1910

The losses of gold during cupellation using various makes of cupels

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Department: Mining and Nuclear Engineering

THESIS

for the Degree of

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1910.

THE LOSSES OF GOLD DURING CUPELLATION USING VARIOUS MAKES OF CUPELS.

BY

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There are on the market various cupels. Many of the assay-supply firms sell a "manufactured" cupel, presumably made of bone-ash. The great majority of all cupels used, are made of bone-ash in the assay office itself.

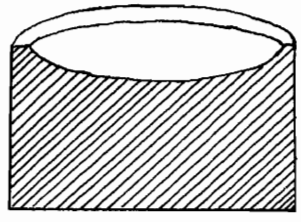
The object of this work is to compare the losses of gold when the various patented, the various manufactured and the ordinary hand made cupels are used.

Four different makes of cupels were used.

No.1. A manufactured bone-ash cupel made by the Denver Fireclay Co.

Diameter-1½"

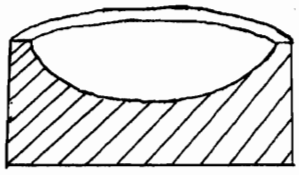
Weight-42 grm.



No.2. A manufactured bone-ash cupel from the Henry Heil Chemical Co.

Diameter-1½"

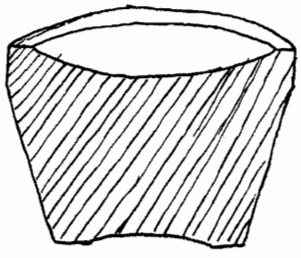
Weight-30 grm.



No.3. A patented Morganite cupel.

Diameter-1½"

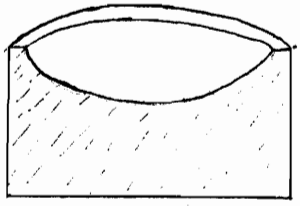
Weight-52 grm.



No.4. A hand made bone-ash cupel, air dried for five months before using.

Diameter 1 1/4"--

Weight 45 grm.



Cupels No.3. had the greatest hardness, and No.2.,No.1., and No.4. follow in the order given, as to hardness.

THE PURE GOLD.

Gold already nearly pure was inquarted with four times the weight of silver. The resulting button was then parted with HNO_3($2H_2O$ to 1 HNO_3). The gold, after annealing, was sponge like, and could easily be broken up for weighing.

The amount of gold used in each cupelation was between 19 and 20 mgs. Each gold sample was weighed to the nearest 1/100 mgm., and the gold was considered pure.

THE LEAD USED.

Three hundred grams of the sheet lead were scorified to about 10 grams and cupeled. No gold or silver resulted from this test. The lead was therefore used as silver-gold free.

All cupelations were made in a coal fired muffle furnace with ordinary draft.

The cupels were put into the muffle and heated from five to ten minutes, four rows of five each being cupeled at the same time in each muffle. Temperatures were taken after the buttons had started to drive and after they had blicked, giving the average temperature of the muffle during the process of cupelation. The temperatures were taken about 1/4" above the top of the cupels. A Platinum Platinum - Rhodium thermo junction being used for this purpose.

The time of cupelation in nearly every case was between 16 and 20 minutes from the time of the start of driving, to the time of blicking.

All beads in the bone-ash cupel after blicking were spherical on a very small axis, and appeared to be much brighter than those in the patented cupels. The beads in the latter cupels seemed to flatten out somewhat, after blicking, and in some instances they seemed to show some indications of a sprouting action but appeared to have been depressed to some extent.

The accompanying tables give the results obtained by the tests performed. The curves show the average loss at each temperature. The average losses with each succeeding temperature is found in Table No.1.

TABLE NO.1.

Temp.	No.1.	No.2.	No.3.	No.4.
720°C	-----	-----	0.15%	0.35%
730°C	6.43%	-----	0.16%	-----
740°C	-----	-----	0.28%	-----
745°C	-----	-----	-----	0.40%
750°C	0.51%	-----	0.32%	-----
760°C	0.73%	0.35%	0.23%	0.36%
770°C	-----	0.45%	0.56%	-----
780°C	0.72%	0.68%	0.32%	0.48%
790°C	-----	0.61%	0.63%	0.70%
800°C	1.91%	0.85%	1.64%	1.35%

CONCLUSIONS.

A comparison of the curves plotted show, that while a loss in the patented is very low, it is also very eratic, giving a small loss at one temperature, and a much greater loss at another temperature.

The loss in the manufactured bone-ash cupels is greater than the loss in the patented cupels and is also very irregular, but follow a more consistent curve, due to increase in temperature, than the patented cupels.

Cupel No.4., which is the hand made bone-ash cupel, shows a much more even loss, due to varying temperatures, also a loss which is lower than the manufactured cupels, and very little higher than the patented cupel.

From the fore-going, it appears, that while the Morganite Cupel gives a slightly smaller loss than the hand made bone-ash cupel, the results are more eratic, and that for practical work the hand cupel is the preferable.

(1)

THESIS-RESULTS

ON

THE-RELATIVE-LOSSES-OF-GOLD-IN-DIFFERENT-KINDS-OF-CUPELS

No	Wt. Au	Wt. button	Loss	% Loss	Temp.	Time
1	19.82	19.42	.40	2.01	740°	20 min
2	19.51	19.44	.13	.66	780	"
3	19.37	19.10	.34	1.70	800	"
4	19.80	19.60	.20	1.01	790	"
5	19.83	19.42	.41	2.06	850	"
6	19.44	19.39	.05	.25	730	"
7	19.38	19.00	.38	1.90	800	"
8	19.29	19.20	.09	.45	790	"
9	19.48	19.21	.27	1.35	830	"
10	19.68	19.50	.18	.91	780	"
11	19.24	19.00	.24	1.20	800	"
12	19.775	19.66	.115	.60	790	"
13	19.91	19.64	.27	1.30	830	"
14	19.52	19.39	.13	.66	730	"
15	19.33	19.00	.33	1.75	800	"
16	19.76	19.69	.07	.40	790	"
17	19.815	19.68	.135	.68	830	"
18	19.52	19.395	.125	.64	780	"
19	19.47	19.445	.025	.13	760	"
20	19.52	19.36	.16	.80	790	"
21	19.80	19.40	.40	2.10	830	"
22	19.91	19.82	.09	.45	860	"
23	19.335	19.305	.03	.18	760	"
24	19.66	19.50	.16	.80	790	"
25	19.60	19.525	.075	.38	760	"
26	19.92	19.82	.10	.50	760	"
27	19.500	19.450	.050	.25	760	"
28	19.36	19.20	.16	.80	790	"
29	19.90	19.82	[illegible]	.40	760	"
30	19.60	19.56	.04	.25	760	"
31	19.78	19.73	.05	.25	760	"
32	19.64	19.50	.14	.70	790	"
33	[illegible]	[illegible]	[illegible]	[illegible]	760	"
34	19.26	19.22	.04	.21	760	"
35	19.40	19.355	.045	.25	760	"
36	19.30	19.14	.16	.80	790	"
37	19.44	19.40	.04	.20	760	"
38	19.75	19.655	.095	.48	760	"
39	19.52	19.46	.06	.309	760	"
40	19.70	19.64	.06	.30	790	"
41	19.48	19.38	.10	.50	760	"
42	19.647	19.59	.057	.29	760	"
43	19.745	19.730	.015	.075	720	"
44	19.62	19.595	.025	.13	790	"
45	19.52	19.49	.03	.15	760	"
46	19.82	19.75	.07	.35	760	"
47	19.00	19.98	.02	.105	720	"
48	19.68	19.59	.09	.40	790	"
49	19.60	19.56	.04	.20	760	"
50	19.60	19.38	.22	1.10	800	"
51	19.69	19.585	.105	.53	720	"
52	19.495	19.355	.14	.70	790	"
53	[illegible]	[illegible]	[illegible]	.29	760	"
54	19.30	19.27	.03	.15	790	"
55	19.76	19.72	.04	.202	720	"
56	19.50	19.38	.12	.60	790	"
57	[illegible]	19.40	.06	.30	750	"
58	19.10	19.06	.04	.205	760	"
59	19.91	19.81	.10	.502	790	"
60	19.600	19.46	.14	.70	790	"
61	19.86	19.76	.10	.50	750°	15 min
62	19.41	19.384	.026	.13	760	"
63	19.589	19.44	.146	.74	740	"
64	19.51	19.49	.02	.10	760	"
65	19.78	19.69	.09	.45	750	"
66	19.20	19.16	.04	.208	760	"
67	19.58	19.56	.02	.103	740	"
68	19.40	19.35	.05	.35	760	"
69	19.415	19.29	.125	.64	760	"
70	19.84	19.60	.24	1.20	790	"
71	19.40	19.372	.028	.14	740	"
72	19.32	19.29	.03	.15	760	"
73	19.96	19.90	.06	.30	790	"
74	19.72	19.57	.15	.76	740	"
75	19.455	19.41	.045	.24	740	"
76	19.33	19.28	.05	.25	760	"
77	19.815	19.69	.125	.62	790	"
78	19.386	19.265	.117	.58	740	"
79	19.36	19.315	.055	.27	740	"
80	19.44	19.38	.06	.30	760	"
81	19.82	19.71	.11	.55	720	"
82	19.63	19.61	.02	.10	790	"
83	19.41	19.365	.045	.23	740	"
84	19.44	19.36	.08	.40	760	"
85	19.71	19.55	.16	.81	720	"
86	19.75	19.69	.06	.30	720	"
87	19.59	19.449	.041	.20	740	"
88	19.38	19.16	.22	1.04	800	"
89	19.74	19.62	.12	.60	720	"
90	19.30	19.24	.06	.30	740	"
91	19.708	19.65	.058	.29	740	"
92	19.57	19.47	.10	.50	760	"
93	19.42	19.25	.17	.85	720	"
94	19.64	19.56	.08	.40	770	"
95	19.48	[illegible]	[illegible]	.25	[illegible]	"
96	[illegible]	19.01	.11	.55	800	"
97	19.84	19.57	.27	1.36	730	"
98	19.44	19.30	.14	.72	770	"
99	[illegible]	[illegible]	.06	.31	740	"
100	19.16	19.10	.06	.30	760	"
101	19.75	19.64	.11	.55	750	"
102	[illegible]	[illegible]	.06	.30	770	"
103	19.255	19.22	.035	.18	740	"
104	19.82	19.66	.16	.80	790	"
105	19.72	19.66	.06	.301	720	"
106	19.75	19.70	.05	.25	720	"
107	19.09	19.04	.05	.25	740	"
108	19.57	19.40	.17	.87	770	"
109	19.818	19.72	.098	.49	750	"
110	19.69	19.62	.07	.35	750	"
111	19.56	19.54	.02	.10	740	"
112	19.16	19.04	.12	.60	790	"
113	19.45	19.40	.05	.25	720	"
114	19.206	19.095	.111	.57	770	"
115	19.35	19.32	.03	.15	740	"
116	19.62	19.50	.12	.60	790	"
117	19.92	19.58	.34	1.72	750	"
118	19.56	19.37	.19	.97	800	"
119	20.00	19.96	.04	.20	740	"
120	19.55	19.45	.10	.50	790	"
121	[illegible]	19.24	.026	.11	730°	16 to 20
122	19.39	19.23	.16	.806	800	"
123	19.30	19.18	.12	[illegible]	730	"
124	19.21	19.12	.09	.45	790	"
125	19.44	19.35	.09	.45	730	"
126	19.43	19.30	.13	.66	800	"
127	19.52	19.46	.06	.307	750	"
128	[illegible]	19.31	.05	.25	790	"
129	19.69	19.33	.36	1.83	800°	"
130	19.56	19.42	.14	.71	800	"
131	19.738	19.71	.028	.14	730	"
132	19.64	19.52	.12	.60	790	"
133	19.66	19.32	.34	1.73	800	"
134	19.59	19.52	.07	.35	760	"
135	19.24	19.21	.03	.15	730	"
136	19.71	19.645	.065	.33	750	"
137	19.865	19.65	.215	1.09	800	"
138	19.84	19.75	.09	.45	760	"
139	19.29	19.27	.02	.12	730	"
140	19.96	19.39	.07	.40	790	"
141	19.40	19.21	.34	1.80	800	"
142	19.81	19.72	.08	.404	760	"
143	19.54	19.326	.024	.16	730	"
144	[illegible]	19.50	.10	.50	790	"
145	19.37	19.00	.37	1.92	800	"
146	19.74	19.63	.06	.31	760	"
147	19.34	19.31	.03	.15	730	"
148	19.36	19.32	.13	.70	790	"
149	19.71	19.60	.31	1.55	800	"
150	19.72	19.62	.10	.50	760	"
151	19.38	19.31	.07	.35	730	"
152	[illegible]	[illegible]	.05	.25	790	"
153	19.57	19.32	.25	1.20	800	"
154	19.15	19.055	.095	.49	760	"
155	19.29	19.25	.04	.20	720	"
156	19.58	19.54	.04	.20	745	"
157	19.91	19.68	.23	1.20	800	"
158	19.22	19.16	.06	.31	760	"
159	19.36	19.335	.025	.11	720	"
160	19.75	19.70	.05	.25	745	"
161	19.62	19.46	.16	.55	740°	"
162	19.53	19.27	.06	.30	720	"
163	19.72	19.70	.02	.10	720	"
164	19.54	19.525	.015	.075	745	"
165	19.24	19.21	.03	.43	730	"
166	19.96	19.90	.06	.30	760	"
167	20.02	19.995	.025	.12	720	"
168	19.30	19.22	.08	.41	745	"
169	19.60	19.46	.14	.71	790	"
170	[illegible]	[illegible]	.08	.41	745	"
171	19.98	19.954	.026	.13	720	"
172	19.54	19.47	.07	.35	745	"
173	19.44	19.26	.18	.91	760	"
174	19.74	19.635	.105	.53	760	"
175	19.90	19.872	.028	.13	720	"
176	19.295	19.24	.055	.27	745	"
177	19.52	19.41	.09	.45	760	"
178	19.76	19.69	.06	.33	760	"
179	[illegible]	19.17	.05	.21	720	"
180	19.90	19.85	.05	.25	745	"

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No	Wt Au	Wt button	Loss	% Loss	Temp	Time Min
181	19.16	19.09	.07	.38	760	18½ Min
182	19.29	19.22	.07	.45	790	"
183	19.17	19.15	.02	.10	760	"
184	19.21	19.19	.02	.10	745	"
185	19.39	19.23	.16	.82	730	"
186	19.12	19.07	.05	.26	790	"
187	19.896	19.84	.056	.28	760	"
188	19.19	19.14	.05	.26	745	"
189	19.61	19.45	.16	.81	760	"
190	19.60	19.495	.105	.54	790	"
191	19.969	19.88	.089	.45	750	"
192	19.36	19.31	.05	.25	745	"
193	19.665	19.525	.14	.72	760	"
194	19.625	19.53	.095	.48	790	"
195	19.79	19.75	.04	.21	750	"
196	19.36	19.25	.11	.56	745	"
197	19.57	19.42	.15	.77	760	"
198	19.92	19.86	.06	.301	790	"
199	19.939	19.77	.48	.25	750	"
200	19.60	19.08	.52	★2.60	775	"
201	19.60	19.46	.14	.72	760	"
202	19.79	19.64	.12	.61	790	"
203	19.94	19.92	.02	.11	760	"
204	19.73	19.42	.31	1.60	745	"
205	19.76	19.60	.16	.81	760	"
206	19.26	19.14	.12	.61	790	"
207	19.31	19.27	.04	.21	760	"
208	19.84	19.73	.11	.57	760	"
209	19.413	19.37	.043	.21	760	"
210	19.10	19.04	.06	.31	790	"
211	19.31	19.26	.05	.26	760	"
212	19.61	19.54	.07	.35	750	"
213	19.62	19.53	.09	.45	760	"
214	19.68	19.61	.07	.35	790	"
215	19.826	19.80	.026	.13	760	"
216	19.48	19.41	.07	.35	790	"
217	19.27	19.18	.09	.47	760	"
218	19.56	19.42	.14	.71	790	"
219	19.90	19.81	.09	.46	760	"
220	19.80	19.66	.14	.74	790	"
221	19.38	19.24	.14	.73	760	"
222	19.568	19.41	.158	.80	790	"
223	19.72	19.64	.08	.42	760	"
224	19.31	19.22	.09	.50	790	"
225	19.75	19.71	.04	.21	760	"
226	19.882	19.76	.122	.62	790	"
227	19.46	19.43	.03	.16	790	"
228	19.71	19.60	.11	.60	790	"
229	19.59	19.54	.05	.27	760	"
230	19.96	19.90	.06	.30	790	"
231	19.69	19.62	.07	.36	750	"
232	19.56	19.40	.16	.82	790	"
233	19.655	19.61	.045	.26	760	"
234	19.84	19.64	.20	1.04	790	"
235	19.78	19.69	.09	.45	750	"
236	19.63	19.50	.13	.65	790	"
237	19.22	19.10	.12	.61	760	"
238	19.20	19.16	.04	.21	790	"
239	19.98	19.94	.04	.20	780	"
240	19.27	19.19	.08	.42	790	"
241	19.26	19.21	.05	.26	760	"
242	19.73	19.64	.09	.46	790	"
243	19.32	19.28	.04	.21	780	"
244	19.33	19.11	.22	1.14	790	"
245	19.82	19.73	.09	.45	760	"
246	19.50	19.36	.14	.71	790	"
247	19.54	19.51	.03	.16	780	"
248	19.61	19.52	.09	.45	790	"
249	19.62	19.54	.08	.41	760	"
250	19.82	19.75	.07	.35	790	"
251	19.635	19.58	.055	.31	780	"
252	19.82	19.70	.12	.57	790	"
253	19.385	19.27	.115	.60	760	"
254	19.96	19.86	.10	.50	790	"
255	19.24	19.19	.05	.25	780	"
256	19.86	19.76	.06	.30	790	"

No	Wt Au	Wt button	Loss	% Loss	Temp	Time
257	19.32	19.21	.11	.57	760	16 to 19
258	19.72	19.62	.10	.51	790	"
259	19.305	19.22	.085	.44	780	"
260	19.72	19.60	.12	.60	790	"
261	19.50	19.38	.12	.62	760	"
262	19.60	19.54	.06	.31	790	"
263	19.61	19.56	.05	.25	760	"
264	19.55	19.45	.10	.50	790	"
265	19.89	19.79	.10	.51	760	"
266	19.92	19.82	.10	.50	790	"
267	19.31	19.21	.10	.52	760	"
268	19.60	19.51	.09	.46	790	"
269	19.24	19.15	.09	.46	760	"
270	19.31	19.22	.09	.45	790	"
271	[illegible]	19.22	.241	1.25	840	"
272	19.29	19.18	.11	.57	790	"
273	19.81	19.54	.27	1.36	760	"
274	19.52	19.39	.13	.66	790	"
275	19.365	19.30	.065	.34	780	"
276	19.51	19.45	.06	.31	790	"
277	19.82	19.62	.20	1.01	760	"
278	19.61	19.59	.02	.10	790	"
279	19.305	19.22	.085	.44	780	"
280	19.425	19.135	.29	1.49	790	"
281	19.90	19.63	.27	1.37	760	"
282	19.94	19.84	.10	.50	790	"
283	19.41	19.26	.15	.77	780	"
284	19.42	19.30	.12	.62	790	"
285	19.68	19.47	.21	1.06	760	"
286	19.76	19.62	.14	.71	790	"
287	19.972	19.92	.052	.26	780	"
288	19.71	19.55	.16	.82	790	"
289	19.54	19.39	.15	.80	760	"
290	19.44	19.34	.10	.51	780	"
291	19.36	19.31	.05	.25	760	"
292	19.24	19.14	.10	.52	790	"
293	19.60	19.51	.09	.45	760	"
294	19.64	19.49	.15	.77	790	"
295	19.44	19.39	.05	.25	760	"
296	19.21	19.12	.09	.46	790	"
297	19.75	19.64	.11	.57	760	"
298	19.66	19.50	.16	.82	780	"
299	19.21	19.16	.05	.26	760	"
300	19.63	19.53	.10	.51	790	"
301	19.43	19.33	.10	.51	760	"
302	19.30	19.12	.18	.93	790	"
303	19.20	19.17	.03	.16	780	"
304	19.71	19.64	.07	.36	790	"
305	19.38	19.17	.21	1.10	760	"
306	19.42	19.32	.10	.52	790	"
307	19.32	19.29	.03	.16	780	"
308	19.52	19.43	.09	.45	790	"
309	19.30	19.22	.08	.42	760	"
310	19.30	19.20	.10	.52	790	"
311	19.33	19.27	.06	.33	750	"
312	19.62	19.50	.12	.63	790	"
313	19.79	19.63	.16	.81	760	"
314	19.75	19.62	.13	.66	790	"
315	19.22	19.16	.06	.31	760	"
316	19.55	19.35	.20	1.04	790	"
317	19.61	19.52	.09	.47	760	"
318	19.72	19.68	.04	.21	790	"
319	19.29	19.25	.04	.20	760	"
320	19.43	19.31	.12	.63	790	"
321	19.61	19.44	.17	.85	760	"
322	19.76	19.62	.14	.71	790	"
323	19.94	19.85	.09	.45	760	"
324	19.91	19.82	.09	.46	790	"
325	19.84	19.57	.27	1.40	760	"
326	19.30	19.19	.11	.57	790	"
327	19.74	19.71	.03	.15	760	"
328	19.76	19.63	.13	.67	790	"
329	19.43	19.31	.12	.62	760	"
330	19.28	19.09	.19	.98	790	"
331	19.30	19.28	.02	.10	760	"
332	19.335	19.26	.075	.38	790	"

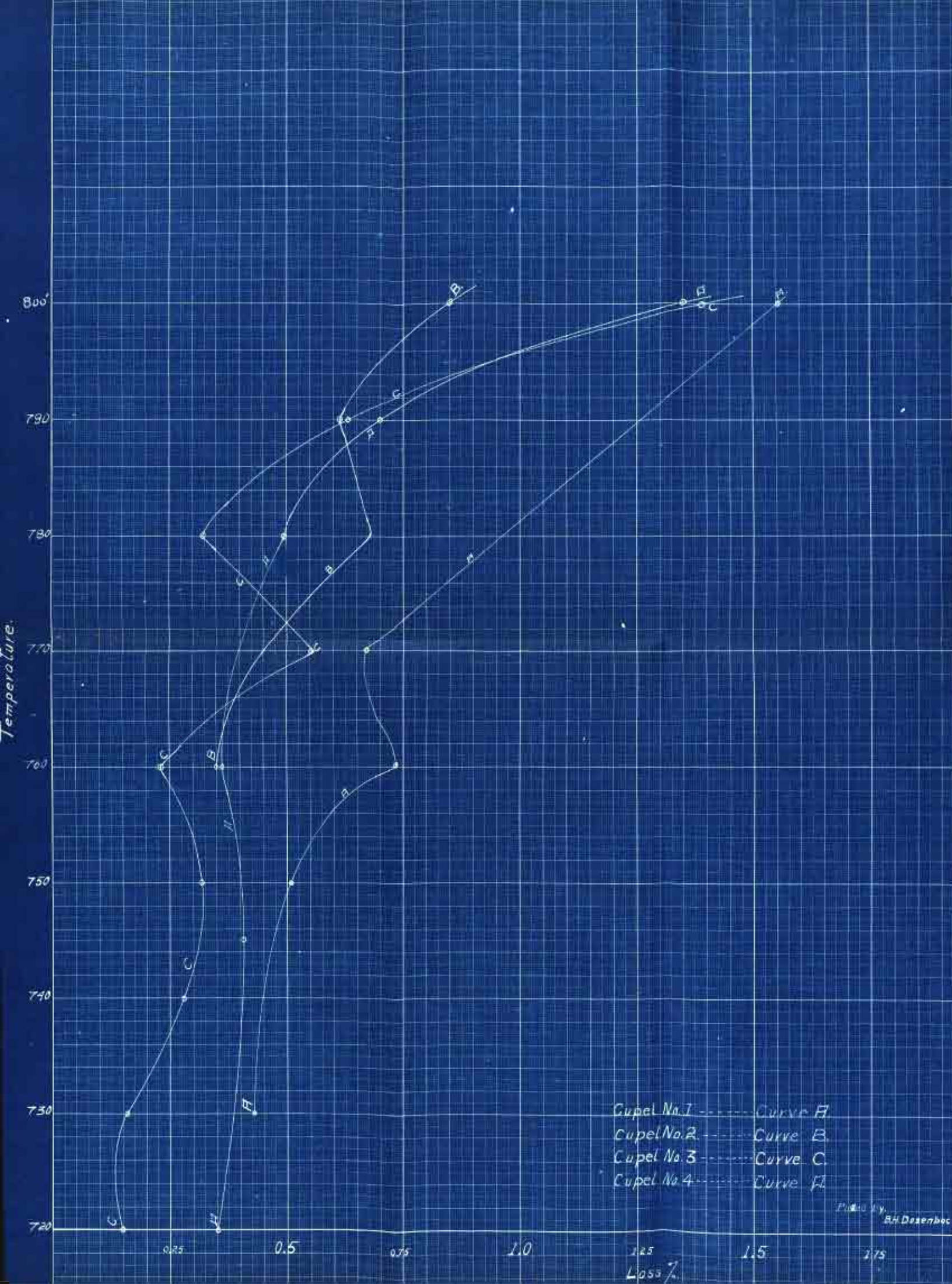
No	Wt Au	Wt button	Loss	% Loss	Temp	Time
333	19.49	19.35	.14	.72	760	20 Min
334	19.40	19.26	.14	.71	770	"
335	19.37	19.29	.08	.41	760	"
336	19.46	19.32	.14	.72	790	"
337	19.75	19.59	.16	.81	760	"
338	19.475	19.42	.055	.28	770	"
339	19.200	19.150	.050	.25	760	"
340	19.72	19.60	.12	.61	790	"
341	19.91	19.63	.28	1.47	760	"
342	19.70	19.58	.12	.62	770	"
343	19.62	19.58	.04	.21	760	"
344	19.61	19.54	.07	.36	790	"
345	19.33	19.19	.14	.70	760	"
346	19.30	19.19	.11	.56	770	"
347	19.76	19.71	.05	.25	760	"
348	19.45	19.38	.07	.36	790	"
349	19.52	19.395	.125	.64	760	"
350	19.76	19.62	.14	.72	770	"
351	19.75	19.655	.095	.48	760	"
352	19.335	19.24	.095	.49	760	"
353	19.42	19.27	.15	.77	760	"
354	19.615	19.47	.145	.73	770	"
355	19.48	19.39	.09	.47	790	"
356	19.19	19.16	.03	.16	790	"
357	19.47	19.31	.16	.82	760	"
358	19.62	19.50	.12	.62	770	"
359	19.82	19.75	.07	.35	770	"
360	19.36	19.23	.13	.67	760	"
361	19.44	19.30	.14	.70	760	"
362	19.72	19.58	.14	.71	790	"
363	19.65	19.54	.11	.56	770	"
364	19.83	19.71	.12	.61	760	"
365	19.52	19.40	.12	.64	760	"
366	19.16	19.03	.13	.68	790	"
367	19.55	19.49	.06	.30	770	"
368	19.46	19.36	.10	.51	760	"
369	19.60	19.51	.09	.46	760	"
370	19.62	19.54	.18	.92	790	"
371	[illegible]	[illegible]	.11	.57	770	"
372	19.88	19.68	.20	1.02	760	"
373	19.52	19.42	.10	.51	760	"
374	19.46	19.36	.10	.52	790	"
375	19.46	19.33	.13	.67	770	"
376	19.52	19.44	.08	.41	760	"
377	19.71	19.44	.27	1.39	760	"
378	19.36	19.21	.15	.77	790	"
379	19.72	19.57	.15	.76	770	"
380	19.31	19.26	.05	.26	760	"
381	19.61	19.50	.11	.56	760	"
382	19.70	19.56	.14	.71	790	"
383	19.364	19.26	.104	.54	770	"
384	19.63	19.58	.05	.26	760	"
385	19.64	19.50	.14	.71	760	"
386	19.30	19.19	.11	.55	790	"
387	19.84	19.67	.17	.87	790	"
388	19.48	19.41	.07	.36	760	"
389	19.76	19.62	.14	.70	760	"
390	19.60	19.515	.135	.69	780	"
391	19.62	19.55	.12	.61	790	"
392	19.18	19.09	.09	.46	760	"
393	19.91	19.61	.17	.85	760	"
394	19.96	19.90	.06	.33	790	"
395	19.92	19.81	.11	.56	790	"
396	19.26	19.18	.08	.42	780	"
397	19.81	19.56	.25	1.29	760	"
398	19.69	19.62	.07	.36	790	"
399	19.92	19.72	.10	.50	790	"
[illegible]	19.82	19.74	.08	.44	760	"

Notice.

The plotted curves and the explanatory matter incidental to the chart will be found on sheet #5 of this series of blue prints. The sizes and makes of the different kinds of cupels used will also be noted.

★ High Results --- due to poor work[illegible]

B.H. Dusenbach.


Temperature.
800°
790
780
770
760
750
740
730
720
0.25
0.5
0.75
1.0
1.25
1.5
1.75
Loss %.
Cupel No. 1 ------ Curve A.
Cupel No. 2 ------ Curve B.
Cupel No. 3 ------ Curve C.
Cupel No. 4 ------ Curve D.
Plotted by B.H. Dasenbock