United States Patent [19]

Watmough et al.

[11] **3,791,818**

[45] **Feb. 12, 1974**

[54] **STEEL ALLOY**

[75] Inventors: **Thomas Watmough,** Dolton; **Robert P. O'Shea,** Lombard, both of Ill.

[73] Assignee: **The United States of America as represented by the Secretary of the Air Force,** Washington, D.C.

[22] Filed: **Aug. 14, 1972**

[21] Appl. No.: **280,282**

[52] **U.S. Cl.** ..... **75/126 E,** 75/126 P, 102/67

[51] **Int. Cl.** **C22c 39/26,** F42b 13/48

[58] **Field of Search** ..... 75/126 P, 126 D, 126 E, 75/123 R, 123 N, 123 B, 123 J

[56] **References Cited**

UNITED STATES PATENTS

2,737,455	3/1956	Kirkby	75/126 P
3,615,879	10/1971	Herzog	75/126 P
3,547,032	12/1970	Horvath	102/67
3,288,600	11/1966	Johnsen et al.	75/126 P
2,858,206	10/1958	Boyce et al.	75/126 P
2,528,867	11/1950	Day	75/123 B
2,683,086	7/1954	Clark	75/126 D

Primary Examiner—Carl D. Quarforth
Assistant Examiner—R. E. Schafer

[57] **ABSTRACT**

A low alloy steel which utilizes boron as an essential alloying ingredient. The boron controls and manipulates the fragment mass distribution characteristics of alloy steels used in fabricating explosive warheads.

3 Claims, 2 Drawing Figures

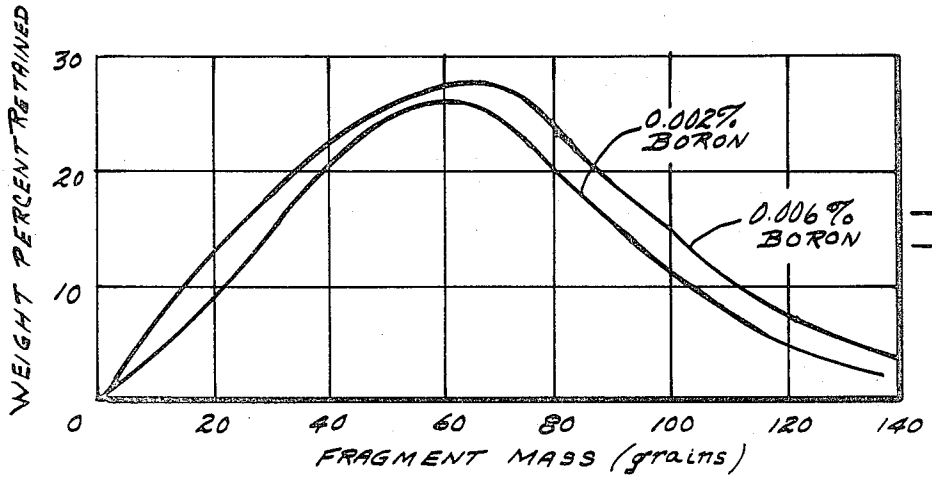

WEIGHT PERCENT RETAINED
30
20
10
0
20
40
60
80
100
120
140
FRAGMENT MASS (grains)
0.002% BORON
0.006% BORON

FIG. 1

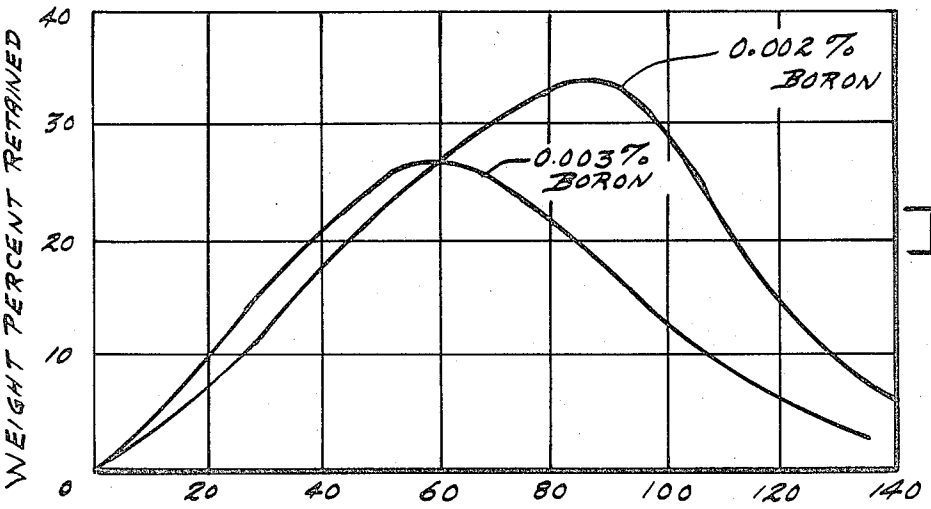

WEIGHT PERCENT RETAINED
40
30
20
10
0
20
40
60
80
100
120
140
0.002% BORON
0.003% BORON

FIG. 2

STEEL ALLOY

BACKGROUND OF THE INVENTION

This invention relates to an alloy steel containing boron as an alloying ingredient. The boron is used to control the fragmentation characteristics of low alloy steels having a pearlitic matrix.

The fragment mass distribution characteristics of steel alloys used in fabricating explosive warheads constitutes a problem of considerable importance for those concerned with evaluating the fragmentation effects achieved when such warheads are detonated against both light and heavy targets. Different types of targets require different fragment distribution patterns and the distribution pattern depends, to a great extent, on the compositional characteristics of the fragment material as well as the processing controls utilized during its formation.

In attempting to control the fragment mass distribution characteristics of low alloy steels, it was found that the incorporation of boron, as an essential alloying ingredient, provided an alloy steel with improved fragmentation characteristics. The utilization of boron in the compositional content of the low alloy steels of this invention provides very desirable fragment mass distribution characteristics upon detonation of a warhead fabricated from such an alloy.

SUMMARY OF THE INVENTION

In accordance with the broad concept of this invention, it has been discovered that the incorporation of boron, as an alloying ingredient, in low alloy steels having a ferritic-pearlitic matrix influences their fragment mass distribution characteristics in an unexpectedly favorable manner. The boron addition produces a network of brittle iron-boron compounds in the ferritic-pearlitic matrix and provides the desirable fragmentation characteristics exhibited by the low alloy steels of this invention.

The boron containing steel alloys of this invention find special usefulness as structural materials in the manufacture of explosive warheads for use against both light and heavy targets. Antipersonnel grenades, aerial bombs, light and heavy artillary shells, as well as other explosive warheads, can be fabricated from the steel alloys of this invention. The addition of boron provides the means for achieving control over the fragment mass distribution patterns emanating from exploding warheads fabricated from the steel alloys of this invention.

Accordingly, the primary object of this invention is to provide a steel alloy that possesses desirable fragmentation characteristics for use as a structural material in exploding warheads.

Another object of this invention is to provide a low alloy steel whose fragmentation characteristics are controlled by the addition of boron as an alloying ingredient.

Still another object of this invention is to provide a structural material that possesses the type of fragment mass dis-tribution characteristics that make it especially useful in the manufacture of antipersonnel and antivehicle weapons for use against both light and heavy targets.

The above and still other objects and advantages of the present invention will become readily apparent upon consideration of the following detailed description thereof when taken in conjunction with the following drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIGS. 1 and 2 are graphical representations showing the effects of boron content on the fragment mass distribution characteristics of the low alloy steels of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The fragmentation materials of this invention are low alloy steels of medium carbon content and are characterized by having a ferritic-pearlitic matrix. The addition of boron, as an essential alloying ingredient, provides the control needed to produce the desirable fragment mass distribution characteristics required by exploding warheads that are employed against both light and heavy targets.

The boron is incorporated as an alloying ingredient in accordance with standard alloying procedures. The alloys are then austenitized at 2,100°F then directly isothermally transformed at 1,200°F, to develop the preferred structure and cooled to room temperature. The graphical representations in FIGS. 1 and 2 illustrate the fragment distribution effects achieved by the alloys of this invention. The compositional characteristics of the alloys are set forth in the following table.

Table I

		Composition, weight percent					
Example	Structure	C	Mn	Cr	V	Be	Fe
1	Forged	0.49	1.38	1.18	0.22	0.003	bal.
2	Forged	0.50	1.37	1.21	0.19	0.002	bal.
3	Cast	0.53	1.37	1.20	0.17	0.006	bal.
4	Cast	0.53	1.36	1.21	0.17	0.002	bal.

The boron additions to the steel alloys of this invention produce a network of brittle iron-boron compounds in the ferritic-pearlitic matrix and influence the fragmentation characteristics of the alloy. In this invention the influence of boron additions on the fragmentation characteristics of both forged and cast steels were evaluated by adding two levels of boron to the medium carbon low alloy steels illustrated in Table I.

It was found, as shown by the graphs of FIGS. 1 and 2, that the influence of boron content on fragmentation characteristics was greater in forged structures whereas with cast structures the effects were not as readily apparent. This is understandable since the cast structure would be expected to greatly influence fragmentation, thereby masking the effects of the boron addition. The graphical results clearly demonstrate that in conjunction with proper heat treatment, the control of boron content can provide for the controlled fragmentation of forged steels. This type of control appears to be most amenable in the medium to large fragment ranges and, as such, makes the alloy especially useful as an element in weapons employed against light and heavy targets.

From an examination of the foregoing, it can be seen that the present invention involves a technique that provides a simple and efficient means for producing military warheads having a high degree of fragmentation. By utilizing and properly selecting the compositional content of low alloy steels having a ferritic-

pearlitic matrix, warheads for use against both light and heavy targets can be obtained.

While the principles of this invention have been described with particularity, it should be understood that various alterations and modifications can be made without departing from the spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. A fragmentation type steel alloy consisting of by weight about 0.002 to 0.006 percent boron; about 0.49 to 0.53 percent carbon; about 1.36 to 1.38 percent manganese; about 1.18 to 1.21 percent chromium; about 0.17 to 0.22 percent vanadium; and the balance essentially all iron.

2. An alloy in accordance with claim **1** containing about 0.002 percent boron.

3. An alloy in accordance with claim **1** containing about 0.006 percent boron.

* * * * *