NATIONAL BUREAU OF STANDARDS REPORT

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Progress Report on Pertinent Data on Some Physical Properties of Different Investments Used in the Casting of Gold Alloys

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Abstract

Fineness, time of setting, compressive strength, linear thermal expansion, hygroscopic expansion, normal setting expansion, and surface defects of alloy castings were determined using casting investments of three types - thermal inlay, hygroscopic inlay, and thermal partial denture. The use of the normal setting expansion combined with either the hygroscopic or thermal expansion to compensate for the shrinkage of casting gold alloys is discussed.

1. Introduction

This survey of some pertinent physical properties of ten American and three Japanese dental casting investments for gold alloys includes thermal inlay, hygroscopic inlay, and thermal partial denture types as shown in Table 1.

2. Methods

The test methods as described in the American Dental Association Specification No. 2 for Casting Investment for Dental Gold Alloy [1] were employed in obtaining the data given in Table 2.

3. Results and Discussion

Fineness - 3.3 and 4.3.2.(numbers refer to sections in American Dental Association Specification No. 2 for Casting Investment for Dental Gold Alloy). The specification [1] requires that 85 percent shall pass a No. 200 sieve; 95 percent shall pass a No. 100 sieve and that 100 percent shall pass a No. 30 sieve. All of the investments were at least as fine as these minimum requirements.

Testing consistency - 3.4 and 4.3.3. The water powder ratio for each investment is determined by measuring the diameter of a pat of investment extruded vertically from a cylinder. Reference to data in Table 2, column 2 shows the milliliters of water necessary to mix with 100 grams of powder to produce pats having diameters within the range required for the different types. These amounts vary depending upon the characteristics of the investments. Thus, among the investments of the thermal inlay type only 29 ml is needed for investment D while 40 ml is needed for investment C even though the final consistency is about the same.

Time of setting - 3.5 and 4.3.4. The range of the times of setting, 9 to 18 minutes, in Table 2, column 3, is well within the range of 5 to 25 minutes permitted by the specification.

Compressive strength - 3.6 and 4.3.5. The values of compressive strength are expressed in kg/cm^2 in column 5 of Table 2. These values multiplied by 14.223 will give the strength in pounds per square inch. Only investment F failed to meet the minimum requirement for compressive strength and then the value of 22 kg/cm^2 is very near that of the minimum requirement of the specification.

Combined linear expansion - 3.7; 4.3.6 and 4.3.7. The linear expansion on setting ranged from 0.3 to 0.7 percent on the thermal inlay type of investment (Table 2, column 6). Since the maximum limit in the specification is 0.5 percent, investment G would not comply. The hygroscopic expansion on setting (Table 2, column 7) ranged from 0.6 to 1.3 percent. As the minimum permitted by the specification is 1.2 percent, investment J with a value of 0.6 percent would not comply.

The thermal expansion of the thermal inlay type of investment from room temperature to 700°C ranged from 0.8 to 1.4 percent (Table 2, column 8). Investment H would not comply with the minimum requirement of 1.0 percent in the specification. In the hygroscopic inlay types investment L has 0.6 percent which is just the maximum limit of the specification. The thermal expansion of the hygroscopic inlay type is measured over the range - room temperature to 500°C.

In the combined setting and thermal expansion values (Table 2, column 9) only investment G fails to comply at 2.1 percent as the maximum value for the thermal inlay type of investment is 2.0 percent.

Thermal expansion curves of the investments (Fig. 1) give some idea of the form of silica present. The investments containing cristobalite expand earlier and higher than those containing only quartz. It would appear that some of the investments

contain both quartz and cristobalite. The recessions in the curves are due principally to the loss of the water of hydration from the gypsum binder.

The spread in the data from repeated trials is shown in Figure 2 for cristobalite investment, F, for quartz investment, H (Fig. 3) and for two hygroscopic inlay type investments, J and K, (Fig. 4).

Surface defects of alloy - 3.8 and 4.3.8. None of the castings made in any of the investments showed surface contamination from the investment nor did any of the investments cause pitting, fins, rough surfaces or voids in the alloy castings.

The limiting values for the expansions given in the specification were based upon the best extant knowledge. It is known that many variables affect the values for shrinkage of gold alloys. To cite a few, one could mention the size and shape of the casting, sprue dimensions, location of the casting in the ring, the bulk of investment, degree of restriction of the investment during hardening and heating, and its access to free water at a critical period during setting. It has also been shown that casting shrinkage is a function of the composition of the alloy. It is these and other variables that dictate an arbitrary range of permissible values obtained under controlled laboratory conditions as given in the specification.

4. Summary

The values for significant properties of some commercial casting investments, along with the corresponding requirements of American Dental Association Specification No. 2 for Casting Investment for Dental Gold Alloy are presented. The setting times of all the investments were in the lower or middle third of the 5 to 25 minute range permitted by the specification. Compressive strengths of most of the investments were 1 1/2 to 2 1/2 times the minimum specification value. Setting expansion in air was generally near the specified maximum while setting expansion in water was near or below the specified minimum.

Reference

1. Guide to dental materials, ed. 2, Chicago, Illinois, American Dental Association, 1964, p. 84.

Table 1

Investments Tested

Brand of Material	Batch No.	Date Received	Manufacturer
Baker Cristobalite Inlay[1]	202166	12-10-62	Baker Dental Division Englehard Industries, Inc.
G. C. Cristobalite Inlay[1]	TZ-9	12-18-62	The G. C. Chemical Mfg. Co.
G. C. Quartz Inlay[1]	TX-32	12-18-62	The G. C. Chemical Mfg. Co.
Kerr Cristobalite Inlay[1]	0624RA9257	8-1-62	Kerr Mfg. Co.
Kerr Cristobalite Model[3]	6083RA5170	10-8-62	Kerr Mfg. Co.
R and R Aquascopic[2]	1KV	7-20-62	The Ransom and Randolph Co.
R and R Cristo-Vest[1]	1LI	10-16-62	The Ransom and Randolph Co.
R and R Gray[3]	2EM	10-9-62	The Ransom and Randolph Co.
R and R Hygroscopic[2]	1KV	7-18-62	The Ransom and Randolph Co.
Shofu Cristobalite Inlay[1]	923	11-16-62	Shofu Dental Mfg. Co.
Whip-Mix Beauty-Cast[1,5]	0625201	10-30-62	Whip-Mix Corporation
Whip-Mix Beauty-Cast[2,5]	0625201	10-30-62	Whip-Mix Corporation
Whip-Mix Cristobalite Inlay[1]	0416202	6-22-62	Whip-Mix Corporation
Whip-Mix Shiny-Brite[1]	0645101	10-8-62	Whip-Mix Corporation

[1] Thermal inlay type
[2] Hygroscopic inlay type
[3] Thermal partial denture type
[4] The investments are arranged in order alphabetically
[5] This material is sold for use as both a thermal inlay type and a hygroscopic inlay type investment.

Table 2

Data on Physical Properties of Casting Investments for Gold Alloys

1	2	3	4	5	6	7	8	9
Investments[4]	Testing Consistency	Time of Setting	Compressive Strength		LINEAR EXPANSION			Combined Setting and Thermal Expansion
					Setting Expansion		Thermal Expansion	
			Loading Rate	Strength	In Air	In Water		
	Milliliter[5]	Minutes	kg/min	kg/cm²	%	%	%	%
A[1]	39	13	170	54	0.4	-	1.2	1.6
B[1]	32	11	140	27	0.3	-	1.2	1.5
C[1]	40	14	150	38	0.3	-	1.2	1.5
D[1]	29	16	160	56	0.5	-	1.4	1.9
E[1]	32	18	140	52	0.4	-	1.2	1.6
F[1]	37	9	140	22	0.5	-	1.3	1.8
G[1]	34	10	110	63	0.7	-	1.4	2.1
H[1]	30	10	160	27	0.5	-	0.8	1.3
I[1]	34	12	-	51	0.4	-	1.3	1.7
J[2]	31	13	170	74	-	0.6	0.4	1.0
K[2]	31	17	150	57	-	1.3	0.4	1.7
L[2]	32	18	140	52	-	1.2	0.6	1.8
M[3]	31	9	160	65	0.3	-	1.1	1.4
N[3]	25	11	150	81	0.3	-	1.2	1.5
Specification Requirements		Min. Max. 5 25	150±30	Min. 25[1, 2] 50[3]	Min. Max. 0.0 0.5[1] 0.0 0.4[3]	Min. Max. 1.2 2.2[2]	Min. Max. 1.0 2.0[1] 0.0 0.6[2] 1.0 1.5[3]	Min. Max. 1.3 2.0[1] 1.3 2.7[2] 1.2 1.9[3]

[1] Thermal inlay type
[2] Hygroscopic inlay type
[3] Thermal partial denture type
[4] The investments are arranged according to types
[5] Milliliters of water in 100 grams of powder required to produce a mix of standard testing consistency.

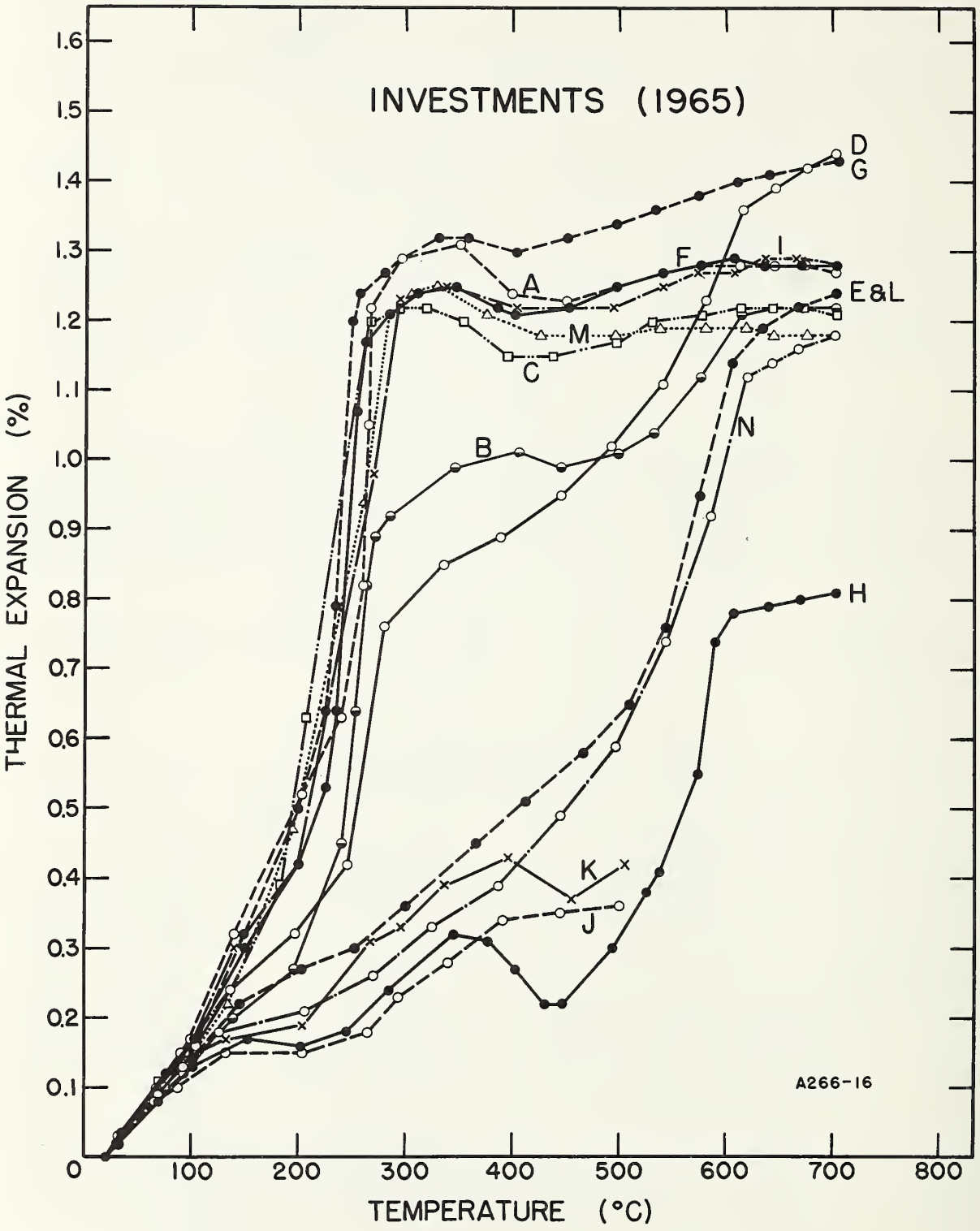

Figure 1. Thermal expansion curves of investments (1965).

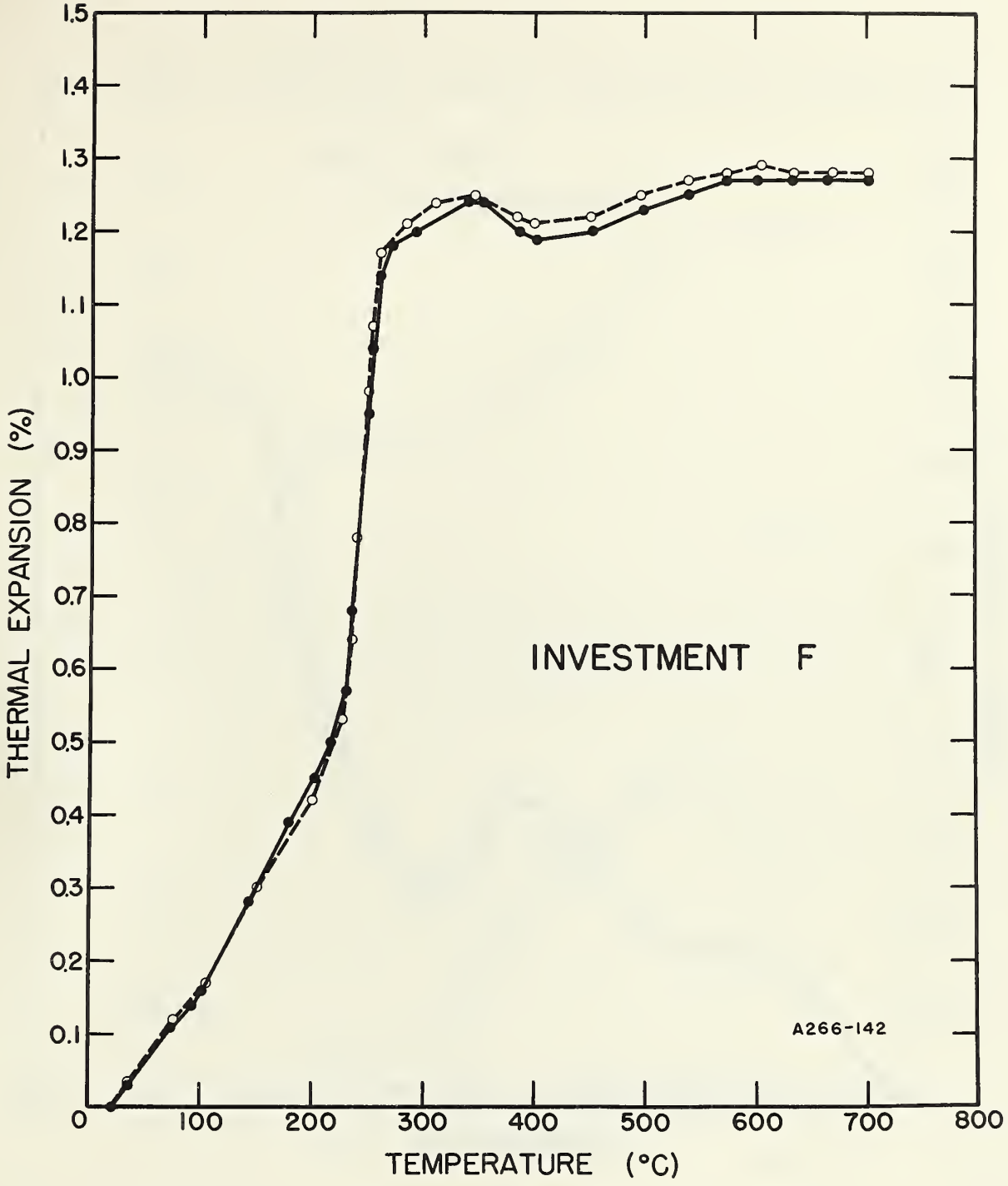

Figure 2. Thermal expansion curve of cristobalite investment F.

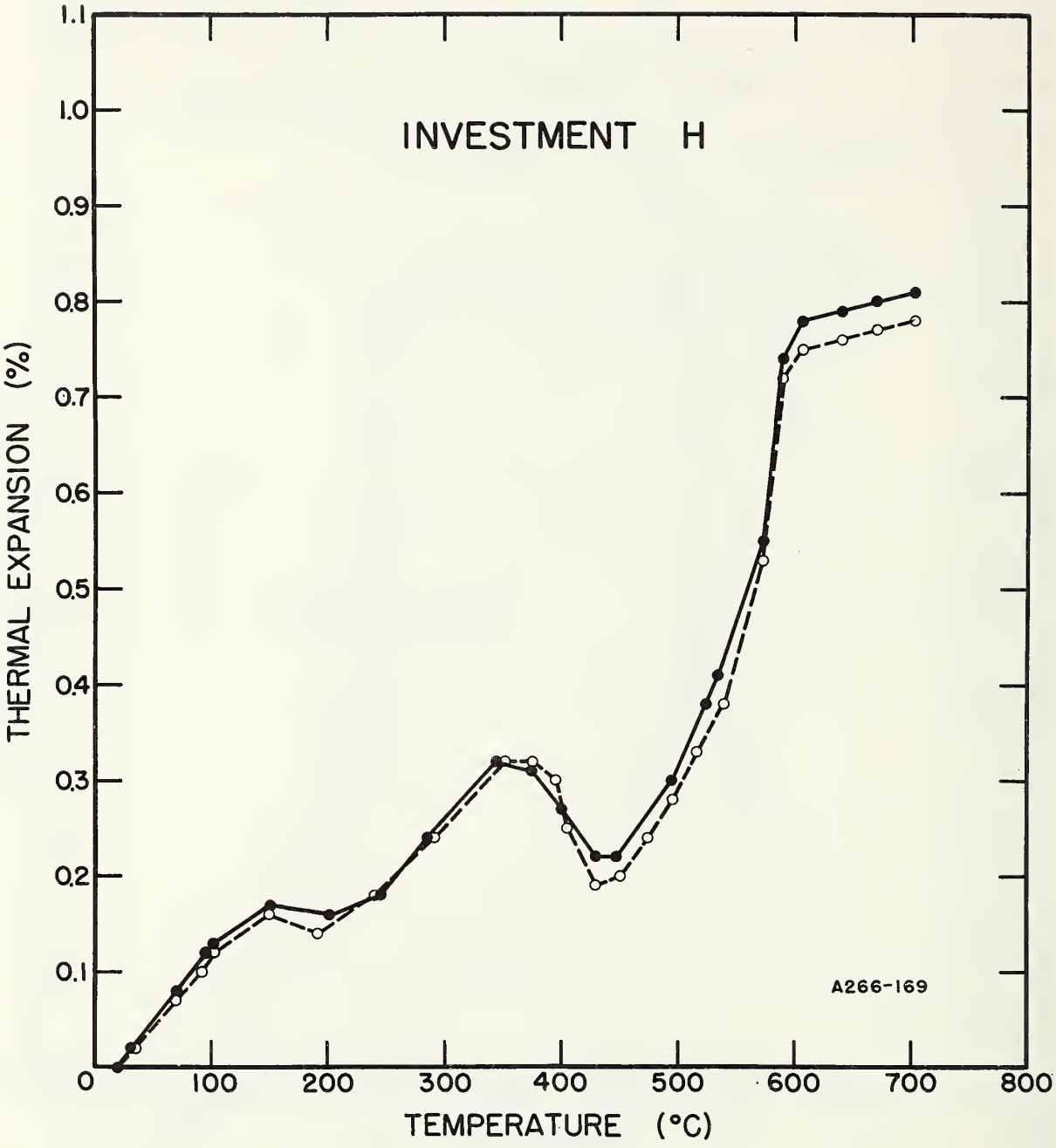

Figure 3. Thermal expansion curve of quartz investment H.

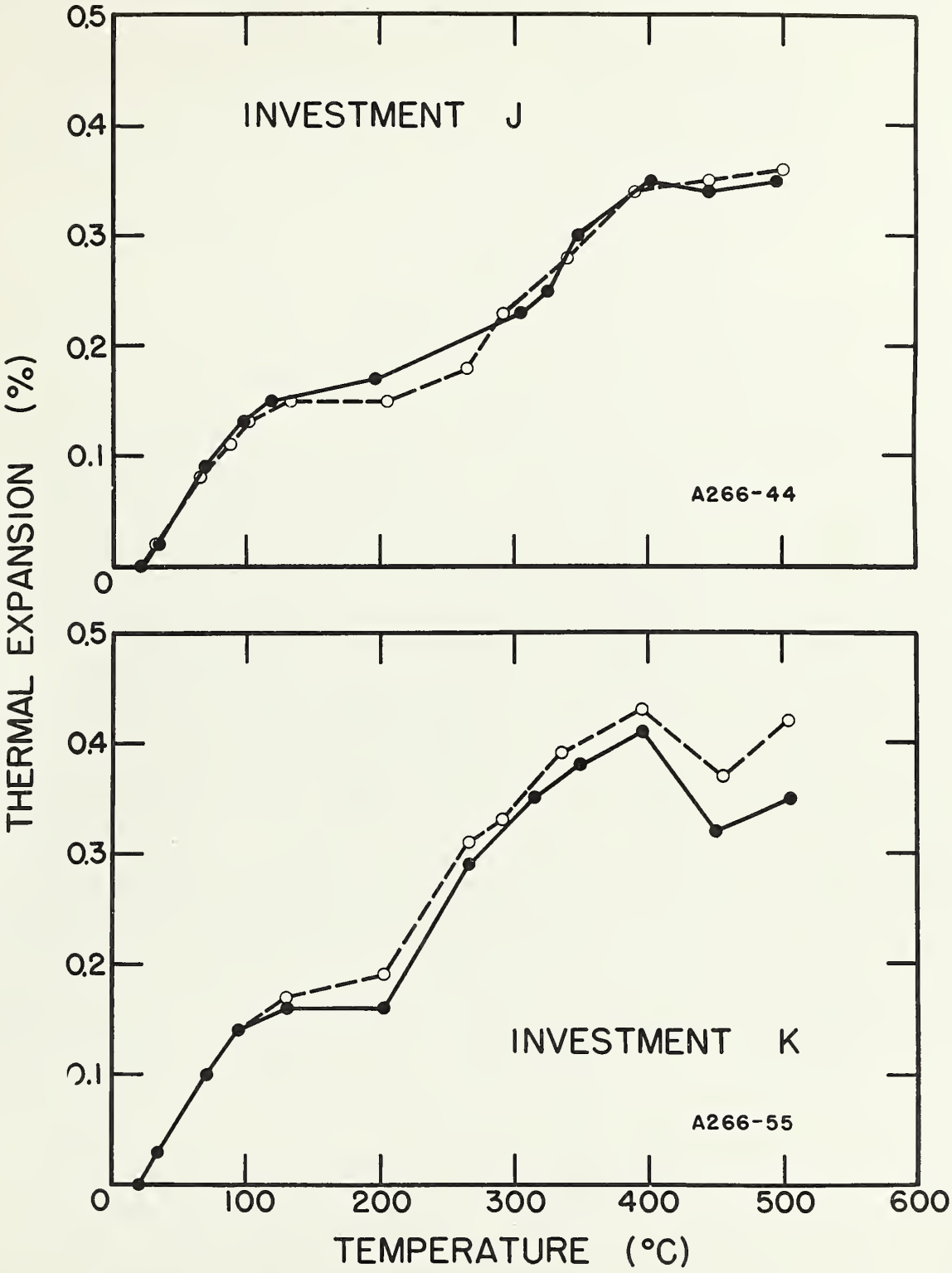

Figure 4. Thermal expansion curves of hygroscopic investments J and K.

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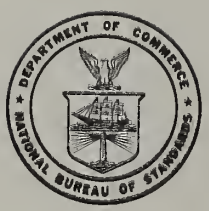
** Located at Boulder, Colorado.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