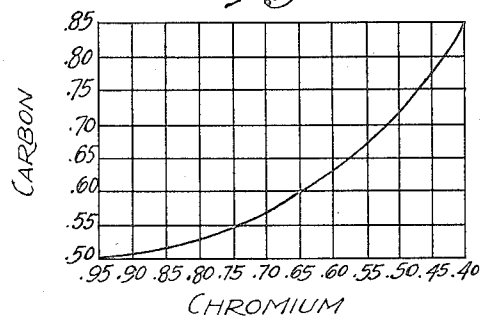
Aug. 7, 1923. 1,464,174

W. F. FINKL

AIR HARDENING STEEL ALLOY

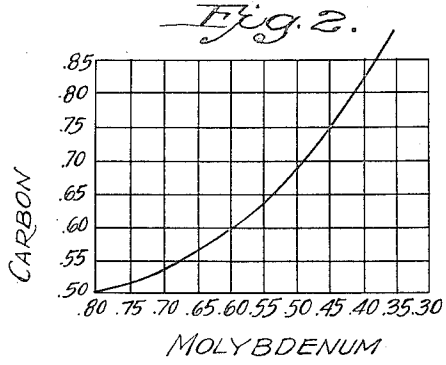
Original Filed May 5, 1921

Fig. 1.



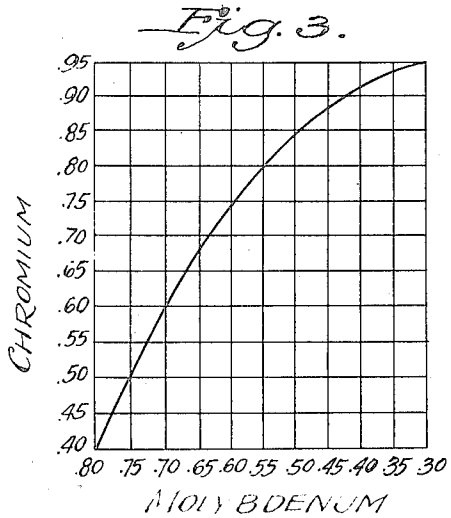
NICKEL .50 TO 2.00
MO, AS IN TABLE #2

Fig. 2.



NICKEL .50 TO 2.00
CR, AS IN TABLE #1

Fig. 3.



CARBON CONSTANT .50/.60
NICKEL .50 TO 2.00

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UNITED STATES PATENT OFFICE.

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AIR-HARDENING STEEL ALLOY.

Continuation of application Serial No. 467,201, filed May 5, 1921. This application filed February 11, 1922. Serial No. 535,689.

To all whom it may concern:

Be it known that I, WILLIAM F. FINKL, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented an Improvement in Air-Hardening Steel Alloys, of which the following is a specification.

This invention relates to steel alloys which are particularly adapted for use in machine parts requiring great hardness, durability and strength, and has for its principal object to provide an alloy of the class described capable of being air-hardened during heat treatment, with a minimum danger of shrinking, cracking or warping of the piece.

In carrying out my invention, I utilize as alloying metals, chromium, nickel and molybdenum. In a copending application for United States Letters Patent, bearing Serial No. 467,201, filed May 5, 1921, of which this application is a continuation, I have described a form of air-hardening chrome-nickel-molybdenum alloy which is particularly adapted for use in die-blocks, altho not restricted to such use. This alloy broadly includes a steel alloy having the elements substantially within the following ranges:

Carbon	.30 to 1.10%
Nickel	.50 to 2.00%
Chromium	.25 to 1.10%
Molybdenum	.15 to 2.00%

Other elements, such as manganese in fractions up to 1.00%, or silicon, in small fractions, may be present as is often the case in steels used in special alloys of this class.

My improved alloy is characterized chiefly by its capability of being air-hardened. In its annealed condition it may be readily machined, but is capable of being hardened within wide ranges of temperature, and during the hardening process may be cooled in air, with a minimum danger of cracking, warping or shrinking. Heat treatment may be carried out with less than the ordinary precautions necessary with common types of alloys. The alloy shows an unusual uniformity and depth of hardening, yet is capable of selective hardening to a marked degree, the hard portions, such as the wearing face of a gear, may be file hard, while the softer portions, such as the gear center, may be machinable with only slight difficulties. The alloy is capable of being hardened sufficiently for all practical purposes by the simple process of air-hardening.

As a result of extensive experiments with my alloy, I find that it is desirable to restrict the ranges of the elements to certain relative proportions, particularly as to the carbon, chromium and molybdenum contents, as the air-hardening qualities apparently depend largely upon the proportions of these elements. The nickel, in limited proportions specified, is essential to add toughness to the metal, but in excessive quantities the alloy becomes difficult to anneal, and shows a tendency to crack during heat treatment.

For most uses, best results are obtained by confining the ranges of the carbon, chromium and molybdenum to the following ranges:

Carbon	.50 to .85
Chromium	.40 to .95
Molybdenum	.30 to .80

And the nickel ranging from .50 to 2.00%, depending upon the toughness desired. Within the ranges above specified, the alloy exhibits the maximum air-hardening characteristics consistent with economy and uniformity in results in the production of the alloy.

In the accompanying Figures 1 and 2, I have illustrated graphically the preferable proportions of the elements within these ranges. For instance, if .65% carbon is to be used, reference to Figure 1 shows that .55–.60% chromium is recommended, and reference to Figure 2 shows that .50–.55% molybdenum is recommended. As before stated, nickel may range from about .50 to 2.00% in all cases, depending upon toughness desired. From these figures, therefore, three typical analyses may be derived, as follows:

	A.	B.	C.
Carbon	0.50%	0.60%	0.70%
Chromium	.80–.85%	.65–.70%	.50–.55%
Molybdenum	.70–.75%	.60–.65%	.50–.55%
Nickel	1.25–1.50%	1.00–1.25%	1.00–1.25%

These analyses are suggestive of the ranges in which maximum air-hardening qualities may be obtained, but it will be un-

derstood that these proportions may be varied considerably within the ranges specified. Furthermore, substantial air-hardening qualities may be obtained by varying the proportions beyond the ranges described in connection with Figures 1 and 2. For instance, a carbon content as low as .30–.40% might be used. Reference to the tables shows the general rule to be that the chromium and molybdenum should be increased as the carbon content is decreased. Therefore, with .30–.40% carbon, approximately the following analysis is recommended for best air-hardening qualities:

Carbon	.30– .40
Chromium	1.00–1.10
Molybdenum	1.50–2.00
Nickel	1.00–1.50

Such an analysis, however, is not as practical, ordinarily, as the ranges recommended in Figures 1 and 2, because of the increased expense in providing larger amounts of chromium and molybdenum, and also on account of the added difficulty in maintaining relatively large amounts of these last named elements in the furnace bath during the manufacture of the alloy.

In Figure 3, I have shown graphically the analysis which will probably be suitable for most purposes. This form has a constant carbon range from .50% to .60%, with the molybdenum decreasing from about .80% to .30% while the chromium ranges in inverse proportion from about .40% to .95%.

A typical heat treatment of my alloy is as follows: The piece is annealed for machining preferably by heating it to about 1400 degree Fahrenheit and cooling in the furnace. The critical temperature is about 1350 to 1355 degrees Fahrenheit. Hardening is accomplished by heating to approximately 1600 degrees Fahrenheit and cooling the piece in still air or in a blast, or, if desired, by quenching. The temper may be drawn as desired by reheating in the usual manner to the desired point.

My improved alloy has a wide range of uses, but is particularly adapted for use in machine parts which are irregular in shape, or have relatively heavy and light portions, such as ordinarily are subject to warping or shrinking after they have been machined to size and are heat treated by ordinary methods. When such pieces are made of my improved steel alloy they are readily machinable in annealed condition, but are capable of being hardened in air sufficiently for ordinary purposes without appreciable warping, shrinking or cracking. In case greater hardness is desired, the pieces may be quenched. Hardening and drawing of temper may be accomplished with less than ordinary care, as the variation in physical properties for given differences in temperature is smaller than in the case of ordinary alloy steels.

I claim as my invention:

1. A steel alloy containing carbon ranging from .50% to .85%; chromium from .40% to .95%; molybdenum from .30% to .80%, and nickel from .50% to 2.00%.

2. A steel alloy containing carbon ranging from .50% to .85%; nickel from .50% to 2.00%; chromium varying from .40% to .95% and inversely as the carbon content, and molybdenum varying from .30% to .80% inversely as the carbon content, substantially as described.

3. A steel alloy containing carbon .50% to .60%; nickel .50% to 2.00%, and chromium varying from .40% to .95% inversely as the molybdenum content varies from .30% to .80%, substantially as described.

4. A steel alloy containing carbon .30% to .50%; nickel from .50% to 2.00%; molybdenum varying from .80% to 2.00%, approximately in inverse proportion to the carbon content, and chromium varying from .95% to 1.10%, approximately in inverse proportion to the carbon content.

5. A steel alloy containing carbon .30% to 1.10%; nickel from .50% to 2.00%; molybdenum from .15% to 2.00%, and chromium from .25% to 1.10%, the molybdenum and chromium contents respectively varying in approximately inverse proportions to the carbon content.

6. A steel alloy containing carbon .30 to 1.00 per cent, nickel .50 to 2.00 per cent, chromium .25 to 1.10 per cent, and molybdenum .15 to 2.00 per cent.

7. As a new article of manufacture, a die-block or the like containing carbon .30 to 1.00%, nickel in substantial fractions up to 2.00%, chromium in substantial fractions up to 1.10%, and molybdenum in substantial fractions up to 2.00%, and iron approximately sufficient to complete the 100%.

8. A steel alloy containing carbon approximately .50 per cent, nickel approximately 1.25 per cent, chromium approximately .70 per cent, and molybdenum approximately .60 per cent.

Signed at Chicago, in the county of Cook and State of Illinois, this 8th day of February, 1922.

WILLIAM F. FINKL.