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G. M. EATON

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SUCKER ROD

Filed March 13, 1928

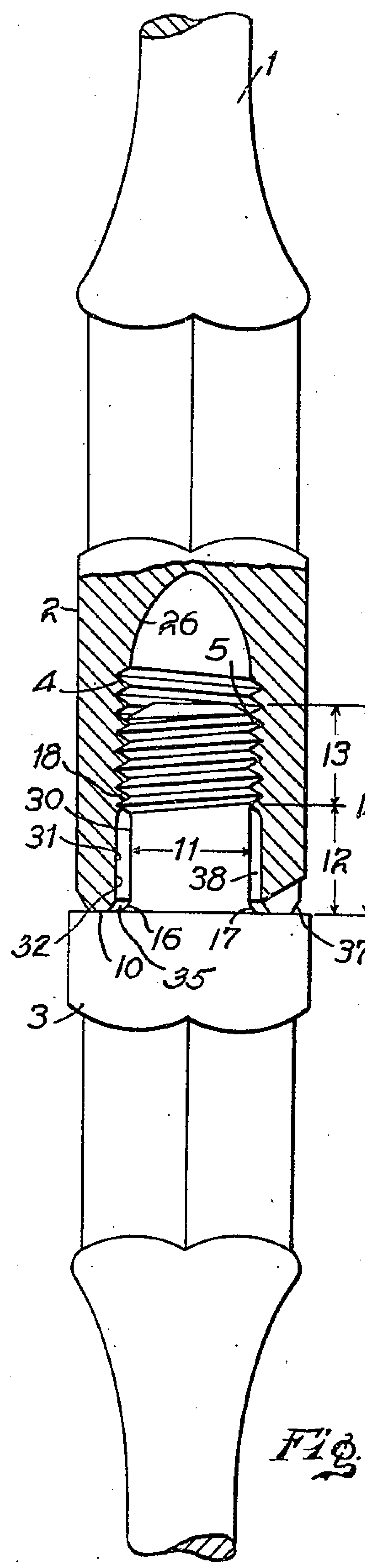

Fig. 1

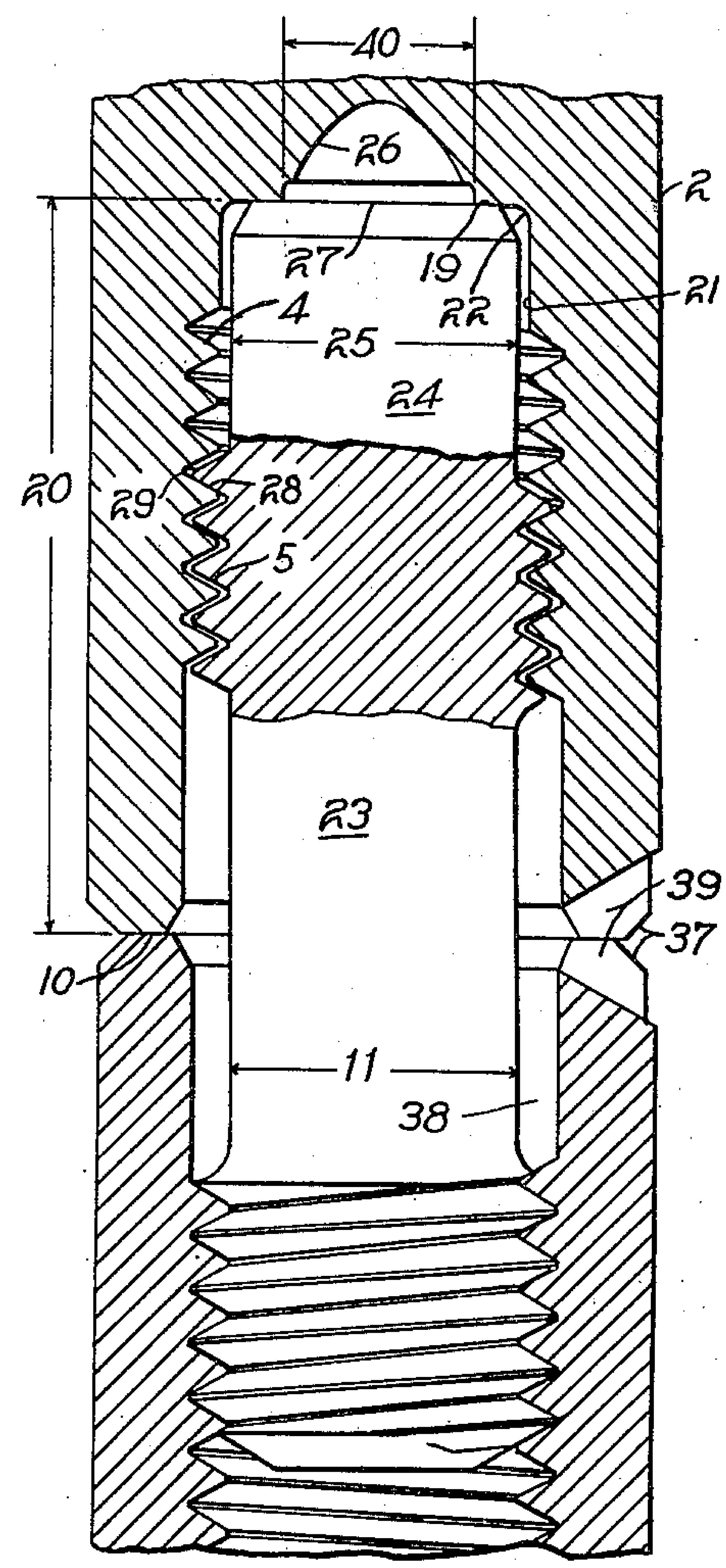

Fig. 2.

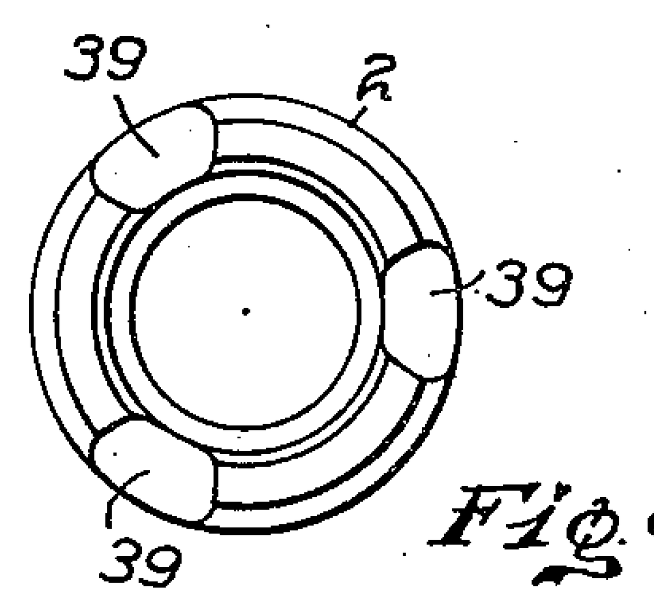

Fig. 3

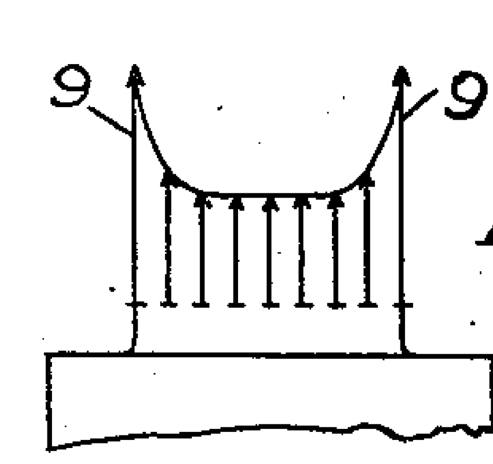

Fig. 4.

WITNESSES

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UNITED STATES PATENT OFFICE

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SUCKER ROD

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My invention relates to improvements in joints for rods, more especially to sucker rods for pumping oil wells. In the oil well industry, sucker rods are a thoroughly recognized part of the standard equipment, consisting of a string of about thirty foot lengths coupled together end to end and extending from a source of reciprocating motion above the ground down to a pump whose suction connection dips into the oil pool.

In shallow wells the sucker rods give very little trouble. But as the wells are driven deeper, the sucker rods are subject to an increasing amount of stress resulting in failure. Sucker rods are joined by screwing the threaded end of one rod into a threaded socket end of another rod. The majority of failures are caused by the breaking off of the stud end of the rod at or near the end of its thread.

In accordance with the present invention the failures referred to are largely prevented by remedying the cause from which they originated.

The invention will be more clearly illustrated in connection with the accompanying drawing in which like reference characters designate like parts and in which Fig. 1 shows an elevation, partly in section, through a sucker rod coupling, embodying the principles of my inventon; Fig. 2 an elevation, partly in section, through a sucker rod embodying an improved form of joints; Fig. 3 an end view of one of the half couplings of Fig. 2; and Fig. 4 a diagram of the stress distribution at the end of the thread of the coupling which is at the point where failures most frequently occur.

Referring to Fig. 1 of the drawing, sucker rods are made from a rolled or drawn round 1. This round is cut into lengths and each length is upset on each end. With present practice this upsetting forms a socket end 2 and a stud end 3 on the respective ends of the rod 1. Wrench and elevator holds are formed in the upsetting but are not described in detail as they are not relevant to this invention. The socket end 2 has a thread 4 and the stud end 3 a thread 5 adapted to interact with the thread 4. The failures dealt with occur at the end of the thread and are due to a phenomenon known in the science of mechanics, as stress concentration. When a cylindrical piece of elastic material which is grooved circumferentially, or approximately circumferentially, is subjected to direct tension or to bending, the actual stress at the bottom of the groove is very much greater than is indicated by the usual stress formulæ. This fact has been definitely proven by means of the photo-elastic analysis. The intensity of the stress concentration is a function, among other details, of the sharpness of the bottom of the groove, and of the depth of the groove. The seriousness of this stress concentration is a function of the physical characteristics of the material and also of the way in which the load is applied.

I have discovered that under the conditions existing in the end thread, the stress 9 at the root of the thread, as diagrammatically illustrated in Fig. 4, is over twice as great as the average stress found by applying the usual formulæ. If the metal is extremely ductile, and if the local stress exceeds the elastic limit, the stressed metal undergoes plastic flow and the stress is relieved, dropping down to the elastic limit. If the assembly is permanent, and if the plastic flow referred to occurred under the influence of assembly forces which are in excess of any working loads imposed by service, the structure may be entirely safe.

But in the case of a sucker rod installation, the assembly is not permanent. During the pumping operation the well becomes fouled with sand and with deposits from the oil, and it is necessary to withdraw the string of sucker rods to clean the well. In the operation of withdrawing the string it is necessary to uncouple many of the rod-to-rod joints. When the axial load is removed by the act of unscrewing, the stress 9 at the critical point drops off, and on reassembly again rises. Since the screwing up and unscrewing are hand operations, wide force variations will occur and further plastic flow of the nature referred to will inevitably occur. Furthermore, the sucker rod comes out from a well thickly covered with oil which carries more or less sand or other hard material in suspension. It is unreasonable to expect that the mating surfaces contacting at 10 will be clean when they make contact during the act of assembly. It is also unreasonable to assume that the hard foreign material will be equally distributed around the circular contact surface 10. Therefore eccentrically located foreign material will produce bending tendencies when the final screwing home act is performed.

Thus it is evident that in addition to the stress concentration shown at 9, there will be a further concentration of stress at the region of the critical section which centers in the axial plane passing through the foreign material that has been caught on the mating surface 10. This produces further plastic flow in that part of the critical section centering in the axial plane noted. On the next overhaul of this sucker rod joint, foreign material will lie in some other axial plane and plastic flow will attack a different part of the critical section. It is thus evident that during the life of a sucker rod it is subjected to an erratic cycle of local plastic flow.

It is the purpose of my invention to relieve this destructive plastic flow cycle, since repeated plastic flow of the nature described, leads inevitably to ultimate failure. In Fig. 1 I have shown a method of improving existing sucker rods in which the seeds of failure have not already been planted by the cycle already described. In practicing this method, the threads 5 are cut away clear to the root 11 or even to a somewhat smaller diameter, for an axial distance 12, which is, in the case shown, about half of the distance 14 from the shoulder 10 over the end of the thread 5. There remains a length of active thread 13 which is capable of carrying over twice as much axial load as the body 1 of the sucker rod. It is utterly essential that the machining operation leave the surface 30 in a smooth condition, since a sharp tool mark at the root 16 of the fillet 17 would again permit stress concentration to set up the fatal plastic flow. Photo-elastic analysis has further proven that under the conditions of structure shown and described in Fig. 1 there is only a very slight stress concentration at the end 18 of the stud thread 5. It is therefore evident that in a sucker rod constructed under the principles of my invention there is a very material reduction in the stresses to which the critical section 6 is subjected by the exigencies of the service cycle involved in the operation of sucker rods. The socket end 2 is preferably counterbored at 31 to reduce the number of turns required in the assembly and dismembering of the rod joint.

While the structure shown in Fig. 1 is of advantage in that it permits the improvement of existing sucker rods, as well as the making of new rods which are superior to those now in use, there remains a small but unnecessary stress concentration at 16. Fig. 2 shows a construction which eliminates this stress concentration, while permitting the use of existing forging dies for upsetting the ends of the rod 1. In this construction a socket end 2 is formed on each end of the rod 1. The machining of the ends 2 differs in several particulars from that involved in rods of the type indicated in Fig. 1. A flat seat 19 is machined at a definite distance 20 from the mating surface 10. The diameter 21 of the recess forming this seat is equal to the diameter of the tap drill for the thread 4. A fillet 22 joins the bore 21 of the tap drill and the surface of the seat 19. The seat 19 is used in only one of the ends 2, but it is preferably machined in both ends, because it is formed in the same operation as the counterbore and it is therefore cheaper to include it in both ends.

The ends 2 are secured together by an independent stud 23. This stud has a reduced diameter 11 extending over its mid-length with a character of surface described in connection with the length 12 of Fig. 1. It also has an extension 24 on one end. The diameter 25 of this extension 24 is slightly less than the diameter of the tap drill for the thread 4. This extension 24 serves the double purpose of a pilot for aligning the stud 23 with the mating surface 10, and also of assisting in locking the stud 23 securely in place in the end 2. It is clear that if the stud 23 were screwed hard home in the thread 4, and with its end 27 abutting hard on the forged surface 26 (Fig. 2) of the recess, misalignment would be sure to occur. This misalignment would produce improper mating of the surfaces 10, with resulting stress imposed on the stud 23. But with the square and flat seat 19 the stud goes home in true alignment.

The locking of the stud 23 into the end 2 which surrounds the extension 24 is accomplished in the following preferred manner. The end 2 is heated at a rate and to a temperature as high as may be permitted by any drawing operations which may be involved in any thermal treatments to which the parts are subjected in the course of production. The upper socket member 2 of Fig. 2 is shown expanded, it being slightly larger than the lower member 2. When a balanced temperature has been secured in the expanded socket 2, the stud 23 is run home quick and hard with a stud driver, and with its end 27 bottoming hard on the seat 19. The assembled members 2 and 23 are then allowed to cool. It is possible to use a temperature of from 300 to 400 degrees F. for this heating operation with the structure which I prefer.

Ordinarily in locking a small male screw into a female thread by shrinking, it is necessary to perform very precise machining operations to insure that the female thread grips the male thread because of the small expansion available. But in the construction involved in my invention, the degree of refinement at present commercially employed in machining sucker rods is entirely adequate to insure a secure locking of the stud, for the following reason. When the socket 2 is heated, the threads 4 expand axially as well as radially. The proportions existing (including the clearance between the male and female threads as machined) are such that at any temperature within the practical range, the stud goes home readily. The final screwing home produces the relative positions of the stud threads 5 and the socket threads 4 shown (in an exaggerated degree) in Fig. 2. The stud thread 28 first makes hard contact with the socket thread 29. This contact travels back away from the stud end 27 by a distance dependent upon the forces involved and the elastic characteristics of the stressed metal. The stud extension 24 is put into axial compression, and the corresponding length of the socket 2 is put into tension. When the socket 2 is cooled down these tension and compression forces are increased, and the stud 23 is thus set harder into the end 2 than it is possible to set it with the stud driver alone. It is evident from an operating standpoint that the stud 23 is an integral part of the sucker rod into which it has been locked. Counterbore 40 limits the active area of seat 19 and protects threads from damage due to over shrinking.

Reference has been made to the tendency for hard foreign material to become trapped between the abutting surfaces 10, and to set up series stress concentrations. To reduce this tendency, it is current practice, as shown in Fig. 1 to make a counterbore 32 and thus provide a recess 38 to receive such of this foreign material as tends to squeeze inwardly from between the surfaces 10 as they come into working contact. This tendency is in current practice further assisted by machining the chamfer 35 which increases the capacity of the recess 38 and at the same time reduces the dirt entrapping area of the surfaces 10. In actual practice however a condition arises which is worse than that which the chamfer 35 is intended to correct. The exposed sharp edge becomes badly scarred, and the degree of this scarring is often so great that the resulting burrs prevent the proper alignment of the surfaces 10. To correct this defect, I partially replace the inner chamfer 35 with the outer chamfer 37. This presents a surface far less susceptible to damage and preserves the principle of reduced mating surface 10. The recess 38 is also of much greater capacity than has been available prior to my invention.

The amount of dirt actually hard trapped between the surfaces 10 is still further reduced by interrupting the circular continuity of these surfaces by grooves 39 which are formed in the end 2 during the upsetting operation. These grooves 39 are shaped to flare outwardly and will become completely filled with a mixture of thick oil and grit, but the pressure set up in screwing the rod ends together will always be sufficient to introduce new material into the grooves by forcing out enough old material for its accommodation.

It is evident that with the practicing of my invention sucker rods of carbon steel become practical for wells deeper than those where carbon steel rods are now entirely satisfactory. When the depth of well reaches a point where rods as shown in Fig. 1 are no longer satisfactory, the construction of Fig. 2 may be employed since the stud 23 may be made of the highest grade of alloy steel without a serious increase in the cost of a string of rods. When the depth of well becomes so great that epidemic failure occurs in the body of the rod 1, the entire rod may be made of alloy steel. When this is done I prefer to employ an air hardening or normalizing steel in order to avoid the stress concentrations necessarily accompanying the quenching of a piece of the shape of a sucker rod with its radical changes of cross section. Also the heating operation involved in locking the stud 23 into the socket 2 becomes entirely free from the danger of deteriorating the material of the end 2, when the rod is in a normalized condition with the class of steel which I prefer.

I claim herein as my invention:

1. In a sucker rod a removable coupling comprising a pair of socket ends provided with screw thread portions, and a stud having threaded portions interacting with the threads of said sockets, said stud having a constricted body portion intermediate its threaded portions and being further provided with a constricted portion at one end thereof to abut against the bottom of one of said sockets.

2. In a sucker rod a removable coupling comprising a rod having a socket end provided with a screw thread portion and having a plurality of grooves extending radially through the wall of the socket, a second rod having a threaded stud end adapted to interact with the thread of said socket, said second rod having an abutment for engagement with the end of said socket and forming clearance spaces with the grooves of said first named rod.

3. A sucker rod comprising a plurality of rod sections having socket ends provided with threaded portions and a stud member having threaded portions adapted to interact with the threads of said socket ends to join said sections with their ends in abutment and having its body portion radially spaced from the walls of the socket members at their point of abutment, said stud engaging said

threaded portions at portions spaced from said abutting ends.

4. In a well drilling coupling member of the type comprising a cylindrical body having an integral extension at one end, an end-facing shoulder at the inner end of said extension, and a screw thread on said extension; means to distribute the breaking strain previously localized at the last turn of said thread, along an extended portion of said extension, said means comprising a zone of substantial width between said shoulder and said thread, said zone being of a diameter no greater than that of the valley of said last turn of the thread.

In testimony whereof, I have hereunto set my hand.

GEORGE M. EATON.