REMOVAL OF ALUMINIUM FROM COPPER-BASED ALLOYS TO ENSURE PRESSURE-TIGHT CASTINGS

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Abstract

The presence of aluminium is harmful in gunmetal particularly meant for the production of pressure-tight castings, because aluminium, if present in gunmetal even in traces, causes leakage; but the metal is sometimes introduced into the alloy along with the used scraps which may contain aluminium varying from 0·5 to 2·5 per cent., viz. naval parts, impellers, propellers, etc. The passing of dry compressed air under 100 lb./sq. in. through the melt containing different proportions of intentionally added aluminium caused the removal of even traces of the metal practically without any loss of zinc or tin, as aluminium has the tendency for preferential oxidation. The extent of its removal has been shown to depend on its percentage in the melt and the amount of compressed air passed through it.

Introduction

GUNMETAL or other bronzes are made of virgin elements to ensure pressure-tight castings, and the soundness of such castings is highly affected by the presence of aluminium even in traces. Notwithstanding this, the metal may be accidentally introduced into the alloy in traces along with the scraps sometimes used for making such alloys, because most of the naval scraps used contain aluminium. Owing to its strong tendency for oxidation, aluminium is a highly objectionable impurity in gunmetal or other bronzes, because it gives rise to an oxide film on the surface of the molten metal, while surface defects are caused by the trapping of the oxide skin against the mould-wall. Apart from this, a white skin is formed on the surface of the casting, this effect being noticeable, according to Silberstein[1], with even as low as 0·001 to 0·003 per cent aluminium contents. Films of alumina between the crystals tend to retain gases and thereby cause leakage and unsound castings. So even traces of aluminium should not be tolerated either in gunmetal or bronzes where pressure-tight castings are to be produced in green-sand moulding[2]. The presence of aluminium in such alloys can be so ascertained from the fact that with 0·05 per cent aluminium the castings develop a silvery appearance, while with 0·13 per cent they are white in colour.

Attempts were made in the present investigation to artificially introduce aluminium and then to remove even the traces of the metal practically without any loss of tin or zinc by means of compressed air, since

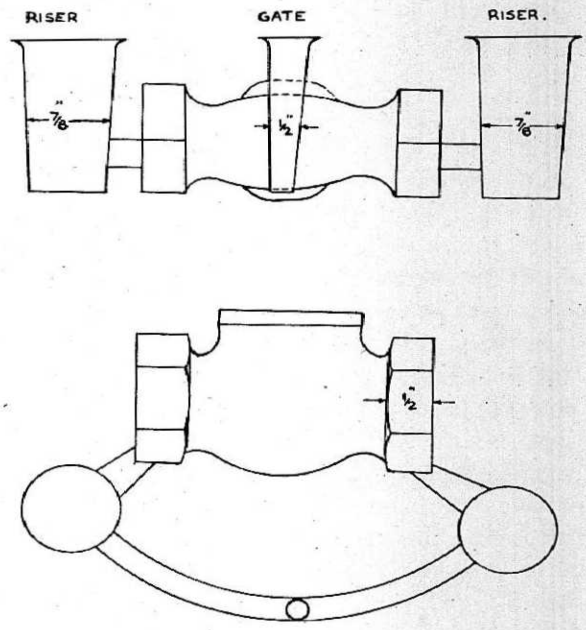

FIG. 1 — GATES AND RISERS

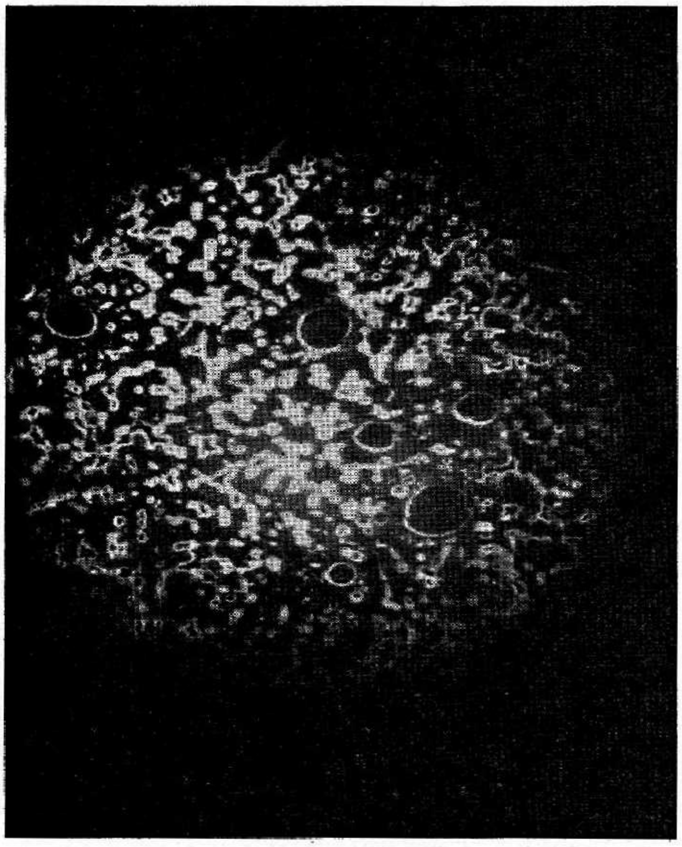

FIG. 2 — MAGNIFICATION (× 100)
MARK — 1

aluminium has a tendency for preferential oxidation[3].

Experimental

Firstly, 86.8.3.3 gunmetal ingots were melted under an oxidizing flux in the Pits' furnace. When the melt was ready, 10 per cent aluminium was added to it. After about three minutes, the crucible had been drawn out and the whole melt was thoroughly deoxidized by phosphor-copper (4 oz. per 100 lb. of melt; 16 per cent phosphorus). The slag being further thickened by the addition of sand was skimmed off and the metal partly poured into green-sand moulds to produce the test-pieces marked '1' (FIG. 2). For hydraulic tests in all cases, ½ stop-cock body was cast with gates and risers as shown (FIG. 1).

The crucible containing the remaining melt was placed in a coke-fired chamber to maintain the temperature as far as possible when dry and compressed air had been passed through the melt by means of a graphite tube.

Compressed air could not be dried by passing it through dried calcium chloride as usual, but only the recoverable water was taken out from the pipe-line by means of the water extractor connected with the main line. About 100 cu.ft. of air per second under 100 lb./sq. in. pressure were available from the compressor used. The graphite tube was dipped 3 in. below the surface of the melt (nearly 16 in. deep) and compressed air bubbled through the melt for one minute. The test-pieces cast were marked '2' (FIG. 3).

The test-pieces that were cast after passing compressed air exactly as above for two minutes more, i.e. in all 3 minutes, had been marked '3' (FIG. 4).

To collect the sample marked '4' (FIG. 5), compressed air was passed for one minute

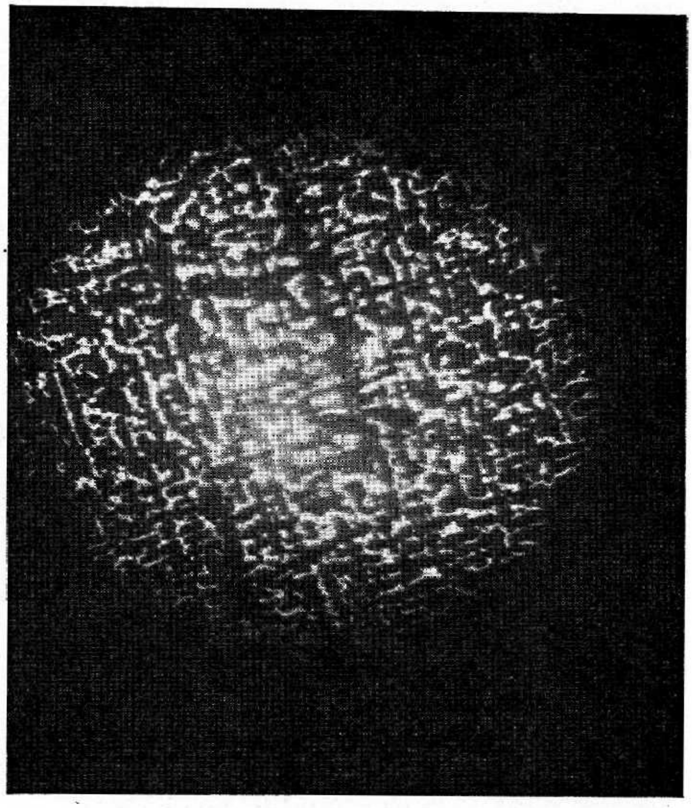

FIG. 3 — MAGNIFICATION (× 100)
MARK — 2

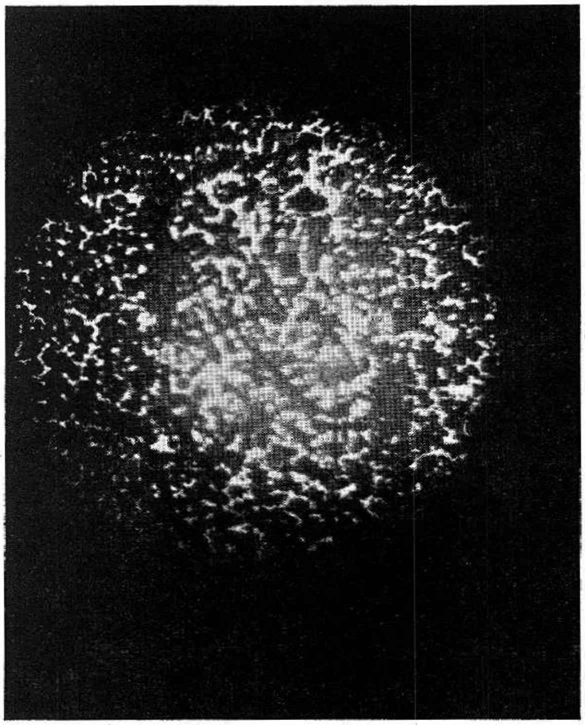

FIG. 4 — MAGNIFICATION (× 100)
MARK — 3

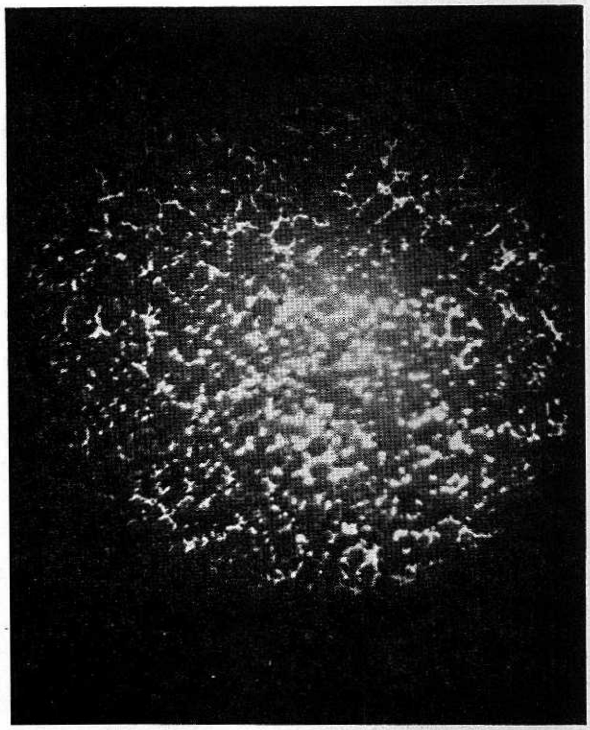

FIG. 5 — MAGNIFICATION (× 100)
MARK — 4

further through the remaining melt, after which the melt had become too cold to be cast. The crucible containing the cold melt was removed into the Pits' furnace and the melt brought up to the required temperature in 15 minutes. The crucible was then taken out, kept as usual in the coke-fired chamber and the compressed air passed through the melt for $4\frac{1}{2}$ minutes (in all $3+1+4\frac{1}{2} = 8\frac{1}{2}$ minutes) before casting. In all these cases, castings were done in green-sand moulds.

The second experiment also was carried out under the same conditions with intentional addition of 1·5 per cent aluminium,

TABLE 1—RESULTS

EXPT.	MARKS	CHEMICAL ANALYSIS (METAL CONTENT, %)							MECHANICAL TESTS		
		Cu	Sn	Pb	Zn	Fe	Al	Total	Hydraulic tests, 300 lb./sq. in.	Sp. gravity	B.H.N. 500 kilos & 30 secs.
1st	1	76·67	7·46	2·80	2·60	0·08	10·00	99·60	Could not be machined	7·33	119
	2	81·99	8·27	3·05	3·01	0·13	3·50	99·94	Leaked	8·07	73
	3	83·28	7·79	3·25	3·08	0·16	2·40	99·96	Leaked	8·38	62
	4	83·83	8·09	3·20	3·14	0·19	1·50	99·95	Leaked	8·42	—
2nd	5	82·98	6·53	2·97	5·89	0·13	1·50	100·00	Leaked	8·26	68
	6	83·50	8·34	3·05	4·23	0·06	0·80	100·02	Leaked	8·45	55
	7	84·03	9·11	2·92	4·28	Tr.	nil	100·34	Withstood the pressure	8·46	70

instead of 10 per cent as in the first experiment. After the melt became ready, the crucible was drawn out from the Pits' furnace and the melt thoroughly deoxidized by phosphor-copper as usual (4 oz. of phosphor-copper per 100 lb. of melt; 16 per cent P). In this experiment, the three samples were obtained by casting the melt as follows:

(a) before passing any compressed air — marked '5' (FIG. 6)

(b) after passing compressed air for $1\frac{1}{2}$ minute — marked '6' (FIG. 7)

(c) after passing compressed air for $1\frac{3}{4}$ minute (in all $1\frac{1}{2}+1\frac{3}{4}=3\frac{1}{4}$ minutes) marked '7' (FIG. 8)

Discussion

The results of chemical analysis indicate that the proportion of aluminium in gun-metal can be diminished by passing compressed air and that the quantity of the loss of the metal is regulated by the amount of compressed air passed through the melt. The loss of 8·5 per cent (10·0-1·5) aluminium in the first experiment as a result of passing compressed air for $8\frac{1}{2}$ minutes has, however, been compensated by the increase in proportions of all the other metals, the highest increase being noticeable in case of copper. This shows that aluminium is preferably oxidized, i.e. there will be no loss of other metals like zinc, tin, copper, etc., by oxidation until and unless the whole of aluminium is first oxidized. The initiation in the loss of other metals only after (and also along with) complete oxidation of aluminium has been observed in the second experiment where the percentage of zinc decreases from 5·89 to 4·20 per cent along with complete removal of aluminium of 1·5 per cent by passing of compressed air for $3\frac{1}{4}$ minutes; these losses in aluminium and zinc are, however, balanced by the increase in proportions of copper and

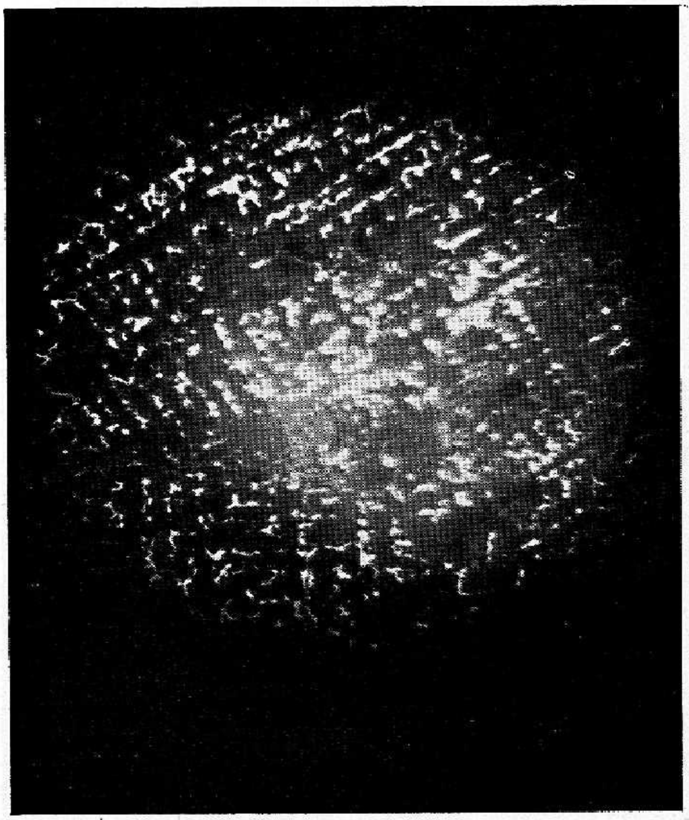

FIG. 6 — MAGNIFICATION (× 100)
MARK — 5

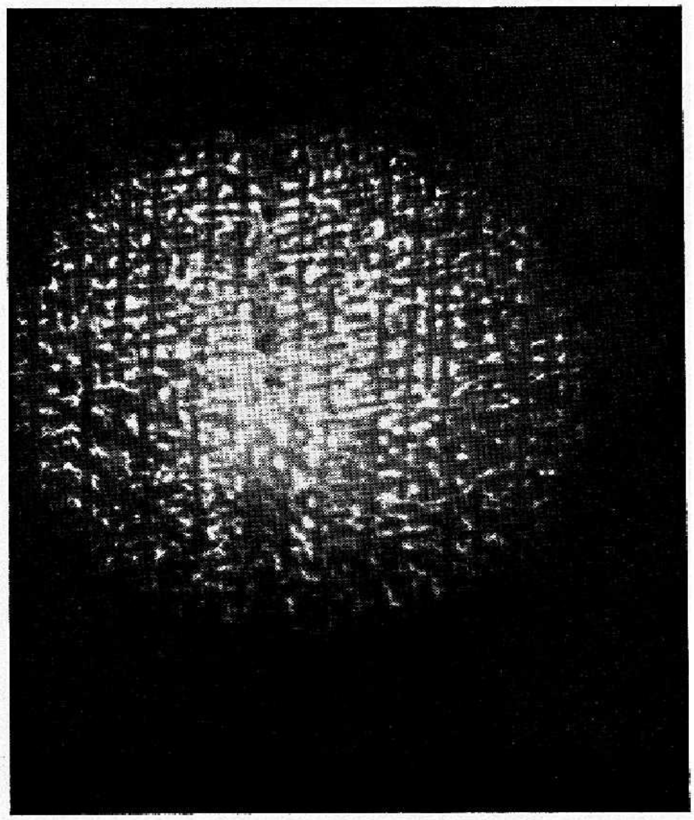

FIG. 7 — MAGNIFICATION (× 100)
MARK — 6

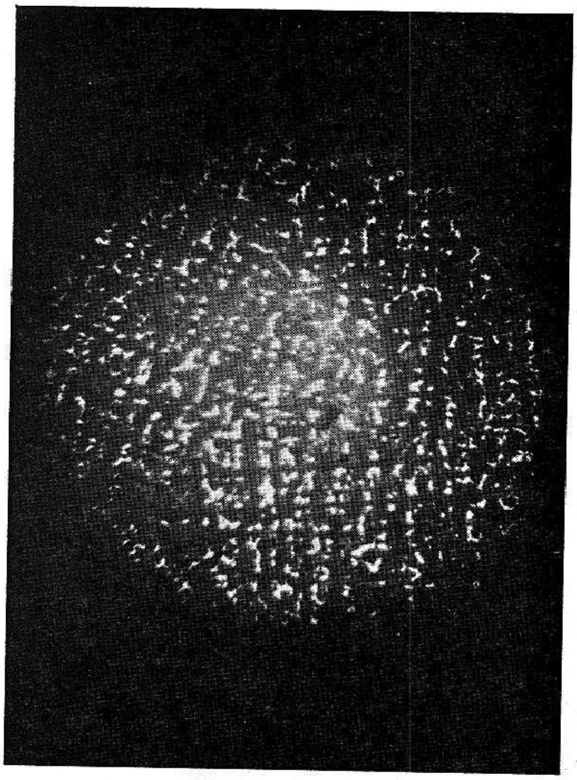

FIG. 8 — MAGNIFICATION (× 100)
MARK — 7

tin, particularly the latter. Thus it seems possible to control, by repeated trials, the supply of compressed air just to ensure complete oxidation of aluminium with minimum loss of zinc.

For the performance of hydraulic tests, the samples (½ stop-cock body) have got to be machined, but sample No. 1 containing 10 per cent aluminium could not be machined due to high brittleness and hardness. The results of hydraulic tests show that even traces of aluminium cause leakage, whereas in case of sample No. 7, from which aluminium was completely removed, there was no leakage at all and the valve-body withstood the pressure of 300 lb./sq. in.

The specific gravities increase with the decrease in percentage of aluminium concomitant with the rise in the proportions of other elements; the increase in specific gravity is also followed by decrease in sponginess.

The Brinell Hardness Number (B.H.N.) gradually decreases with the decrease in percentage of aluminium, i.e. with the decrease in the proportion of aluminium oxide which is a hard constituent; but the rise of B.H.N. in case of sample No. 7 which had no aluminium may, however, be ascribed to the formation of oxides of other metals during the complete removal of aluminium by oxidation.

All the photomicrographs were taken with 100 times magnification, etching reagent being picric acid. The plate of sample No. 1 shows a coarse structure with relatively poor mechanical properties; the rounded portions in the plate are believed to be spongy entrapped oxides of aluminium. The plates of the other samples reveal that with the decrease in aluminium contents, the structures become proportionately finer and finer obviously due to the decrease in entrapped oxides of aluminium.

Acknowledgements

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