Patented Oct. 31, 1950

2,527,731

UNITED STATES PATENT OFFICE

2,527,731

FATIGUE RESISTANT STEEL WIRE AND METHOD OF MAKING THE SAME

Antonio F. Ilacqua, Cleveland, and Henry H. Smith, Lakewood, Ohio, assignors to The American Steel and Wire Company of New Jersey, a corporation of New Jersey

No Drawing. Application March 4, 1949, Serial No. 79,721

6 Claims. (Cl. 267—1)

1

This invention relates to the production of steel wire having enhanced resistance to fatigue.

In the manufacture of high quality medium and high carbon steel wire having good fatigue resistance, it has heretofore been necessary to use single or double lead patenting methods during the processing of the wire to the desired finished gauge. In making use of the single or double lead patenting methods, the hot rolled rod or wire is heated to above the critical temperature in an open furnace or in a lead bath and is then quenched in a lead bath to rapidly cool the rod or wire through the critical range. This results in the rod or wire having a fine pearlitic or so-called sorbitic structure giving the steel enhanced toughness or ductility and increased resistance to fatigue.

The use of lead pans to effect such quenching is quite expensive due to fuel costs, lead costs, renewal of the lead pans and the labor costs inherent therein. Simple air patenting sometimes referred to as "Old Process" patenting wherein the wire is heated in an open flame or muffle to a temperature well above the critical temperature and then cooled in open air is considerably cheaper but does not produce a satisfactory product where high fatigue resistance is necessary. It is accordingly an object of the present invention to eliminate lead bath quenching in the production of high quality medium and high carbon steel products.

It is a further object to produce high quality medium and high carbon steel wire by a simple air patenting practice during the processing thereof.

The foregoing and further objects will be apparent from the following specification which is concerned with steels of the pearlitic type which respond to an air patenting practice. Such steels embrace the following range of analysis:

.37 to .76% carbon
.60 to 1.15% manganese
.10 to .30% silicon
.40% maximum phosphorus
.05% maximum sulphur
Balance substantially iron and residual elements in common amounts.

Such steel in order to produce good fatigue resistance qualities is in accordance with conventional practice given either a single or double lead patenting treatment, as hereinbefore described. We have discovered that if boron is added to the foregoing steel in amounts between .001 and .003% and preferably between .0012 and

2

.0025% and the rod or wire produced therefrom given a simple air patenting treatment wherein the rod or wire is heated above the upper critical and air cooled prior to cold drawing to final size will have a microstructure similar to that produced by lead patenting similar steel not containing boron. Moreover, the cold drawn wire made from the air patented boron bearing steel has considerably enhanced fatigue resistance as compared with cold drawn wire made from air patented boron-free steel as shown by test data obtained from tests on typical spring wire analyses as shown in Table I:

TABLE I

Chemical analysis

Steel	C	Mn	P	S	Si	Boron
A	.61	.94	.015	.029	.23	.0015
B	.55	1.03	.017	.030	.24	--------
C	.65	1.04	.012	.034	.21	--------

Steel A was formed into wire of 12 and 13 gauges and two tests of each made, steel B was drawn to 13 gauge, and steel C to 12 gauge. Test pieces from the aforementioned cold drawn wire sizes gave the following results:

TABLE II

Physical properties

Steel	Gauge	Breaking Weight, Lbs.	Tensile Strength, P. s. i.	Endurance Limit, P. s. i.	Endurance Ratio
A	12	1,980	232,900	71,500	.308
	12	1,895	223,300	76,500	.343
	13	1,645	261,000	82,700	.317
	13	1,590	252,000	80,000	.317
B	13	1,540	225,000	51,000	.226
C	12	2,170	250,000	67,000	.267

The endurance ratio in the foregoing table is the endurance limit divided by the tensile strength. This figure is used for comparison purposes due to slight differences in chemical analysis and sizes of the various test pieces.

An inspection of Table II shows that the boron addition has greatly improved endurance or fatigue properties. Thus the endurance ratio of steel A drawn to 13 gauge is 40% higher than that of boron-free steel B drawn to the same size. Likewise the endurance ratio of steel A drawn to 12 gauge is 21.5% higher than that of boron-free steel C drawn to the same size.

Comparative tests were also made on such a steel, which may contain normal amounts of residual alloys as illustrated by the following analysis:

TABLE III

Chemical analysis

Steel	C	Mn	P	S	Si	Cr	Ni	Mo	Boron
D	.62	.92	.008	.028	.22	.051	.106	.014	-------
E	.62	.93	.009	.026	.21	.051	.108	.016	.0013

Cold drawn, 12 gauge wire as made from the aforementioned air patented steels, D and E, had the following physical properties:

TABLE IV

Physical properties

Steel	Gauge	Breaking Weight, Lbs.	Tensile Strength, P. s. i.	Endurance Limit, P. s. i.	Endurance Ratio
D	12	2,000	232,000	67,000	.289
E	12	2,060	238,000	84,000	.353

Here again there is considerable increase in the endurance ratio which is raised from .289 to .353 by the boron addition, an increase of about 22%.

An examination of the microstructure of the boron-bearing and boron-free steels after air patenting showed that the boron-bearing steels had a microstructure similar to boron-free steels that had been lead patented (i. e. quenched in a lead bath maintained between 800 and 1200° F. after heating to above the critical temperature). Thus the ferrite constituent of the boron-bearing steels was well defined giving a finely divided pearlitic structure. On the other hand, in the boron-free steels after air patenting, a coarse pearlite existed in the ferrite phase.

While we have shown and described several specific embodiments of our invention, it will be understood that these embodiments are merely for the purpose of illustration and description and that various other forms may be devised within the scope of our invention, as defined in the appended claims.

We claim:

1. A fatigue resistant air patented steel spring composed of pearlitic steel containing .37 to .76% carbon, .60 to 1.15% manganese, .04% maximum phosphorus, .05% maximum sulphur, .15 to .25% silicon and .001 to .003% boron.

2. The method of producing fatigue resistant steel wire containing between .37 and .76% carbon, .60 and 1.15% manganese, .04% maximum phosphrous, .05% maximum sulphur, .15 and .30% silicon, comprising adding between .001 and .003% boron to the steel while molten, forming wire from the boron containing steel and air patenting said wire.

3. The method of producing fatigue resistant steel wire composed of pearlitic steel containing between .37 and .76% carbon, .60 and 1.15% manganese, .04% maximum phosphorus, .05% maximum sulphur, .15 and .30% silicon, comprising adding between .001 and .003% boron to the steel while molten, forming wire from said steel, air patenting said wire and then cold drawing said air patented wire to the gauge desired.

4. The method of producing fatigue resistant steel wire composed of pearlitic steel containing between .37 and .76% carbon, .60 and 1.15% manganese, .04% maximum phosphorus, .05% maximum sulphur, .15 and .30% slicon, comprising adding between .001 and .003% boron to the steel while molten, forming hot rolled rods from said steel, air patenting said rods and then cold drawing said air patented rods into wire of the gauge desired.

5. The method of eliminating lead patenting in the manufacture of fatigue resistant steel wire comprising adding between .001 and .003% boron to said steel while molten, said boron addition being regulated to permit air patenting to be substituted for lead patenting without sacrifice of fatigue qualities of said wire, forming wire from said boron containing steel and air patenting said wire.

6. The method of eliminating lead patenting in the manufacture of fatigue resistant steel wire comprising adding between .001 and .003% boron to pearlitic steel while molten, said boron addition being regulated to permit air patenting to be substituted for lead patenting without sacrifice of fatigue qualities of said wire, forming wire from said boron containing steel, air patenting said wire and then cold drawing said air pattented wire to the gauge desired.

ANTONIO F. ILACQUA.
HENRY H. SMITH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,519,388	Walter	Dec. 16, 1924
2,185,617	Welch	Jan. 2, 1940
2,288,762	Winkler	July 7, 1942

OTHER REFERENCES

Boron in Iron and Steel, Department of Interior information circular I. C. 7363, pages 9 and 10. By R. S. Dean and B. Silkes.