File.

FILE COPY

O T T A W A November 23rd, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1750.

Experimental Heat Treatment of Naval Compass Parts to Reduce Magnetic Properties.

(Copy No. 10)

Mines Branch
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

DEPARTMENT
OF
MINES and RESOURCES

Mines and Geology Branch

O T T A W A November 23rd, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1750.

Experimental Heat Treatment of Naval Compass Parts to Reduce Magnetic Properties.

==========

Origin of Material and Object of Investigation:

On November 13th, 1944, two compass bowls, a compass verge, and a compass weight were submitted by Commander F. G. S. Poile, R.N., of the British Admiralty Technical Mission, 58 Lyon Street, Ottawa, Ontario, for examination of magnetic properties and experimental heat treatment to reduce those properties. All material was stated to be very magnetic for this type of application.

One of the bowls, the verge, and the weight supplied were from one previously assembled compass (#353) and these pieces were saved for the final heat treatment after the experimental work had been done on portions of the other compass bowl.

Preparation of Samples for Chemical Analysis:

All four parts supplied were analysed chemically. Precautions were taken to avoid contamination by iron filings.

Chemical Analysis:

The following are the chemical analysis results:

	Test Bowl	PARTS FROM COMPASS #355		
		Bowl	Verge	Weight
		- Per Cent -		
Iron -	0.21	0.17	0.08	0.19
Copper -	85.42	85.30	94.66	62.14
Zinc -	4.24	3.64	N.D.*	36.11**
Tin -	5.00	5.37	N.D.	1.05
Lead -	4.94	5.39	N.D.	0.51
Manganese -	-	N.D.	1.04	N.D.
Nickel -	0.14	0.13	N.D.	N.D.
Aluminium -	-	-	N.D.	-
Silicon -	-	-	3.92	-

* N.D. = None detected.

** Zinc on compass weight calculated by difference.

Preparation of Samples for the Magnetic Tests:

Samples of material, $\frac{1}{2}$ in. x $5\frac{1}{2}$ in. x 7/64 in. in size, were cut from the bowl, special precautions being taken to remove all surface material and to avoid contamination during machining by iron filings.

Magnetic Tests:

The magnetic properties were measured by the use of mutual inductance coils. A steady direct current in the primary coil maintains a constant magnetic linkage with the secondary. The method of testing consists of quickly withdrawing the test sample from the centre of the mutual inductance coils. If the permeability of the sample differs from that of air, the withdrawal of the material will thus change the number of magnetic lines linking the primary and secondary coils and a charge will be generated in the secondary winding. This charge is measured

(Magnetic Tests, cont'd) -

on a ballistic galvanometer, the deflection being a measure of the charge produced and hence a basis for comparison of the magnetic permeabilities.

Both of the samples cut from the bowl gave a deflection of about 14 mm. before heat treatment. They were then packed in a carburizing compound to avoid oxidation and were maintained at a temperature of 800° C. (1472° F.). Sample No. 1 was held at this temperature for 12 hours and Sample No. 2 for 24 hours. Samples were water-quenched, in an effort to keep as much of the iron in solid solution in the copper as possible. It is believed by workers in this field(1)(2)(3) that any of the iron that is precipitated from alloys of this type is face-centred cubic in structure like the mother-lattice in copper and is therefore non-magnetic. This face-centred non-magnetic form of iron is analogous to the face-centred austenitic form of iron.

The specimens were examined after heat treatment and no measurable deflections could be obtained, although a deflection of less than 0.5 mm. is difficult to detect. It can thus be said that the magnetic susceptibility has been reduced to less than 3 per cent of its original value.

Heat Treatment of the Compass Parts:

The three parts of Compass #353 were then packed in a carburizing compound, held for 15 hours at 800° C. (1472° F.), and water-quenched. The quenching had the effect of slightly warping the parts, so that the diameters of the verge and bowl were different by 0.02 inch at one point. A little machining was therefore necessary before the compass could be reassembled. It is possible that a less severe quench would suffice to hold

(Heat Treatment of the Compass Parts, cont'd) -

the iron in the non-magnetic state and would minimize warpage. This could be determined by experiment.

If at all possible the heat treatment used above should be given before the first machining is done, so as to avoid a second machining step in assembling the compass. Subsequent cold-working with material of the iron content given above would not be likely to restore the magnetism to harmful proportions(4)(5).

References.

(1) R. B. Gordon and M. Cohen: "Age-Hardening of a Copper-Cobalt and Copper-Iron Alloy." Symposium on Age Hardening of Metals, pp. 161-184, American Society for Metals, 1940.

(2) F. Bitter and A. R. Kaufmann: "Magnetic Studies of Solid Solutions, I -- Methods of Observation and Preliminary Results on the Precipitation of Iron from Copper." Phys. Rev. (1939), 56. pp. 1044-1051.

(3) F. W. Constant, H. E. Leander and R. E. Faires: "Effect of Heat Treatment on Ferro-magnetic Impurities" (Abstract). Phys. Rev. (1940), 57, p. 1089.

(4) A. Butts and J. H. Frye: "Investigation of the Effects of Impurities on the Ferro-Magnetism of Non-ferrous Alloys." O.S.R.D. (NDRC) Report CD-156, May, 1944.

(5) A. Butts, J. H. Frye and P. L. Reiber Jr.: "Investigation of the Effects of Impurities on the Ferro-Magnetism of Non-ferrous Alloys." O.S.R.D. (NDRC) Report OD-156, Sept., 1944.

oooooooooo
oooooo
oo

RLC:GHB.