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Title Investigation of Zinc Distillation in Yellow Brass

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C O N F I D E N T I A L

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INVESTIGATION OF ZINC DISTILLATION IN YELLOW BRASS

INTRODUCTION

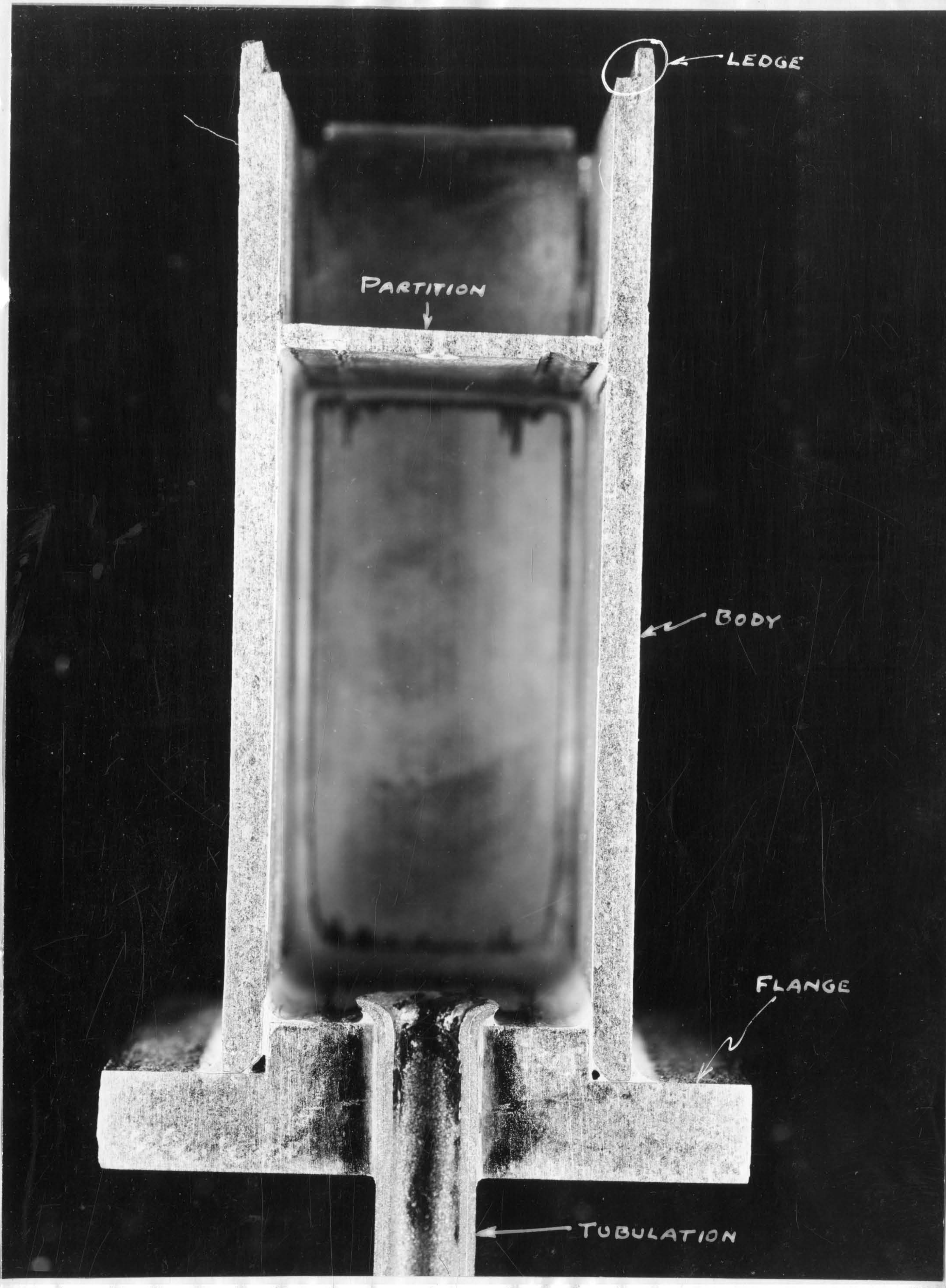
This investigation originally started as a brazing problem. The problem was to find a method of brazing yellow brass gap tubes (GL-1B35 and GL-1B37) in a hydrogen atmosphere furnace using a suitable hard solder.

The specification called for copper-silver eutectic brazing alloy, General Electric Specification B20F3. However, a few other silver alloys were tried and the furnace temperatures in this investigation ranged from 725°C to 900°C. These higher temperatures brought out one other eccentricity of yellow brass; namely, zinc distillation.

At this point, it might be well to define or describe zinc distillation as covered in this report. Zinc distillation is a phenomenon in which the zinc actually passes off as a vapor leaving tiny cracks or a porous condition, and resulting in a decrease of the zinc content of the yellow brass.

As the time necessary for this investigation was short, and due to the fact that only one application was covered, the data will only serve as an indication of what may be expected on other types of parts made of yellow brass and subjected to the above mentioned range of temperatures.

Any reference to gap tubes in this report will mean either the GL-1B35 or the GL-1B37. The macrophotograph which follows shows a cross-section of one of these tubes.


LEDGE
PARTITION
BODY
FLANGE
TUBULATION

SUMMARY

1. The distillation of zinc from yellow brass proceeds more rapidly from the point having the higher temperature and gradually decreases toward the cooler sections. On the surface of the brass the zinc distills from the alpha solid solution. The inner portions of the brass show the zinc distilling from the alpha solid solution and forming between the grains.

2. The smaller or thinner sections of the gap tubes exhibit a greater percentage of porosity and penetration from which the zinc has distilled. (See photomicrograph, figure #2)

3. The porosity and depth of penetration of zinc distillation increases as the heating time increases.

4. The higher the furnace temperature employed, the faster the zinc distills from the brass and the more critical the time necessary for good brazing. (See graph) Zinc distillation was in evidence at temperatures ranging from 725°C to 900°C. From the vapor pressure-temperature curve of pure zinc it would seem that small amounts of zinc would distill from the brass at temperatures under 725°C. (See zinc vapor pressure-temperature curve, page 9)

5. It is a fact that impurities such as bismuth or lead in the neighborhood of from 0.01% to 0.001% in copper alloys will form low melting eutectics and these form along the grain boundaries. Microscopic examination shows some alloy forming along the grain boundaries within the brass. (See photomicrograph, figure #4)

6. The distillation of zinc from the brass effects brazing or soft soldering in that it leaves voids or cracks through which the solder will run more readily. This makes a subsequent soldering or brazing job very critical with respect to time and temperature. The work can very easily be ruined by the solder actually breaking up the base metal into a network of isolated particles surrounded by solder. (See photomicrograph, figure #3)

EQUIPMENT and MATERIALS

A large conveyor type hydrogen atmosphere furnace was used in Building #8 for brazing a few tubes. Most of the brazing was done in a 4 inch "D" shaped hydrogen atmosphere, muffle type furnace located in the Development Shop of the Schenectady Tube Works.

The boats consisted of either a carbon block 5 3/4" long x 1 5/8" wide x 2" deep weighing about one pound with room for five tubes, or a small steel fixture weighing about three-quarters of a pound with room for two tubes.

GL-1B35 and GL-1B37 tubes whose parts have compositions as follows:

Body - 65% - 70% copper
35% - 30% zinc
small amount of lead (approximately 0.8% max.)

Partition - Same as body

Tubulation - Bundy tubing (B30E23)

Hard Solder Rings - B20F3

Flange - 80% copper
20% zinc

PROCEDURE

The gap tubes have three joints which have to be brazed. The partition is brazed to the body, the body to the flange, and the tubulation to the flange. The ledge referred to in the data is the top part of the body and is 0.025" thick and 0.040" deep according to N-24501MC.

The tubes were assembled by swedging the partition to the body and then putting a hard solder ring on top of the partition, a hard solder ring under the flange of the tubulation, and one on top of the flange base. The assembled tubes were then put on the boats and brazed in the furnace.

DATA AND GENERAL INFORMATION

The following table shows the depth to which zinc distillation will penetrate and the brazing temperatures and times used.

MICROSCOPIC EXAMINATION OF THE PENETRATION OF ZINC DISTILLATION OF YELLOW BRASS WHEN BRAZED AT TEMPERATURES BETWEEN 725°C and 900°C

Tube No.	Type of Furnace Used	Temp. of Furn. (°C)	Total Time in Furn. (Min.)	Microscopic Examination of Zinc Distillation: Average Depth of Penetration (Inches)	Maximum Depth of Penetration (Inches)	Part Of Tube Measured	Remarks
1	4" D-shape Dev. Shop	900	10	All the ledge	Way thru (.025")	Ledge part of body	* Zinc distillation penetrated into lower part of body to an average depth of .0049" and a maximum depth of .0071". (Carbon fixture was used as a boat.)
2	4" D-shape Dev. Shop	900	7 1/2	.0030	.0051	Ledge part of body	* (1) This was a good braze. Looked as though it had been in the furnace a trifle long. (Low carbon steel fixture used as a boat.)
3	4" D-shape Dev. Shop	900	7	.0016	.0021	Ledge part of body	* This is the standard time and temperature as used by the Development Shop. However, time is increased in some cases to 7 1/2 minutes or slightly longer if not thoroughly brazed in 7 minutes. (Carbon fixture was used as a boat.)
4	Large Cont. furnace Bldg.#8	825	17 1/4	.0057	.0090	Ledge part of body	* Lower part of body showed average penetration of .0039". (Carbon fixture was used as a boat.)
5	4" D-shape Dev. Shop	825	13	.0034	.0046	Ledge part of body	* Showed a good braze. The solder had alloyed with the brass a little too much. (Carbon fixture used as a boat.)
6	4" D-shape Dev. Shop	825	10	.0024	.0034	Ledge part of body	* Average depth of penetration of lower part of body was .0020". (Carbon fixture was used as a boat.)
7	4" D-shape Dev. Shop	825	9	.0026	.0042	Ledge part of body	* This tube was copper flashed before firing. Looked as though zinc distillation penetrated deeper with the copper flash then without it. (Carbon fixture was used as a boat.)
8	4" D-shape Dev. Shop	825	9	.0017	.0025	Ledge part of body	* This tube was not thoroughly brazed. (Low carbon steel fixture used as a boat.)
9	4" D-shape Dev. Shop	725	8	.0008	.0017	Ledge part of body	# Sil-Fos was used as a hard solder. The tube did not braze thoroughly. Parts which did braze showed the braze as lumpy and did not alloy with all parts in which it was in contact. (Carbon fixture was used as a boat.)

<u>Notations referring to preceding Table:</u>

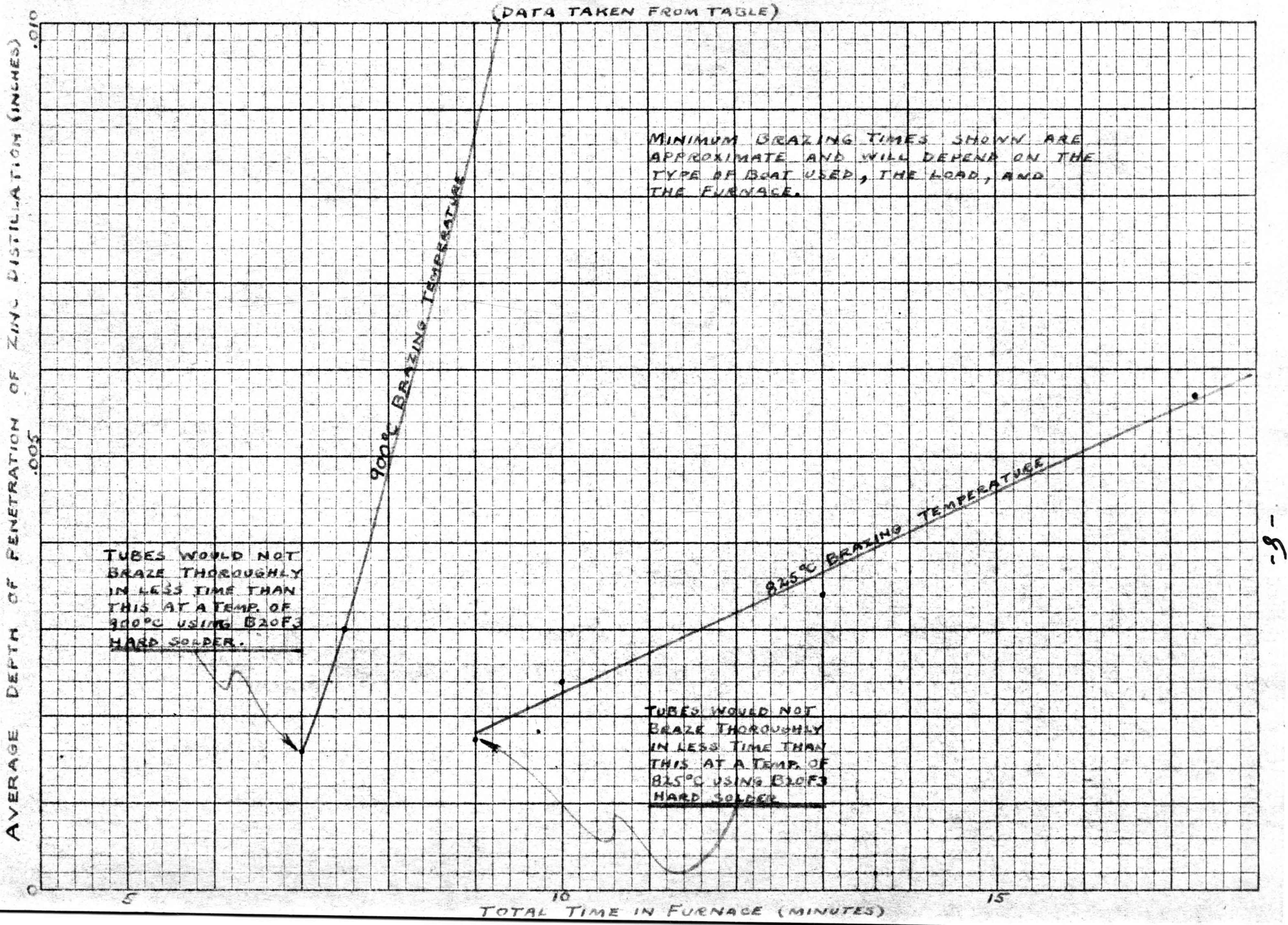
* Copper-Silver Eutectic brazing alloy was used (G.E. Mat'l. Spec. B20F3)

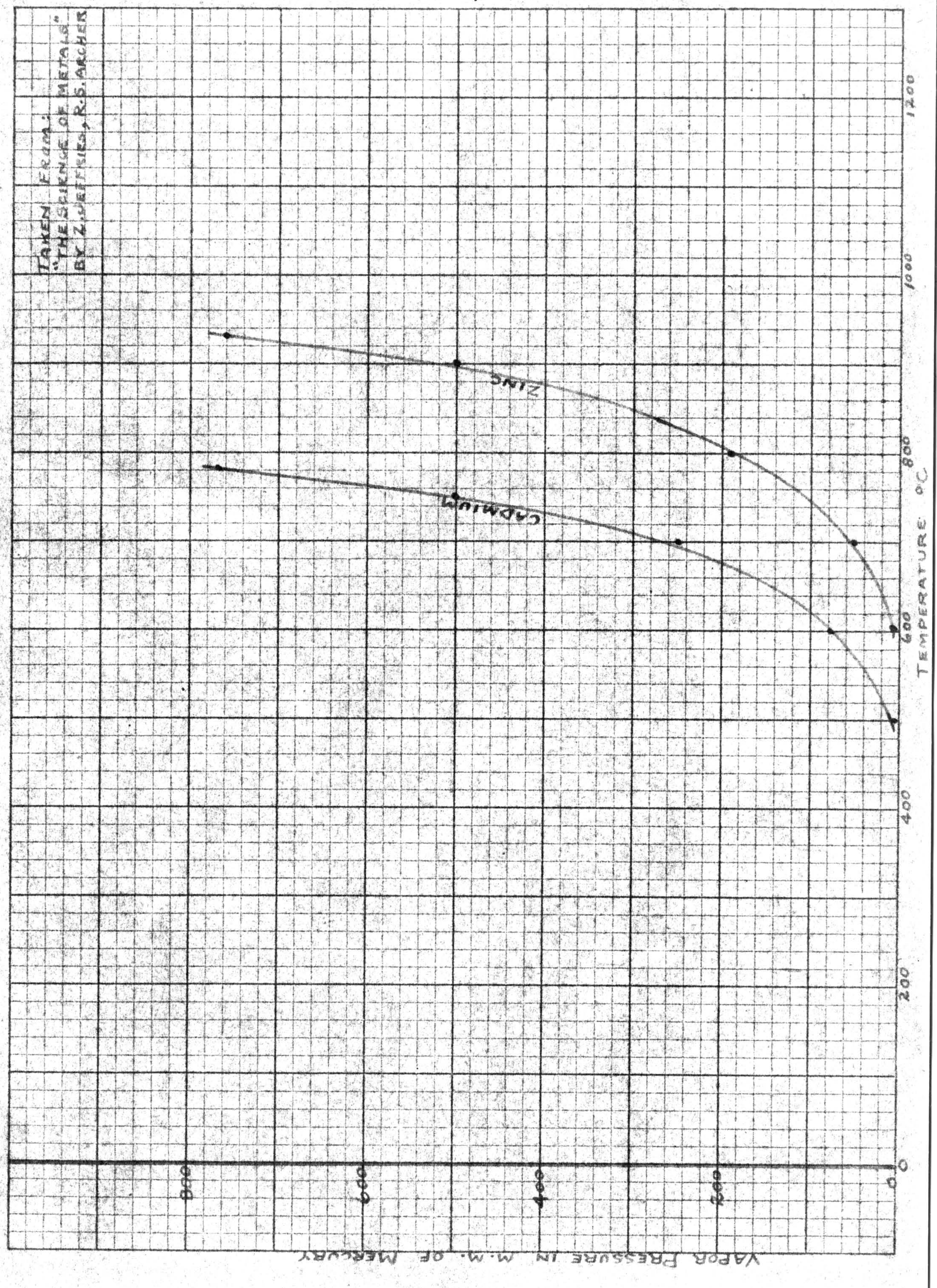
Sil-Fos brazing alloy was used. (G.E. Mat'l. Spec. B20A6)

(1) This showed the body as a trifle bowed. The partition is put in the body and exerts a pressure on the body. When the tube is brazed for approximately 7 1/2 minutes or longer the body begins to bow. The Development Shop recognizes this point and throws out all tubes which exhibit this bowing effect.

PENETRATION OF ZINC DISTILLATION IN YELLOW BRASS

(DATA TAKEN FROM TABLE)



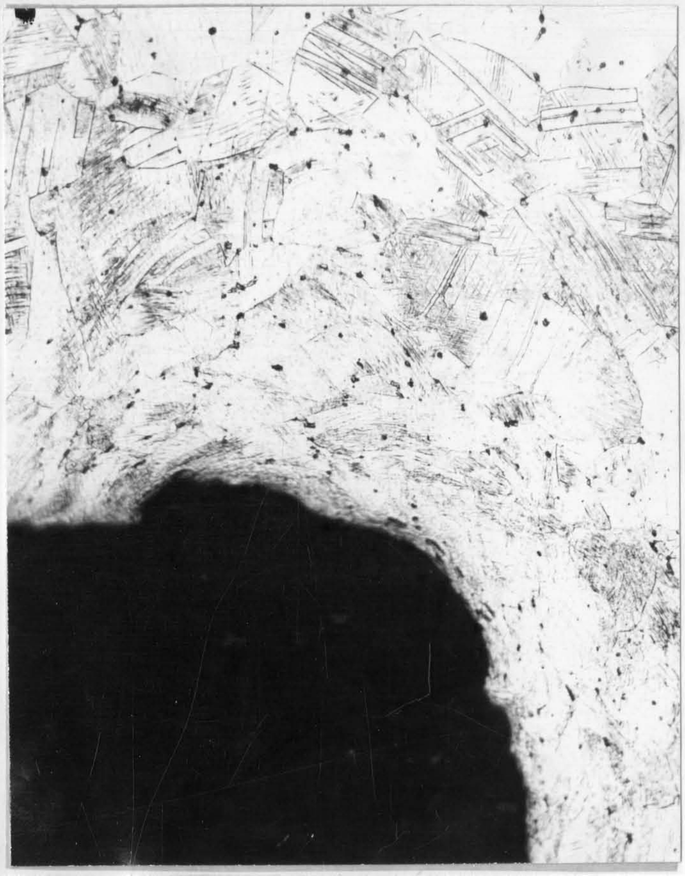

TAKEN FROM:
"THE SCIENCE OF METALS"
BY Z. JEFFRIES, R.S. ARCHER
ZINC
CADMIUM
TEMPERATURE °C
0
200
400
600
800
1000
1200
VAPOR PRESSURE IN M.M. OF MERCURY
0
200
400
600
800

All the tubes mentioned in the table were mounted, polished, etched and viewed at 210 magnification. All measurements were made microscopically with the use of a filar eyepiece. All measurements were taken at the ledge part of the tube as this was the thinnest section of the tube and showed the greatest amount of zinc distillation. It may be mentioned at this point, that the flange having a composition approaching that of red brass and being made of heavier material than the rest of the tube, did not exhibit the phenomenon of zinc distillation to any noticeable extent. This is also shown by the photomicrograph, figure #6.

It must be noted that brazing times and depth of penetration of zinc distillation will vary according to the type furnace used, the total load in the furnace, and the structure of yellow brass material being brazed. This data, therefore, will only serve as an indication of what may be expected on other types of parts made of yellow brass which have to be subjected to temperatures between 725°C and 900°C in a hydrogen atmosphere furnace.

As can be seen from the table and the graph, the time in the furnace becomes more critical as the brass approaches its melting point. From the constitutional diagram, yellow brass of this composition will become mushy at about 905°C. It was also noted that greater distortion seemed to take place the higher the brazing temperature.

PHOTOMICROGRAPHS



250X

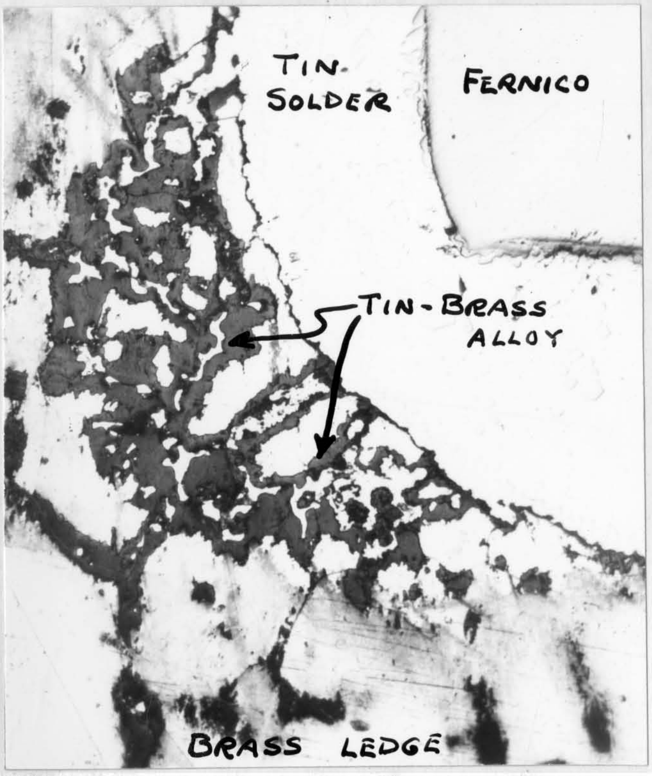
FIGURE #1

This shows a cross-section of a gap tube taken at the corner of the ledge in the "as received" condition. Note that the black dots are lead inclusions. The grain structure shows fine strain lines which indicate that the material has been cold worked (machining and drawing) rather heavily.

100X

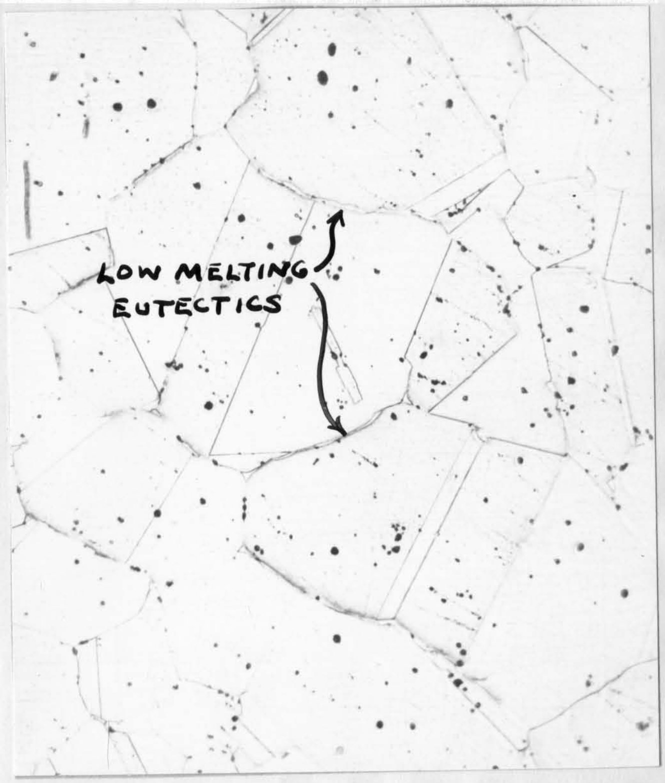
FIGURE #2

This photomicrograph is a cross-section of the ledge portion of the body. This tube had been brazed in a hydrogen atmosphere for 17 1/4 minutes at 825°C. You will note that the zinc has distilled from the outer surface of the brass leaving large cracks which follow the grain boundaries. At some points, low melting eutectics and pure zinc have formed between the grains and can easily be seen in the picture. Also note that the depth of cracks resulting from zinc distillation gradually decreased as it approached the heavier portion of the body.



250X

FIGURE #3



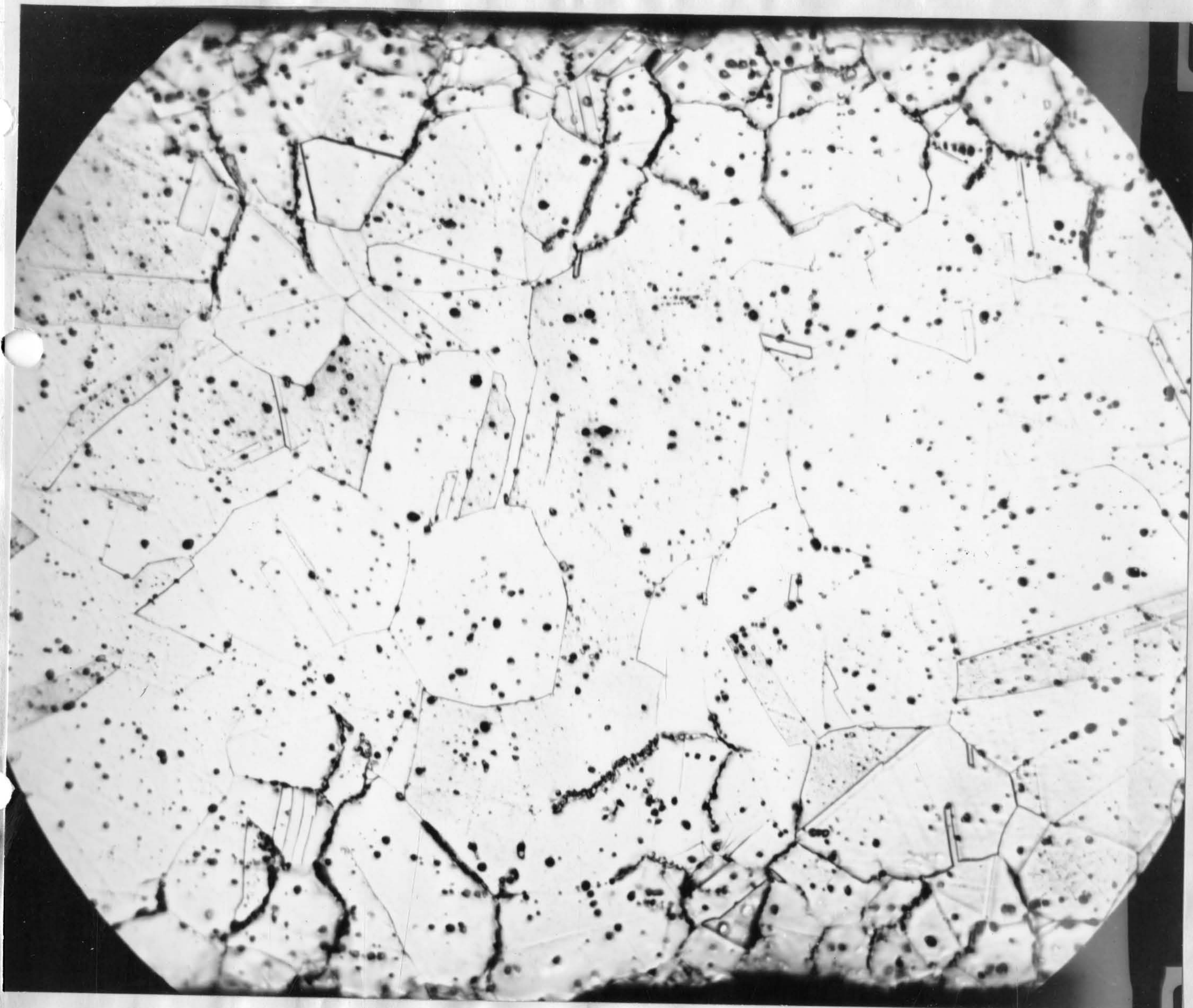
250X

FIGURE #4

Figure #3 and #4 are photomicrographs of cross-sections of the same tube. This gap tube was picked at random from a number of completed tubes. After brazing, a fernico window frame and window are soldered onto the ledge part of the body. The solder used was pure tin. The whole body is then silver plated.

Figure #3 is a cross-section of the ledge which shows a corner of the fernico window frame soldered to the ledge. The tin solder has run through the voids, which were caused by zinc distillation in brazing, and has alloyed with the brass. You will note isolated particles of the brass base which are surrounded by tin and tin-brass alloy. In some cases the alloying almost went across the full width of the body, thereby weakening the body at these points.

Figure #4 is a section showing the grain structure in the center portion of the body. From the structure it is probable that this tube was in the furnace slightly longer than the prescribed time at 900°C, as the grain broundaries show evidence of zinc and low melting eutectics froming. It is also probable that the zinc distilling from the brass condenses between the grains as the tube is shoved into the cooler of the furnace.



250X

FIGURE #5

This is a photomicrograph of the cross-section of the center portion of the body which was brazed in the Development Shop of the Schenectady Tube Works. The brazing was done in a 4 inch "D" shaped hydrogen atmosphere furnace at 900°C for a total time of ten minutes. Again cracks are in evidence proceeding toward the center of the body from the surface. At other portions of the body as viewed microscopically it was noted that zinc distillation had proceeded through the total width of the body. The black dots denote lead.

50X

FIGURE #6

This shows a cross-section of the body brazed to the flange using B20F3 brazing alloy. This tube was in the furnace a little longer than necessary in order to give a more noticeable comparison of the effects of a silver braze on two types of brass. Note that in the upper left-hand section of the body that cracks are in evidence at the surface. At the braze portion of the body the silver alloy has flowed into the cracks and alloyed to a much greater extent than with the flange part of the tube. We are reminded that the body is a true yellow brass with a small addition of lead and the flange is 80% copper, 20% zinc which is closer to a true red brass.