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P. E. McKINNEY

2,281,850

SUCKER ROD STEEL

Filed Feb. 14, 1939

2 Sheets-Sheet 1

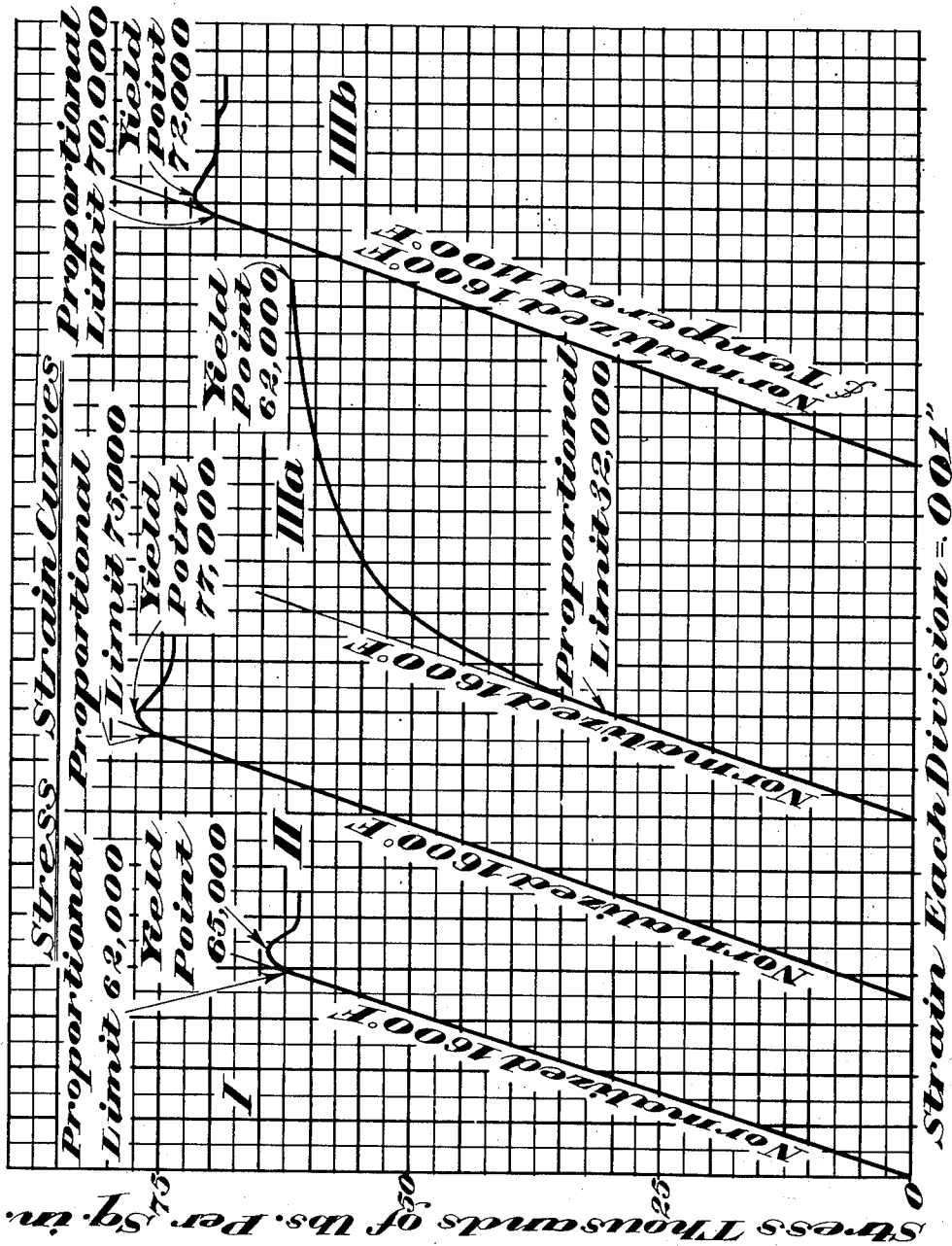


Fig. 1.

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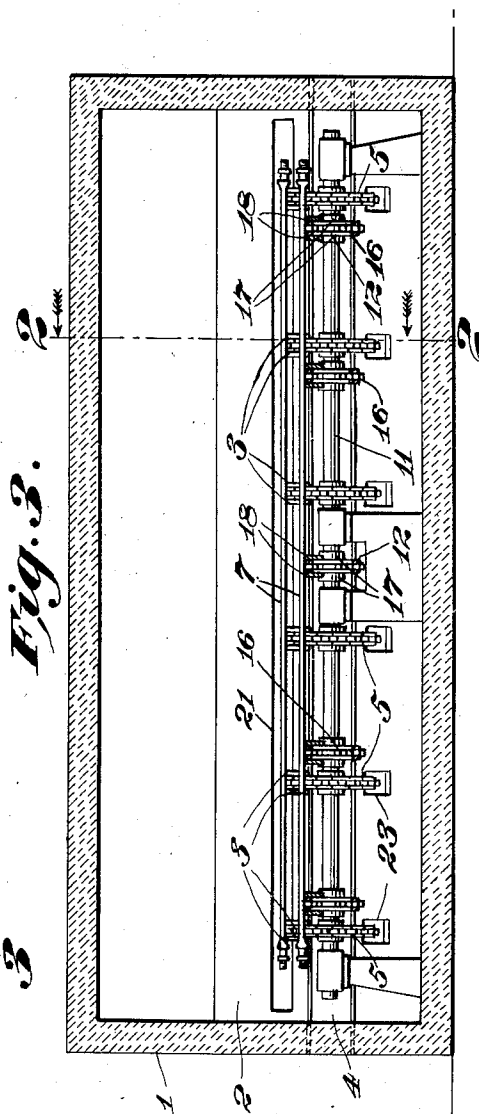
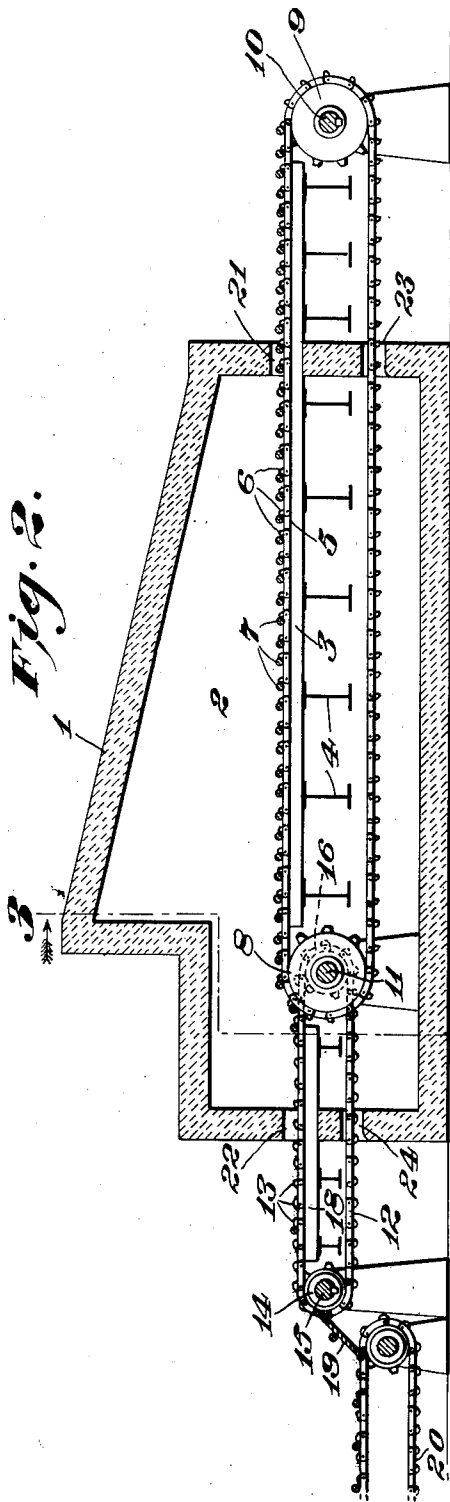
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2 Sheets-Sheet 2



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SUCKER ROD STEEL

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4 Claims. (Cl. 255-28)

This invention relates to an improved sucker rod steel and to an improved method of heat treating sucker rods, particularly rods which are suitable for drilling deep oil wells containing corrosive substances such as hydrogen sulphide. The steel for such sucker rods must have a high corrosion fatigue resistance to withstand the alternating high stresses and the corrosive conditions which are imposed on the sucker rods.

My experience with sucker rods and with sucker rod steel has led me to the conclusion that the presence of residual stresses in the steel is conducive to early failure in the well by corrosion fatigue and that a high ratio of proportional limit to yield point is indicative of the absence of residual stresses. I have found that certain nickel-chromium steels which have been used for sucker rods have a high ratio of proportional limit to yield point in the normalized condition, whereas in other steels such a high ratio can only be obtained by quenching and tempering or by normalizing and tempering. Eliminating the tempering treatment after normalizing effects a considerable reduction in manufacturing costs. Moreover, my experience has shown that this may be done without lowering the service life of the rod. Thus using these nickel-chromium steels as normalized gives both a saving and maximum quality.

I have discovered that the addition of vanadium to such nickel-chromium steels raises the values of the proportional limit and yield point without decreasing the ratio of the proportional limit to the yield point. Thus, the same high ratio is maintained in the normalized condition with considerably higher values of these properties. The tensile strength is not materially increased, and the ductility is not substantially decreased. This gives a steel with improved elasticity and sucker rods made from it can withstand higher stresses in corrosive wells. Similarly, when operated at moderate stresses increased service life is obtained.

Figure 1 illustrates stress-strain curves of I, a nickel-chromium sucker rod steel with a high ratio of proportional limit to yield point after normalizing; II, a nickel-chromium-vanadium sucker rod steel with an equally high ratio of proportional limit to yield point after normalizing, but with considerably higher values of these properties; III(a), a nickel-molybdenum sucker rod steel with a low ratio of proportional limit to yield point after normalizing only; and III(b), the same steel as III(a), but normalized and

tempered, with a high ratio of proportional limit to yield point.

The table below gives the compositions and mechanical properties of the steels shown in Figure 1.

	Steel I	Steel II	Steel III (a)	Steel III (b)
Carbon.....percent..	.34	.23	.21	.21
Manganese.....do....	.60	.68	.60	.60
Phosphorus.....do....	.015	.028	.028	.028
Sulphur.....do....	.029	.041	.031	.031
Silicon.....do....	.24	.18	.18	.18
Nickel.....do....	.92	.95	1.88	1.88
Chromium.....do....	.43	.40		
Vanadium.....do....		.14		
Molybdenum.....do....			.26	.26
Proportional limit				
pounds per square inch..	62,000	75,000	32,000	70,000
Yield point.....do....	65,000	77,000	62,000	72,000
Tensile strength.....do....	95,000	100,000	94,000	88,000
Elongation percent in 2".....do....	27	27	27	29
Reduction of area.....do....	60	60	63	66
Ratio P. L./Y. P.....do....	.95	.97	.51	.97

I, therefore, consider that the nickel-chromium-vanadium steels are especially favorably balanced compositions for sucker rods. The range of compositions I have found to give the beneficial effects described are given below:

Carbon	Manganese	Silicon	Nickel	Chromium	Vanadium
Percent 0.1-.5	Percent 0.3-1.2	Percent .0.1-.8	Percent 0.4-1.2	Percent 0.2-.8	Percent 0.1-.4

The following is a preferred analysis within this range:

Carbon	Manganese	Silicon	Nickel	Chromium	Vanadium
Percent .28	Percent .65	Percent .20	Percent .95	Percent .45	Percent .18

In normalizing sucker rods it is preferable to use a continuous type furnace in which the sucker rods, placed perpendicular to the length of the furnace, are fed slowly through the furnace from the cool entering end to the hot exit end. The rods rest on skids passing longitudinally through the furnace and are pushed on their way through the furnace by lugs on conveyor chains. As they are pushed along, the rods tend to roll or turn over. There are several skids so that the sucker rods are supported not only at their ends but also at points along their length. Being thus supported and turning over continuously as they are heated to the normalizing temperature, the sucker rods do not kink or sag,

but come out very straight and do not need to be straightened by stretching as was formerly the practice.

Now, at the exit end of such a furnace there is a region extending inward for about a foot or so from the end, at which the temperature is appreciably lower than the normalizing temperature to which the sucker rods are to be heated prior to air cooling. I have observed that if the rods pass through this cooler region at the exit end of the furnace at the same slow rate as they travel through the furnace while they are being heated, they do not attain the optimum structure and properties, and in particular they do not attain the high proportional limit and yield point and high ratio of these values which as described above, is desirable in sucker rods which are subjected to alternating high stresses and corrosive conditions. That is, if the rods are discharged at the same slow rate as they are fed through, they are not cooled from the proper temperature and the rate of cooling from the effective heat treating temperature, is slower than the rate of air cooling which gives the optimum structure and properties.

Thus, I have discovered that for the optimum structure and properties the sucker rods must be immediately cooled in the outer air from the normalizing temperature without for a considerable interval passing through a lower temperature zone before being cooled in the outer air. The latter treatment might indeed be termed intermediate between normalizing and annealing, and is not the normalizing treatment which I have found to be desirable for sucker rods.

As an important part of this invention, therefore, I have devised a method of discharging the sucker rods which retains the advantageous features of the continuous method of feeding, such as rolling of the rods, etc., which give straight sucker rods, but removes the rods from the furnace at a much faster rate than they are fed through. Thus, the rods are air cooled rapidly enough from the proper normalizing temperature to give the desired properties. This I accomplish by transferring the rods when they reach the proper normalizing temperature within the furnace onto a much faster moving discharge conveyor which removes them from the furnace into the outer air at the desired fast rate.

The means employed are illustrated in Figures 2 and 3.

Figure 2 is a longitudinal section on the line 2—2 of Figure 3, illustrating a furnace and conveying system in which my invention can be practiced.

Figure 3 is a sectional view on the line 3—3 in Figure 2.

Numeral 1 is the furnace as a whole. Numeral 2 is the heating chamber, the entrance end being at the right and the exit end at the left. Numeral 3 shows the main skids for supporting the sucker rods, the skids being supported by I-beams 4.

Numeral 5 shows the main chain conveyor for slowly feeding the sucker rods through the furnace. Numeral 6 shows the lugs on the chain conveyor which engage the sucker rods 7. Numerals 8 and 9 are sprocket wheels for the main chain conveyor, 10 being the drive shaft for 9 and 11 the drive shaft for 8. Numeral 12 is the auxiliary fast moving conveyor for discharging the sucker rods, 13 being the lugs on 12 and 14 the driven sprocket wheel for 12, and 15 the drive shaft for 12. Numeral 16 is an idler sprocket wheel on shaft 8. Numeral 17 represents collars on shaft 8 for holding the idler sprockets in position. Numeral 18 represents the skids for the auxiliary fast moving conveyor. Numeral 19 is an inclined plate. Numeral 20 is a receiving conveyor. Numerals 21 and 22 are openings at the entrance of the furnace and at the exit end, through which the sucker rods enter and leave the heating chamber. Numerals 23 and 24 are openings in the wall of the furnace to permit passage of the chain conveyors, opening 23 being for the slow moving feeding conveyor 5, and opening 24 for the fast moving discharge conveyor 12.

The sucker rods 7 are slowly fed into the furnace on the slow moving conveyor 5 and are slowly heated to the normalizing temperature which is attained when the rods reach the left end of the conveyor 5. At this point the sucker rods are transferred to the fast moving conveyor 12 which rapidly discharges them from the furnace so that they are cooled rapidly in the outer air from the proper normalizing temperature. Conveyor 12 travels about 30 times as fast as conveyor 5. The relative speed may vary as desired, however, within wide limits, for example, conveyor 12 may travel from 10 times as fast to 60 times as fast as conveyor 5.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A sucker rod of steel containing carbon between approximately .1% and .6%, nickel between .4% and 1.2%, chromium between .2% and .8%, vanadium between approximately .1% and .4% having a normalized structure.

2. A sucker rod of steel containing carbon between approximately .1% and .6%, nickel between .4% and 1.2%, chromium between .2% and .8%, vanadium between approximately .1% and .4% having a ratio of proportional limit to yield point not less than .9 after normalizing.

3. A sucker rod of steel containing carbon between .15% and .35%, manganese between .5% and .9%, silicon between approximately .1% and .4%, nickel between .6% and 1.1%, chromium between .3% and .6%, vanadium between approximately .1% and approximately .2%, having a normalized structure.

4. A sucker rod of steel containing carbon .28%, manganese .65%, silicon .20%, nickel .95%, chromium .45%, vanadium .18%, having a normalized structure.

PAUL E. MCKINNEY.