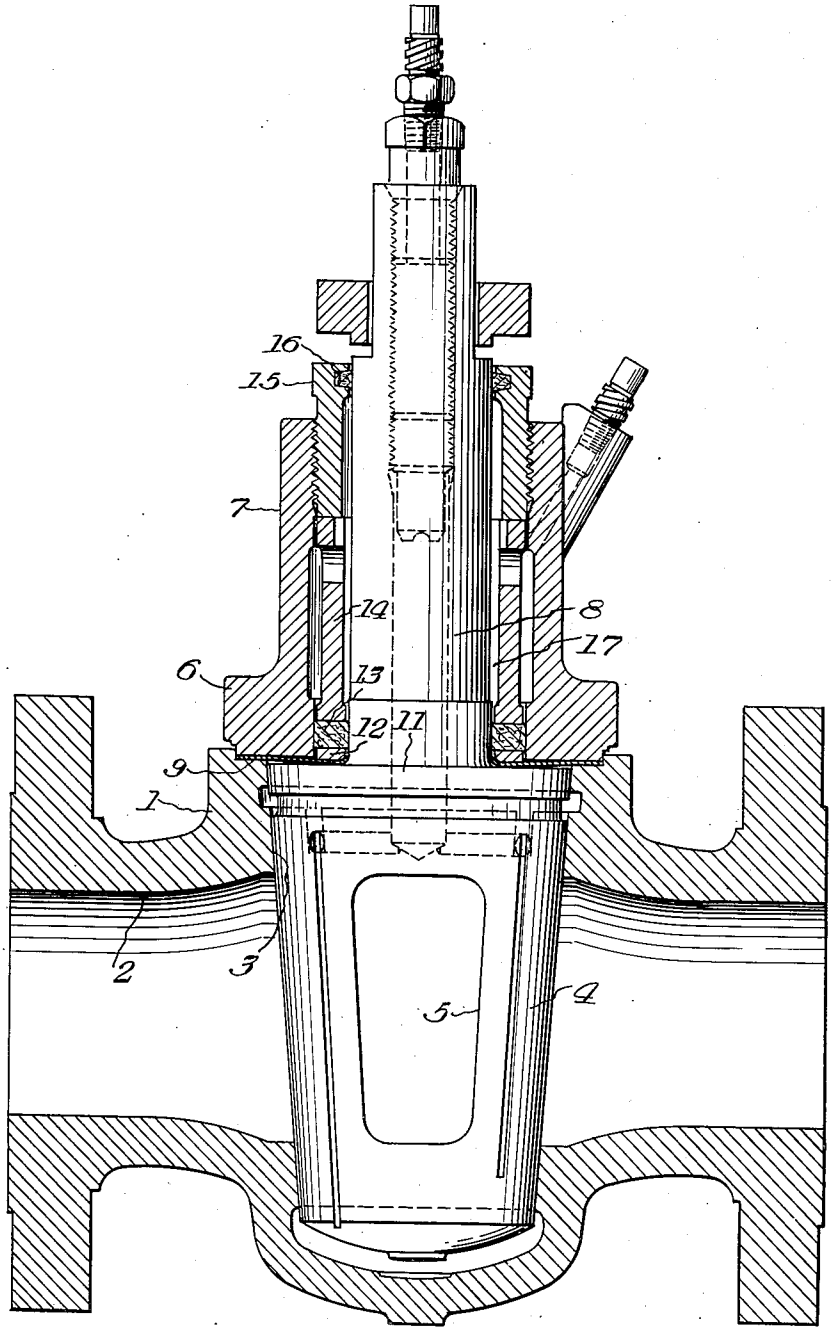
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LOW TEMPERATURE ALLOY AND VALVE OR THE LIKE

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LOW TEMPERATURE ALLOY AND VALVE OR THE LIKE

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The present invention relates to steel alloys having high tensile strength and high resistance to shock or impact at very low temperatures, and which are particularly applicable to the construction of valves and other pipe fittings for use at such temperatures.

Quite recently, in connection with the manufacture of chemicals from refinery by-products, processes have been developed which involve the use of high pressures and extremely low temperatures which run into the neighborhood of 600 lbs. per square inch pressure and minus 150° Fahrenheit. Valve metals for these services include both cast and forged materials to provide bodies, covers, bolting materials, stems, and other trim. While some of the physical properties of these valve metals change in a favorable direction with decrease in temperature, as, for instance, the tensile strength, yield point, modulus of elasticity, and hardness, another important characteristic, shock resistance, is affected adversely with the decline in temperature. The metals used for the construction of valves which are to be subjected to the sub-zero temperatures are frequently subjected to heavy stresses not only as the result of internal pressure or bolting stresses, but must withstand as well the sudden shocks which may result from other sources such as water hammer, pump vibration, or accidentally applied mechanical forces. The resistance to shock or impact as measured by the energy absorption of a test specimen when subjected to a sudden blow from an impact producing apparatus such as a Charpy testing machine, is the most difficult qualification to be met in the selection of suitable metals for sub-zero service. To provide a satisfactory shock resisting metal most specifications call for a minimum Charpy test of 15 foot pounds on a standard 10 x 10 x 50 millimeter specimen with keyhole notch, at a minimum temperature at which the part is to be stressed.

The high nickel steels of the fully austenitic type have the desirable impact resisting properties and other properties required, but the effect of work hardening on these steels render them undesirable for use on low temperature operation, for if the material is subject to stresses it may work harden to an appreciable degree and lower its impact resistance. Also, although certain alloys having high shock resistance at low temperature in rolled or forged form are known, such alloys are not satisfactory for making cast objects.

Accordingly, it is an object of the invention to provide a steel alloy and castings made therefrom having high tensile strength and high resistance to shock at low temperatures.

A further object is the provision of a relatively low cost steel alloy and castings made therefrom having high resistance to shock at very low temperatures, high tensile strength and which can be machined.

Another object is the production of a steel alloy having a high tensile strength and high impact value which may be used for valves or fittings on high pressure low temperature conduits.

A further object is the provision of a steel alloy which has been subject to a heat treatment to develop high resistance to impact and high tensile strength at low temperatures.

Another object is the provision of a steel alloy which may be formed into castings containing thick sections having satisfactory resistance to shock at low temperatures.

More specifically, it is an object to provide a plug valve of a steel alloy and castings made therefrom having an average Charpy test higher than 15 foot pounds at a temperature as low as minus 150° Fahrenheit or lower.

Alloys made according to the present invention have in general the following composition:

	Per cent
Carbon (preferably as low as possible)	.08 to .15
Manganese	.30 to .50
Silicon	.12 to .45
Nickel	3.5 to 7.5
Molybdenum	.40 to .50
Vanadium	.10 to .20

Primarily, it is desirable to have the carbon content as low as practicable, as the embrittlement at low temperatures increases rapidly with increase in carbon content. It is also important to have the carbon in a highly dispersed condition in the steel, and therefore a quenched and tempered structure gives the best resistance to embrittlement.

For securing Charpy values of 15 foot pounds or better at minus 150° F., nickel may be present to the extent of about 3½% to 7½%, and preferably to about 4.5. Although increasing the amount of nickel above about 4½% increases the shock resistance, at least in the range of temperatures of 0° F. to minus 150° F., this end may be more economically attained by reducing the carbon content within the range above stated, or by adding the other alloying elements stated above. On account of the characteristics of nickel

in a steel as a non-carbide forming element, the addition of nickel provides an offset to a higher carbon content, where higher carbon content is desirable.

Small quantities of vanadium are highly desirable, especially for temperatures as low as minus 150° F. Vanadium contributes to a very fine grain structure, improves fatigue resistance, and to thorough deoxidation of the melt, the fine grained structure being especially desirable for the lower temperature range. Silicon gives fluidity to the melt in casting. Where aluminum is used as a deoxidizer an excess should be avoided.

Scrap iron frequently contains small amounts of chromium, which is an advantage, for as the carbon content of the alloy is low enough to prevent the formation of excessive amounts of chromium carbide, the chromium increases the tensile strength. It will be understood that the remainder of the alloy is composed of iron and such incidental impurities as ordinarily are present, such as phosphorus and sulphur, which are maintained as low as possible.

After the alloy has been prepared and cast into the desired form, as for example, a plug valve casing, it is subjected to a heat treatment in order to obtain an extremely fine grain structure and to increase its impact value. The heat treatment consists of a homogenizing treatment at a temperature of 1800° F. to 1850° F. for a period of time depending on the size of the casting, slow cooling in air, then reheating to about 1500° F. for a sufficient length of time, quenching in oil and reheating to a temperature below the critical point to draw the temper and allowing to cool in air or again quenching in oil. The temperature of the draw may be varied depending on the strength and hardness desired in the finished casting. Maximum softness and maximum impact resistance are secured by heating just below the critical point and allowing the casting to cool slowly. The period of heating will depend on the thickness of the casting, and in general one hour of heating for each inch of thickness in cross section may be allowed.

The invention is explained in detail in connection with the following specific preferred example, by way of illustrating the invention.

A charge of low carbon steel and steel scrap is melted together with silicon, manganese and nickel under a suitable slag, preferably in an electric furnace, and the charge is heated to about 3100° F. A suitable portion of molybdenum and vanadium preferably as the ferro-alloys, is added to the metal in the ladle. The molten alloy is then poured into suitable molds of any desired form, as for example, valve casings or plugs. The proportion of the ingredients in the casting are substantially as follows:

	Per cent
Carbon	.08
Manganese	.29
Silicon	.12
Nickel	4.06
Molybdenum	.50
Phosphorus	.015
Vanadium	.16
Sulphur	.018

The casting is dressed and then subjected to a heat treatment as follows:

The casting is heated to 1800° to 1850° F. for a period depending on the thickness of the section and is then cooled slowly to atmospheric temperature. It is then reheated to 1500° to 1550° F. for two hours or longer depending on the thickness of the section and quenched in oil. The casting is then drawn to 1200° F. and allowed to cool in air, or if desired it may be quenched in oil.

The physical characteristics of a standard test bar of the alloy having the above composition and treated in this manner are as follows:

Ultimate strength	pounds per square inch	107,000
Yield point	do	88,000
Elongation in two inches	per cent	22.5
Reduction in area	do	61.
Charpy test at minus 150° F. (average of 3 bars)	ft. lbs.	20.0

Another example made in substantially the same way and similarly heat treated showed the following properties:

Average analysis

	Per cent
Carbon	.10
Manganese	.30
Silicon	.34
Nickel	3.64
Molybdenum	.48
Vanadium	.10

Tensile strength	lbs./sq. in.	73,450
Yield point	do	61,850
Elongation in two inches	per cent	36.5
Reduction in area	do	64.0
Brinell hardness		152
Charpy test at minimum minus 150° F. (average 3 bars)		16.8

The Charpy test was taken at minus 150° F. on a standard keyhole notched specimen.

In manufacturing plug valves from this alloy, the plugs and casings are cast, then subjected to the above heat treatment and machined. The plug then preferably is case hardened by lightly carburizing and after lapping or grinding it into its seat the valve is then assembled. Case hardening the plug prevents or reduces galling or seizing between the plug and its seat and the high carbon content of the surface of the plug does not affect the strength and impact resistance of the body of the plug.

In the accompanying drawing Figure 1 shows a plug valve constructed in accordance with the present invention.

Referring to the drawing, there is shown a casing 1 having a passageway 2 therethrough for flow of fluid and a tapered bore 3 3 extending transversely thereof adapted to receive a valve plug 4 having a port 5 therethrough. A cover 6 is provided having an extension 7 adapted to receive an insulation layer of cork or other suitable material. The plug has an operating stem 8 extending through the cover and a thin flexible metal washer 9 is pressed at its inner periphery against the shoulder 11 by a metal packing ring 12, resilient packing ring 13, filler ring gland 14 and threaded adjustment gland 15 having a packing 16 therein. The outer periphery of washer 9 is clamped between the casing 1 and cover 6. The valve may be lubricated by any suitable lubricating system, one preferred system being illustrated. The casing 1, cover 6 and plug 4 are made of an alloy comprising carbon .08%, manganese .29%, silicon .12%, nickel 4.06%, molybdenum .50%, vanadium .16%, phosphorus .015%, and sulphur .018%, which have been subjected to a heat treatment comprising heating to 1800° to 1850° F. for two hours, then cooling slowly in air, reheating to 1500° F. for

two hours, quenching in oil, then reheating to 1200° F. to draw the temper, then cooling in air or quenching in oil. After machining, the plug is then case hardened by any suitable method and is then ground and lapped into its seat and the valve is assembled.

Although I have illustrated my invention in connection with a plug valve, it will be understood that the invention is not limited thereto, and may be employed for pipe fittings, gate valves, or other parts requiring high resistance to impact at low temperatures and high tensile strength. For example, valves of the design shown in the application for patent of Sven J. Nordstrom, Serial No. 691,213 filed September 27, 1933, may be constructed according to the present invention of the herein described alloy.

It will be understood that although the alloy of the present invention has high resistance to shock at sub-zero temperatures, it has correspondingly higher resistance to shock at normal temperatures.

It will be understood that the alloy of the present invention may be rolled or forged into various forms and heat treated.

I claim as my invention:

1. A casting composed of a steel alloy comprising up to about .20 per cent vanadium; .40 to .50 per cent molybdenum, about 3.5 to 7.5 per cent nickel, up to about .5 per cent manganese, and not more than about .15 per cent carbon which has been subject to homogenizing heat treatment of about 1800° to 1850° F., followed by slow cooling, then reheated to about 1500° F., and quenched, followed by reheating below its critical point to draw the temper, characterized by high tensile strength and high shock resistance at sub-zero temperatures.

2. A casting composed of a steel alloy comprising about .1 per cent vanadium; .48 per cent molbdenum; 3.64 per cent nickel; .3 per cent manganese, and about .10 per cent carbon, which has been subject to a homogenizing heat treatment of about 1800° to 1850° F., followed by slow cooling, reheated to about 1500° F., quenched and reheated to just below its critical point, characterized by high tensile strength and high shock resistance at sub-zero temperatures.

3. A casting composed of a steel alloy comprising up to about .20% vanadium, .40% to .50% molybdenum, 3.5% to 4.5% nickel, up to about .5% manganese, and not more than about .15% carbon, which has been subject to homogenizing heat treatment of about 1800° to 1850° F., followed by slow cooling, then reheated to about 1500° F. and quenched, followed by reheating below its critical point to draw the temper, and characterized by high tensile strength and high resistance to shock at sub-zero temperatures.

4. A plug valve having a plug and body composed of a steel alloy comprising up to about .20 per cent vanadium, .40 to .50 per cent molybdenum, about 3.5 to 7.5 per cent nickel, up to about .5 per cent manganese, and not more than about .15 per cent carbon, which has been subject to homogenizing heat treatment of about 1800° to 1850° F. followed by slow cooling, then reheated to about 1500° F. and quenched, followed by reheating to about 1200° F. to draw the temper, characterized by high tensile strength and high shock resistance at sub-zero temperatures.

5. A plug valve having a plug and body composed of a steel alloy comprising up to about .20% vanadium, .40 to .50% molybdenum, 3.5 to 4.5% nickel, up to .5% manganese, and not more than about .15% carbon, which has been subject to homogenizing heat treatment of about 1800° to 1850° F. followed by slow cooling, then reheated to about 1500° F. and quenched, followed by reheating to about 1200° F. to draw the temper, and characterized by high tensile strength and high resistance to shock at sub-zero temperatures.

6. A plug valve having a plug and body composed of a steel alloy comprising about .1 per cent vanadium, .48 per cent molbdenum, 3.64 per cent nickel, .3 per cent manganese, and not more than about .15 per cent carbon, which has been subject to a homogenizing heat treatment of about 1800° F. to 1850° F., followed by slow cooling, reheated to about 1500° F., quenched and reheated below its critical point, the plug being case hardened, characterized by high tensile strength and high shock resistance at sub-zero temperatures.

7. A plug valve having a plug and body composed of a steel alloy comprising about .16 per cent vanadium, .50 per cent molybdenum, about 4.06 per cent nickel, .29 per cent manganese, and .08 per cent carbon, which has been subject to homogenizing heat treatment of about 1800° to 1850° F., followed by slow cooling, then reheated to about 1500° F., and quenched, followed by reheating, below its critical point, to draw the temper, characterized by high tensile strength and high shock resistance at sub-zero temperatures.

8. A steel alloy containing the following constituents: vanadium, up to .20%, molybdenum, .40 to .50%, nickel, about 3.5 to 7.5%, manganese, up to about .50%, and not more than about .15% carbon, which has been subject to a homogenizing heat treatment of about 1800 to 1850° F., followed by slow cooling, reheated to about 1500° F., quenched, and reheated to just below its critical point to draw the temper, and characterized by high tensile strength and high shock resistance at sub-zero temperatures.

9. A steel alloy containing the following constituents: vanadium, up to .20%, molybdenum, .40 to .50%, nickel, 3.5 to 4.5%, manganese, up to about .50%, and not more than about .15% carbon, which has been subject to a homogenizing heat treatment of about 1800 to 1850° F., followed by slow cooling, reheated to about 1500° F., quenched, and reheated to just below its critical point to draw the temper, and characterized by high tensile strength and high shock resistance at sub-zero temperatures.

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