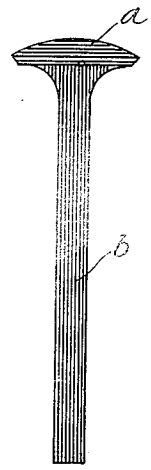
June 17, 1941. W. ROHN ET AL 2,246,078

VALVE MADE OF COBALT-NICKEL-CHROMIUM-IRON ALLOY

Original Filed July 26, 1938




annealed

cold worked

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Patented June 17, 1941

2,246,078

# UNITED STATES PATENT OFFICE

2,246,078

## VALVE MADE OF COBALT-NICKEL-CHROMIUM-IRON ALLOY

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Application December 24, 1938, Serial No. 247,697, which is a division of application Serial No. 221,394, July 26, 1938. Divided and this application October 23, 1939, Serial No. 300,840. In Germany July 31, 1937

2 Claims. (Cl. 123—188)

This application is a division of our copending patent application Ser. No. 247,697, filed Dec. 24, 1938, which was divided out from our copending original application Ser. No. 221,394, filed July 26, 1938.

This invention relates to valves, especially exhaust valves made of certain cobalt-nickel, chromium-iron-alloys having improved mechanical properties at elevated temperatures.

It is known that alloys which in addition to nickel as main constituent contain alternatively proportions of chromium, molybdenum or tungsten as well as on occasion iron, show a high creep resistance in hard rolled condition at operating temperatures between about 400 and 600° C.

Investigations by the applicants have now led to the development of alloys which on the one hand exhibit particularly high values of creep resistance at temperatures between 400 and 600° C. and which probably in this range show the optimum with regard to strength at high temperatures and which on the other hand still show also a high creep resistance at higher temperatures that is to say at temperatures up to and above 900° C. Consequently they are for example suitable for the exhaust valves of internal combustion engines and exhaust turbines which operate in the temperature range of 600 to 900° C.

The annexed drawing is a side view of a valve made according to the present invention. Both the head and the stem of the valve consist of the same material the composition of which is described hereafter, the material of the head *a* being annealed at a temperature above the temperature at which the valves are used, whereas the material of the stem *b* is hardened by cold working.

The alloys according to this invention contain as main constituents cobalt and nickel in a total quantity of 50 to 70% the cobalt content amounting to at least 10% and the nickel content amounting to at least 0.05%. Tungsten and molybdenum may be present separately or together in amounts of from 0.05% up to 20%, for example from 2.5 to 15%, and the chromium content amounts to between 8 and 25%. In addition the alloys may contain up to 30% of iron, for instance, from 0.5 to 30% of iron. A particularly good composition is 14 to 17% chromium, 14 to 16% iron, 5 to 7% molybdenum, 0 to 5% tungsten, 15 to 27% (particularly 21%) of cobalt, and the remainder essentially nickel apart from the usual deoxidising and manufacturing additions, for example of manganese and silicon. The manganese content may for example amount up to 1.5% and the silicon content up to 0.5%. If the alloys are to be used at temperatures above their recrystallisation temperatures, the highest creep resistance is exhibited by the alloys stated when they have been annealed prior to their use at temperatures exceeding the temperatures of use, for example at 1150 to 1300° C. If desired the alloys can also be employed in cast condition. If the alloys are to be used at temperatures below their recrystallisation temperatures the creep resistance may be increased by forging, rolling, drawing or hammering at the temperature between the temperature at which the alloys are to be used, and the recrystallisation temperature. By this special method not only the creep resistance but especially the elongation under the first loading of the material is decreased.

An alloy with about 16% chromium, about 15% iron, about 6% molybdenum, about 40% nickel and about 21% cobalt besides small proportions of de-oxidising and manufacturing additions exceeds by about 10 to 15% as regards creep resistance in the temperature range 500 to 600° C. an alloy hitherto considered as particularly good in this respect and consisting of 60% nickel, 15% chromium, 7% molybdenum and 18% iron. The advance over the known alloys is clear if the creep limit as such is not taken for comparison, but creep with time which is frequently adopted for comparison, that is to say the elongation per unit of time which as test piece undergoes when loaded with a given weight at constant temperature for a long time.

A comparative investigation about the creep resistance shows that the rate of creep of the cobalt-containing alloys according to the invention at constant temperature under a given load is only about one fifth to one tenth as compared with the abovementioned alloys of known composition.

By cold working, the alloys according to the invention which show no transition point up to 1000° C. can be considerably hardened (up to about 300 Brinell). This is important in the case of valves for internal combustion engines, the stems of which in use are frequently deficient of lubrication. When annealed at high temperature to obtain high creep resistance, which is particularly necessary for the valve head and its neck, the stem is too soft to withstand operation in the dry or semidry state. As a result of the considerable hardening which can be effected by cold working the stem may be provided with a thin hardened surface layer by hammering, pressing, pressure polishing or pressure rolling

and thus valuable running properties under conditions of deficient lubrication obtained.

A further improvement, in particular as regards the resistance to creep at high temperatures, can be attained with the said alloys if an addition is made of one or more of the elements of the first columns of the fourth and fifth group of the periodic system of elements (titanium, zirconium, thorium, vanadium, columbium, tantalum). The amounts in which these elements may be contained in the alloy are as follows:

Titanium from 0.05% up to 12%, particularly up to 5%
Zirconium from 0.05% up to 12%, particularly up to 5%
Thorium from 0.05% up to 8%, particularly up to 5%
Vanadium from 0.05% up to 15%
Columbium from 0.05% up to 15%
Tantalum from 0.05% up to 15%

The lower limit of these additions is generally not below 0.3% and the upper limit of the additions together not above 15%. The alloys so modified can be subjected to still higher mechanical load at high temperatures, that is to say the mechanical properties at a given temperature are better than those of the alloys without the specified additions, or the temperature at which the alloys can stand a predetermined mechanical load may be higher.

The abovementioned annealing at excessive temperatures before use for improving the properties as regards creep limit at temperatures above the recrystallisation temperature, or the above-mentioned forging, rolling, drawing, or hammering at temperatures between the recrystallisation temperature and the temperature at which the alloys are to be used, for the purpose of increasing the creep resistance at temperatures below the recrystallisation temperature and the surface hardening by means of cold working can also be applied to the alloys with the additions of titanium, tantalum, columbium, vanadium, zirconium and thorium with good results. The composition of the alloys with the said additions so far as the main constituents are concerned, lies within the limits given above. Thus a particularly advantageous alloy can be obtained with about 15 to 27% cobalt, 14 to 17% chromium, 6 to 16% iron, 5 to 7% molybdenum, 0 to 7% tungsten, especially 3 to 7% tungsten, besides nickel as main constituents, with addition of up to 5% titanium, up to 15% tantalum, up to 15% columbium, up to 8% thorium, and possibly the usual deoxidising and manufacturing additions.

We claim:

1. Valve for internal combustion engines made of an alloy consisting of from 50 to 70% together of cobalt and nickel with at least 10% cobalt and at least 0.05% nickel, from 6 to 25% chromium, from 0.05 to 15% metals of the group consisting of molybdenum and tungsten, from 0.05 to 30% iron, and from 0.05 to 15% of metals of the group consisting of titanium, zirconium, thorium, vanadium, columbium and tantalum, of which valve the head consists of a material annealed at a temperature above the temperature at which the valves are used, and of which the stem consists of the same material hardened by cold working.

2. Valve for internal combustion engines made of an alloy consisting of from 50 to 70% together of cobalt and nickel with at least 10% cobalt and at least 0.05% nickel, from 6 to 25% chromium, from 0.05 to 30% iron, and from 0.05 to 15% of metals of the group consisting of titanium, zirconium, thorium, vanadium, columbium and tantalum, of which valve the head consists of a material annealed at a temperature above the temperature at which the valves are used, and of which the stem consists of the same material hardened by cold working.

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