

June 17, 1930.

W. J. CROOK

1,764,068

STEEL SUCKER ROD AND THE LIKE AND ITS PRODUCTION

Filed Jan. 8, 1927

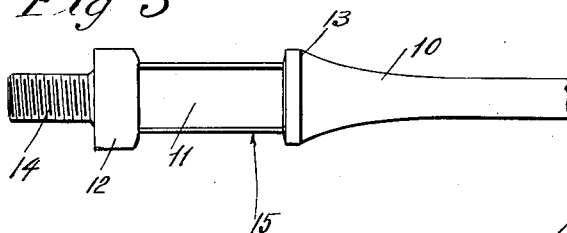
Fig 1.



Fig. 2



Fig 3



Inventor
Wilton J. Crook

Attorney

UNITED STATES PATENT OFFICE

WELTON J. CROOK, OF STANFORD UNIVERSITY, CALIFORNIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO EMSCO DERRICK & EQUIPMENT COMPANY, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF CALIFORNIA

STEEL SUCKER ROD AND THE LIKE AND ITS PRODUCTION

Application filed January 8, 1927. Serial No. 159,808.

This invention has to do with the production of steel sucker rods and other steel products called upon to resist stresses and strains similar to those to which such rods are exposed. It is also concerned with the rods or like products produced by the method herein set forth.

The invention is peculiarly applicable to sucker rods and was evolved to meet a serious, universally acknowledged situation which has arisen in the oil pumping art. Therefore, I will hereinafter describe the invention as applied only to sucker rods, but this description of a single particular product and its production will serve to advise those skilled in the art how the invention may be applied with advantage to other products and their production and is in no way to be considered as limitative on the invention, considered in its broader aspects.

Sucker rods are made up from round stock in lengths of about twenty-five feet. They are swedged or upset to provide so-called "pins" which include enlarged wrench-taking portions of polygonal cross-section near the rod ends, there being annular flanges forged at opposite ends of each portion. The outermost flanges present shoulders at the base of cylindrical studs formed at the extreme ends of the rods. These studs are later threaded to take collars whereby the individual rods are coupled to one another to form a "string" of sucker rods adapted to extend from reciprocating mechanism at the top of a well to a pump plunger at the well bottom.

The total load on the rods is of very considerable magnitude, the rods, especially at the junction point of the threaded and wrench-taking portions, being subjected to very heavy stresses and strains, and most particularly to fatigue stresses. The depths of wells have been increasing steadily, and in order to withstand the consequent increase of rod loads and stresses, the carbon content of the rods has been raised correspondingly. This naturally has been accompanied by a coincident tendency to increase the brittleness of the rods until it has finally reached the point where rod failures due to overbrit-

tleness have become frequent occurrences. The serious aspect of this condition is of common knowledge to those skilled in the art.

Therefore, it is the principal object of my invention to produce rods having the requisite high degrees of tensile strength and resistance to fatigue and yet having proper ductility, to the end that the rods may be well suited to withstand the most severe service conditions to which they are exposed.

It has been observed that by far the greater proportion of rod and pin failures is due to fatigue and that fatigue failure is most liable to occur in the ferrite areas of slowly cooled steel containing less than 0.9% carbon.

I have discovered that if, instead of raising the carbon content of the steel to resist failure under heavy load, a steel of comparatively low carbon content and containing a proper proportion of manganese is chosen and if after the pins have been formed on the rod ends by proper forging and machining operations, the steel is suitably heat treated, there is obtained a rod and pin superior to those previously produced.

Generally stated, my method includes the forging of pins, in any suitable manner, on the end of normal steel rods containing from 0.26% to not more than 0.50% carbon and between 0.40% and 1% manganese. After the forging step, the pins are machined (usually including a threading operation) in cold state. The rods with their forged and machined pins, or the pin-portions of the rods, alone, are then heated to a temperature above the transformation point or "critical range" and comparatively rapidly quenched in oil or other suitable quenching medium.

In practicing this process I have made numerous tests both in the laboratory and in the field, the results of which have been carefully recorded. For example, one series of tests was made on sucker rods which were made from steel containing:

	Per cent	
Carbon	0.30	
Manganese	0.60	
Phosphorus	0.008	
Sulphur	0.047	

Before being subjected to the heat treatment, the pins were tested and showed an ultimate strength of 79,360 pounds per square inch and an elastic limit of 49,400 pounds per square inch.

All of the bars were first heated to a temperature of 1600° Fahrenheit and held at this temperature for thirty minutes and thereafter quenched in oil. After cooling to room temperature, the bars were tested and shown to have an ultimate strength of 108,000 pounds per square inch, an elastic limit of 80,000 pounds per square inch and an elongation of 27% in two inches, as against the properties shown above in the untreated sucker rod. The ductility of the treated steel was such that it could be bent flat in the cold state without fracture or crack.

Another test made on standard test bars machined from forged and heat treated rod pins gave an ultimate strength of 99,200 pounds per square inch, an elastic limit of 67,600 pounds per square inch with an elongation of 20% in 2" and a reduction of area of 54%.

The following is a table setting forth the details of the tests above mentioned:

tion but merely as illustrative of what appeared to give the best results for the particular purpose at hand. Therefore, in practicing my process, it will be borne in mind that some temperature above the critical range may be selected for the heating. In the class of steel with which this invention is concerned, the critical ranges will occur between 1300° and 1700° Fahrenheit. Also, the time of heating will determine to some extent the exact temperature, since when the time of the heating is increased a lower temperature will suffice.

All this is well understood by those skilled in the art, and the various times and temperatures will be modified according to the experience of the individual heat-treatment man and the method of heat application.

Photomicrographs of sections of two specimens of steel, enlarged 1,000 times, are reproduced in the accompanying drawing wherein:

Fig. 1 shows a section of a steel sucker rod before treatment;

Fig. 2 shows a section of the rod after being forged, cooled, then heated for 30 minutes at 1600° Fahrenheit and quenched in oil; and

Treatment of bars

Bar No.	1	2	3	4	5	6
Temperature of quench	1600	1600	1600	1600	1550	1600
Time at quench temperature	30 min.	30 min.	30 min.	30 min.	30 min.	30 min.
Condition of bar	Plain.	Plain.	Plain.	Threaded.	Threaded.	Threaded.
Designation of steel used	Old stock.	New stock.	New stock.	New stock.	New stock.	New stock.
Bar No.	7	8	9	10		
Temperature of quench	1600	1600	Not quenched.	Not quenched.		
Time at quench temperature	30 min.	30 min.				
Condition of bar	Machined pin.	Machined pin.	As rolled.	As rolled.		
Designation of steel used	Old stock.	Old stock.	Old stock.	Old stock.		

Results of physical tests

Bar No.	1	2	3	4	5
Ult. strength pounds per sq. inch	95,755	106,207	109,362	135,000	135,000
Elast. limit pounds per sq. inch	66,265	76,958	81,040	104,700	104,200
Elongation in 2"		28 per cent.	10 per cent.	10 per cent.	9 per cent.
Reduction area					
Bar No.	6	7	8	9	10
Ult. strength pounds per sq. inch	138,000	99,201	99,249	69,170	79,360
Elast. limit pounds per sq. inch	101,000	68,931	66,416	42,352	49,400
Elongation in 2"	9 per cent.	20 per cent.	20 per cent.	42 per cent.	Lost.
Reduction area		54 per cent.	54 per cent.		

The temperatures and times mentioned above are not to be considered as a limita-

Fig. 3 is a fragmentary elevation of a sucker rod.

The sucker rod shown fragmentarily in Fig. 3 is made up from a round bar 10, the end thereof being "upset" or forged, when hot, to provide a wrench-taking portion 11 between annular collars 12 and 13. The stud end 14 is subsequently machined and threaded while the bar is in cold state.

The entire bar or, if desired, only the "pin" 15 which may be considered as including only stud 14 or both the stud and portion 11, is then heated to a temperature above the transformation point or of from 1300° to 1700° Fahrenheit. This temperature is held for a period of from ten minutes to an hour or more, as may be required, and the rod is then quenched comparatively rapidly in an oil bath or other suitable medium.

A consideration of Figs. 1 and 2 will serve to demonstrate the change brought about in the physical properties of the material by the described method of treatment.

It is found that the structure, after being quenched in oil from 1600° Fahrenheit, has the appearance of a matrix of low carbon martensite in which only a small amount of residual unabsorbed ferrite remains or else in which a small amount of free ferrite has crystallized out owing to the relatively slow rate of cooling in oil as compared with that which would result from water quenching.

It is considered that heating to 1600° Fahrenheit for thirty minutes has converted the iron from the alpha to the gamma state and enabled the cementite of the original pearlite to break down and form a solid solution of carbon in gamma iron, this being known as austenite. In order that a homogeneous austenite may form, the carbon from the pearlite must have time to migrate or diffuse at least across the distance equal to one half the average diameter of one ferrite grain as measured in the original steel.

The austenite formed when the quench temperature has been sufficiently high and has been maintained sufficiently long, e. g., 1600° Fahrenheit for thirty minutes so that the carbon is completely diffused, cannot be preserved as such in steel of 0.30% to 0.50% carbon unless the cooling is very rapid and in the present process the austenite during quenching transforms into martensite. Also when an oil quench is used, as in the present process, some small amount of free ferrite will come out of solution again.

This martensitic structure as produced in sucker rods has very different physical properties from that found in untreated rods made from the same grade and quality of steel. The ultimate strength, upon which fatigue limit has been found to depend, was found to be over 100,000 pounds per square inch but at the same time the treated rod was found in all cases to be capable of withstanding a flat bend in the cold or room temperature condition.

It should be borne in mind that the present invention has to do, not with an alloy steel, but with sucker rods made from plain carbon steel. I am well aware that alloy steels and plain carbon steels have been heat treated for the purpose of altering their physical properties. However, so far as I am aware, there have not previously been produced plain carbon steel sucker rods, of the composition previously stated, which showed in well tests the physical properties or the resistance to fatigue failure that have been found in sucker rods produced by this process.

By subjecting sucker rods of the proper composition to the present process, the strength of the rods may be increased to a point equalling that of high carbon steels but at the same time the rods retain the ductility of low carbon steels with a greatly added resistance to fatigue breakage.

Actual well tests of a million feet of these rods have resulted in no pin breakage in a period of over fourteen weeks whereas in two of the test wells, at least, no other rods have withstood over two weeks operation without pin breakage. The importance of these results in oil well operation is obvious.

I claim:

1. A method of producing plain carbon steel sucker rods and the like of high tensile strength and sufficient ductility for oil well pumping and similar purposes, having a high fatigue resistance as herein mentioned, which includes heating, after forging and machining, sucker rods containing between 0.26% and 0.50% carbon and between 0.5% and 1% manganese to a temperature above the transformation point, and quenching rapidly as a final step in the process.

2. A method of producing plain carbon steel sucker rods of high tensile strength and sufficient ductility for oil well pumping and similar purposes, having a high fatigue resistance as herein mentioned, which includes heating, after forging and machining, sucker rods containing between 0.26% and 0.50% carbon and between 0.5% and 1% manganese, to a temperature of from 1300° to 1700° Fahrenheit, holding this temperature for a period of at least ten minutes, and quenching rapidly in a suitable medium as a final step in the process.

3. The method of increasing the ultimate strength and resistance to fatigue and yet retaining the ductility of carbon steel sucker rods, the ends of which have been forged and machined to form pins by subjecting said rods, containing between 0.26% and 0.50% carbon and between 0.5% and 1% manganese, to heat at a temperature above the transformation point and for a sufficient period of time to bring about complete migration of carbon across the ferrite grains and then quenching the steel rapidly in suitable medium as a final step in the process.

4. A method of producing plain carbon steel sucker rods of high tensile strength and sufficient ductility for oil well pumping and similar purposes, having a high fatigue resistance as herein mentioned, which includes
5 heating, after forging and machining, sucker rods containing between 0.26% and 5.50% carbon and between 0.5% and 1% manganese, to a temperature of from 1300° to 1700°
10 Fahrenheit, holding this temperature for a period of at least ten minutes, and quenching rapidly in an oil bath as a final step in the process.

5. A method of producing plain carbon steel sucker rods and the like of high tensile
15 strength and sufficient ductility for oil well pumping and similar purposes, having a high fatigue resistance as herein mentioned, which includes heating, after forging and machining, sucker rods containing between 0.26%
20 and 0.50% carbon and between 0.5% and 1% manganese to a temperature above the transformation point, and quenching rapidly in an oil bath as a final step in the process.

25 6. The method of increasing the ultimate strength and resistance to fatigue and yet retaining the ductility of carbon steel sucker rods, the ends of which have been forged and machined to form pins, by subjecting said
30 rods, containing between 0.26% and 0.50% carbon and between 0.5% and 1% manganese, to heating at a temperature above the transformation point and for a sufficient period of time to bring about complete migration of
35 carbon across the ferrite grains and then quenching the steel rapidly in oil as a final step in the process.

In witness that I claim the foregoing I have hereunto subscribed my name this 17th day
40 of December 1926.

WELTON J. CROOK.

CERTIFICATE OF CORRECTION.

Patent No. 1,764,068.

Granted June 17, 1930, to

WELTON J. CROOK.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, line 7, claim 4, for "5.50%" read "0.50%"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of July, A. D. 1930.

(Seal)

Wm. A. Kinnan,
Acting Commissioner of Patents.