EFFECT OF HIGH PRESSURES ON THE KINETICS OF PHASE TRANSFORMATION IN GOLD-CADMIUM ALLOYS (BETA PHASE)

by

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ABSTRACT

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In the present investigation attempts have been made to determine the effect of high pressure on the kinetics of phase transformation in the gold-cadmium system (beta phase). Resistivity measurements were carried out for four alloy compositions in the beta phase region in the temperature range of 0°C to 120°C at pressures of 15000 to 30000 atmospheres. The results indicate significant changes in resistivity and transformation temperatures. The change in the transformation temperatures has been interpreted on the basis of a thermodynamic equation using independent parameters. The other results have been interpreted on the basis of the Band Theory of Metals. The experimental results agree well with theoretically predicted values.

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Dr. Shaffiq Ahmed, Chairman, Department of Metallurgical Engineering and Materials Science, Youngstown State University, for his guidance, assistance and patience without which this work could not have been completed.

Special thanks to Dr. George J. Filatovs, Assistant Professor of the department, for his help in building a high pressure unit, and to Mr. Herman Weddell of Reactive Metals, Inc., for his help in the preparation of alloys.

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CHAPTER I

INTRODUCTION

The diffusionless phase transformation in the Au-Cd alloy system has been the subject of intensive investigation in the last decade. Beta phase of Au-Cd alloys exhibits two types of diffusionless phase transformations - cubic to orthorhombic transformation in alloys having compositions in the range of 46 to 48.5 atom percent cadmium, and cubic to tetragonal transformation in alloys having compositions in the range of 48.7 to 50 atom percent cadmium. In these phase transformations a single crystal of cubic phase, upon cooling, transforms to low temperature modifications which is either twinned orthorhombic or twinned tetragonal.

The crystal uniquely transforms at different temperatures on cooling and on heating, with a resulting hysterisis loop which is larger in the case of alloys having non-stichiometric composition. The crystallographic mechanisms for these phase transformations have been studied extensively by Read and Collaborators,[1,2,3] and also by

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[1] D. S. Lieberman, T. A. Read, and M. S. Wechsler, <u>J. Appl. Phys.</u>, <u>26</u>, 473 (1955).

[2] Lieberman, Read and Wechsler, <u>ibid.</u>, <u>28</u>, 532 (1955).

[3] Lieberman, Read and Wechsler, <u>Trans. AIME</u>, 1503 (1953).

Ahmed.[4] Also, the thermodynamic properties of the beta phase were extensively investigated by Ahmed.[5]

However, no previous attempts have been made to study the effect of extremely high hydrostatic pressure on the kinetics of phase transformations in these alloys.

In the present investigation, attempts have been made to study the effect of pressure on the kinetics of phase transformation including its effects on phase transformation temperature, on resistance, and also on temperature coefficients of resistance. Also a thermodynamic equation to describe the change in transformation temperature with pressure has been derived. The experimental results have been interpreted on the basis of this equation and the Band Theory of Solids.

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[4] S. Ahmed, Thermodynamics of Phase Transformation (Washington, D. C.: Office of Naval Research, December, 1965).

[5] S. Ahmed, Phase Transformation in Metals and Alloys (Washington, D. C.: U. S. Atomic Energy Commission, March, 1958).

CHAPTER II

EXPERIMENTAL PROCEDURE

Preparation of Samples

The alloys were prepared by using high purity gold and cadmium. The metals were properly cleaned and weighed and then placed into a quartz tube and sealed under vacuum. Then the tubes were placed in the furnace at 600°C and then the alloys were homogenized and allowed to furnace cool. The alloys were further annealed at 450°C for 24 hours. Size of samples was 1/2 inch in diameter and 1/16 inch thick. The surfaces of these samples were carefully polished by hand so as to produce to parallel flat surfaces.

In this manner samples of the following compositions were prepared:

Alloy Composition	Group No.	Sample No.
Au-Cd (48 atom percent Cd)	D	D-1, D-2
Au-Cd (48.5 atom percent Cd)	C	C-1, C-2
Au-Cd (49 atom percent Cd)	B	B-1, B-2
Au-Cd (50 atom percent Cd)	A	A-1, A-2, A-4

Experimental Procedure

Two modified hydraulic presses capable of heating and cooling the samples were used in this experiment--one for the low pressure region and the other for the high pressure region. (Figures 1 and 2)

The anvils were equipped with resistance heating coils. The temperature of anvils was controlled by temperature controllers. The pressure of these presses can be controlled by the link mechanism such that the pressure can be kept constant at a certain load for a length of time.

The specimens were placed on a nickel foil with four connecting leads between two mica pieces (Figure 3). The complete assembly was then carefully placed between the anvil pieces which has been cooled to 0°C. Resistance measurements were carried out by using Double Kelvin Bridge after the proper temperatures has been attained. The first resistance reading was taken at 0°C without anypressure. Then the pressure was increased to 20 tons and resistance measurements were carried out as a function of temperature up to 120°C.

The sameprocedure was followed for all alloys at 20, 30 and 40 tons (i.e. at 15000, 22500, and 30000 atmospheres, respectively).

Precautions were taken to protect the insulation of connecting leads and also the mica pieces.

CHAPTER III

EXPERIMENTAL RESULTS

The experimental results consisted of resistance values as a function of temperature from 0°C to 120°C. The results thus obtained represent absolute values of the resistances for the given sample. It is necessary to present the resistance change in the form of percent resistance change, by using the following formula:

$$\text{Percent resistance change} = \frac{Rt-Ro}{Ro} \times 100 \qquad (1)$$

where Rt is resistance at temperature t °C, Ro is resistance at temperature 0°C.

The results are shown in Figures 4 to 17 and in Tables 1 to 14.

The transformation characteristics starts on heating at a given temperature (Ts), and ends at a different temperature (Tf). The mean transformation temperature represents the mean of Ts and Tf (Tables 15 and 16). Transformation temperature in alloy composition increases with increase in pressure as shown in Figures 22 to 29.

Results indicate that all alloy compositions have characteristic temperature coefficients of resistance change (Figures 30 to 36).

CHAPTER IV

DISCUSSION OF RESULTS

In general, alloys in these investigations have pressure effects qualitatively alike, in that the resistance decreases under pressure. The decrease of resistance is not linear with pressure, but as the pressure increase, the change in resistance becomes less (Figures 22 to 29). The decrease in resistance can be explained by the general theory of resistance of metals and alloys on the basis of the Sommerfield Theory of Solids. In a metal or an alloy, free of structural defects and foreign impurities, the resistance is mainly due to scattering of conduction electrons by the lattice ions. With increase in temperature, the frequency of lattice vibration increases and this results in the movement of the ions about its equilibrium position in a lattice. This increases the probability of scattering of the electrons by the ions in lattices. Consequently, the resistance increases. The hydrostatic stress, although it does not cause any plastic deformation but will put in a constrain on a normal mode of lattice vibration which will effectively reduce the frequency and amplitude of lattice vibration. Also, ions of the metal lattice under high pressure are held in position by stronger forces, and therefore, at a given temperature, vibrate with smaller amplitude than at atmospheric pressure. The resistance in this case is proportional to the mean square amplitude of the ionic vibrations. Therefore, it follows that the resistance will decrease due to the changes in the frequency and amplitude of lattice vibration.

In our case, the resistance of gold-cadmium alloys decreases with increase in pressure. This experimental observation can be explained on the basis of the above theory.

However, the resistance at a given pressure increases with temperature, with a discontinuity at the temperature of phase transformations. The temperature coefficient of the resistance of the high and low modifications of each alloy were different (Figures 30 to 36). This is probably due to the changes in the thermal expansion coefficient and in the frequency of lattice vibration of these alloys under high pressure.

The experimental results (Tables 15 and 16) and (Figures 18 to 21) indicate that the transformation temperature increases monotonically with pressure for all alloy compositions. For all alloys undergoing cubic to tetragonal (alloys having compositions 49 atom percent Cd and 50 atom percent Cd) transformations have the same rate of change of transformation temperature with pressure. However, other groups of alloys undergoing cubic to orthorhombic (alloys having compositions 46 atom percent Cd to 48.5 atom percent Cd) transformations have different rates of change of transformation temperature with pressure

(Table 17). The important considerations here are that the same type of transformation exhibits similar rates of change of transformation temperature with pressure and that it differs from other types of transformation. The difference is due to several factors. The volume change accompanying the transformation, the enthalpy change due to transformation, and the density of the alloy play important roles here. It can be seen from the following equation (2) that they directly determine how the phase transformation temperature will change with pressure.

$$\frac{dT}{d\sigma} = \frac{T\varepsilon}{\rho\Delta H} \qquad (2)$$

where T = the transformation temperature; ε = the transformation strain; ρ = the density of alloy; ΔH = the enthalpy change during phase transformation; $d\sigma$ = the applied stress; dT = the change in the transformation temperature. This theoretical equation predicts the transformation temperature at different pressures determined from independent parameters. The values of these parameters were obtained from papers published by Ahmed.[4,5] These independently determined values (Tables 18 and 19) agree well with the experimental values. They are in excellent agreement.

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[4] Ahmed, Thermodynamics, December, 1965.

[5] Ahmed, Phase Transformation, March, 1958.

CHAPTER V

CONCLUSION

In the present investigation attempts have been made to determine the effect of high pressure on the kinetcs of phase transformation in the gold-cadmium system (beta phase). Resistivity measurements were carried out for four alloy compositions in the beta phase region in the temperature range of 0°C to 120°C at pressures of 15000 to 30000 atmospheres. The results indicate significant changes in resistivity and transformation temperatures. The change in the transformation temperature has been interpreted on the basis of a thermodynamic equation using independent parameters. The other results have been interpreted on the basis of the Band Theory of Metals. The experimental results agree well with theoretically predicted values.

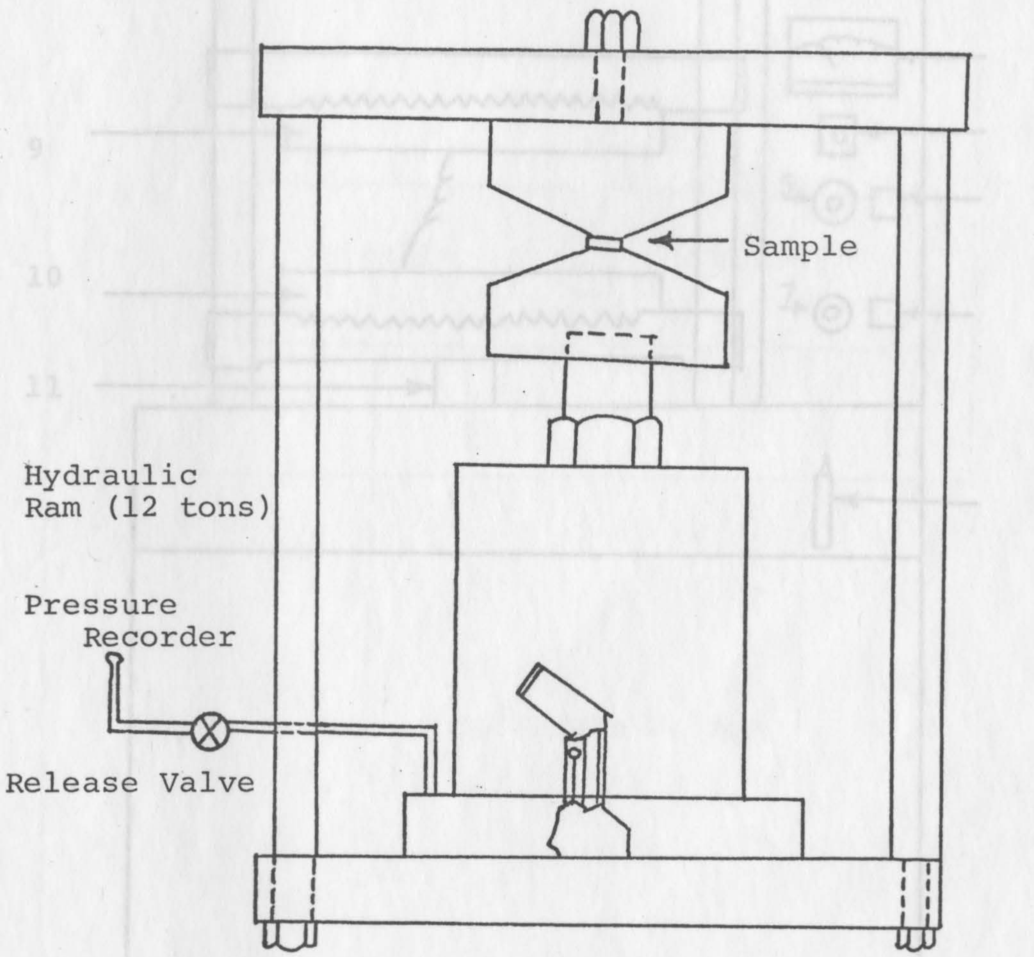

Fig. 1. Schematic layout of a complete opposed-anvil apparatus with a 20 tons hydraulic jack.

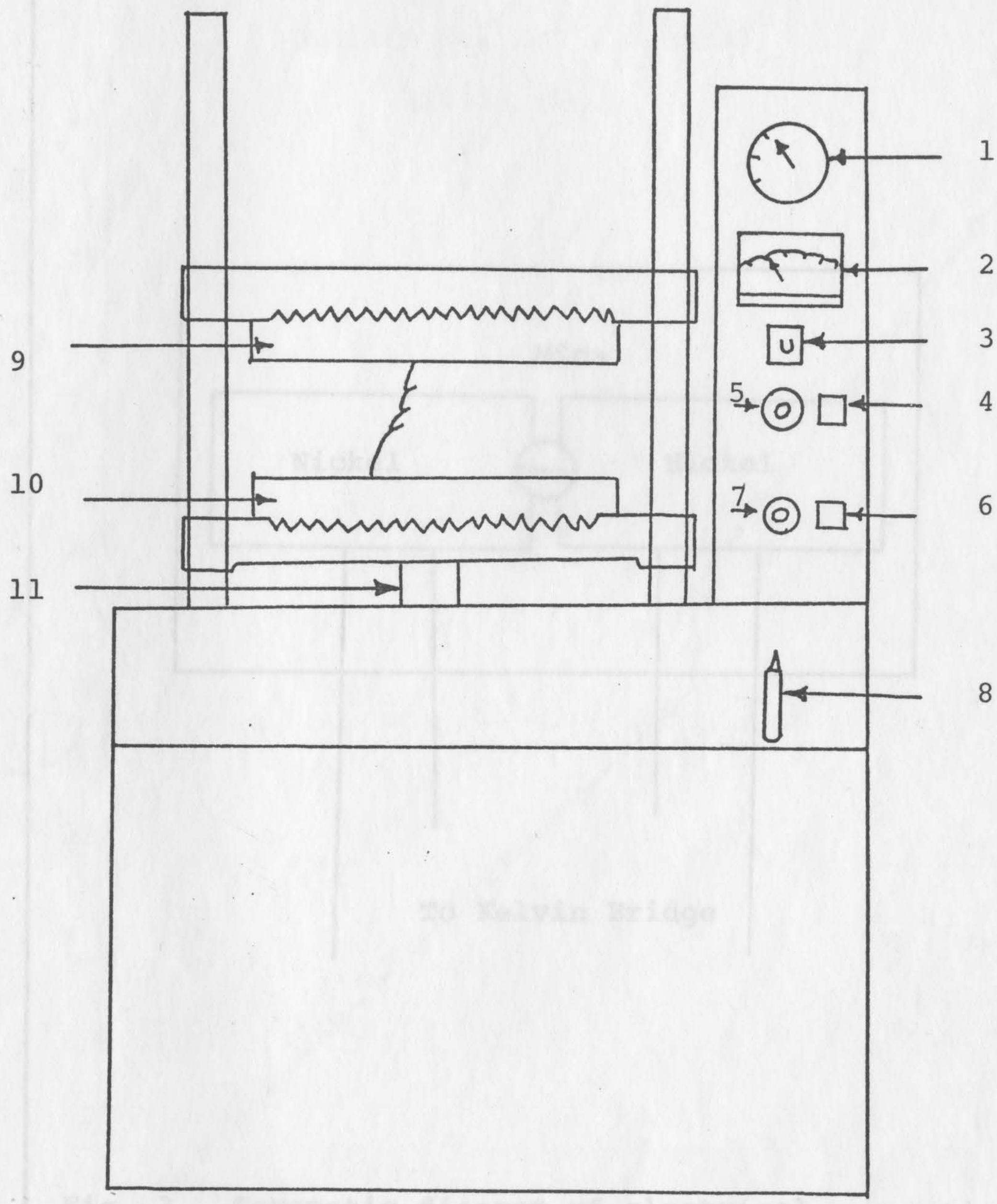

Fig. 2. Wabash Hydraulic Press: (1) Presser recorder; (2) Temperature recorder; (3) Temp. switch; (4) Temp. signal [top plate]; (5) Temp. controller [top]; (6) Temp. signal [bottom]; (7) Temp. controller [bottom]; (8) Link mechanism; (9) Top plate; (10) Bottom plate; (11) Ram.

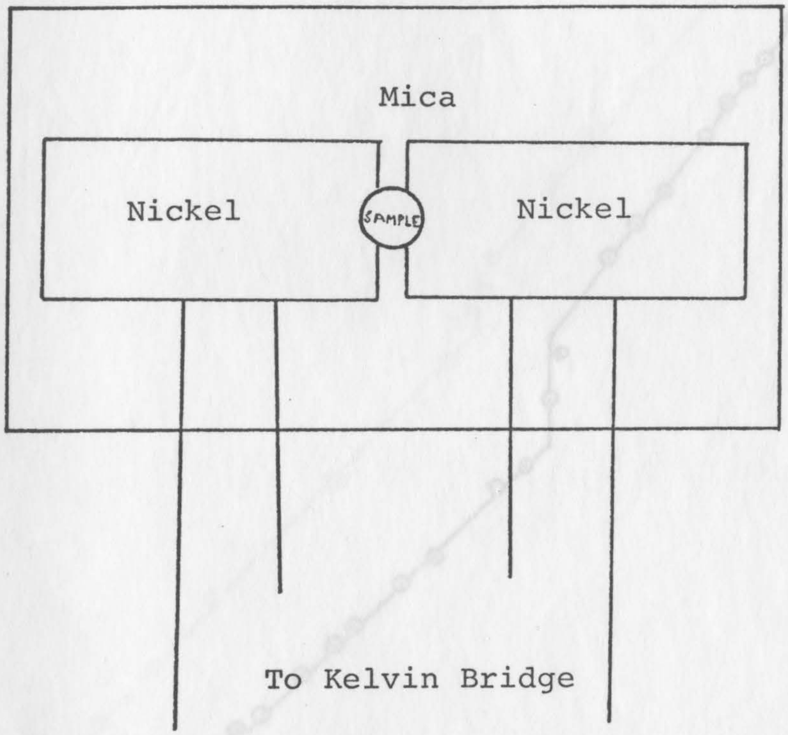

Fig. 3. Schematic diagram of electrical connection to sample.

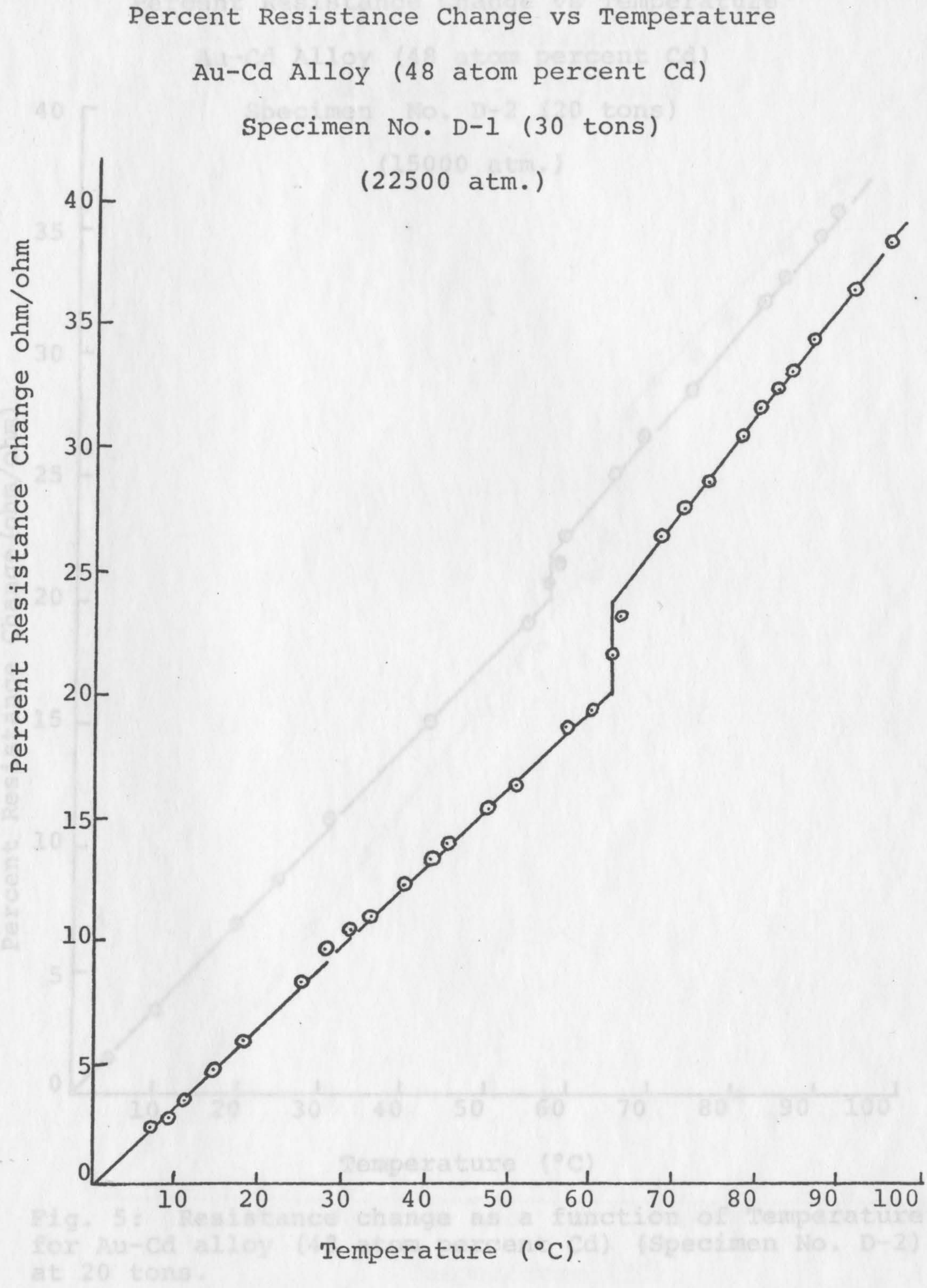

Fig. 4. Resistance change as a function of temperature for Au-Cd alloy (48 atom percent Cd) (Specimen No. D-1) at 30 tons.

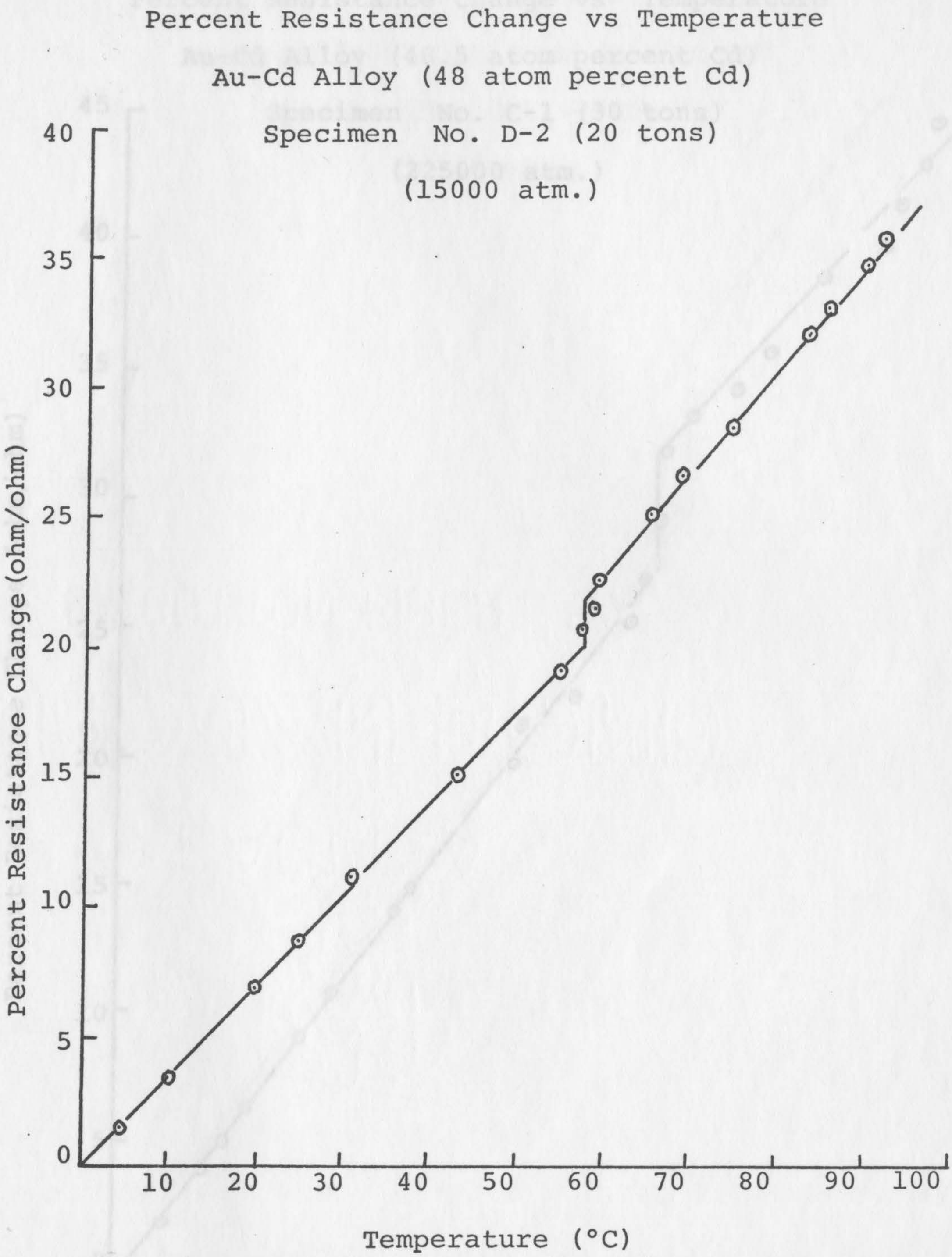

Fig. 5: Resistance change as a function of Temperature for Au-Cd alloy (48 atom percent Cd) (Specimen No. D-2) at 20 tons.

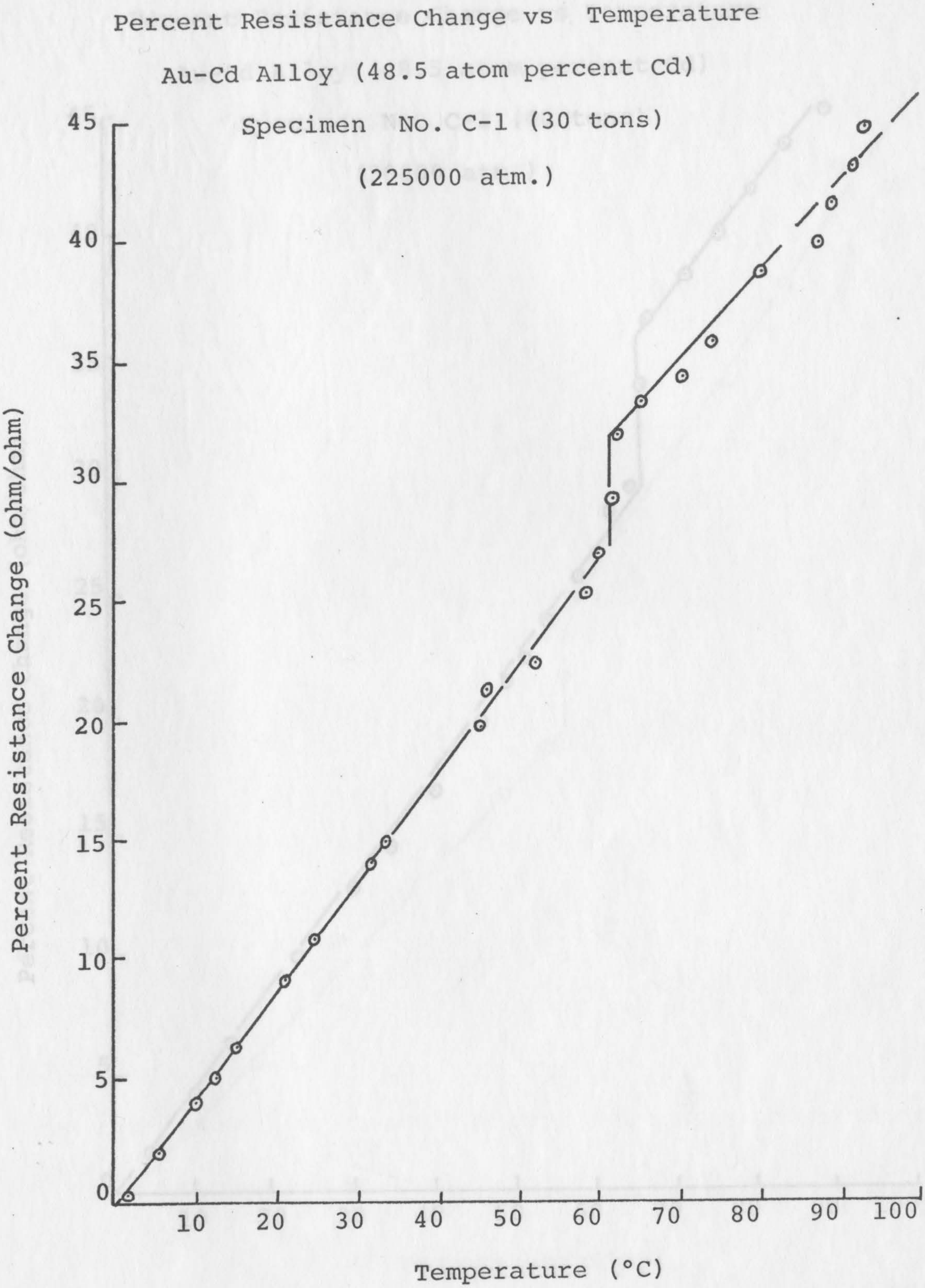

Fig. 6. Resistance change as a function of temperature for Au-Cd alloy (48.5 atom percent Cd) (Specimen No. C-1) at 30 tons.

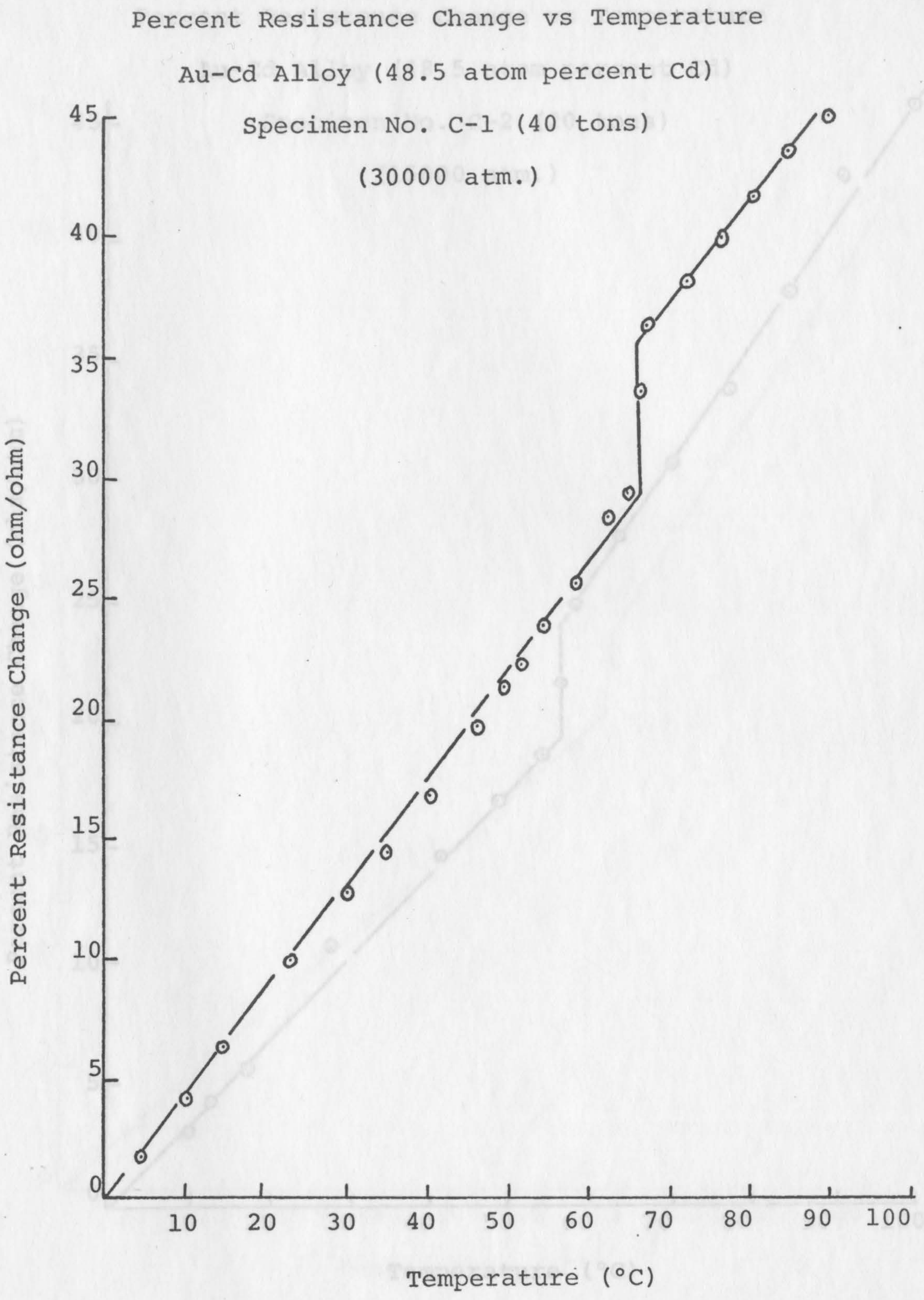

Fig. 7. Resistance Change as a function of Temperature for Au-Cd alloy (48.5 atom percent Cd) (Specimen No. C-1) at 40 tons.

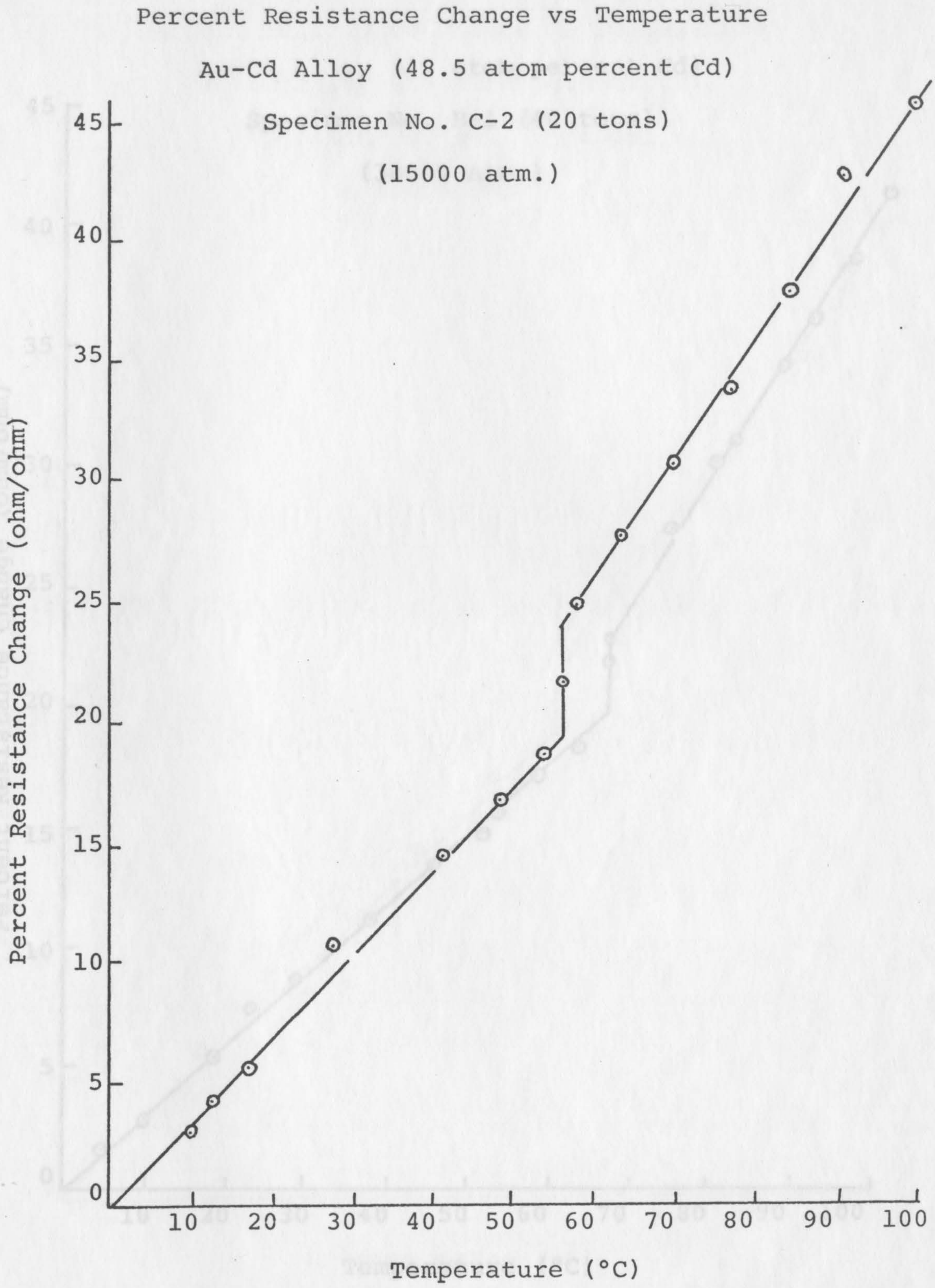

Fig. 8. Resistance change as a function of Temperature for Au-Cd alloy (48.5 atom percent Cd) (Specimen No. C-2) at 20 tons.

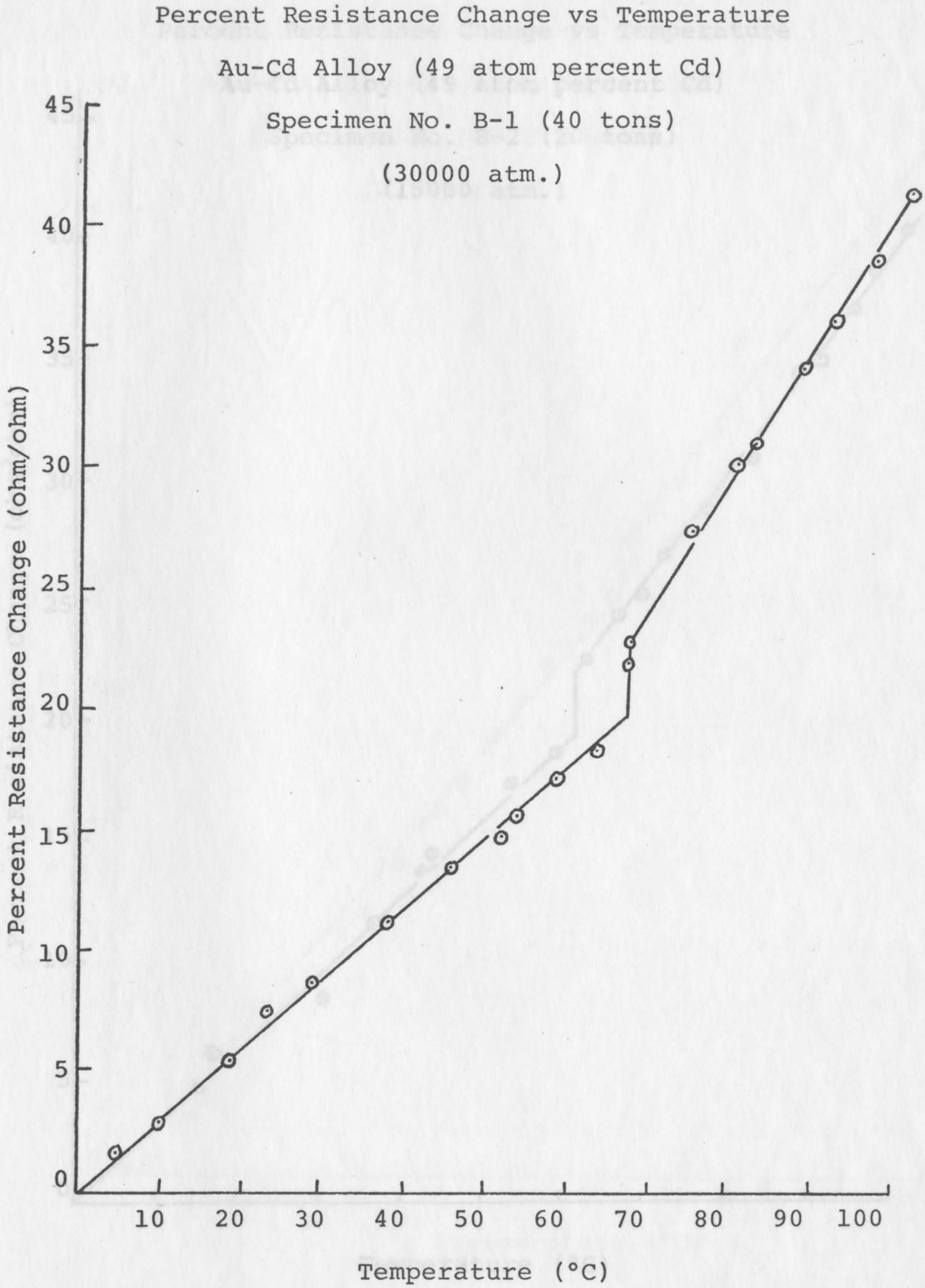

Fig. 9. Resistance change as a function of Temperature for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-1) at 40 tons.

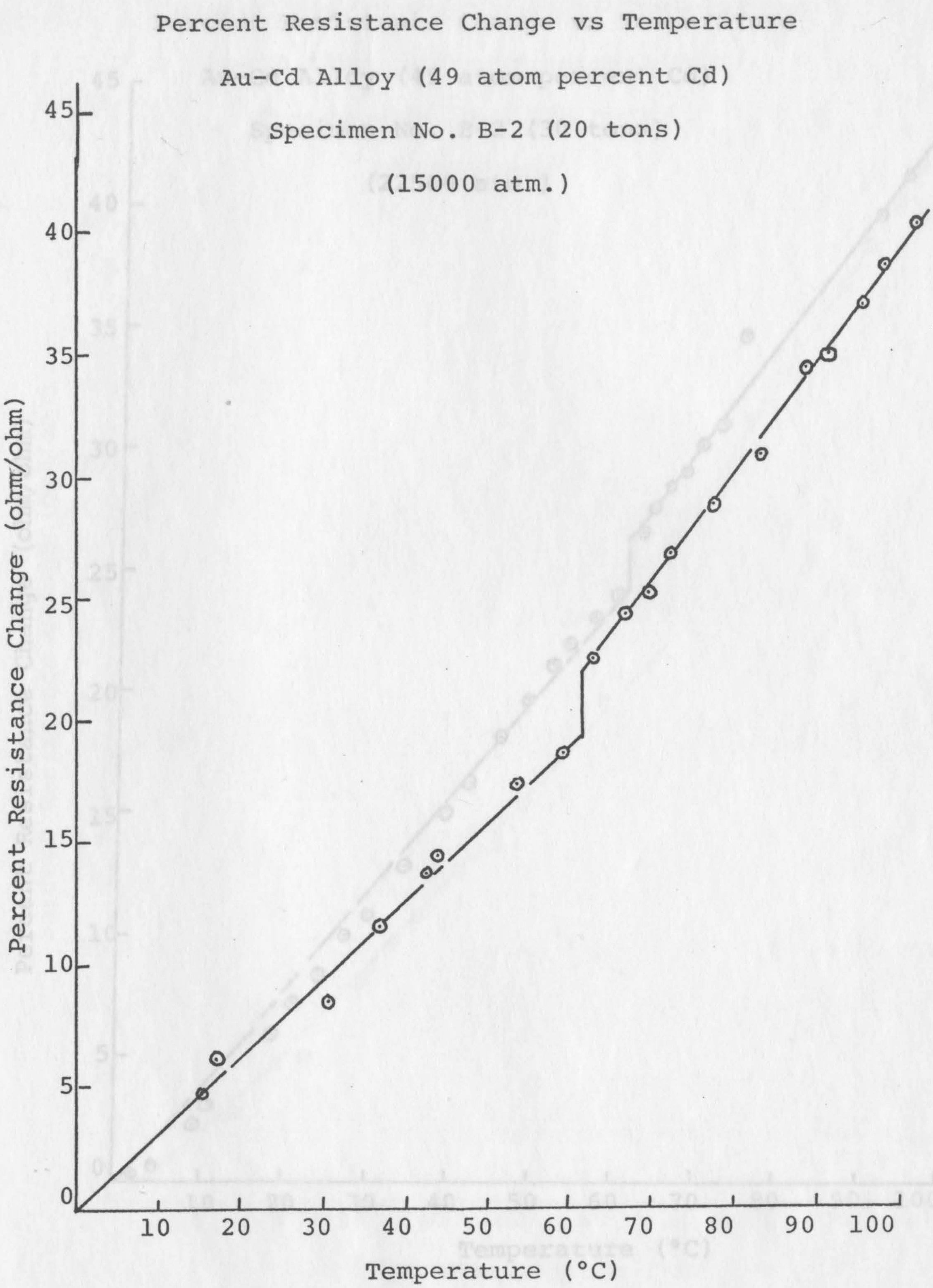

Fig. 10. Resistance change as a function of Temperature for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-2) at 20 tons.

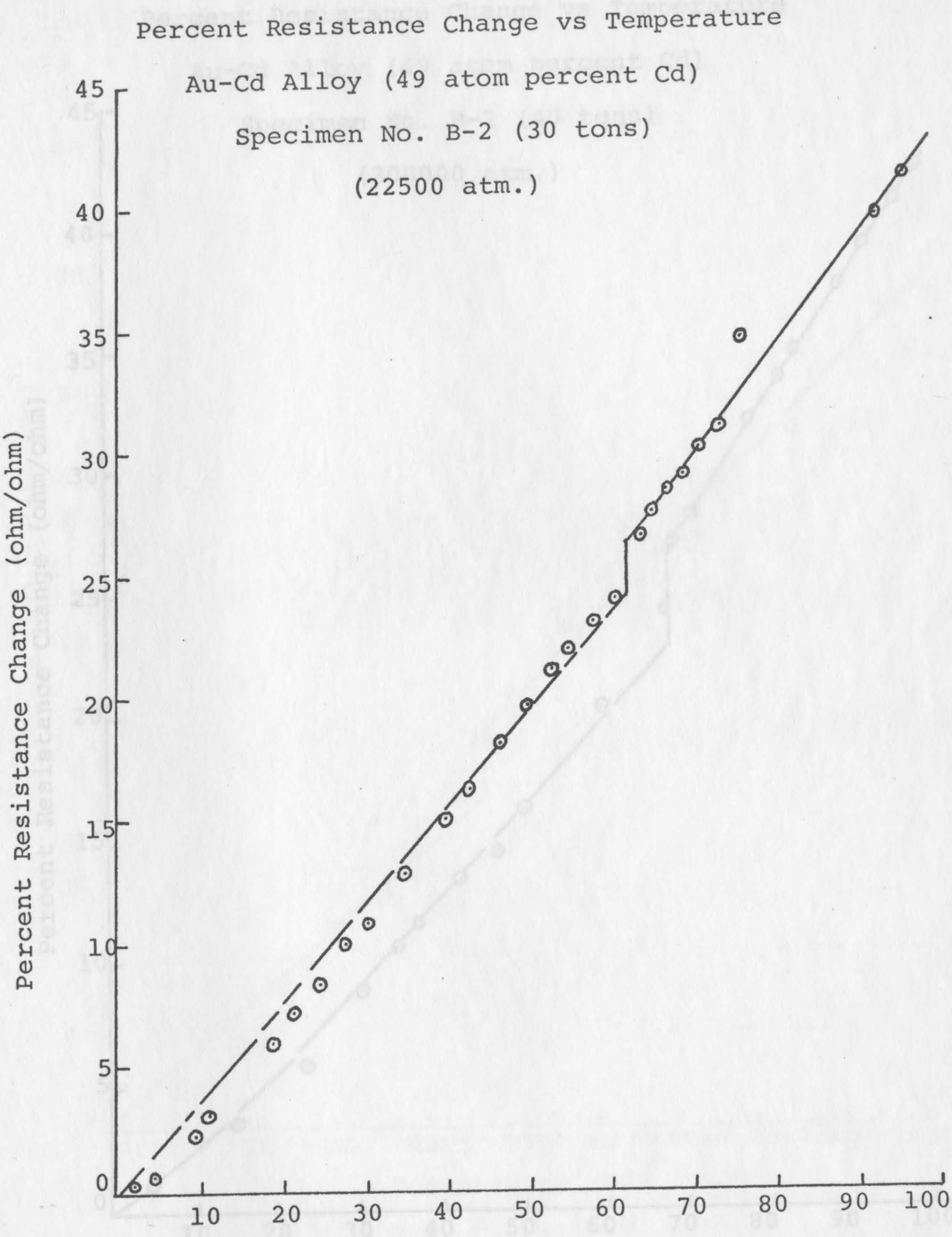

Fig. 11. Resistance change as a function of Temperature for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-2) at 30 tons.

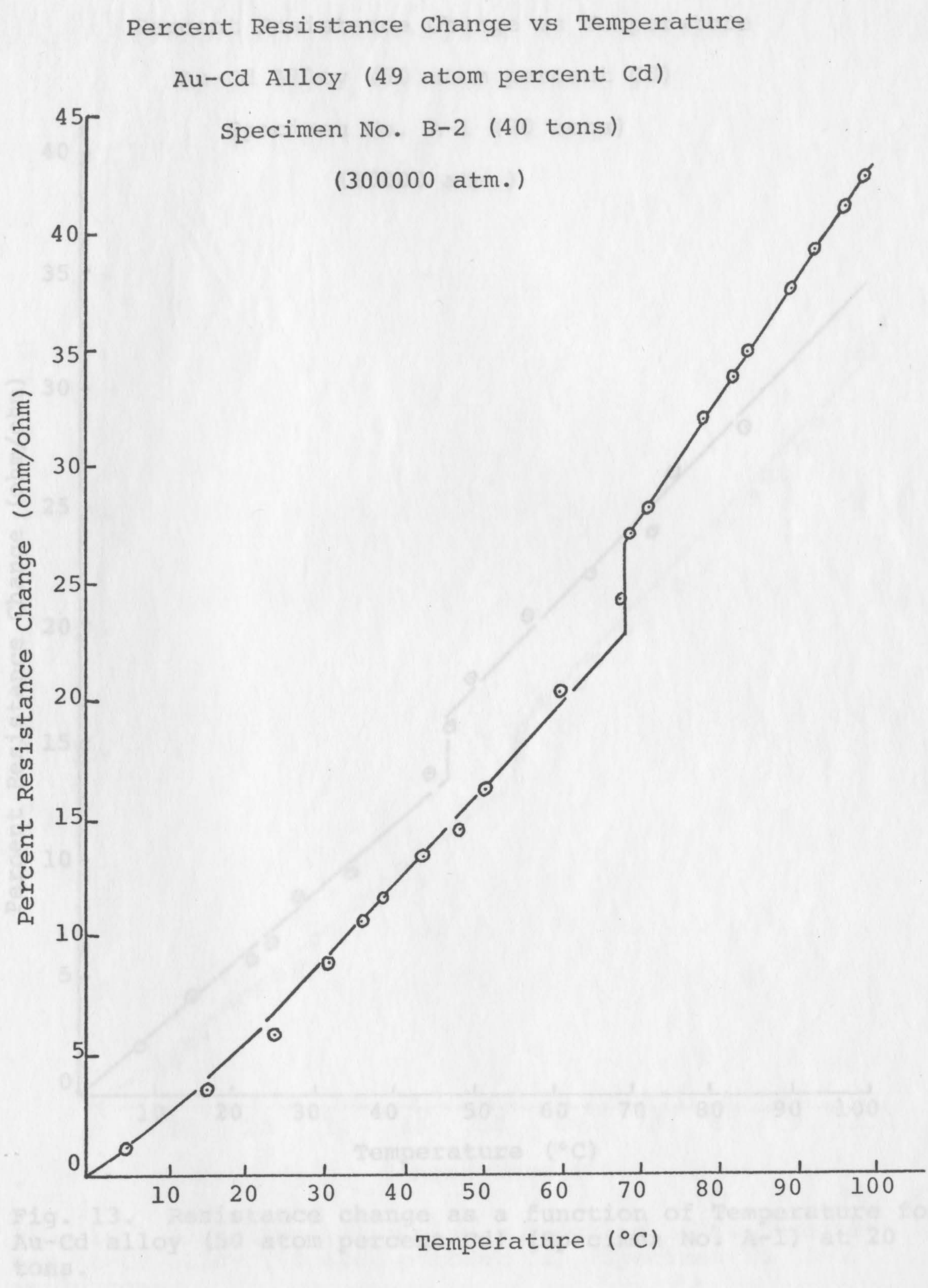

Fig. 12. Resistance change as a function of Temperature for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-2) at 40 tons.

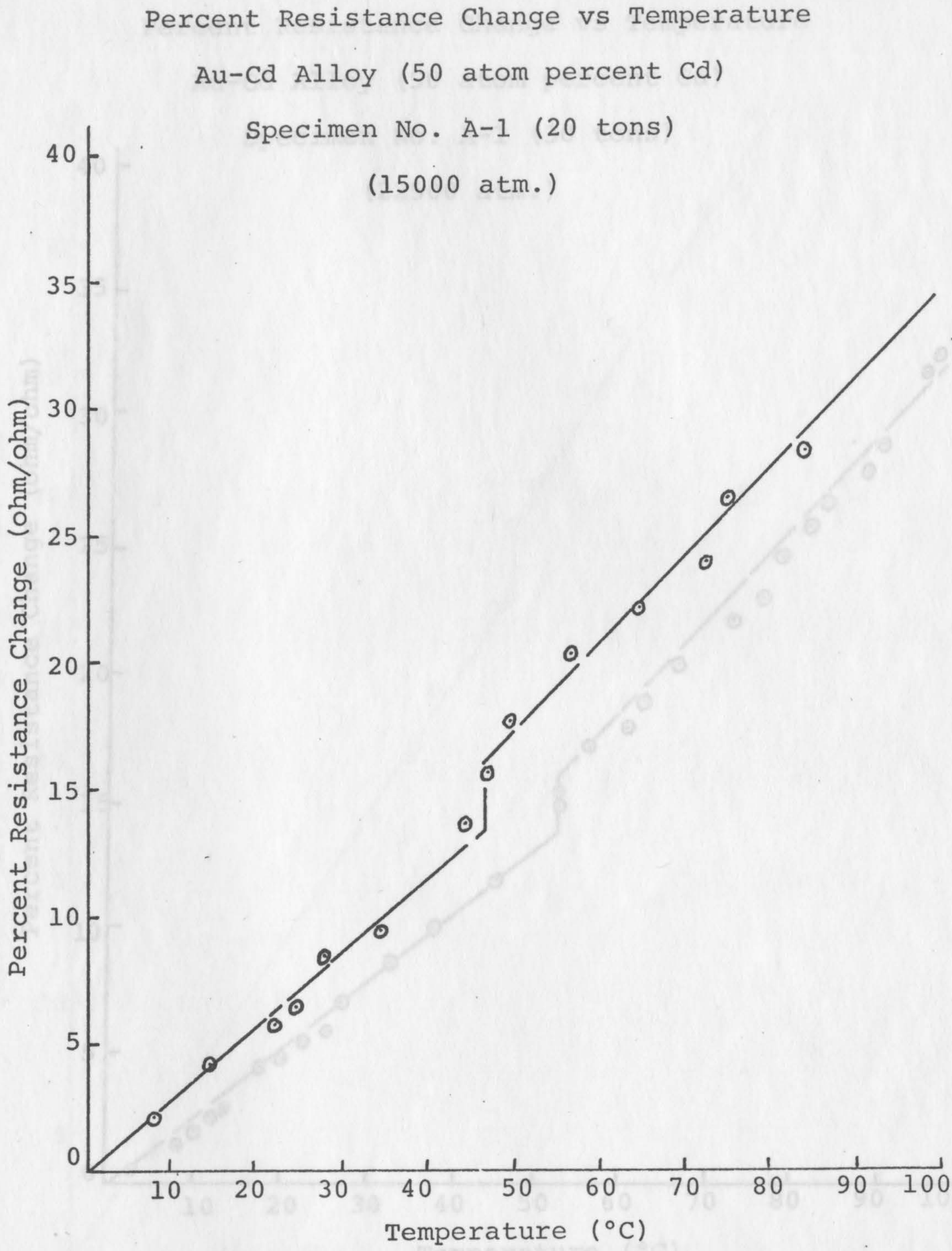

Fig. 13. Resistance change as a function of Temperature for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-1) at 20 tons.

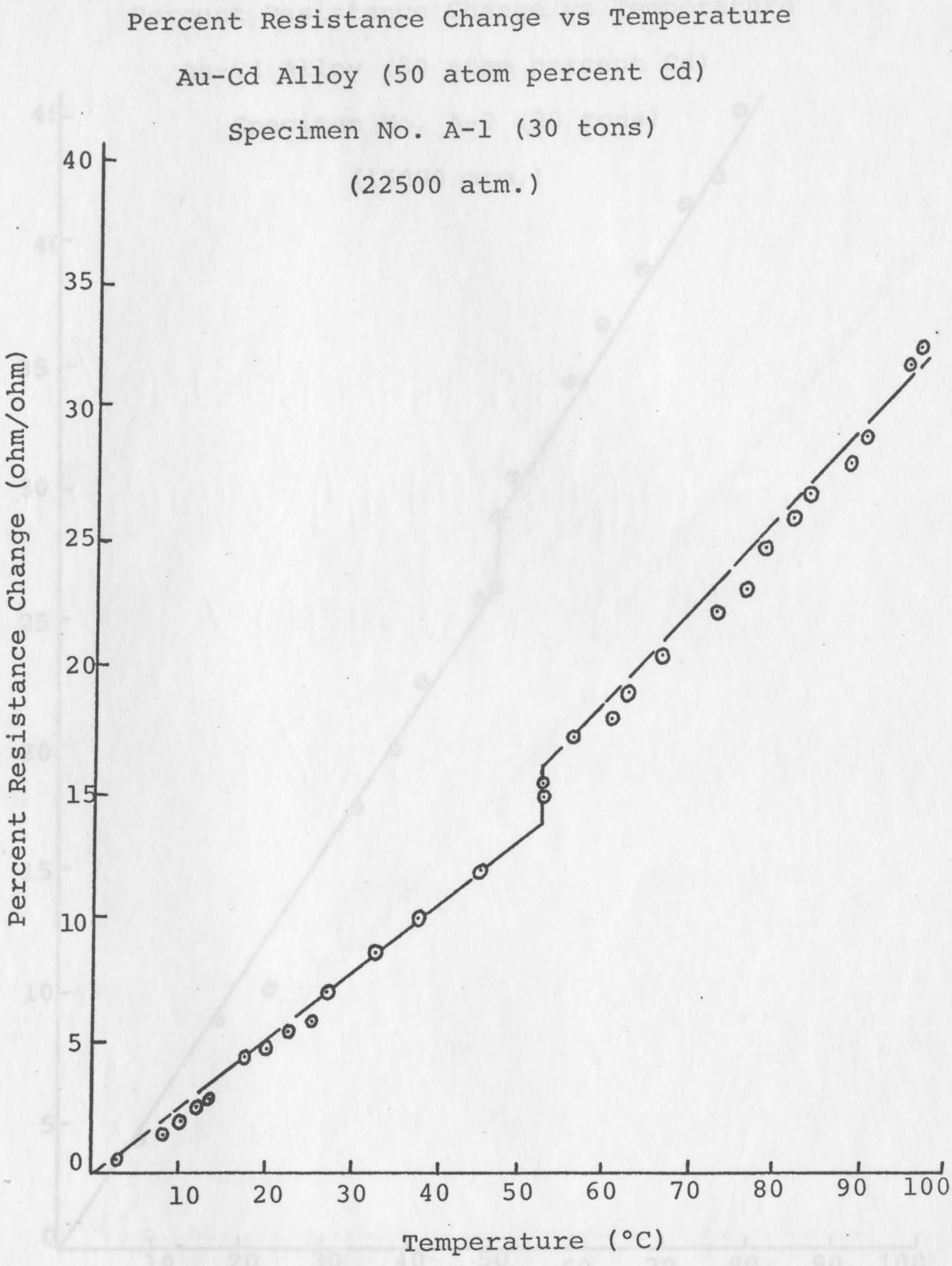

Fig. 14. Resistance change as a function of Temperature for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-1) at 30 tons.

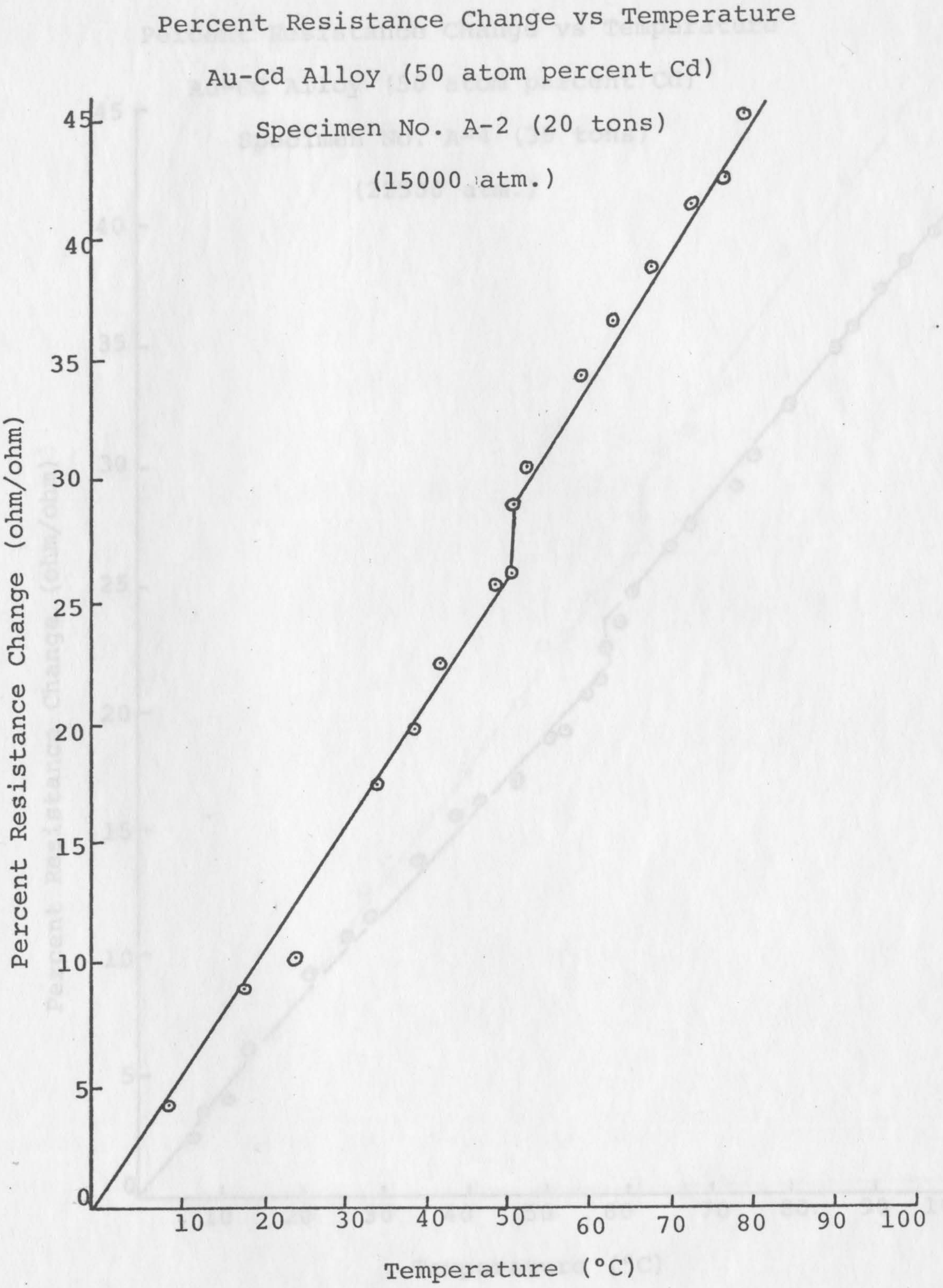

Fig. 15. Resistance change as a function of Temperature for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-2) at 20 tons.

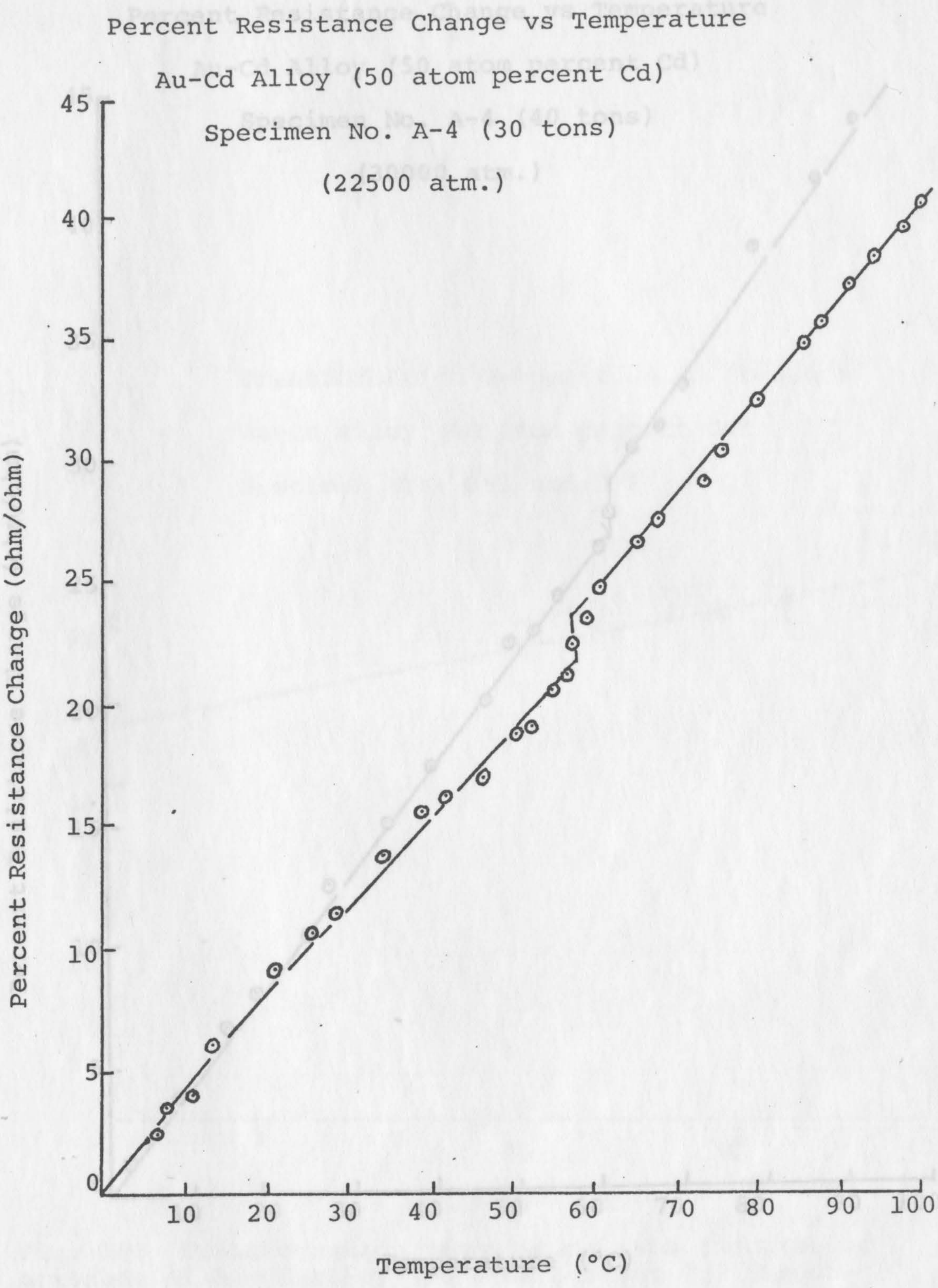

Fig. 16. Resistance change as a function of Temperature for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-4) at 30 tons.

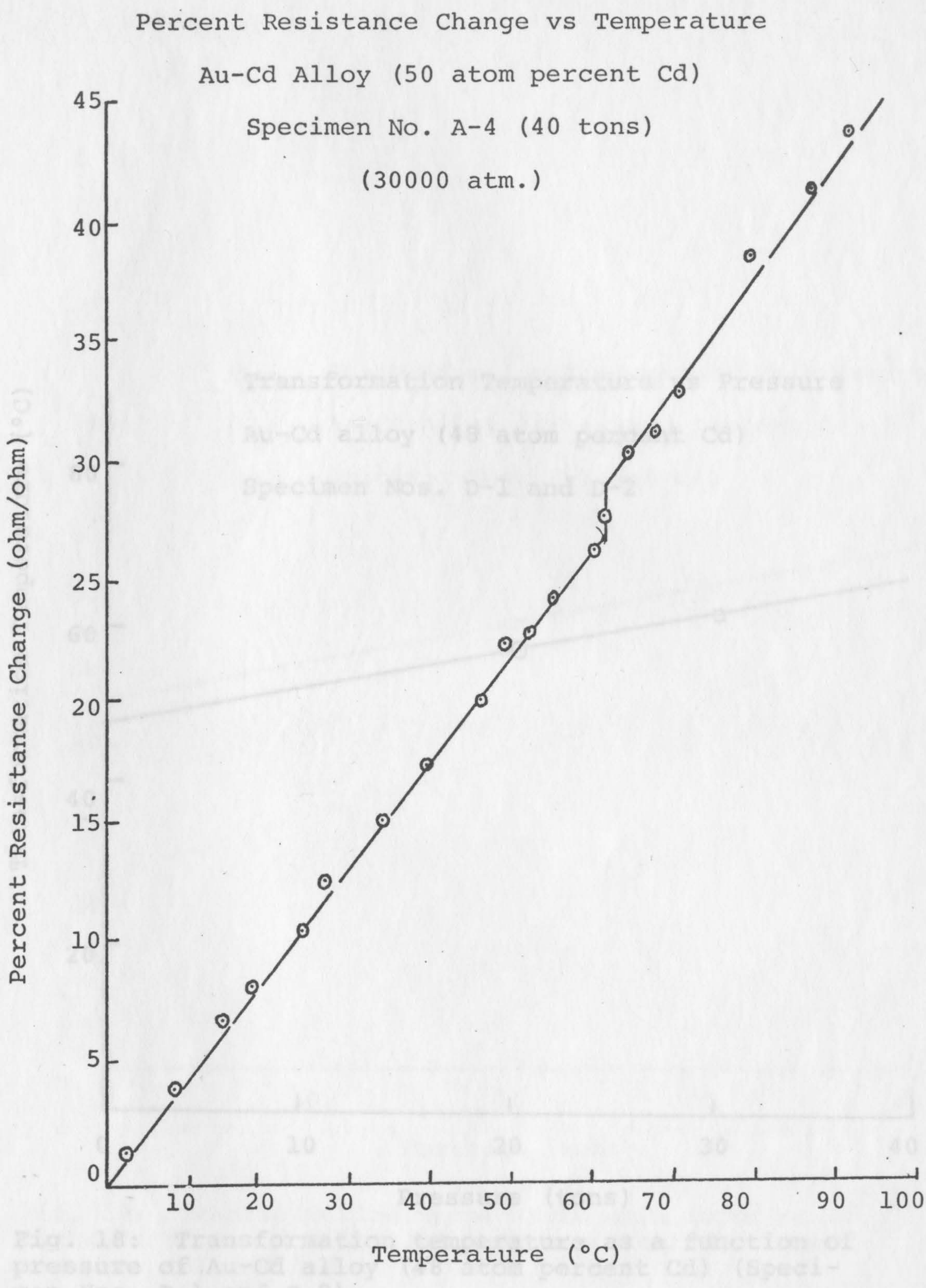

Fig. 17. Resistance change as a function of Temperature for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-4) at 40 tons.

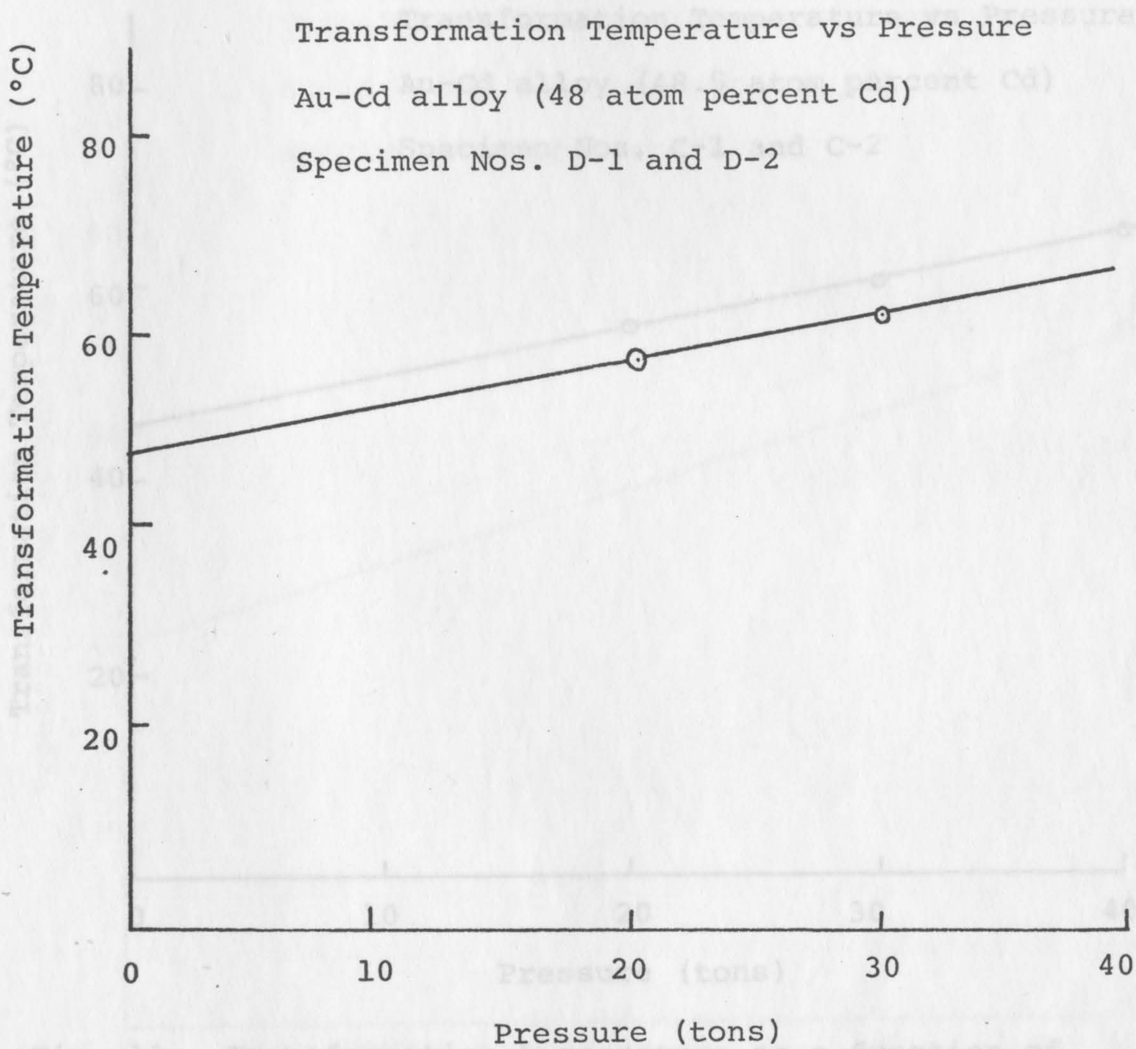

Fig. 18: Transformation temperature as a function of pressure of Au-Cd alloy (48 atom percent Cd) (Specimen Nos. D-1 and D-2).

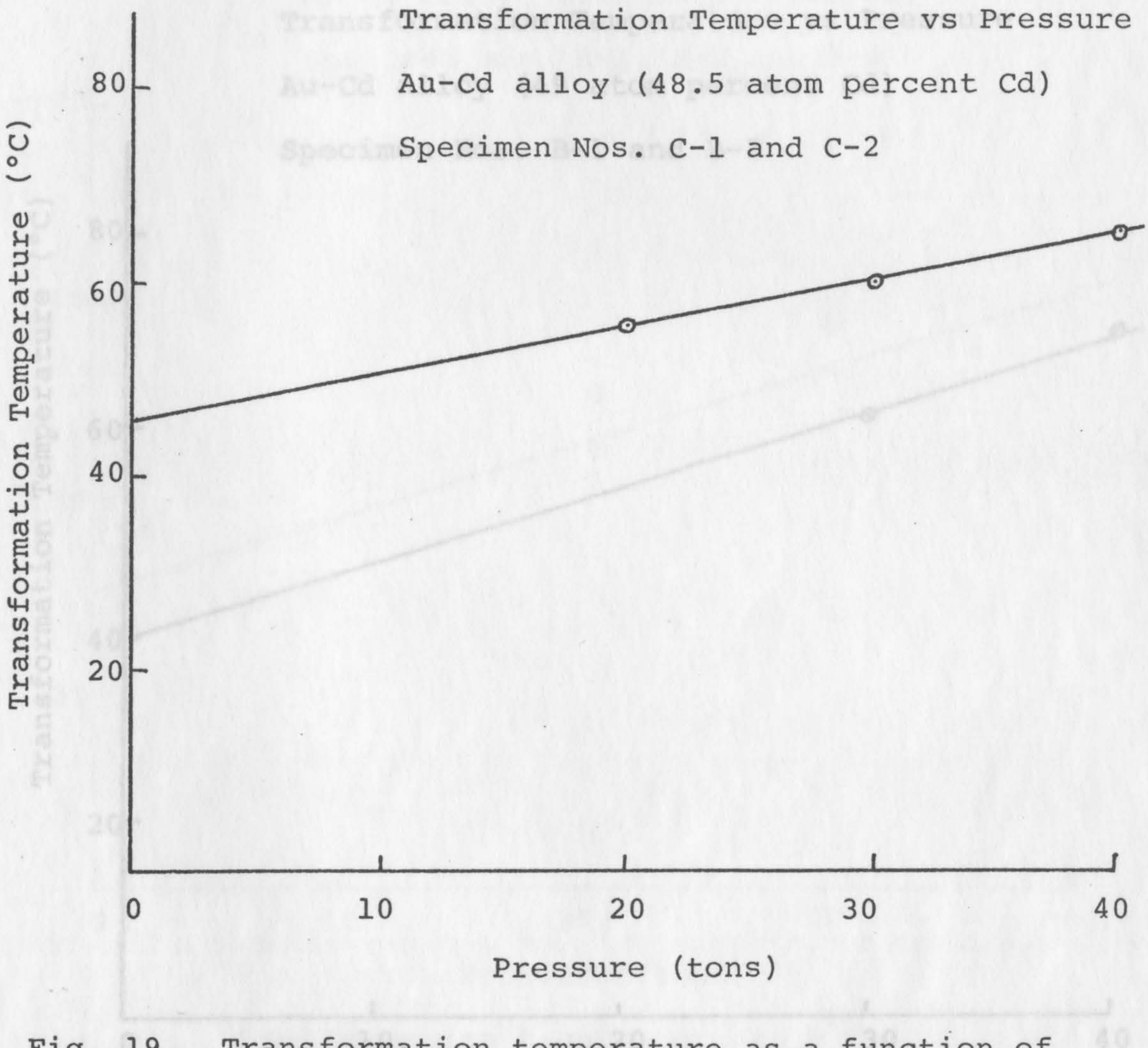

Fig. 19. Transformation temperature as a function of pressure of Au-Cd alloy (48.5 atom percent Cd) (Specimen Nos. C-1 and C-2).

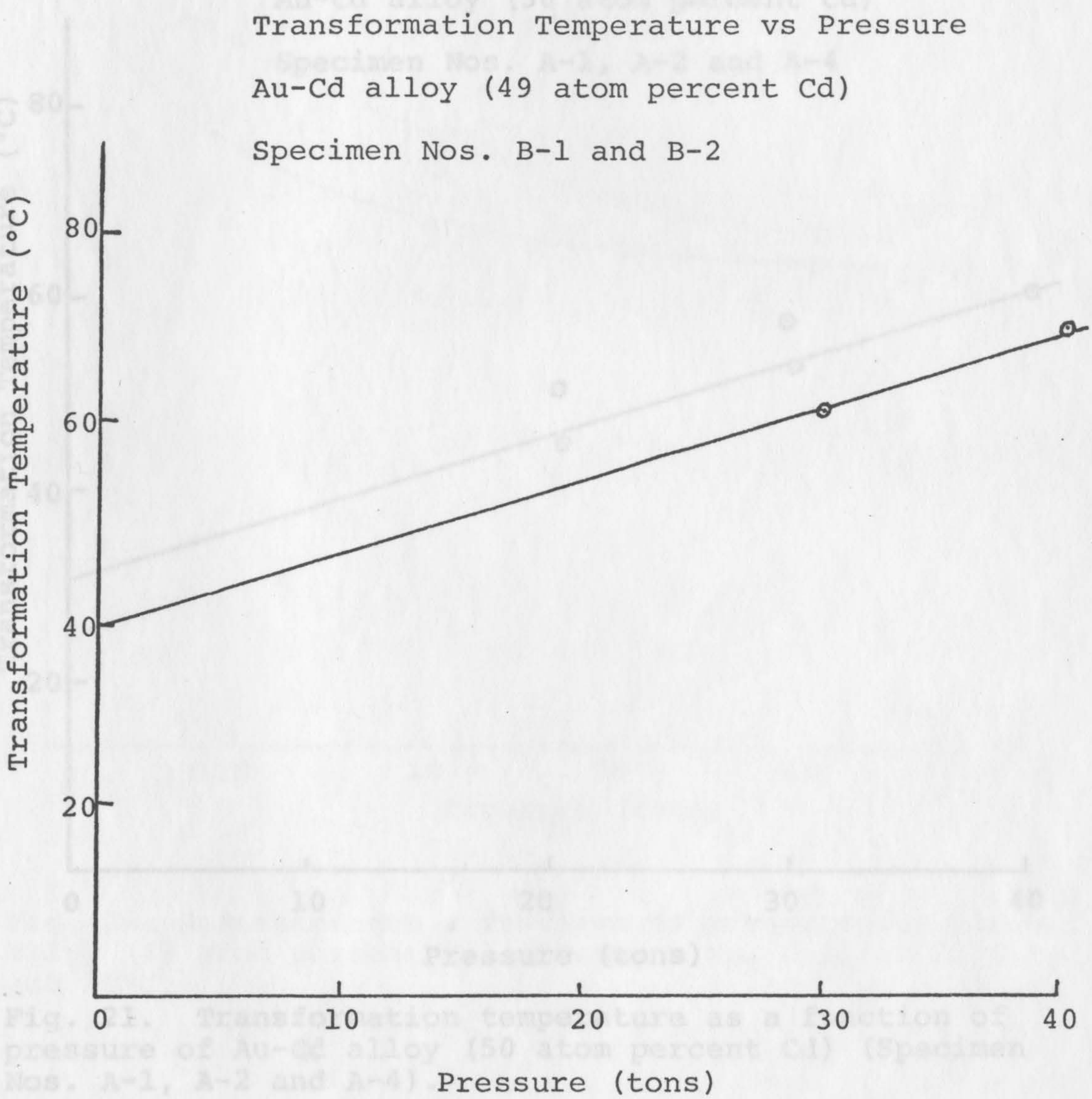

Fig. 20. Transformation temperature as a function of pressure of Au-Cd alloy (49 atom percent Cd) (Specimen Nos. B-1 and B-2).

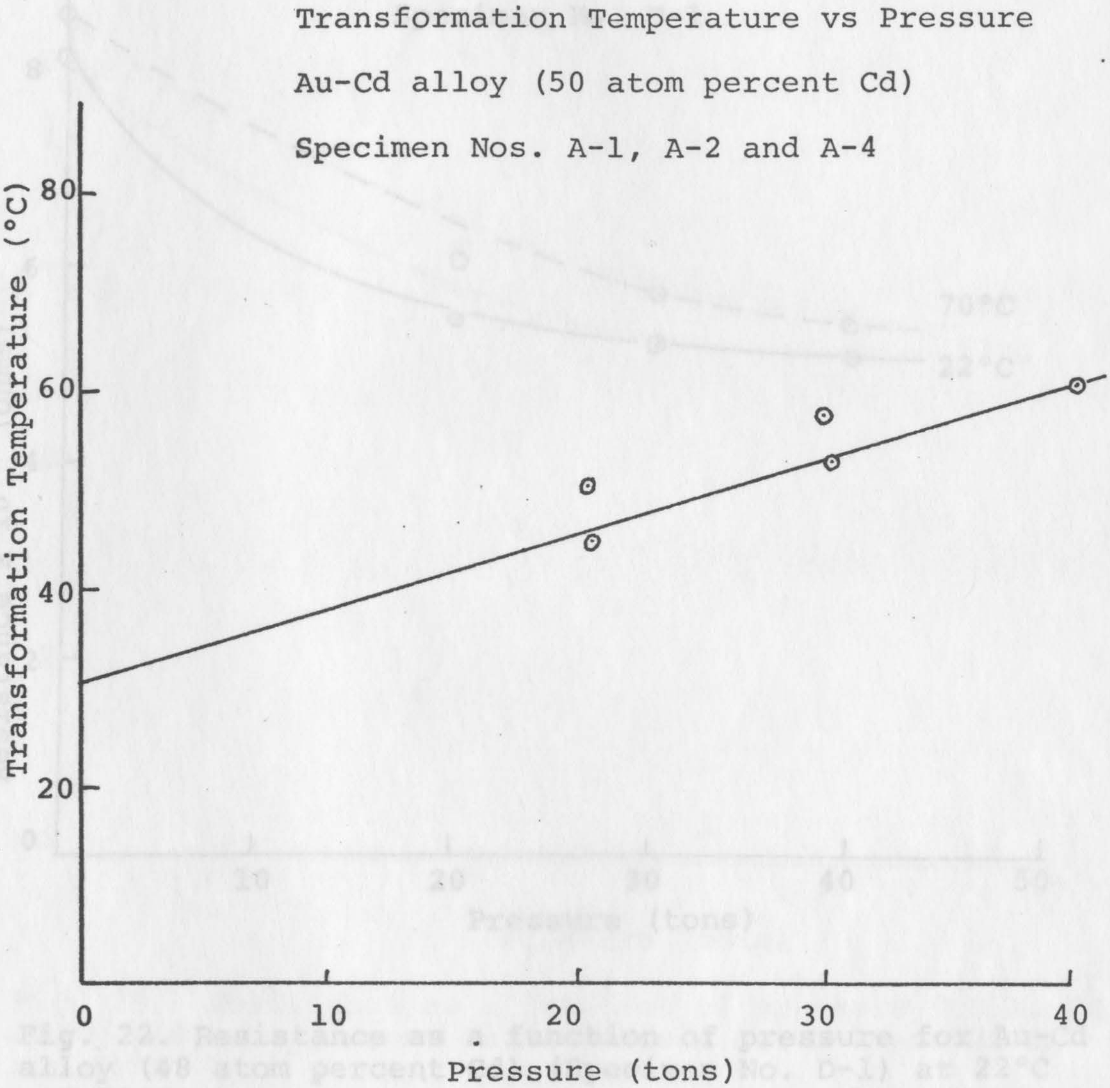

Fig. 21. Transformation temperature as a function of pressure of Au-Cd alloy (50 atom percent Cd) (Specimen Nos. A-1, A-2 and A-4).

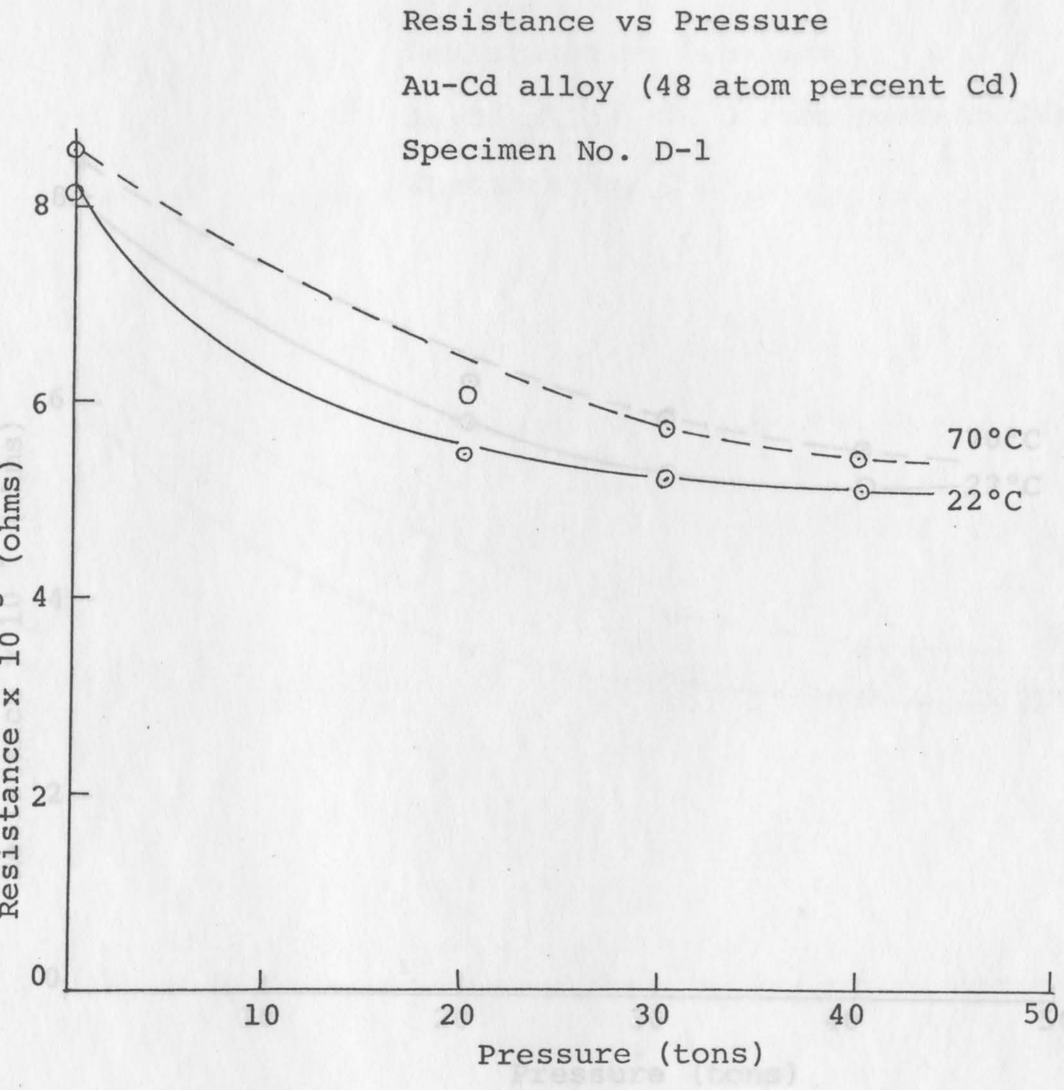

Fig. 22. Resistance as a function of pressure for Au-Cd alloy (48 atom percent Cd) (Specimen No. D-1) at 22°C and 70°C.

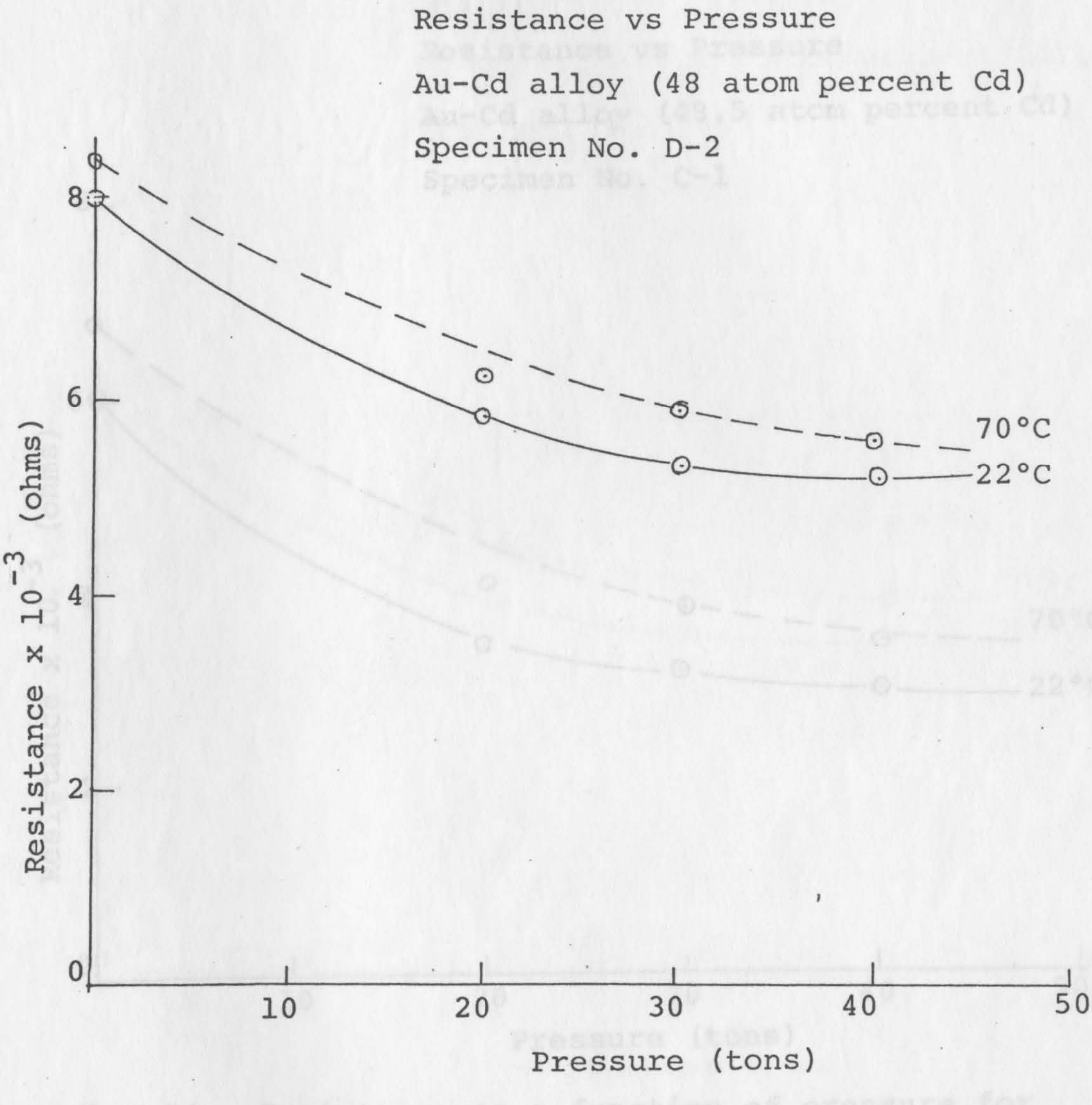

Fig. 23. Resistance as a function of pressure for Au-Cd alloy (48 atom percent Cd) (Specimen No. D-2) at 22°C and 70°C.

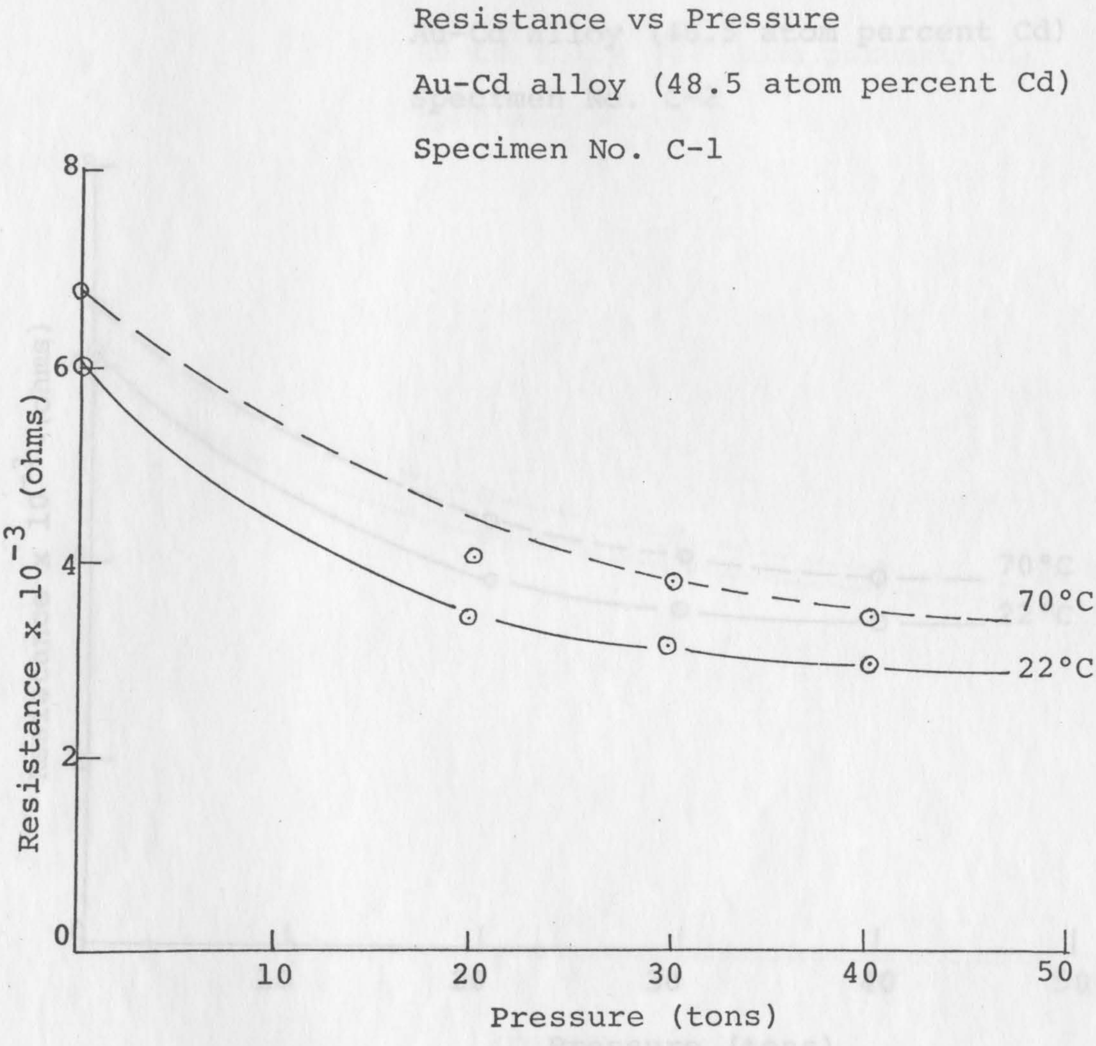

Fig. 24. Resistance as a function of pressure for Au-Cd alloy (48.5 atom percent Cd) (Specimen No. C-1) at 22°C and 70°C.

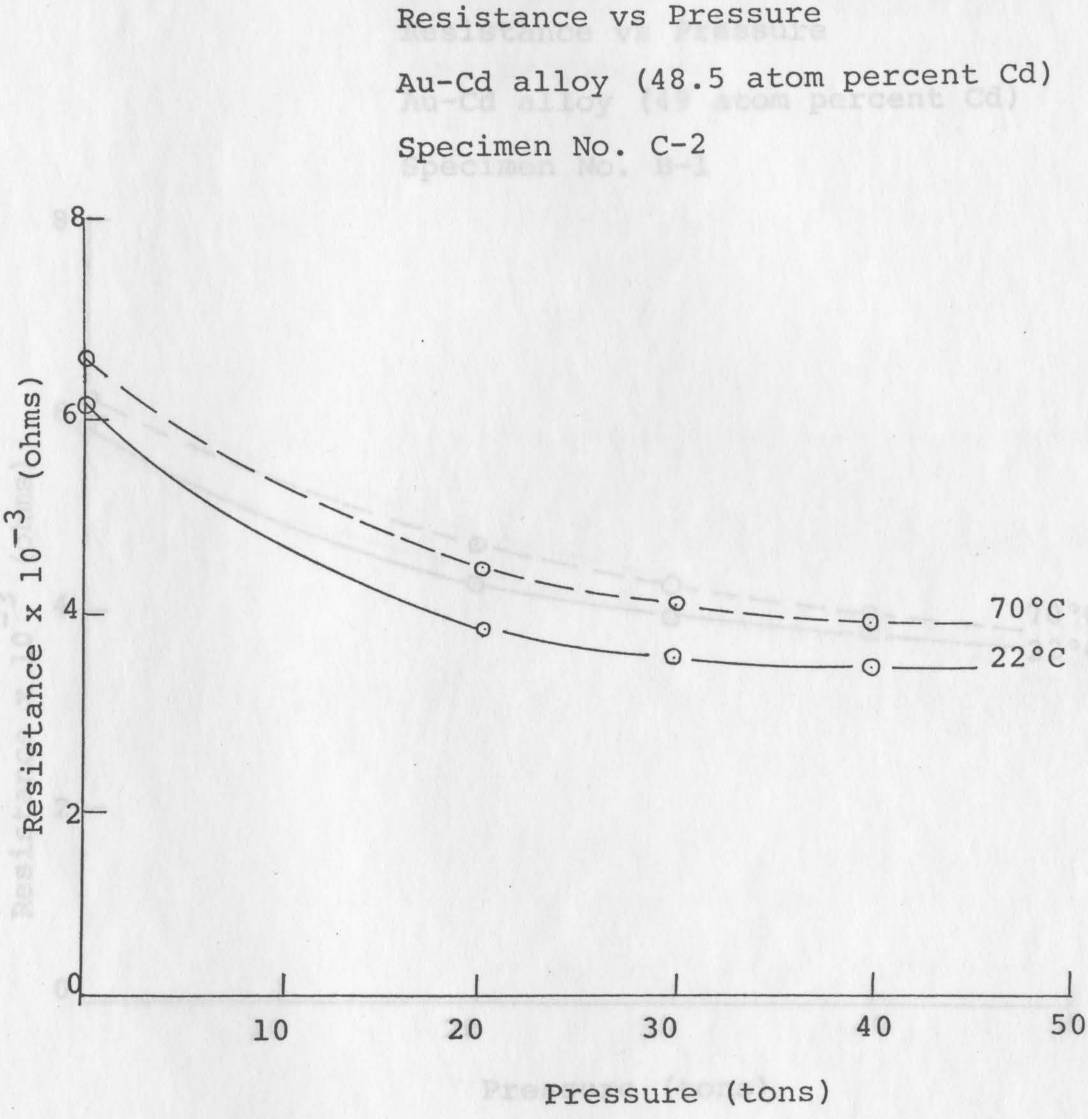

Fig. 25. Resistance as a function of pressure for Au-Cd alloy (48.5 atom percent Cd) (Specimen No. C-2) at 22°C and 70°C.

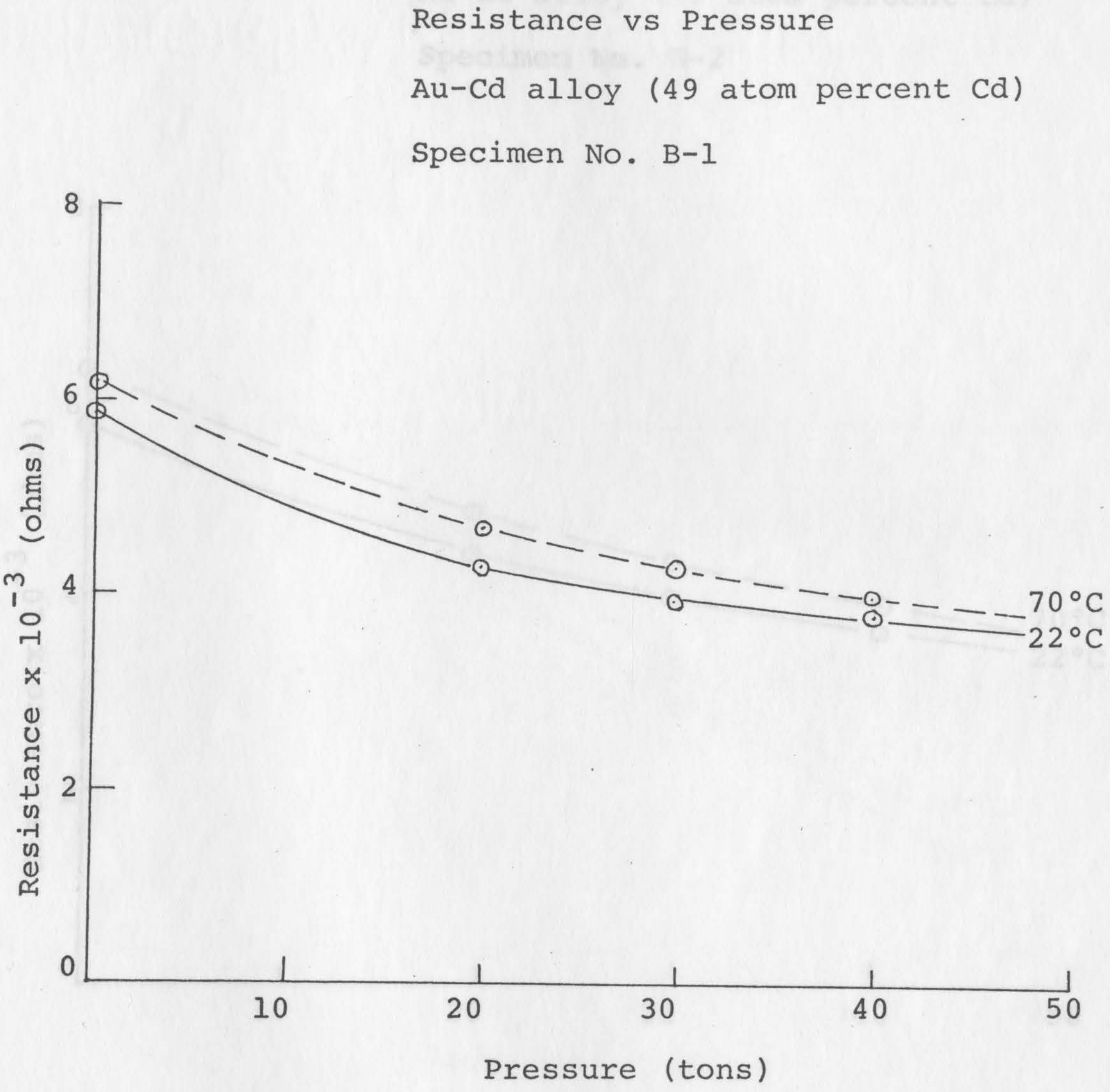

Fig. 26. Resistance as a function of pressure for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-1) at 22°C and 70°C.

Resistance vs Pressure

Au-Cd alloy (49 atom percent Cd)

Specimen No. B-2

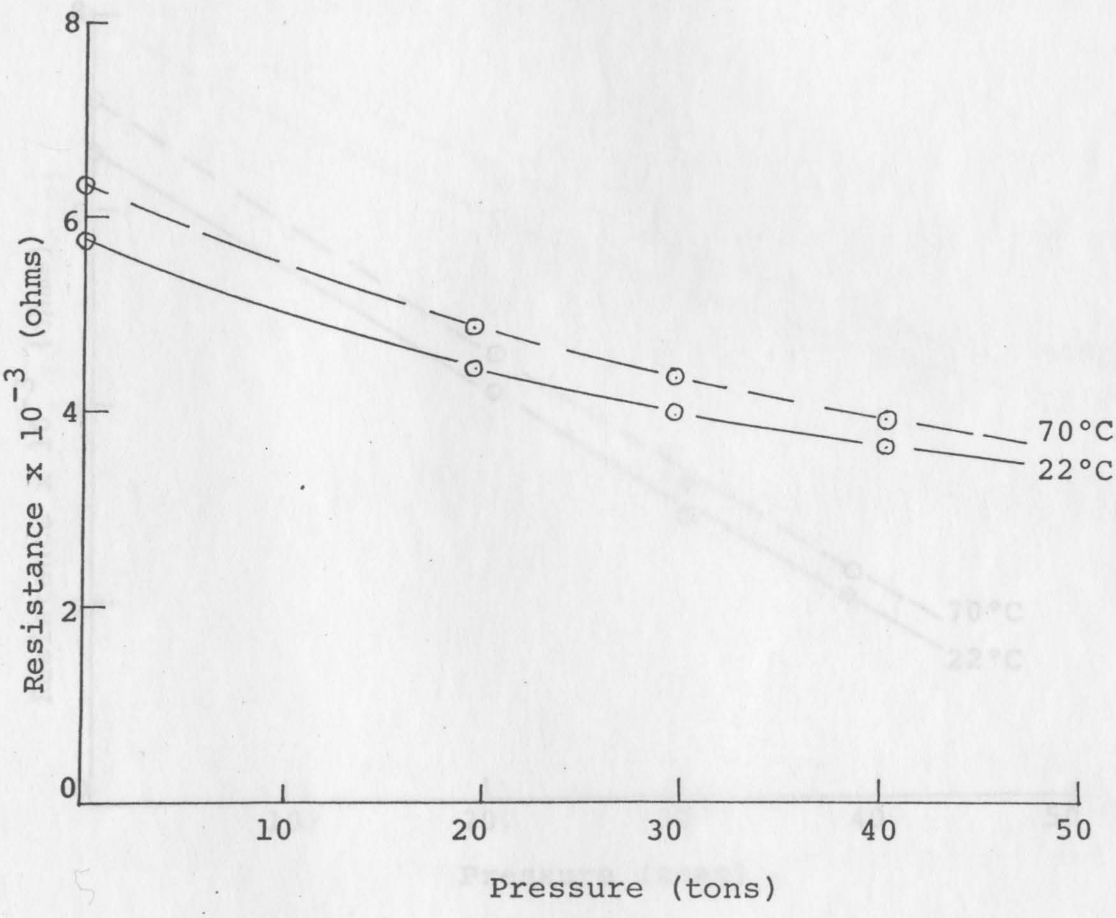

Fig. 27. Resistance as a function of pressure for Au-Cd alloy (49 atom percent Cd) (Specimen No. B-2) at 22°C and 70°C.

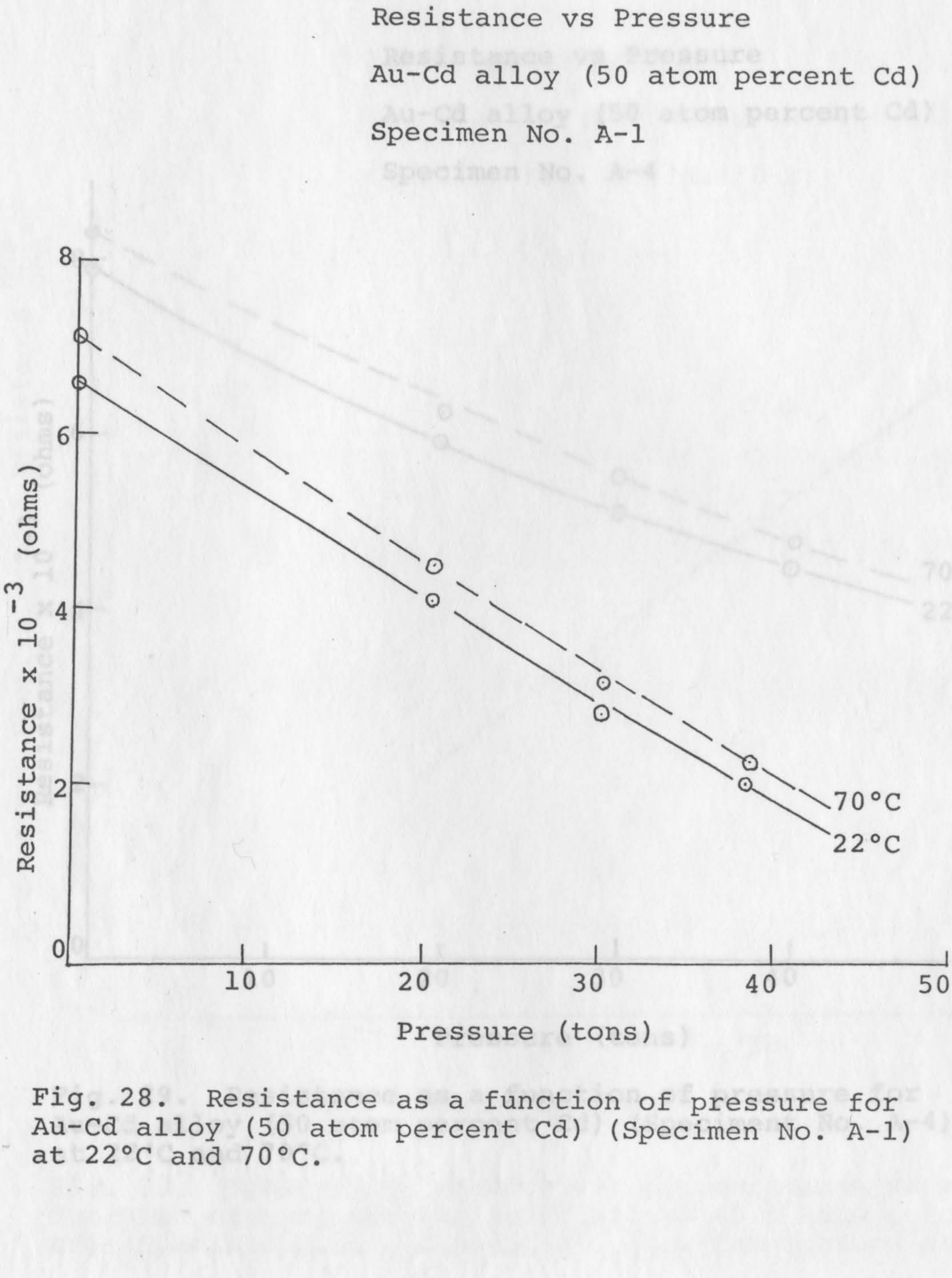

Fig. 28. Resistance as a function of pressure for Au-Cd alloy (50 atom percent Cd) (Specimen No. A-1) at 22°C and 70°C.

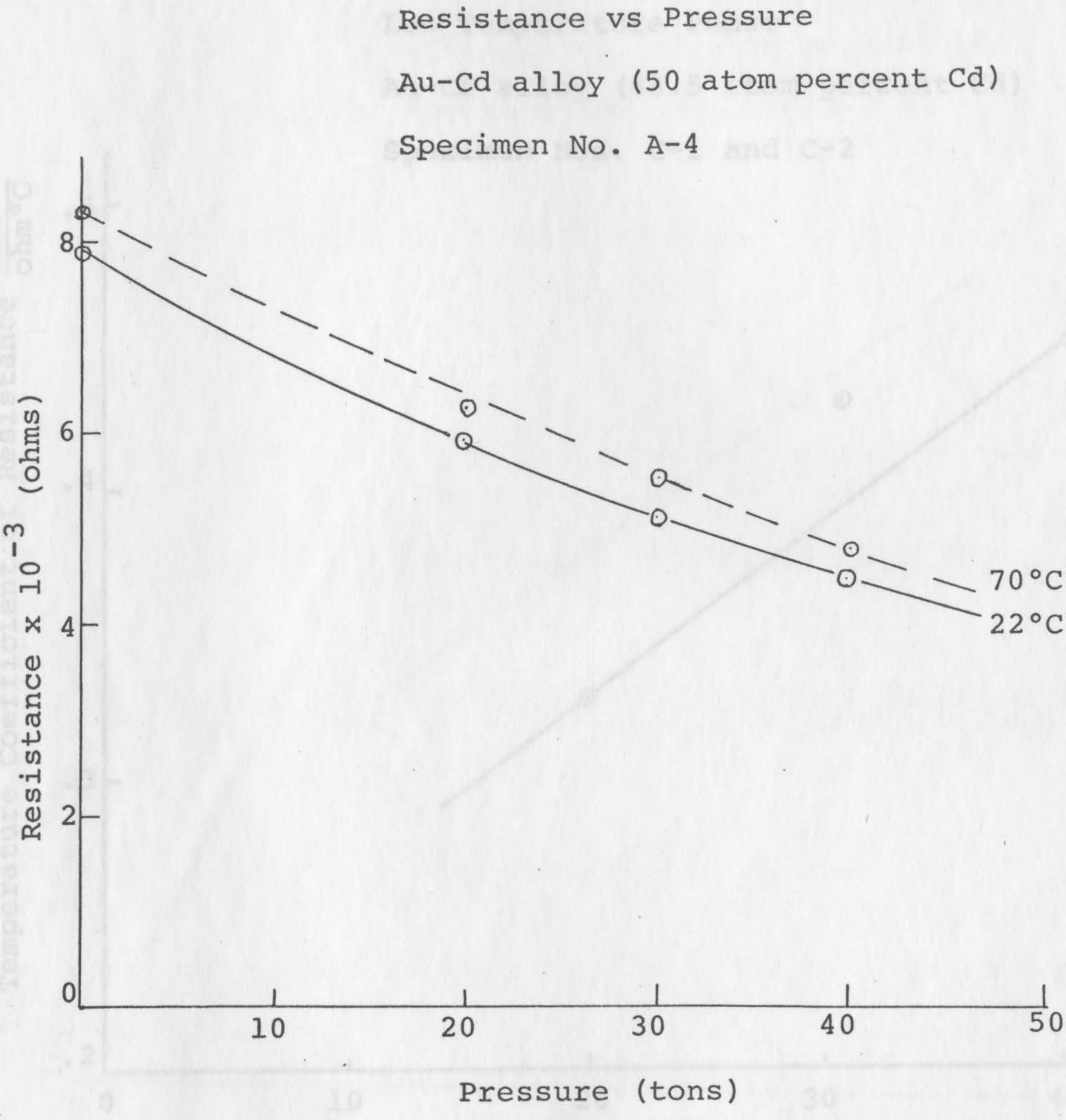

Fig. 29. Resistance as a function of pressure for Au-Cd alloy (50 atom percent Cd) (Speciment No. A-4) at 22°C and 70°C.

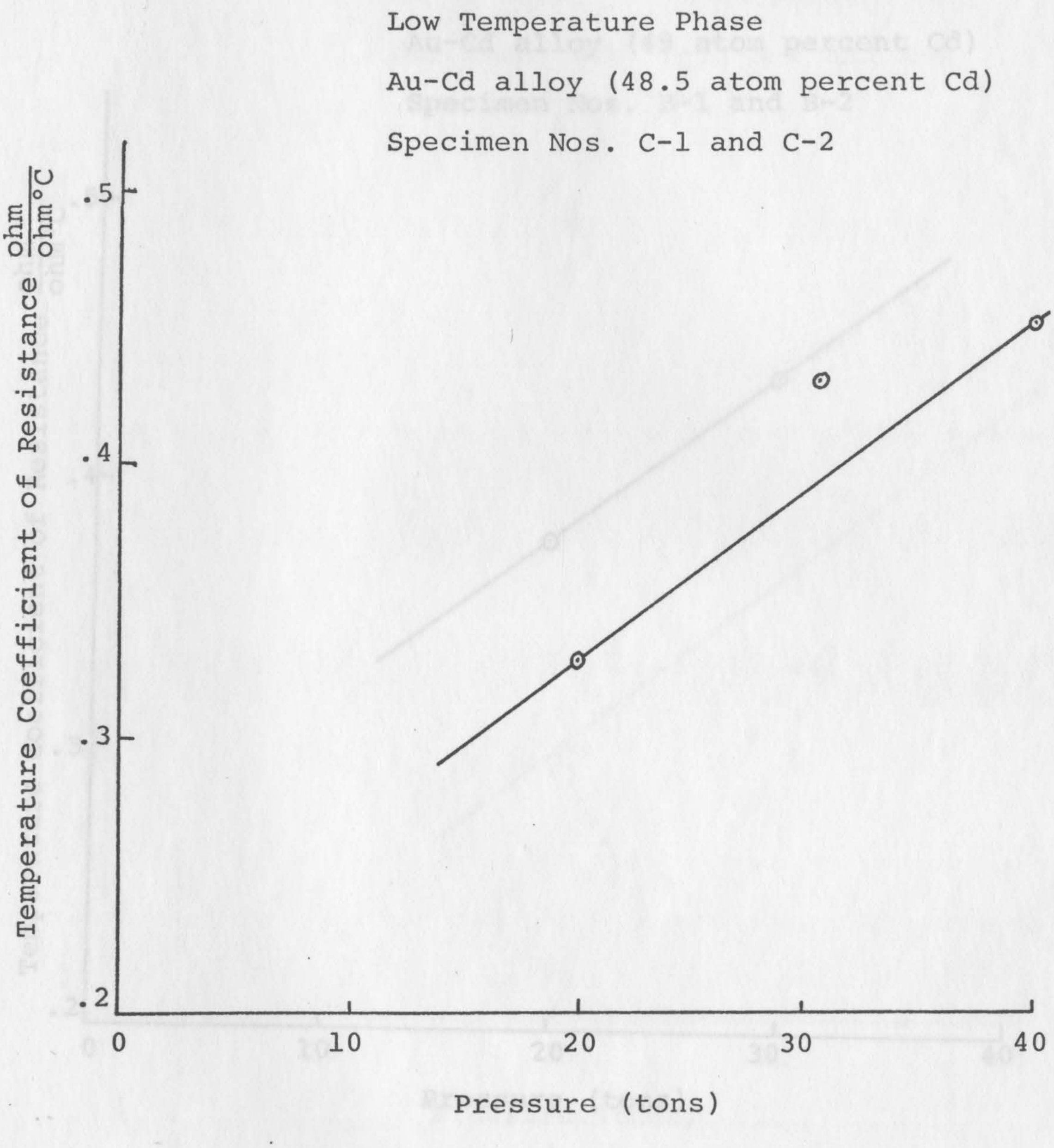

Fig. 30. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (48.5 atom percent Cd) (Specimen Nos. C-1 and C-2). (Low temperature phase)

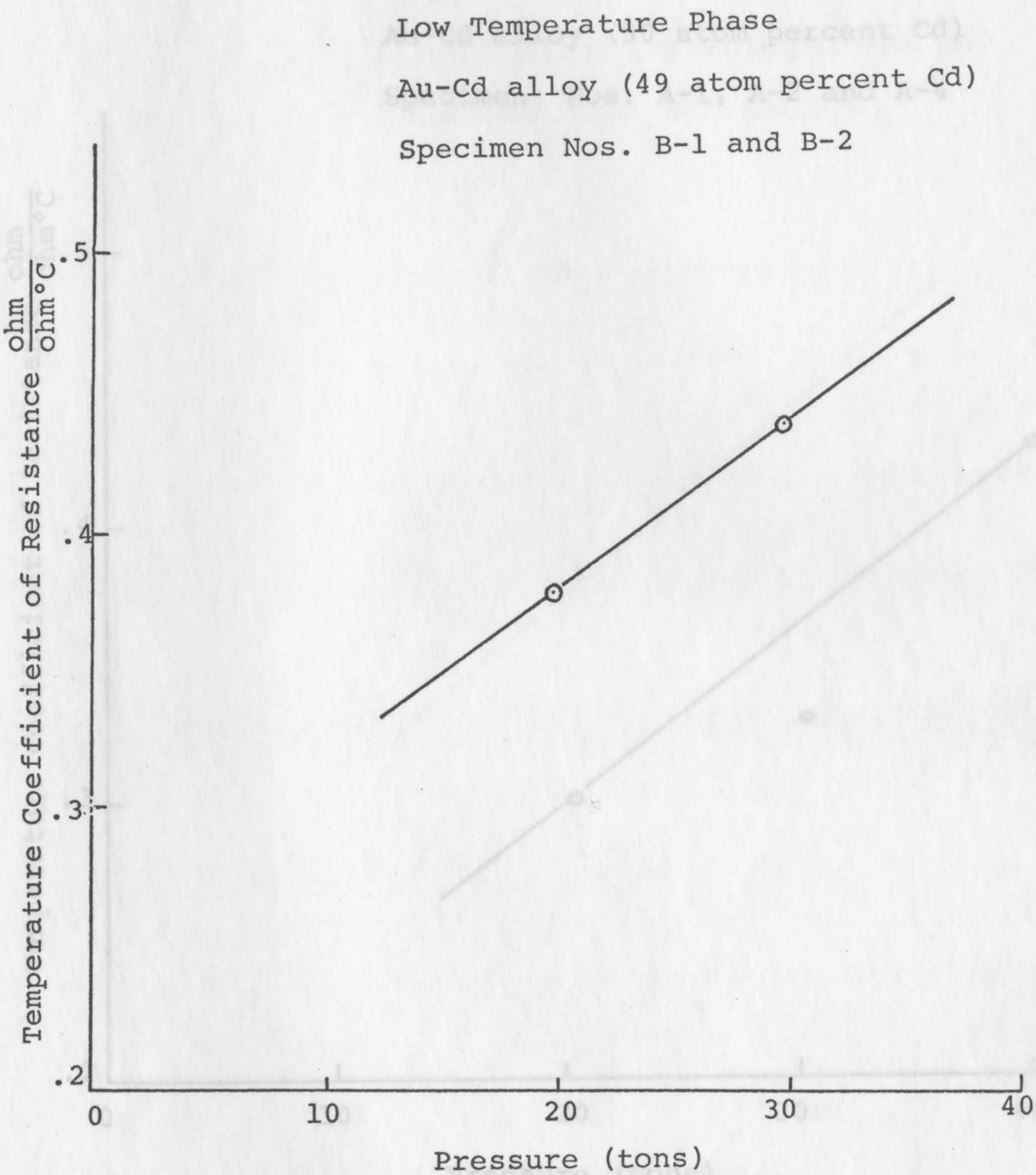

Fig. 31. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (49 atom percent Cd) (Specimen Nos. B-1 and B-2). (Low temperature phase)

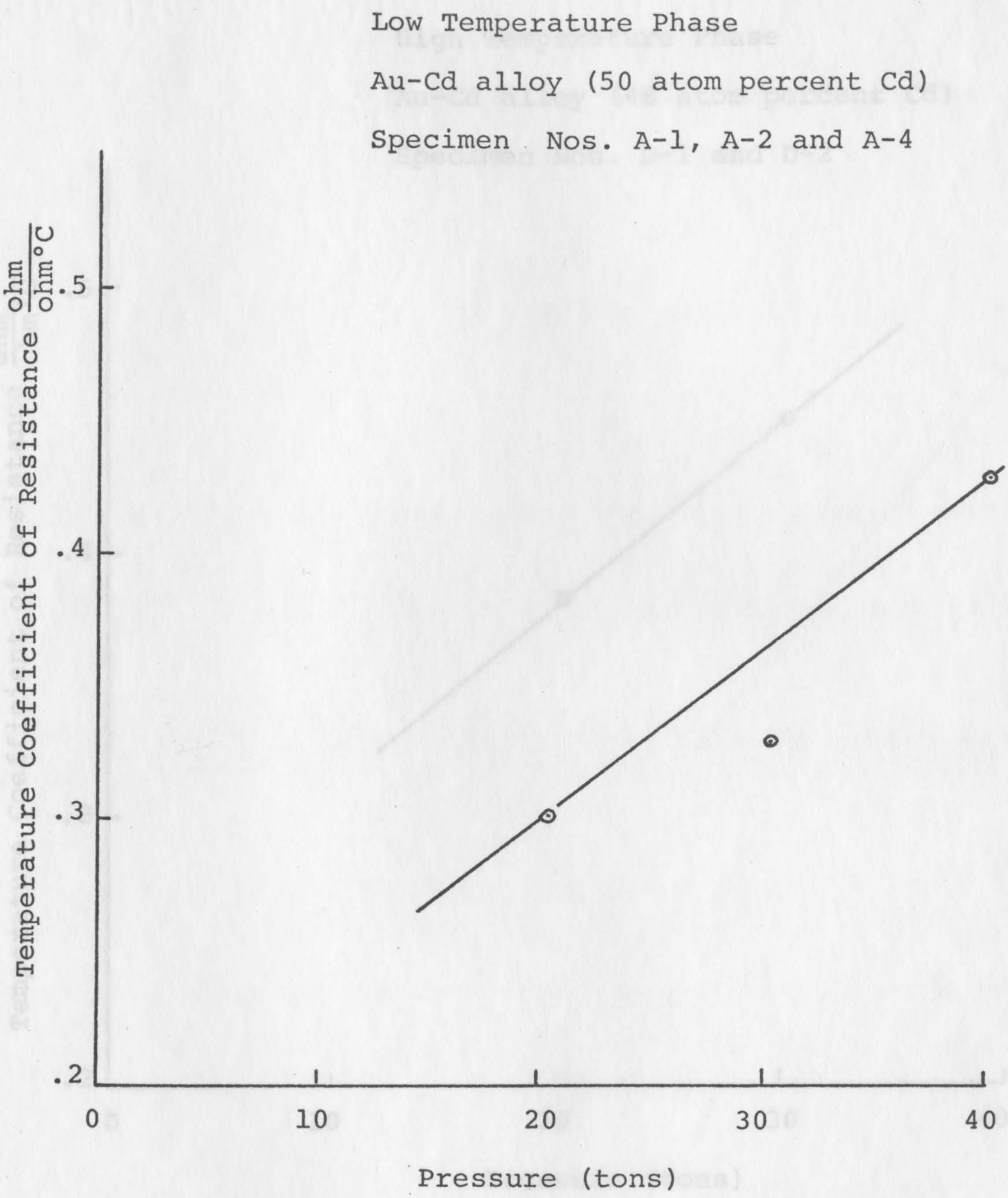

Fig. 32. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (50 atom percent Cd) (Specimen Nos. A-1, A-2 and A-4). (Low temperature phase)

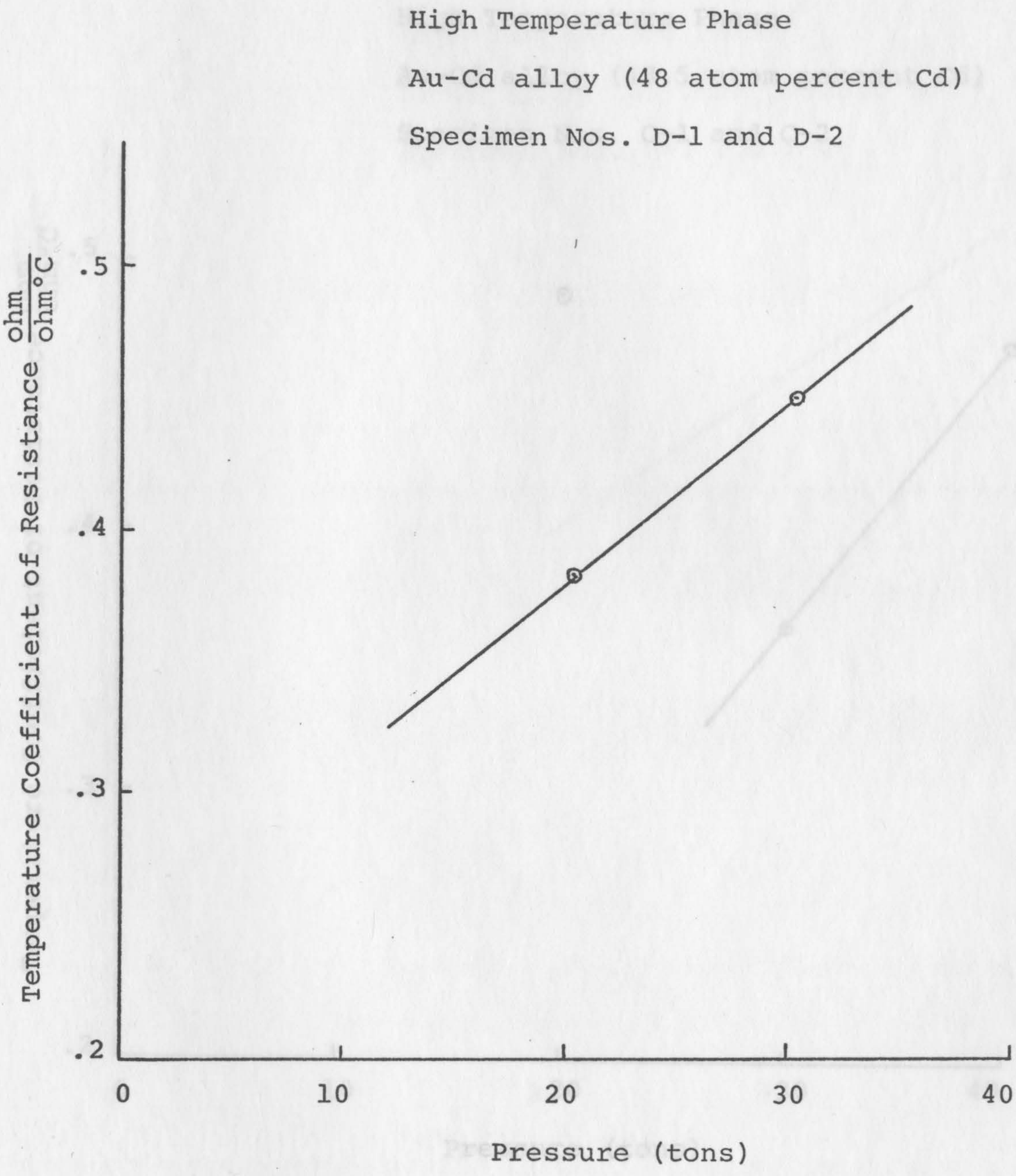

Fig. 33. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (48 atom percent Cd) (Specimen Nos. D-1 and D-2). (High temperature phase)

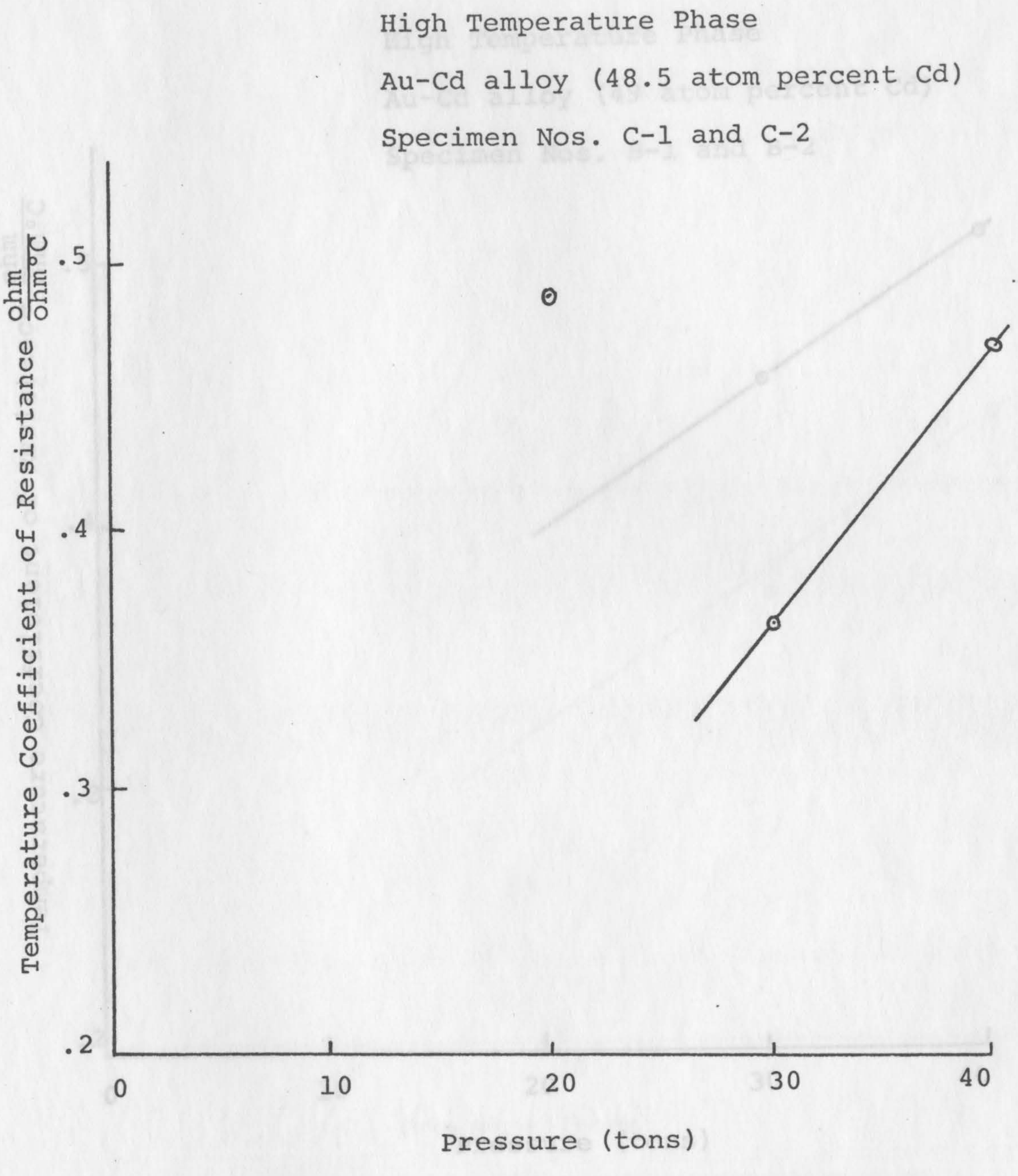

Fig. 34. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (48.5 atom percent Cd) (Specimen Nos. C-1 and C-2). (High temperature phase)

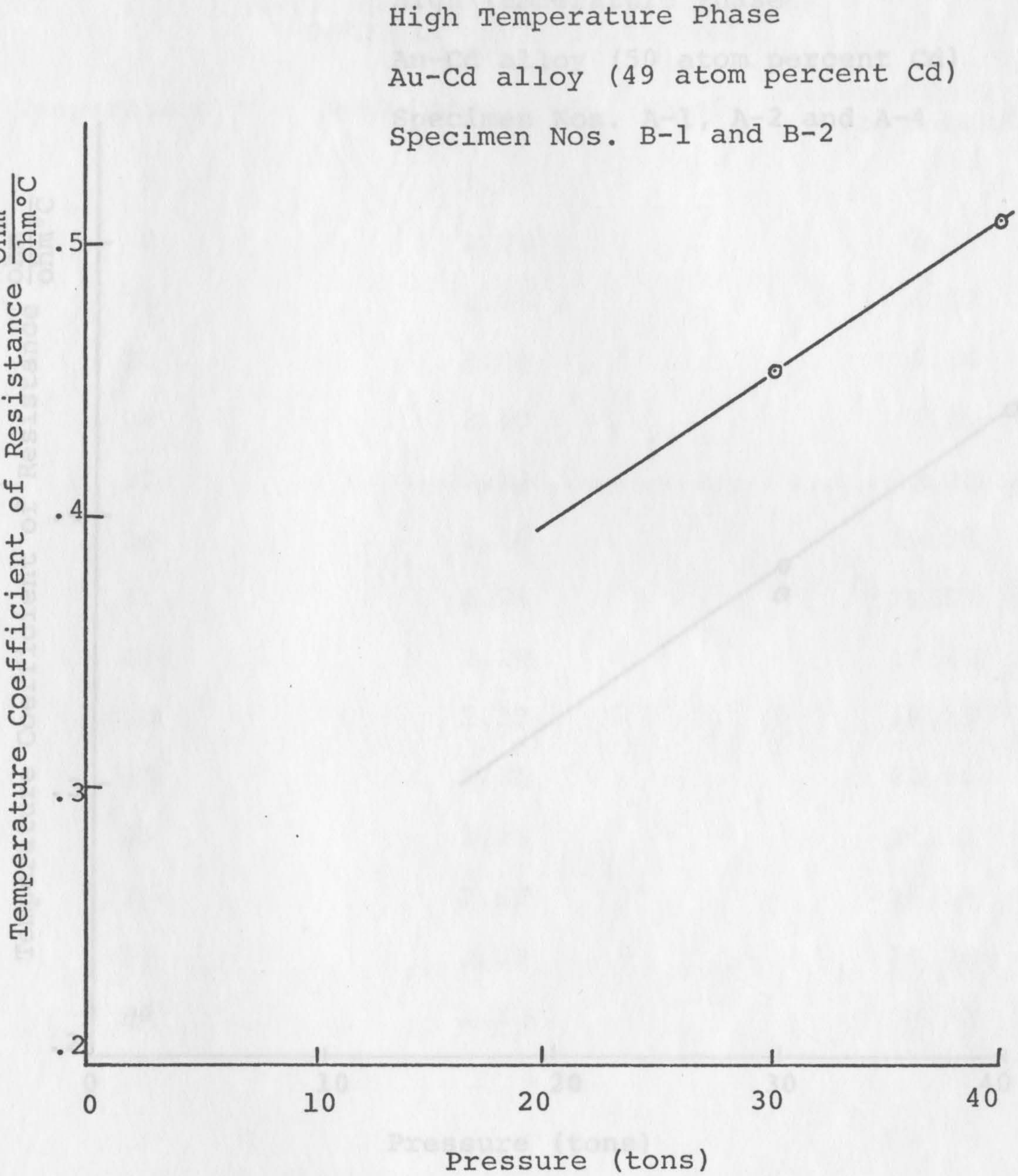

Fig. 35. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (49 atom percent Cd) (Specimen Nos. B-1 and B-2). (High temperature phase)

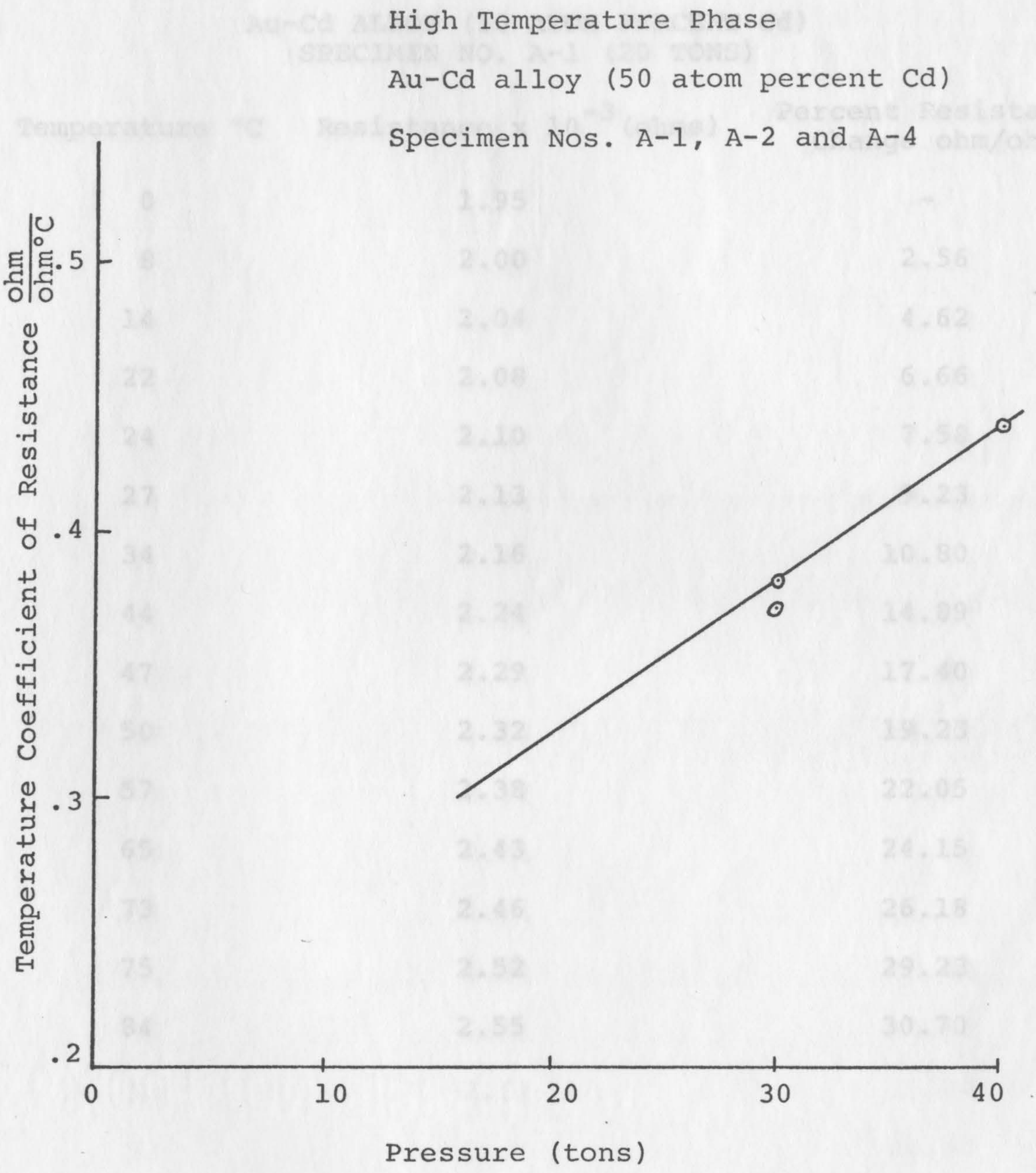

Fig. 36. Temperature coefficient of resistance as a function of pressure for Au-Cd alloy (50 atom percent Cd) (Specimen Nos. A-1, A-2 and A-4). (High temperature phase)

TABLE 1

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-1 (20 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.95	-
8	2.00	2.56
14	2.04	4.62
22	2.08	6.66
24	2.10	7.58
27	2.13	9.23
34	2.16	10.80
44	2.24	14.89
47	2.29	17.40
50	2.32	19.23
57	2.38	22.05
65	2.43	24.15
73	2.46	26.18
75	2.52	29.23
84	2.55	30.70

TABLE 2

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-1 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms	Percent Resistance Change ohm/ohm
0	2.01	--
2	2.03	0.99
7	2.05	1.99
9	2.06	2.48
11	2.07	2.98
13	2.08	3.48
17	2.11	4.97
19	2.12	5.47
22	2.14	6.46
25	2.15	6.97
27	2.17	7.99
33	2.21	9.95
38	2.24	11.44
45	2.28	13.40
50	2.31	14.92
52	2.32	15.44
52	2.34	16.40
53	2.35	16.90
53	2.36	17.40
56	2.39	18.90
60	2.41	19.90
62	2.43	20.80
66	2.46	22.30

Table 2 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
70	2.49	23.80
73	2.50	24.40
75	2.52	25.40
78	2.55	26.80
82	2.58	28.40
84	2.60	29.30
88	2.63	33.30
90	2.65	31.80
92	2.67	32.70
95	2.70	34.30
97	2.72	35.30
99	2.74	36.30
102	2.76	37.30
105	2.78	38.30
109	2.80	39.30
111	2.82	40.20
114	2.85	41.80
117	2.87	42.70

TABLE 3

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-2 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.79	--
9	1.85	4.52
18	1.94	9.60
20	1.99	11.31
35	2.10	18.64
39	2.14	20.90
42	2.19	23.73
48	2.23	25.73
49	2.25	27.19
50	2.26	27.70
51	2.31	30.20
60	2.41	36.16
68	2.49	40.68
73	2.54	43.50
76	2.56	44.63
80	2.61	44.46
87	2.67	50.84
91	2.70	52.54
96	2.75	55.36
100	2.78	57.06
117	2.93	65.55
120	2.96	67.23
124	2.99	68.93

TABLE 4

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-4 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.78	--
3	1.81	1.69
4	1.83	2.81
7	1.85	3.93
9	1.86	4.49
12	1.90	6.74
16	1.92	7.86
20	1.96	10.10
24	1.98	11.24
27	2.00	12.36
33	2.04	15.10
39	2.08	16.85
41	2.09	17.42
46	2.11	18.54
50	2.14	20.22
52	2.15	20.79
54	2.17	21.90
56	2.19	23.03
57	2.21	24.20
59	2.23	25.30
60	2.24	25.80
61	2.26	26.90
73	2.34	31.50

Table 4 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
75	2.36	32.58
80	2.40	34.83
83	2.43	36.50
85	2.44	37.08
87	2.46	38.02
91	2.49	39.89
97	2.53	42.13
100	2.55	43.30
104	2.58	44.90
108	2.62	47.20
113	2.65	47.75
118	2.69	51.12

TABLE 5

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-4 (40 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.93	--
2	1.95	1.04
8	2.01	4.15
14	2.06	6.99
18	2.10	8.81
24	2.16	11.91
29	2.19	13.47
34	2.24	16.06
39	2.29	18.65
44	2.34	21.24
49	2.39	23.83
52	2.41	24.87
55	2.43	25.91
60	2.48	28.24
61	2.49	28.76
62	2.50	29.53
62	2.53	31.09
65	2.55	32.12
68	2.58	33.68
72	2.61	35.23
75	2.65	37.31
80	2.71	40.41
98	2.85	47.66

Table 5 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
103	2.90	50.26
107	2.95	52.85
110	2.97	53.88
114	2.99	54.99
120	3.05	58.03
125	3.08	59.59

TABLE 6

Au-Cd ALLOY (49 ATOM PERCENT CD)
SPECIMENT NO. B-1 (40 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	2.02	--
5	2.06	1.98
10	2.09	3.46
19	2.14	5.94
23	2.18	7.92
29	2.21	9.41
38	2.27	12.38
46	2.32	14.85
52	2.35	16.33
54	2.37	17.33
59	2.40	18.81
64	2.43	20.29
67	2.50	23.76
68	2.52	24.75
68	2.53	25.25
75	2.62	29.70
81	2.68	32.67
84	2.70	33.66
89	2.77	36.80
93	2.80	38.60
98	2.86	41.58
102	2.92	44.55
110	3.10	49.00

TABLE 7

Au-Cd ALLOY (49 ATOM PERCENT Cd)
SPECIMENT NO. B-2 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.92	--
1	1.94	0.52
4	1.95	1.04
9	1.98	2.60
11	2.00	3.63
14	2.03	5.20
17	2.06	6.73
21	2.09	8.30
24	2.11	9.30
27	2.14	10.90
30	2.16	11.90
35	2.20	13.99
39	2.25	16.60
42	2.27	17.60
46	2.31	19.68
49	2.34	21.20
52	2.37	22.80
55	2.39	23.83
57	2.41	24.87
60	2.43	25.90
62	2.45	26.94
63	2.47	27.97
64	2.50	29.53

Table 7 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
67	2.53	30.59
68	2.54	31.11
70	2.55	32.12
73	2.58	33.67
81	2.65	37.30
92	2.75	42.50
95	2.79	44.56
100	2.83	46.63
103	2.86	48.20
107	2.90	50.30
111	2.93	51.80
113	2.95	52.84
118	3.00	55.44
122	3.03	56.99
123	3.05	58.03

TABLE 8

Au-Cd ALLOY (49 ATOM PERCENT Cd)
SPECIMEN NO. B-2 (40 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.97	--
5	2.00	1.52
15	2.05	4.06
23	2.10	6.60
30	2.15	9.14
34	2.18	10.66
37	2.21	12.18
42	2.25	14.21
47	2.29	16.24
50	2.32	17.76
60	2.41	22.33
67	2.47	25.38
68	2.49	26.40
69	2.55	29.44
71	2.57	30.45
78	2.65	34.52
82	2.68	36.04
84	2.71	37.56
89	2.76	40.10
92	2.80	42.13
96	2.83	43.65
99	2.86	45.18
101	2.89	46.70

Table 8 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
108	2.97	50.77
111	3.00	52.30
115	3.04	58.38
119	3.08	60.04

TABLE 9

Au-Cd ALLOY (49 ATOM PERCENT Cd)
SPECIMEN NO. B-2 (20 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.86	--
15	1.96	5.37
17	1.99	6.90
18	2.00	7.53
32	2.04	9.67
37	2.10	12.90
42	2.14	15.05
44	2.15	15.59
51	2.21	18.81
52	2.21	18.98
56	2.215	19.04
60	2.26	20.96
63	2.33	24.73
67	2.36	26.30
70	2.38	27.40
73	2.40	29.00
78	2.44	31.18
84	2.48	33.33
87	2.51	34.94
92	2.56	37.64
97	2.60	39.79
99	2.63	41.39
102	2.66	43.01

Table 9 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
106	2.69	44.62
108	2.71	45.10
110	2.74	47.30
112	2.76	48.38
115	2.79	50.00
117	2.81	57.07

TABLE 10

Au-Cd ALLOY (48.5 ATOM PERCENT Cd)
SPECIMEN NO. C-1 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.92	--
2	1.94	0.78
5	1.97	2.60
9	2.01	4.60
12	2.04	6.25
14	2.05	6.77
20	2.11	9.89
24	2.15	11.97
31	2.21	15.10
33	2.23	16.14
40	2.29	19.27
45	2.33	21.35
46	2.36	22.91
51	2.38	23.95
52	2.39	24.47
58	2.44	27.08
60	2.48	29.16
61	2.52	31.25
63	2.58	34.37
65	2.60	35.42
70	2.62	36.46
79	2.67	39.06
80	2.71	41.15

Table 10 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
89	2.77	44.27
91	2.80	45.83
93	2.83	47.39
97	2.85	48.44
99	2.87	49.48
102	2.89	50.52

TABLE 11

Au-Cd ALLOY (48.5 ATOM PERCENT Cd)
SPECIMEN NO. C-1 (40 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
o	1.88	--
4	1.92	2.12
10	1.97	4.75
15	2.01	6.90
23	2.08	10.60
30	2.14	13.86
35	2.18	15.60
40	2.22	18.06
46	2.28	21.30
49	2.31	22.80
51	2.33	23.74
54	2.36	25.50
58	2.41	27.68
62	2.45	30.30
64	2.47	31.40
65	2.51	33.50
66	2.55	35.60
67	2.60	38.30
72	2.64	40.40
76	2.68	42.04
80	2.71	44.15
84	2.74	45.70
89	2.78	47.87

Table 11 (continued)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
97	2.85	51.60
103	2,90	54.25
109	2.95	56.90

TABLE 12

Au-Cd ALLOY (48.5 ATOM PERCENT Cd)
SPECIMENT NO. C-2 (20 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.88	--
1	1.89	0.53
9	1.95	3.72
13	1.97	4.78
17	2.00	6.38
22	2.04	8.51
28	2.08	10.64
41	2.18	15.95
47	2.22	18.08
49	2.24	18.64
50	2.28	21.27
51	2.33	23.67
57	2.38	26.60
63	2.44	29.78
70	2.50	32.97
77	2.56	35.10
84	2.63	38.80
91	2.70	42.55
97	2.76	45.74
100	2.80	47.87
106	2.84	50.00
109	2.86	51.06

TABLE 13

Au-Cd ALLOY (48 ATOM PERCENT Cd)
SPECIMEN NO. D-1 (30 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.92	--
1	1.93	0.52
3	1.94	1.04
7	1.97	2.60
9	1.98	3.12
11	1.99	3.64
15	2.02	5.20
19	2.05	6.77
25	2.09	8.85
28	2.12	10.40
31	2.14	11.45
33	2.15	11.97
37	2.17	13.02
42	2.20	14.58
43	2.21	15.10
47	2.24	16.66
51	2.25	17.73
57	2.31	20.30
60	2.33	21.35
61	2.36	22.90
63	2.40	25.00
65	2.44	27.08
68	2.46	28.12

Table 13 (continued

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
71	2.49	29.70
74	2.51	30.73
77	2.53	31.77
78	2.55	32.80
80	2.57	33.85
82	2.59	34.90
84	2.61	35.44
87	2.63	36.97
90	2.66	38.54
92	2.67	39.08
96	2.71	41.14

TABLE 14

Au-Cd ALLOY (48 ATOM PERCENT Cd)
SPECIMEN NO. D-2 (20 TONS)

Temperature °C	Resistance x 10^{-3} (ohms)	Percent Resistance Change ohm/ohm
0	1.96	--
4	1.99	1.53
10	2.03	3.57
20	2.11	7.65
25	2.15	9.69
31	2.20	12.20
43	2.28	16.30
50	2.35	19.89
55	2.38	20.94
56	2.38	20.94
57	2.41	22.47
58	2.43	23.50
59	2.44	24.49
65	2.49	27.04
69	2.53	29.08
75	2.58	31.14
83	2.64	34.69
86	2.66	35.70
90	2.77	37.75
102	2.79	42.34
110	2.85	45.40

TABLE 15

Au-Cd ALLOY (50 ATOM PERCENT Cd)
SPECIMEN NO. A-1, A-2 AND A-4

Alloy No.	Pressure	Transformation Temperature
A-1	20 tons	46.0°C
A-1	30 tons	53.0°C
A-2	20 tons	50.50°C
A-4	30 tons	57.0°C
A-4	40 tons	61.50°C

Au-Cd ALLOY (49 ATOM PERCENT Cd)
SPECIMENT NO. B-1 AND B-2

Alloy No.	Pressure	Transformation Temperature
B-1	40 tons	67.50°C
B-2	20 tons	61.0°C
B-2	30 tons	61.50°C
B-2	40 tons	68.0°C

TABLE 16

Au-Cd ALLOY (48.5 ATOM PERCENT Cd)
SPECIMENT NO. C-1 AND C-2

Alloy No.	Pressure	Transformation Temperature
C-1	30 tons	61.0°C
C-1	40 tons	65.50°C
C-2	20 tons	56.0°C

Au-Cd ALLOY (48 ATOM PERCENT Cd)
SPECIMEN NO. D-1 AND D-2

Alloy No.	Pressure	Transformation Temperature
D-1	30 tons	62.50°C
D-2	20 tons	57.50°C

TABLE 17

Alloy No.	Composition	$\frac{dT}{dp}$ $(\frac{°C}{atm.})$
D	48 atom percent Cd	0.19
C	48.5 atom percent Cd	0.16
B	49 atom percent Cd	0.64
A	50 atom percent Cd	0.50

TABLE 18

Au-Cd SYSTEM (50 ATOM PERCENT Cd)
SPECIMEN NO. A-1, A-2 AND A-4

Pressure (atm.)	Transformation Temp. Experimental Values (°C)	Transformation Temp. Theoretical Values (°C)
0 (0 tons)	28*	--
15000 (20 tons)	46	47
22500 (30 tons)	57	56

*From Ahmed's Results.

TABLE 19

Au-Cd ALLOY SYSTEM (48 ATOM PERCENT Cd)
SPECIMEN NO. D-1 AND D-2

Pressure (atm.)	Transformation Temp. Experimental Values (°C)	Transformation Temp. Theoretical Values (°C)
0 (0 tons)	50*	--
15000 (20 tons)	57	57
22500 (30 tons)	63	61

*From Ahmed's Results (3).

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