pitch of the compressed threads of the socket but it is not desired to carry this condition so far that the pitch of the threads on the pin become greater than that of the threads in the socket. It will be clearly apparent that there is no tendency for the threads of the pin to bind in the threads of the socket at any time since it is quite important that the cooperating threads be not marred or deformed in making the connections as the sucker rod connection is desired to be readily detachable and replaceable a number of times. Therefore according to my invention the pressures upon the thread surfaces never become so excessive as to deface or mar the thread and the connections may be readily separated according to the condition of use.

The foregoing description of the improved special thread to be used on one of the connecting parts of a sucker rod connection is of course applicable to different forms of sucker rod connections and I have shown in Figures 1 and 3 a preferred form of making a connection. In these figures 30 and 31 are a pair of connected sucker rods having the squared portions 32 and 33 adjoining cylindrical socket portions 34 and 35. The rods are connected by an internal double ended pin 36. Thus each of the sockets 34 and 35 is internally threaded with a standard thread such as ten threads the inch, while the ends of the pin 36 are externally threaded with a slightly finer thread such as 10.073 threads the inch. The specially formed thread will, as has been previously described, compensate for the stretching of the pin and the compression of the socket members. The construction described permits the manufacture

of the sucker rods with standard and similar ends which is preferable to the old form in which an integral threaded pin is formed on one end of the socker rod while an internal socket is formed on the opposite end. Furthermore, it may be desirable to use a special alloy steel for the pin although it might be too expensive to use the alloy steel for the sucker rod itself. These advantages result when the pin is made as a separable part. However, since the connections must be frequently separated the pin should be substantially permanently held in one of the socket members and I have shown an ordinary lock washer 37 which is inserted in one of the sockets and will bear and bind against the end of the pin 36 after it is threaded in place and therefore securely hold the pin against removal when the other socket member is turned. As shown in Figure 1 the ends 38 and 39 of the lock washer are spread apart and on the outer corner of the ends are formed angular teeth 40 and 41. The tooth 40 of the lock washer will bear into the end of the pin 36 when it is turned in a direction to remove it from the socket while the other tooth 41 will bind against the bottom of the internal socket. Thus after the pin has been threaded tightly in place it will not be removed except for replacement. When the connection between the rods is made the shoulder portions of the sockets 34 and 35 will come into thrust engagement and cause the stretching of the pin and the special threads which have been used on the pin will compensate for the stretching as previously described. There will then be a substantially uniform loading upon each of the contacting tooth faces.

The following described tests will be illustrative of the theory upon which the present invention is based and the approved results obtained. In the initial test standard sucker rod parts were taken from stock and connected together, making a string about 75 feet long, consisting of rods ¾″ in diameter and about 2 feet in length, with one of the ends of each rod upset to make $1\frac{1}{16}$″ pins with ten threads to the inch. The other end of each of the rods was formed into a box or socket $1\frac{5}{8}$″ in diameter and 4″ in length, tapped out with ten threads to the inch. The connections were drawn tight in order to bring the end of each socket in abutting relation with the shoulder of an adjacent rod. The entire string was then subjected to loading by applying a datum load of 5,000 pounds and increasing it to 24,000 pounds, then reducing it back to 5,000 pounds at the rate of 65 times a minute. As the test progressed, it was found that fiber stress presumably above the elastic limit had developed in the same region at the root of one of the last threads of the pin to enter its corresponding socket member, causing complete fatigue failure of the pin while the smooth ¾″ diameter rod to which it was integrally connected did not fail. As there were 12 threads in mesh on each of these pins the maximum load on each thread should not have been more than 2,000 pounds. However, the fact that a ¾″ rod would withstand a greater number of 24,000 pound impulse loadings than a $1\frac{1}{16}$″ threaded pin indicated that the load was not being uniformly distributed to the twelve threads on each pin.

In order to confirm the conclusion that stretching of the pin resulted in an overloading on the last thread to enter the coupling and a relieving of the load on the threads that first entered the coupling, a second test was carried out. In this second test a pin $1\frac{1}{16}$″ in diameter and $2\frac{3}{4}$″ in length was used. The pin was threaded on each end with a 10 pitch thread and a 10 pitch threaded coupling was screwed on each end of the pin until the ends of the couplings came together at the middle of the pin. Measurements of length were taken of the pin and couplings before and after the coupling had been screwed together with sufficient force to stretch the pin and compress the couplings. It was found that the pin was stretched .015 inches and the couplings were compressed .002 inches. The pin and couplings were each threaded 10 to the inch but under the above loading the pin had 10 minus and the couplings had 10 plus threads per inch so that due to the misfit substantially the entire load was presumably carried by one or two threads at the end of each of the couplings near the middle of the pin. It is obvious that if the pins were threaded ten to the inch plus enough to compensate for the compression in the couplings and the stretch in the pins that before the couplings were screwed together the threads would not be a perfect fit, but instead on screwing the couplings together the thread at the end of the pin would take the load first and as the couplings were tightened the load would be distributed progressively until it became uniform on all threads as soon as a sufficient amount of pressure should be applied to stretch the pin and produce an even number of threads per inch both on the pin and in the couplings.

A third test was carried out in which 25 double threaded pins were made with ten threads per inch on one end and 10.073 threads per inch on the opposite end of each pin. The pins were threaded into 25 couplings each 4″ long containing standard 10 threads to the inch, making a string of couplings and pins 100 inches in length. Under a load of from 5,000 pounds to 24,000 pounds applied at the rate of about 65 times per minute, 24 of the pins broke or failed on the end containing ten threads per inch and only one broke at the end containing 10.073 threads per inch. On subsequently cutting

the connections longitudinally and observing the threaded connections it was found that the distribution of thread pressure was more nearly uniform where the 10.073 threads per inch were used.

The present improvements will be applicable to many different forms of screw-threaded connections where threaded bolts or pins are placed under tension thereby causing stretching and consequent variation in the threads. Such connections especially if subjected to impulsive applications of loads are liable to fail in the manner described. By taking measurements the amount of stretch may be determined and the pitch of the special thread computed. The special thread may be either external or internal and will engage a standard thread. Thus in the case of a sucker rod connection a specially designed pin will fit any of the standard sockets and will result in a connection having a much longer life in use.

I claim:

1. A threaded connection between a pair of members intended to be subjected to heavy tensile loading along the axis of the connection, comprising cooperating internal and external threads on the respective connected members, abutments on the connected members designed to come into thrust engagement when the connection is drawn up tight thereby placing the external thread under tension and the internal thread under compression, the external thread having initially a slightly smaller pitch than the internal thread in order to compensate for the increase in pitch of the external thread and tend to equalize the thread pressures upon tightening of the connection.

2. In a device of the class described, a pair of connected members, one of said members having an internally threaded socket and the other of said members having an externally threaded pin, said last-named member also having a shoulder enlarged relative to the pin diameter adapted to abut against the end of said socket whereby the socket is placed under compression and the pin under tension when the members are tightly screwed together, the pitch of the external thread of the pin being initially slightly smaller than the pitch of the internal thread of the socket whereby the respective pitches of the external and internal threads tend to become equal upon tightening of the connection.

3. A coupling connection between a pair of sucker rods comprising an internally threaded socket on one of said rods and an externally threaded pin on the other of said rods, said last-mentioned rod having an abutment adapted to engage the end of the threaded socket on the other of the rods, whereby the pin is subjected to longitudinal tension when the connection is tightened, the thread of the pin being slightly finer than the internal thread of the socket by having a smaller pitch whereby stretching of the pin under tightening and loading substantially equalizes the pitches of the internal and external threads.

4. A sucker rod connection comprising an internally threaded socket on one of a pair of connected rods, an externally threaded pin extending from the other of said rods, the respective threads having similar contours, the pitch of the external thread being slightly smaller than that of the internal thread, the rod from which the threaded pin extends having an abutment adapted to engage a corresponding abutment on the other of the rods and limit the threading together of the connection, to place the pin under tensile loading, the length of the socket being such that the number of threads of the external thread entering the socket are not sufficient, due to the differences in pitches, to cause deformation of the thread contours, whereby the increase in pitch of the external thread under load produces an equalization of the pressures borne by the threads.

5. A sucker rod connection comprising a pair of rods, integral internally threaded sockets on the ends of said rods, a double-ended externally threaded pin designed to be received in the internally threaded portions of the sockets, the length of said pin being such that the ends of said sockets will be drawn into abutting relation when the connection is screwed up tight thereby placing the pin under tensile loading, the pitch of the externally threaded pin being initially slightly smaller than the pitch of the internal thread of the socket.

6. A sucker rod connection comprising a pair of rods, integral internally threaded sockets on the ends of said rods, a double-ended pin designed to thread into a pair of adjacent sockets, the length of said pin being such that the ends of said sockets will be drawn into abutting relation when the connection is screwed up tight, thereby placing the pin under tensile loading, locking means in one of said sockets adapted to bear against one end of said pin, the thread of said pin being initially of a slightly smaller pitch than the internal thread of the sockets whereby when the connection is drawn up tight, the pitch of the threads will be substantially equal.

7. A coupling connection between a pair of sucker rods having standard sockets on the ends thereof with a standard internal thread in each of the sockets comprising a double-ended threaded pin having a similar thread contour to that of the internal thread of the sockets and a pitch slightly smaller than that of the standard internal thread of the socket, the length of the pin being such that the ends of the respective sockets will come into engagement and subject an axial

loading upon the pin thereby producing a stretching of the pin compensating for the relative differences in pitches and more evenly distributing the pressures upon the respective threads preventing breakage of the pin under subsequent impulsive loadings.

Signed at St. Louis, Mo., this 24th day of August, 1929.

PAUL J. McCULLOUGH.