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STRUCTURAL STEEL AND PROCESS FOR MAKING SAME

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FIG. 1

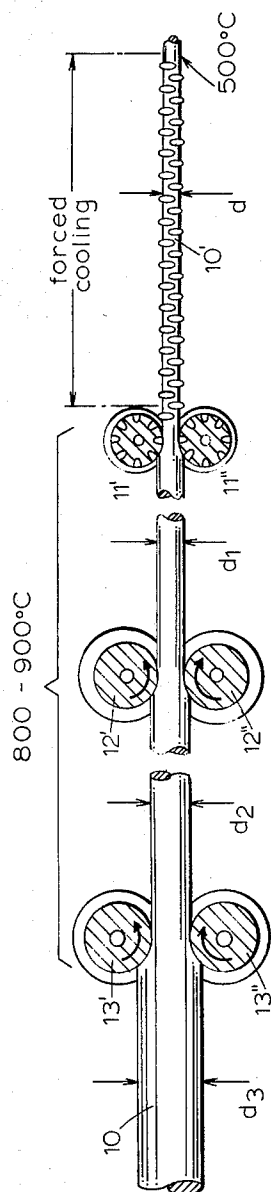
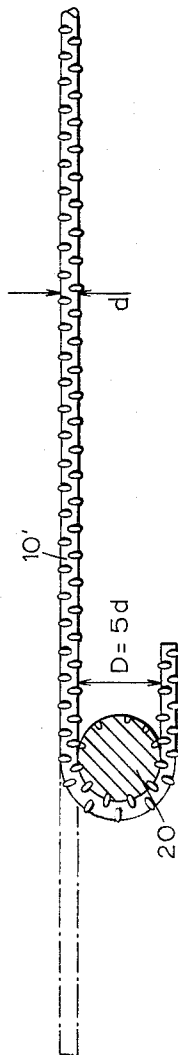


FIG. 2



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STRUCTURAL STEEL AND PROCESS FOR MAKING SAME

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Our present invention relates to the production of structural reinforcing rods and the like from steel.

Heretofore the use of high-strength steels in prestressing or reinforcing rods for concrete structures or similar elements has been limited by the lack of ductility of such steels and their rupture when bent cold to a small radius. When they were used it was necessary to perform them at elevated temperatures before delivery to the building site. The inability to make on-the-job changes in the shape of these elements often required expensive reworking and resulted in delays in construction.

It is an object of this invention to provide an improved ferrous composition adapted to be used particularly for structural reinforcements of the type described.

More particularly, it is an object of the invention to provide a low-alloy steel which, when formed into a rod, will have an elastic limit greater than 45 and preferably 50 kg./mm. while being capable of cold bending through 180° and back about a mandrel whose diameter is less than seven times the rod diameter.

Another specific object of the invention, allied to the preceding one, is to provide a ribbed rod, known as deformed bar, having the physical characteristics set forth above.

It is also an object of the instant invention to provide a ferrous composition of the character described which can be easily welded.

A further object of this invention is to provide a process for producing structural steel of such fine grain size that the aforesaid desiderata of high elastic limit and deformability in the cold state can be realized along with a correspondingly great tensile strength, a large rate of resilient elongation and the ability of the cold-deformed element to return without rupture to its original state.

The foregoing objects are realized, in accordance with the present invention, with the use of a steel alloy having substantially the following composition by weight:

	Percent
C	0.15 to 0.40
Mn	0.70 to 1.80
Si	0.50 to 1.50
Fe, remainder.	

This composition, when hot-rolled into a rod as more particularly described hereinafter, exhibits without further treatment the following physical characteristics:

Tensile strength—above 75 kg./mm.².

Yield point—above 50 kg./mm.².

Elastic elongation—15 to 20% in a specimen five diameters long.

These values compare favorably with those of hitherto available concrete-reinforcing rods of steel which have a yield point of 40 to 45 kg./mm.² while being bendable in the cold state through only 120°, with a reverse bending of only 20°, about a mandrel whose diameter equals seven times the diameter of the rod. Steel produced according to this invention, however, can be bent through an angle of 180°, on a mandrel whose diameter is only five times the rod diameter, and bent back to its original position without any sign of cracking.

A rolling process according to the present invention, which has been found to result in an extraordinary refine-

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ment of the grain structure of the steel and a corresponding toughness thereof, requires for instance the following working conditions to be maintained:

- (1) A very high roller pressure that produces a 12% to 15% reduction in the cross-sectional area of the work piece in the terminal rolling stage, preferably during each of the last three finishing passes;
- (2) A relatively low rolling temperature at this stage which lies near or even below the upper (but above the lower) temperature limit of the pearlite-austenite transition range, i.e. between substantially 800 and 900° C.;
- (3) A rapid cooling after rolling, the temperature being reduced from a level of substantially 800° C. at the last rollers to about 500° C. by forced cooling (e.g. with circulating air, water sprays and/or refrigerated supporting surfaces) at a rate which for rods of the usual diameters (e.g. from 6 to 40 mm.) should be at least 30% faster than the cooling time under normal ambient conditions; thus, with rods of 10 mm. diameter, for example, approximately 100 seconds of cooling time are desirable in lieu of the usual 140 seconds.

It has also been surprisingly found in accordance with a feature of this invention that an addition of about 0.15 to 0.50% of chromium, by weight, further improves the aforescribed characteristics of fineness of the grain and toughness of the steel.

Moreover, it was found that the addition of about 0.10 to 0.20% of aluminum and about 0.05 to 0.20% of either titanium or vanadium, by weight, produces a still further refinement of the grain and yields a steel, especially for low-temperature uses, that readily lends itself to welding. This admixture may be used in a steel with or without the chromium component mentioned above.

The accompanying drawing shows in FIG. 1 a diagrammatic illustration of the preferred rolling process according to the invention and in FIG. 2 a deformed bar produced by this process and bent about a mandrel.

In FIG. 1 the bar stock 10, of diameter d_3 , is passed successively between roller pairs 13' and 13'', 12' and 12'', 11' and 11'' which in practice form part of a single pair of cylinders and represent the last three stages of a rolling mill, only the rollers effective in one dimension of compression being visible. The stock 10 is successively reduced by these rollers to diameters d_2 , d_1 and d , the latter being its final diameter and being assumed to be about 10 mm. The rollers also serve to impress upon the surface of the stock a ribbed profile to produce a so-called deformed bar 10'.

The successive compressions of the stock to diameters d_2 , d_1 and d involve each a step-down ratio of about 14:13 corresponding to the aforesaid cross-sectional reduction. This takes place in the temperature range of 800° to 900° C. with subsequent air cooling to 500° C. in about 100 seconds through suitable control of ambient conditions.

FIG. 2 shows how the bar 10' produced by the process of FIG. 1 can be bent through 180° about a mandrel 20 whose diameter D is only five times as great as the bar diameter d . The bar so bent can also be returned to its original straight position, shown in dot-dash lines, without cracking.

What is claimed is:

1. A process for making a bar of fine-grain structural steel, comprising the steps of successively rolling a stock of steel alloy, consisting essentially of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, and iron as substantially the entire remainder, to progressively smaller diameters at a temperature of substantially 800° to 900° C., and rapidly cooling the rolled stock from said temperature to a level of approximately 500° C.

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2. A process according to claim 1 wherein each of three final rolling steps involves a reduction in cross-sectional area of said stock by substantially 12 to 15%.

3. A process according to claim 1 wherein the air cooling from said temperature to said level is carried out at a rate substantially 30% faster than cooling under normal ambient conditions.

4. A process for making a bar of fine-grain structural steel, comprising the steps of successively rolling a stock of steel alloy, consisting essentially of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, and iron as substantially the entire remainder, to progressively smaller diameters with a reduction in cross-sectional area by substantially 12 to 15% at each of three final rolling steps, at a temperature of substantially 800° to 900° C., and cooling the rolled stock from said temperature to a level of approximately 500° C. at a rate substantially 30% faster than cooling under normal ambient conditions.

5. A process for making a bar of weldable fine-grain structural steel, comprising the steps of successively rolling a stock of steel alloy, consisting essentially of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.15 to 0.50% by weight of chromium, and iron as substantially the entire remainder, to progressively smaller diameters with a reduction in cross-sectional area by substantially 12 to 15% at each of three final rolling steps, at a temperature of substantially 800° to 900° C., and cooling the rolled stock from said temperature to a level of approximately 500° C. at a rate substantially 30% faster than cooling under normal ambient conditions.

6. A process for making a bar of fine-grain structural steel, comprising the steps of successively rolling a stock of steel alloy, consisting essentially of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.10 to 0.20% by weight of aluminum, 0.05 to 0.20% by weight of a metal selected from the group which consists of titanium and vanadium, and iron as substantially the entire remainder, to progressively smaller diameters with a reduction in cross-sectional area by substantially 12 to 15% at each of three final rolling steps, at a temperature of substantially 800° to 900° C., and cooling the rolled stock from said temperature to a level of approximately 500° C. at a rate substantially 30% faster than cooling under normal ambient conditions.

7. A process for making a bar of weldable fine-grain structural steel, comprising the steps of successively rolling a stock of steel alloy, consisting essentially of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.15 to 0.50% by weight of chromium, 0.10 to 0.20% by weight of aluminum, 0.05 to 0.20% by weight of a metal selected from the group which consists of titanium and vanadium, and iron as substantially the entire remainder, to progressively smaller diameters with a reduction in cross-sectional area by substantially 12 to 15% at each of three final rolling steps, at a temperature of substantially 800° to 900° C., and cooling the rolled stock from said temperature to a level of approximately 500° C. at a rate substantially 30% faster than cooling under normal ambient conditions.

8. A bar of fine-grain alloy steel with a tensile strength of at least 75 kg./mm., a yield-point of at least 50 kg./

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mm. and a high degree of cold deformability, said steel being essentially composed of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, and iron as substantially the entire remainder produced by rolling a stock of steel alloy of the stated composition to progressively smaller diameters at a temperature of substantially 800° to 900° C., and rapidly cooling the rolled stock from said temperature to a level of approximately 500° C.

9. A bar of weldable fine-grain alloy steel with a tensile strength of at least 75 kg./mm., a yield point of at least 50 kg./mm. and a high degree of cold deformability, said steel being essentially composed of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.15 to 0.50% by weight of chromium, and iron as substantially the entire remainder, produced by rolling a stock of steel alloy of the stated composition to progressively smaller diameters at a temperature of substantially 800° to 900° C., and rapidly cooling the rolled stock from said temperature to a level of approximately 500° C.

10. A bar of fine-grain alloy steel with a tensile strength of at least 75 kg./mm., a yield point of at least 50 kg./mm. and a high degree of cold deformability, said steel being essentially composed of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.10 to 0.20% by weight of aluminum, 0.05 to 0.20% by weight of a metal selected from the group which consists of titanium and vanadium, and iron substantially as the entire remainder, produced by rolling a stock of steel alloy of the stated composition to progressively smaller diameters at a temperature of substantially 800° to 900° C., and rapidly cooling the rolled stock from said temperature to a level of approximately 500° C.

11. A bar of weldable fine-grain alloy steel with a tensile strength of at least 75 kg./mm., a yield point of at least 50 kg./mm. and a high degree of cold deformability, said steel being essentially composed of 0.15 to 0.40% by weight of carbon, 0.70 to 1.80% by weight of manganese, 0.50 to 1.50% by weight of silicon, 0.15 to 0.50% by weight of chromium, 0.10 to 0.20% by weight of aluminum, 0.05 to 0.20% by weight of a metal selected from the group which consists of titanium and vanadium, and iron as substantially the entire remainder, produced by rolling a stock of steel alloy of the stated composition to progressively smaller diameters at a temperature of substantially 800° to 900° C., and rapidly cooling the rolled stock from said temperature to a level of approximately 500° C.

References Cited by the Examiner

UNITED STATES PATENTS

2,576,223	11/51	Hofmann	148—12.4
2,716,080	8/55	Schwarz	148—12
2,901,346	8/59	Huddle et al.	75—124
2,933,424	4/60	Canney	148—12
2,987,394	6/61	Mueller	75—124

FOREIGN PATENTS

609,730	10/48	Great Britain.
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