Citation:

Behrens, H., On the chemical and microscopical examination of antimonial alloys for axle boxes, in:
KNAW, Proceedings, 1, 1898-1899, Amsterdam, 1899, pp. 35-38

Royal Academy of Sciences. Amsterdam.

PROCEEDINGS OF THE MEETING

of Saturday June 25th 1898.

(Translated from: Verslag van de gewone vergadering der Wis- en Natuurkundige Afdeeling van Zaterdag 25 Juni 1898 Dl. VII).

CONTENTS:

The following papers were read:

Chemistry. — „On chemical and microscopical examination of antimonial alloys for axle boxes." By Prof. H. BEHRENS also in the name of Mr. H. BAUCKE.

By the direction of the „Holl. IJz. Spoorweg-Mij" several cushions of Babbits-metal (82 % Sn, 9 % Sb, 9 % Cu) were put aside for chemical and microscopical examination. Alloys of this kind, when slowly cooling from a melting heat, will split up into a nearly amorphous mother liquor, rich in tin, into rectangular crystals (probably cuboïdal rhombohedrons) of an alloy of tin and antimony and into a whitish bronze, forming radial clusters of brittle rods, composed of hexagonal plates.

The chemical examination of these components has been carried out by Mr. BAUCKE, analytical chemist at Amsterdam, partly by means of analytical, partly by means of synthetical methods, while I have undertaken the microscopical and mechanical investigation of the properties of Babbits metal.

For separating the products of liquation I proposed pressing of the alloys in a semi-liquid state. This suggestion has been adopted by Mr. BAUCKE and the method, worked out and perfected by him, has given very good results. When Babbits metal in a pasty condition is pressed between hot slabs of iron, *tin* will flow out, containing 3 % of antimony and copper and a hard, brittle cake will be left, formed principally by the crystals described above. An alloy composed of 90 % tin and 10 % *copper* gave a hard residue, from which a remnant of mother liquor was removed by treating it with hydrochloric acid and subsequently with caustic soda ley. Powdery copper was washed away in a stream of water, and then analysis gave 35.1 % Cu, 64.8 % Sn for the composition of the cristalline alloy, while the formula Cu Sn would require 34.9 % Cu and 65.1 Sn. Repeated heating and pressing will drive out more tin, so that this alloy may be said to comport itself in a similar manner as some hydrated salts, e. g. crystallized sulfate of sodium.

In alloys with *antimony* the tin was found to be more strongly combined. From an alloy, containing 10 % of antimony, after heating and pressing thrice, a residue was obtained, resembling closely an alloy of 70 % tin and 30 % antimony. Purified by extraction with hydrochloric acid and washing in a stream of water it was found to be composed of 33.7 % Sb and 66.3 % Sn. Calculation from the formula $Sb\,Sn_2$ gave 33.8 % Sb, 66.2 % Sn. With 42 % Sb an alloy was obtained, showing prismatic crystals of higher melting point between the cuboïd ones of the compound $Sb\,Sn_2$. By hot pressing and treatment with hydrochloric acid an alloy was isolated, answering to the formula Sb Sn. Found: Sb 50.55, Sn 49.65 %; calculated: Sb 50.37, Sn 49.63 %. In alloys, containing 80 % of antimony, this element can be made to crystallize in a nearly pure state. Its crystals are enveloped by a compound of prismatic form, probably answering to the formula $Sb_2\,Sn$. This point has hitherto not been settled in a satisfactory manner.

Microscopical examination of cushions, that had done duty under railway cars led speedily to the conviction, that their behaviour depends on the frequency and size of rectangular crystals. In cushions, marked as having been unduly heated by running, the rectangular crystals of the compound $Sb\,Sn_2$ were found poorly developed or absent. By mechanical engineers I was told, that the alloy for bearings must not be heated further than necessary for giving it sufficient fluidity, then stirred and cast without delay in moulds heated to the boiling point of water.

In Babbits metal, heated till its surface becomes smooth and bright the majority of the crystals is not liquified. Castings, made of such metal, without previous stirring, consist of tin, with about 4 % of copper and antimony, while at the bottom of the melting pot a hard porous mass is found, melting at the same temperature with zinc. Made quite liquid, and then chilled, Babbits metal becomes nearly amorphous, sonorous and very smooth when filed or turned. Nevertheless it will stick to an axle, even when liberally lubricated, and when heated to softening it is liable to recrystallization, crystals being formed in a groundmass of liquid tin. Tinning of the axle, sticking, and as an inevitable consequence heating will occur, whenever a heavily weighted axle is run in a box filled with such metal. Finally recrystallization sets in and liquid tin is squeezed out, the newly formed crystals accumulating around the axle. In one case the crystals had formed a compact cylindrical layer, at first sight puzzling, but now easily explained.

With a view to test this theory, experiments were made with model cushion blocks, cast under varied conditions. The blocks were fitted on a mandril of polished steel, running with a speed of 1600 revolutions per minute in a wooden casing. The apparatus was contrived in such a manner, that the pressure on the mandril could be varied at pleasure and the temperature observed on a thermometer fitted into the blocks. The following table gives for some of the experiments the pressures reduced to kilogrammes on the square centim. of the longitudinal section of the mandril and the mean increase of the temperature after a minute of running. Block I was cast in a mould, cooled by running water, block II in a mould heated to 100°, block III in a mould heated in molten zinc.

	0.3 kg.	0.6 kg.	1.2 kg.	3.0 kg.
I	0.50	1.12	1,50	3.80
II	0.64	0.74	0.75	1.64
III	0.65	0.72	2.62	4.64

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After the series of experiments with a charge of 3 kgr. block I presented a running surface scarred by irregular grooves and scratches. On block II the rectangular crystals stood out in a relief, similar to that, produced by etching with hydrochloric acid. They were smooth and bright, the interstices deadened by small scars or dimples. On block III the particulars shown by I and II were found combined.

An unexpected result was obtained by examining the metallic sediment from the oil that had been used as lubricant. Mixed with fine dust (essentially tin) were found: in sediment from block I shavings, threads and angular fragments; in sediment from block II spherical and egglike bodies (0.08—0.1 mm.), looking like small drops of mercury; in sediment from block III spheroids and angular fragments. A few of the spheroids from block II were subjected to microchemical tests and found to consist of tin with a considerable admixture of antimony.

These observations suffice to explain the slow increase of temperature in block II: the oil has been more evenly spread, owing to the peculiar relief, developed on the running-surface of this block, and at the same time a *ball cushion* has been formed, whereby rolling has been brought in the place of sliding friction. Spheroids, similar to those of block II were formed in experiments with model bearings of magnolia metal (77.8 % Pb, 16.3 % Sb, 5.9 % Sn) and of aluminium brass, but not with bearings of common brass and of grey cast iron. In this way I have been able to trace their origin to cubical or polyhedric crystals, scattered in a softer metal and accompanied by smaller crystals of a hard and brittle alloy. In Babbits metal fragments of the brittle rods of bronze act as a grinding powder, undermining and rounding the rectangular crystals of the compound $Sb\,Sn_2$, in the same way, as pebbles are formed in the bed of a river. The tin comes in as a soft cement, possibly its powder has also a favourable influence, augmenting the viscosity of the lubricant. Metal of coarse structure (cast in overheated moulds) is not evenly eroded; the majority of the rectangular crystals, weakened by cracks, are scarred and crushed, instead of being rounded and loosened.

Further reasoning would be misplaced, as it may be expected, that continued experiments and observations in the directions, pointed out above, will speedily throw more light on the subject.