DEPARTMENT OF MINES
SOUTH AUSTRALIA

RB 52/98

THE APPLICATION OF DIFFERENTIAL THERMAL ANALYSIS (DTA) FOR SUBSURFACE AND SURFACE CORRELATION

(FIRST INTERIM REPORT)

by

Dr. H. Wopfner
Geologist

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INTRODUCTION

One of the major sources of information obtainable from a bore are the drill-cuttings. No matter if the rotary or the percussion-method is used, the cuttings can be acquired at no extra cost to the operator. The visual description of these samples together with palaeontological investigations usually supply reliable information for subsurface correlation.

However, a great number of sediments contain very poor fossil faunae or florae or are altogether sterile. In this case, correlation has to rely on lithological descriptions only. As descriptions are largely influenced by the human element, such correlations may be rather unreliable

If any type of down-hole logging device is available, the accuracy of any such correlation will be largely improved. But one has to consider the fact, that any down hole device will only record induced or secondary properties of any particular sediment which are further influenced by the condition of the media surrounding the logging device (e.g. mud resistivity, hole diameter etc.).

When investigating bores which were drilled many years ago, usually none of the down hole logging devices can be applied, either because the bore does no longer exist or it has been cased and completed. Though gamma-neutron devices could be worked in cased holes, the bore would have to be "killed", a procedure which is not only very expensive but also carries some risks of permanent damage to the producing horizon. Thus, the geologist is frequently confronted with the problem of correlating the unfossiliferous sections on purely lithological description.

To bridge this gap, the application of Differential Thermal Analysis, commonly used in the investigation of clay assemblages was suggested by F.H. Bailly (1952) and further evaluated by G.B. Mangold (1955).

DTA is based on the principle that thermally alert minerals will undergo certain physical and chemical changes at specific temperatures which are typical for any particular mineral. These changes are connected either with absorption of heat (endothermic) or with expulsion of heat (exothermic). The changes in temperature can be compared with a thermally inert reference material. The resulting curve will show the differences in temperature between the alert and the inert material. This curve will be of a typical shape for each particular mineral. Thus, a sample consisting of a certain mineral assemblage will result in a curve, showing several peaks (exothermic and/or endothermic) which are directly related to the presence of certain thermally alert minerals. The amplitude of any individual peak is a function of the percentage by which the mineral responsible for that peak is represented (see Fig. 1). A log, consisting of several DTA-curves assembled in their proper sequence with depth, will therefore show certain changes of the curves, which are directly related to the changes in mineral composition. Correlation can be achieved by simply comparing the shapes of the DTA curves within particular sequences. Furthermore, qualitative and semi-quantitative identifications of the thermally alert minerals of any assemblage can be obtained.

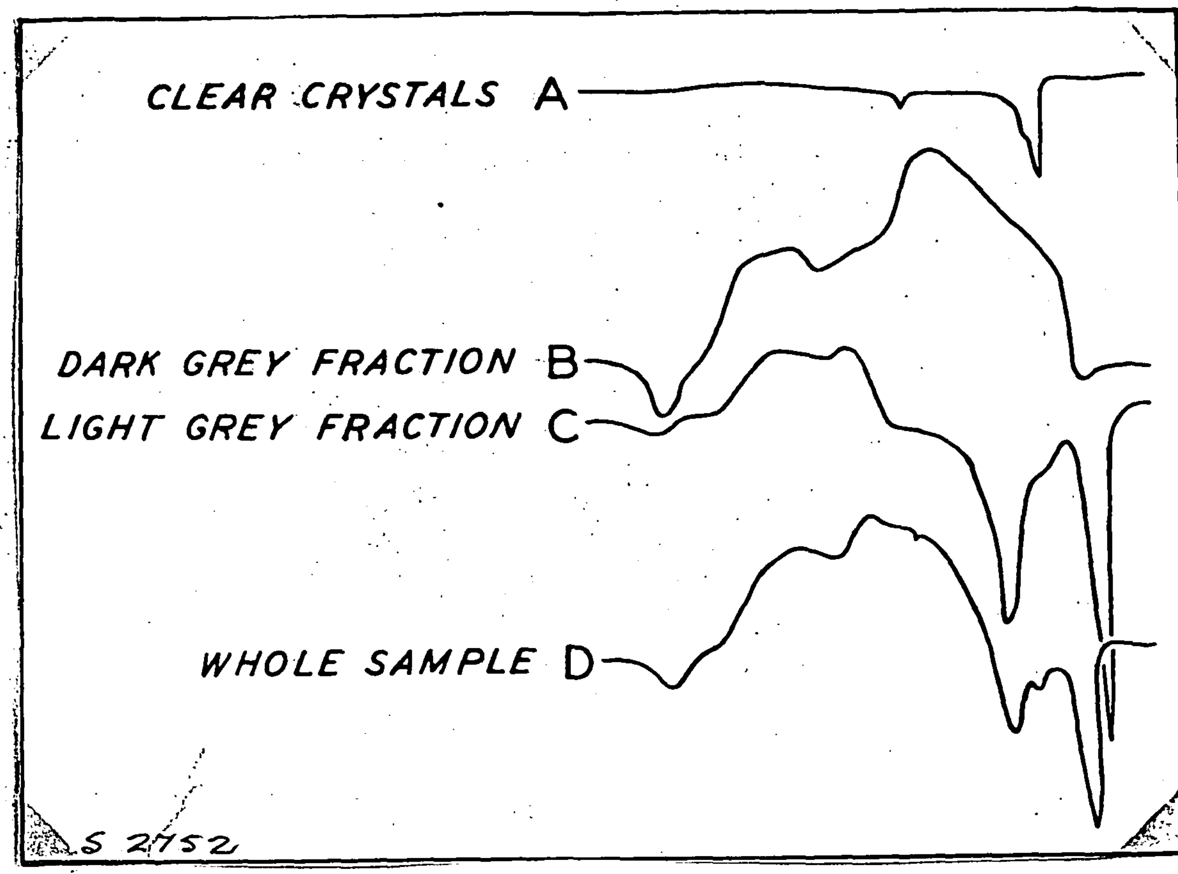

Fig. 1. DTA-curves for mineral assemblage. A sample was separated according to colour and DTA was carried out on each fraction. Curve A represents white and clear crystals (about 20%). It shows a small endothermic peak at about 570°C related to quartz and a higher temperature peak due to halite. Curve B, which was obtained from the dark grey fraction (about 40%) shows clay, organic matter and a considerable amount of pyrite. The remaining light grey fraction produced curve C and shows mainly dolomite and small amounts of pyrite. The curve of the complete sample, D, shows each of the minerals, each reduced in intensity according to its concentration and with consequent reduction of peak temperature. (After Mangold)

METHOD USED

To find out whether DTA-curves were reproducible under actual field conditions, a test run was made on three sections from portions of the Morgan limestone type-section. This locality was chosen for its good exposure and its well defined individual beds, circumstances which assured that the corresponding samples of each section were taken from the same stratigraphi horizon. From each section five channel-samples were taken. The position of the samples in relation to the stratigraphic column is shown in the accompanying plate. The interval between section A and B was 60 feet, the interval between section B and C 150 feet.

The samples were forwarded to the A.M.D.L. and a DTA was made from each sample. In addition, composite samples, each composed of the five samples of each section were prepared and analysed. The differential thermal analyses were carried out by Mr. M.J. O'Connor of the A.M.D.L.

The following conditions were used for each test:

All samples were crushed to pass a 100 mesh Tyler screen.

Sample weight:	0.28 oz. undiluted
Reference:	Calcined alumina
Block:	Stainless steel
Sample holder:	Steatite in stainless steel block.
Heating range:	Room temperature to 1000°C
Heating rate:	400°C per hour
Thermocouples:	Pt - Pt + 10% Rh. *) Temperature recording couple in reference sample.
Chart speed (both recorders):	16 cm per hour
Differential recorder sensitivity:	0.2 mV giving a full scale deflection of approx. 20°C.

RESULTS

The results of this first test run are shown on plate 1. The column on the left shows the lithology and thickness of the individual beds of part of the Morgan limestone type section. To the right of it, the DTA-curves of Sections A, B and C have been assembled to form a log. The base line of each curve corresponds with the position of the individual sample within the lithologic column. In the case of each log, the temperature increases from left (room temperature) to right (1000°C). Peaks developed below the base line represent endothermic reactions, peaks extending above the base line would be exothermic (do not occur in these mineral assemblages).

Footnote *) Platinum wire versus Platinum wire containing 10% Rhodium.

Samples 1, 2 and 3 of each section show an endothermic bulge between 720°C and 750°C. This bulge is related to the decomposition of $MgCO_3$. A well defined, endothermic double-peak appears between 850°C and 900°C, which is related to some double-carbonate, possibly calcite-aragonite or dolomite. The low temperature endothermic bulges between 100°C and 140°C are due to dehydration of the samples. They are possibly connected with the presence of traces of clay.

Samples 4 and 5 of each section show a small endothermic bulge at slightly lower temperatures as the one mentioned above (between 700°C and 710°C). Again this bulge is caused by the presence of $MgCO_3$, the slightly lower peak-temperatures being due to lesser concentration. A strong, single endothermic peak is developed at about 900°C, which is typical for a very high $CaCO_3$ concentration.

If one compared only the shapes and attitudes of the DTA-curves, without considering the mineral composition responsible for their particular shape, one would obviously correlate Samples 1, 2, 3 from Section A with the same of sections B and C and samples 4, 5 of Section A with the same of sections B and C. As we know that the samples were derived from identical horizons, we can conclude that the comparison of the DTA curves alone would have led to a valid correlation.

The value of DTA is particularly emphasised by the sharp break between samples 3 and 4, although, as a glance at the lithological column will show, the sequence above and below appear to be of very similar lithology indeed. This demonstrates that correlation can be achieved with DTA where lithological descriptions alone would fail.

The DTA curves of the composite samples, which can be considered as typical for each section, show all the features of the detailed curves. The amplitude of the limestone-peak is reduced, due to the lesser concentration of $CaCO_3$ in the composite sample. The similarity of the three curves is very remarkable. These composite samples represent a thickness which is considered to be a practical thickness for the application of DTA in sub-

CONCLUSIONS AND RECOMMENDATIONS

One can conclude that the results of this first investigation are very encouraging indeed. Further tests would prove this method a valuable aid for subsurface and also surface correlation, particularly within unfossiliferous sequences.

The next step in this investigation would be to analyse two actual bore-sections. It is proposed to assemble composite samples from 20 feet intervals over a total depth range of 1000 ft. from two bores each. The samples would then be analysed by A.M.D.L. From the analyses a "thermalog" would be prepared for each bore. To test the validity of the correlation achieved by thermalog, the two bores in question should be well controlled by palaeontological evidence. The writer suggests the use of samples from Innamincka No. 1 well from 1500 feet to 2500 feet and comparison of this section with an equivalent section from Patchawarra bore. The section which is suggested comprises Middle Albian to Lower Cenomanian sediments, and shows sufficient lithological variation to promise a variety of DTA-curves. The distance between Innamincka No. 1 Well and Patchawarra bore is 19 miles and no structural complications are known to occur between the two wells.

If these and further investigations should prove successful, a long-term plan might be considered in building up reference thermalogs from both available bores and important surface sections. This would be of valuable assistance in the control of subsurface geology of the sedimentary basins of the State.

H. Wopfner
Geologist
REGIONAL MAPPING SECTION

HW:AGK
14/4/61

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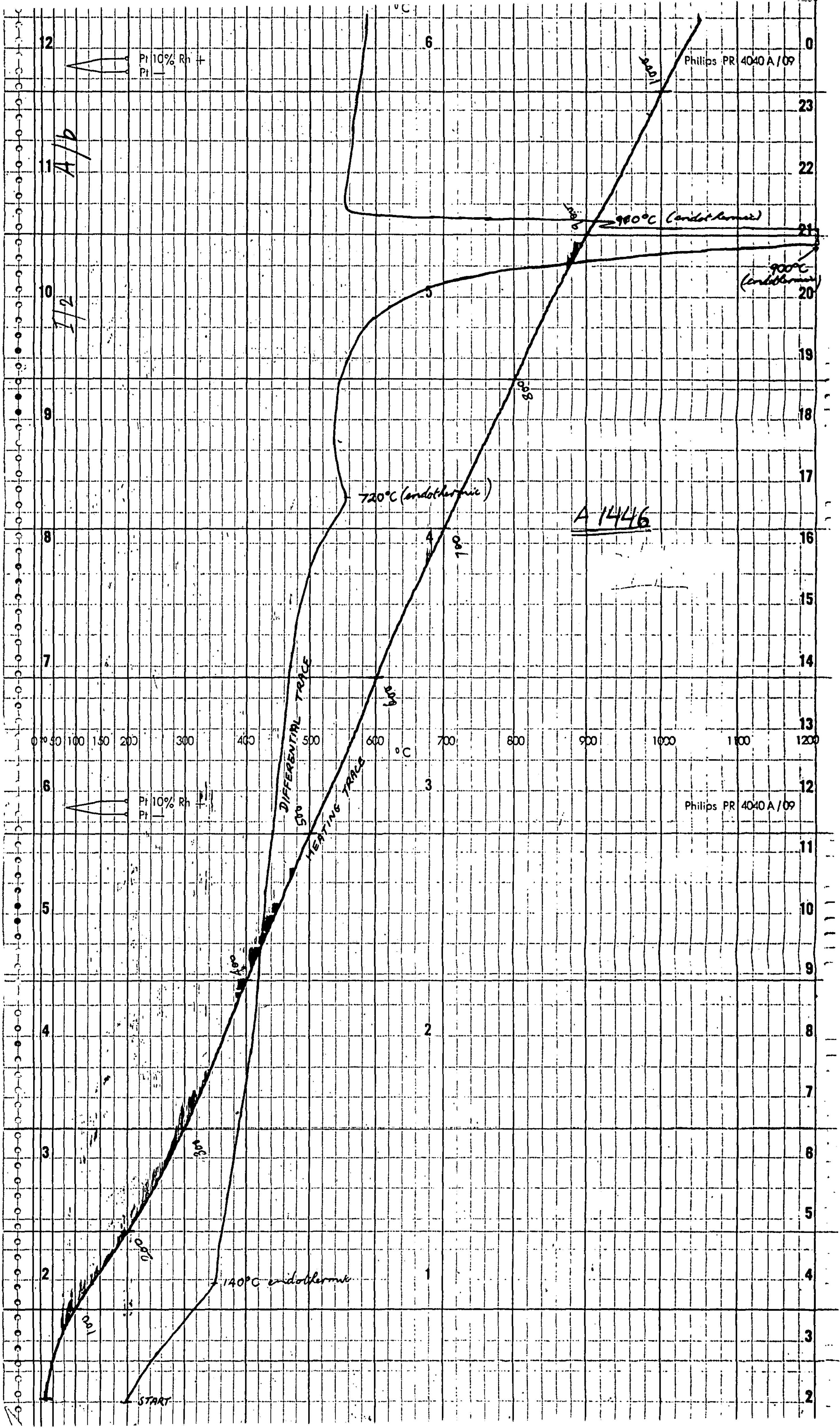
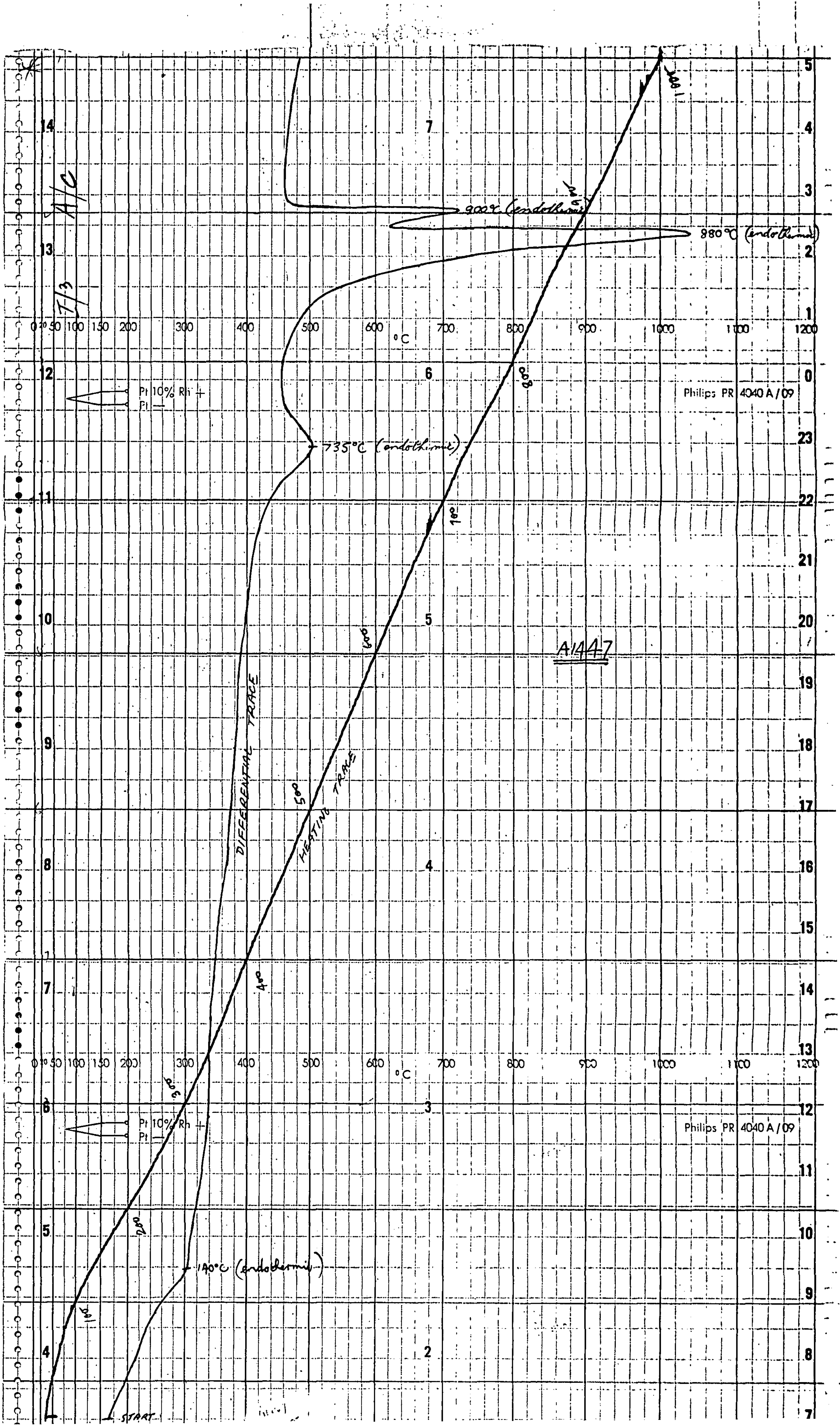
LUDBROOK, N.H. 1958. The type section of the Morgan Limestone and Cadell Marl lens, 4 miles south of Morgan: Pal. Rept. No. 10/58, Geol. Survey S.A. unpublished.

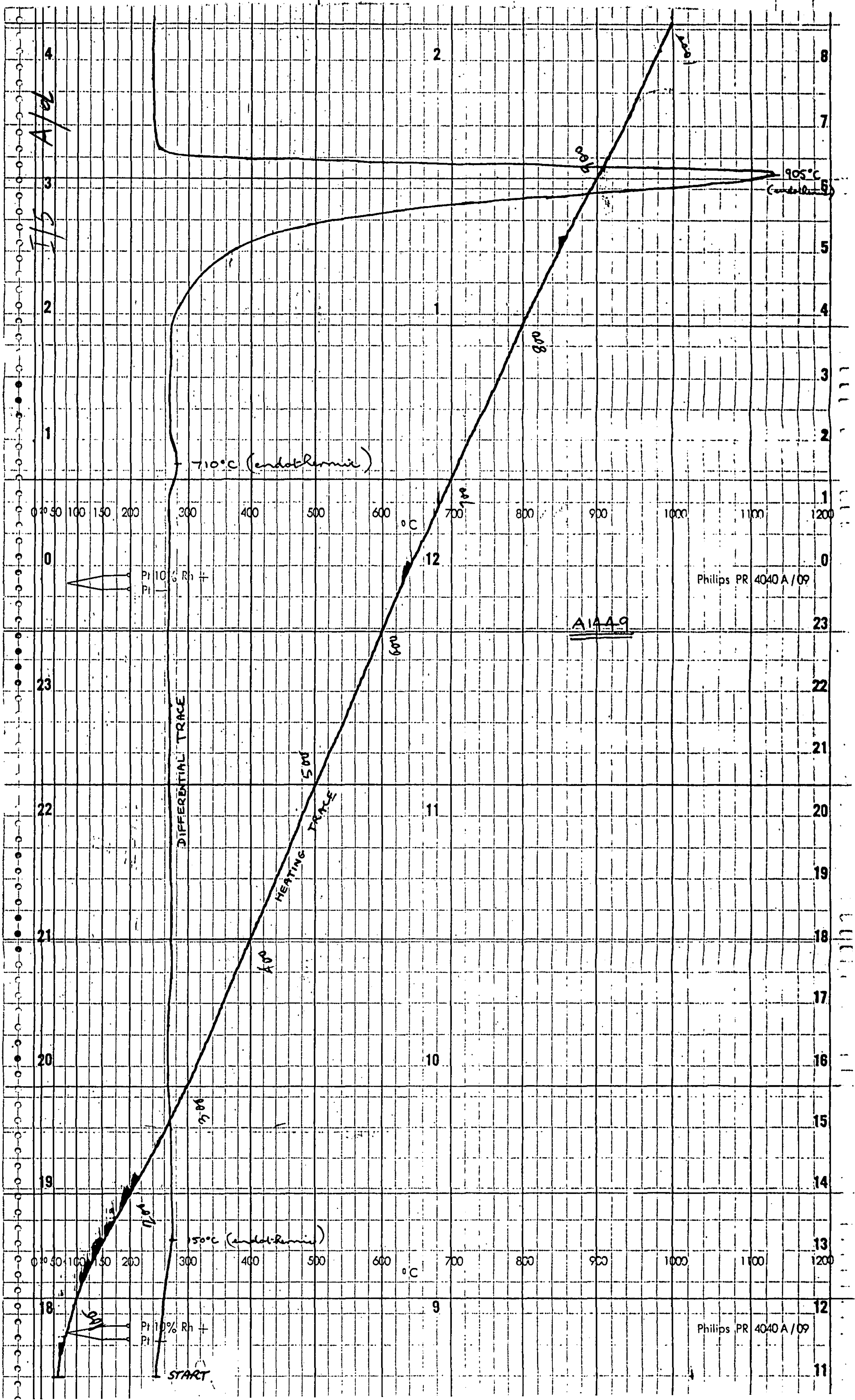
MANGOLD, G.B. 1955. Differential thermal analysis, a new type of formation correlation: World oil, Vol. 140, Nos. 2, 4.



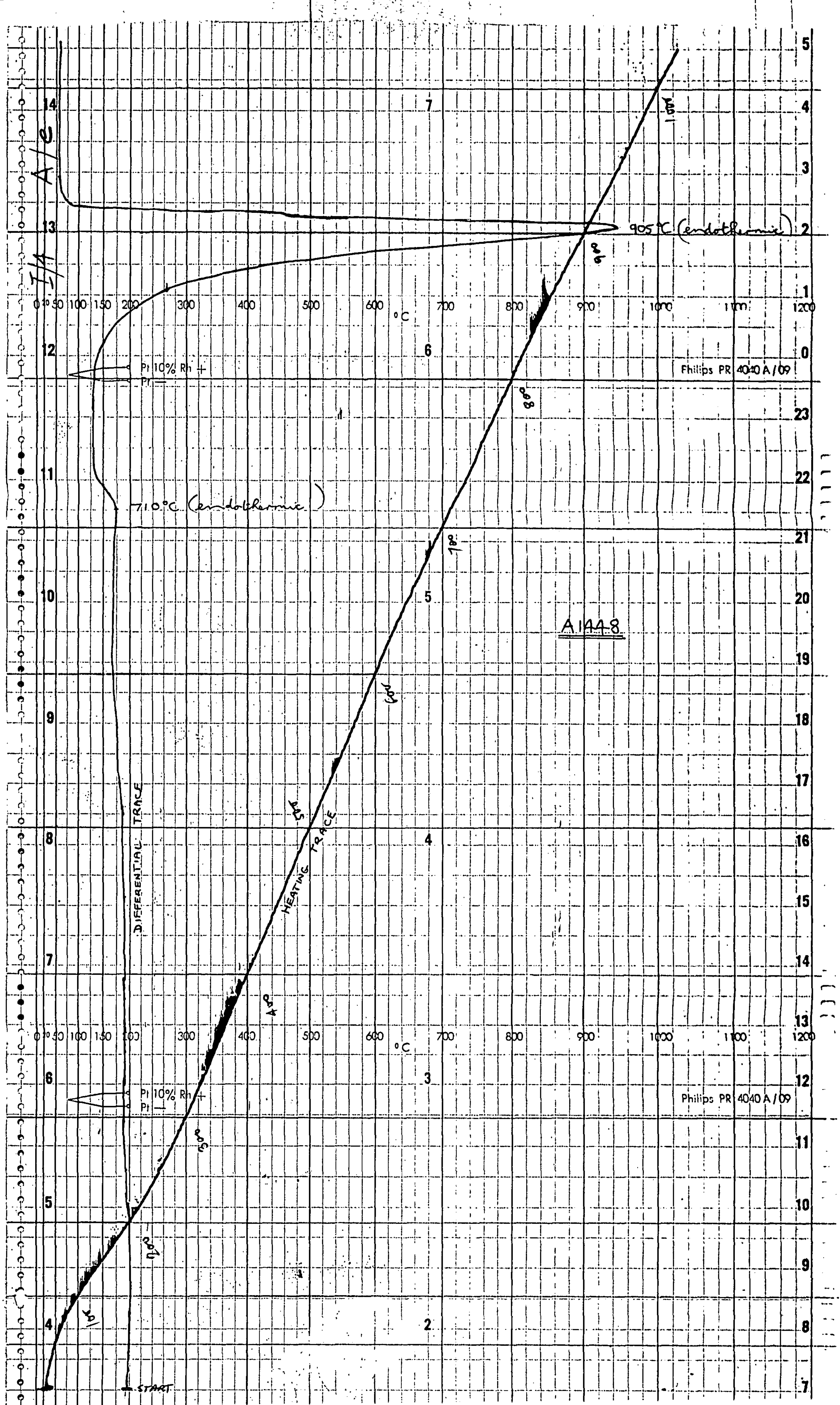
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
A/b
1/2
980°C (endothermic)
900°C (endothermic)
720°C (endothermic)
A 1446
0 20 50 100 150 200 300 400 500 600 °C 700 800 900 1000 1100 1200
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
DIFFERENTIAL TRACE
HEATING TRACE
140°C endothermic
START



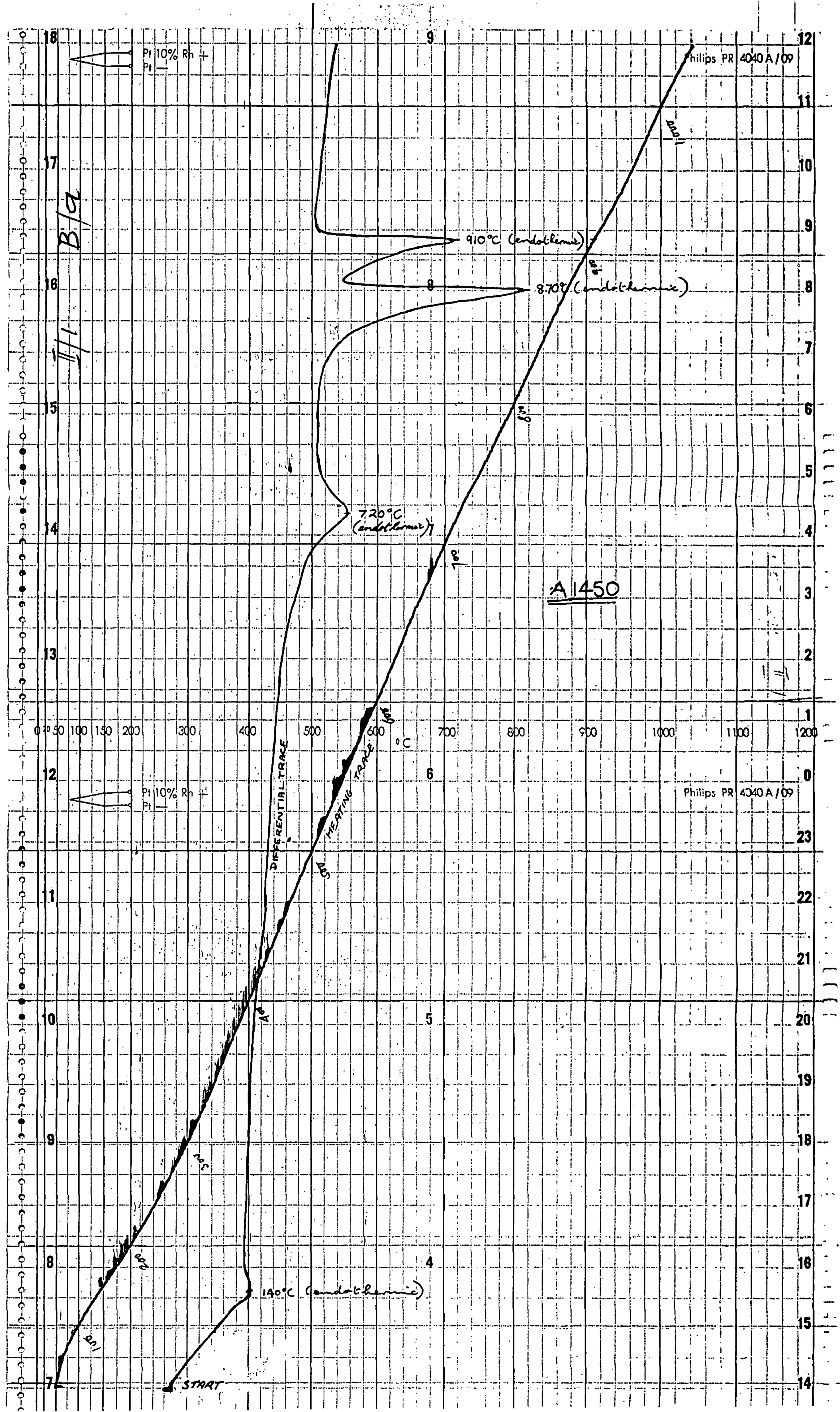
A/C
T/3
900°C (endothermic)
880°C (endothermic)
735°C (endothermic)
140°C (endothermic)
DIFFERENTIAL TRACE
HEATING TRACE
A1447
START
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
0 10 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200



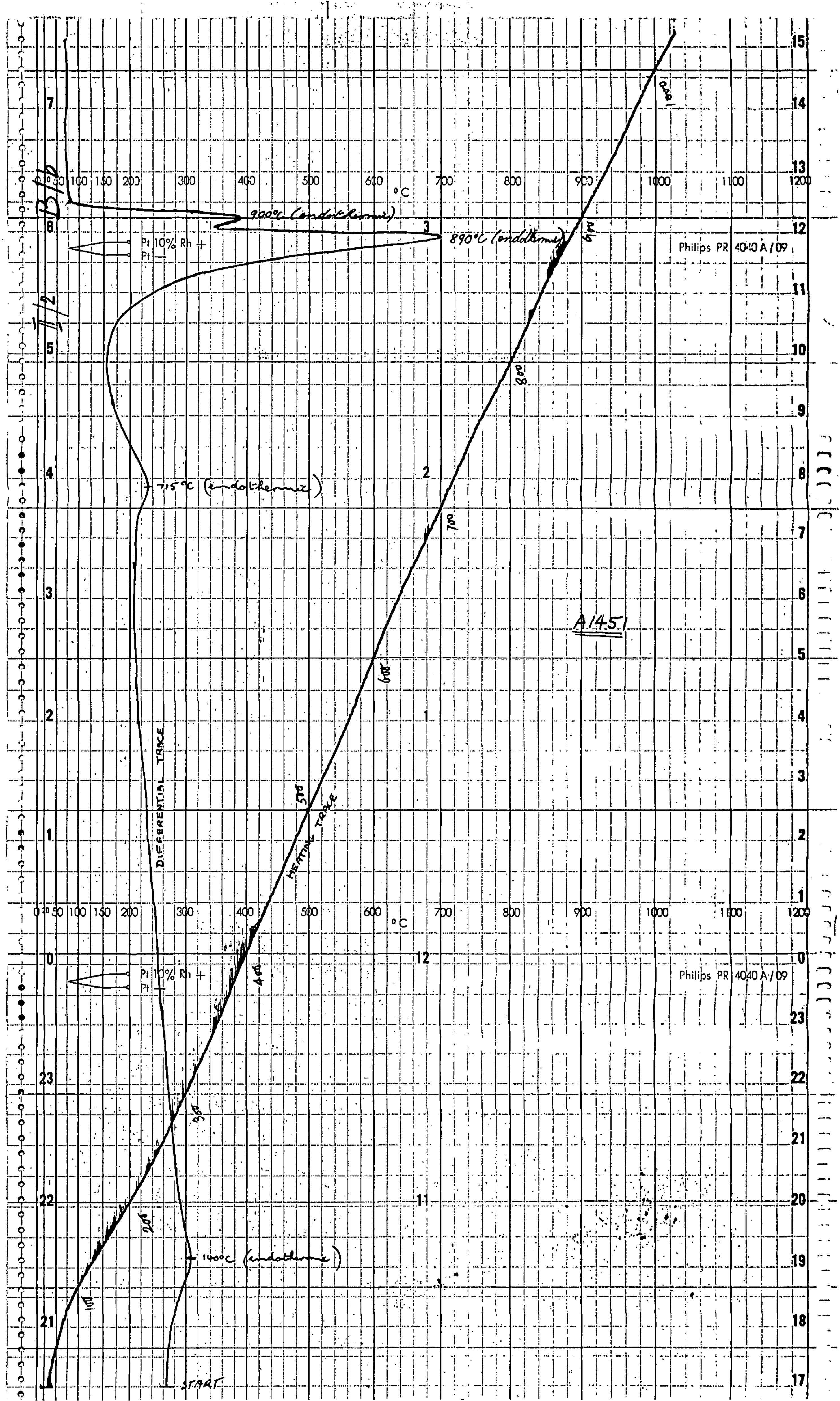
905°C (endothermic)
710°C (endothermic)
150°C (endothermic)
DIFFERENTIAL TRACE
HEATING TRACE
START
A1449
°C
Pt 10% Rh +
Pt −
Philips PR 4040 A/09



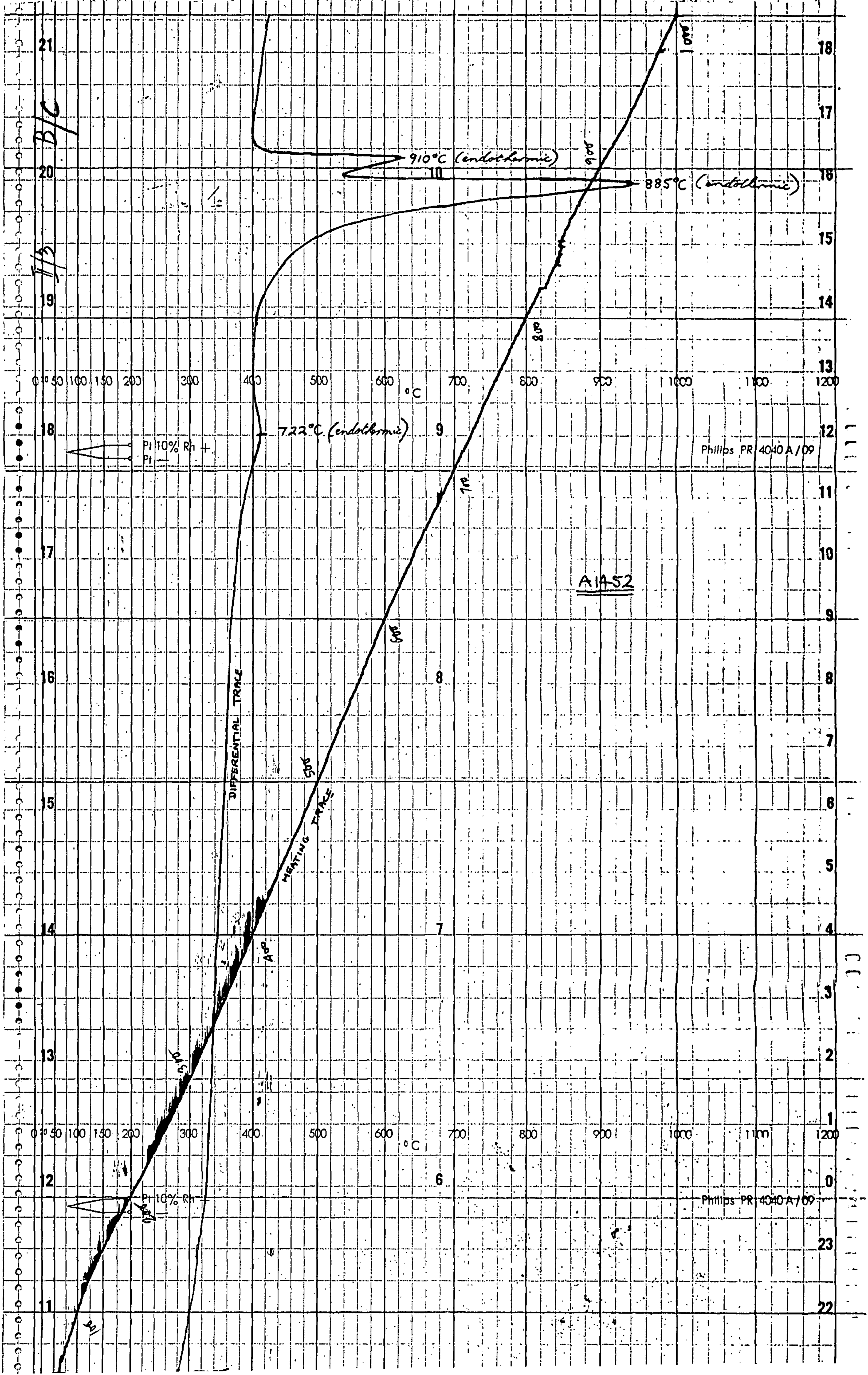
A/C
I/A
905°C (endothermic)
710°C (endothermic)
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
A1448
DIFFERENTIAL TRACE
HEATING TRACE
START



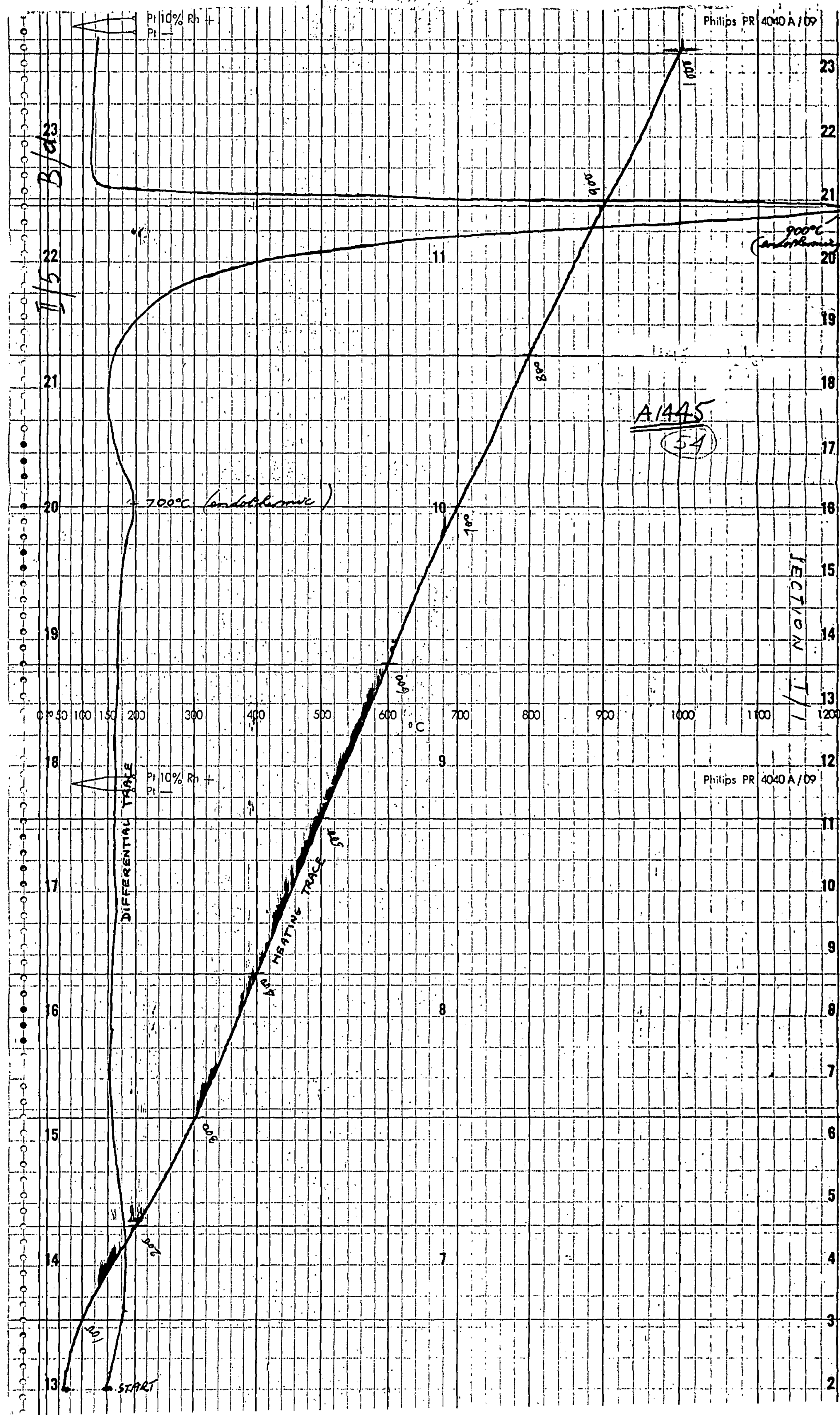
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
B/a
910°C (endothermic)
870°C (endothermic)
720°C (endothermic)
A1450
0 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200
°C
DIFFERENTIAL TRACE
HEATING TRACE
140°C (endothermic)
START



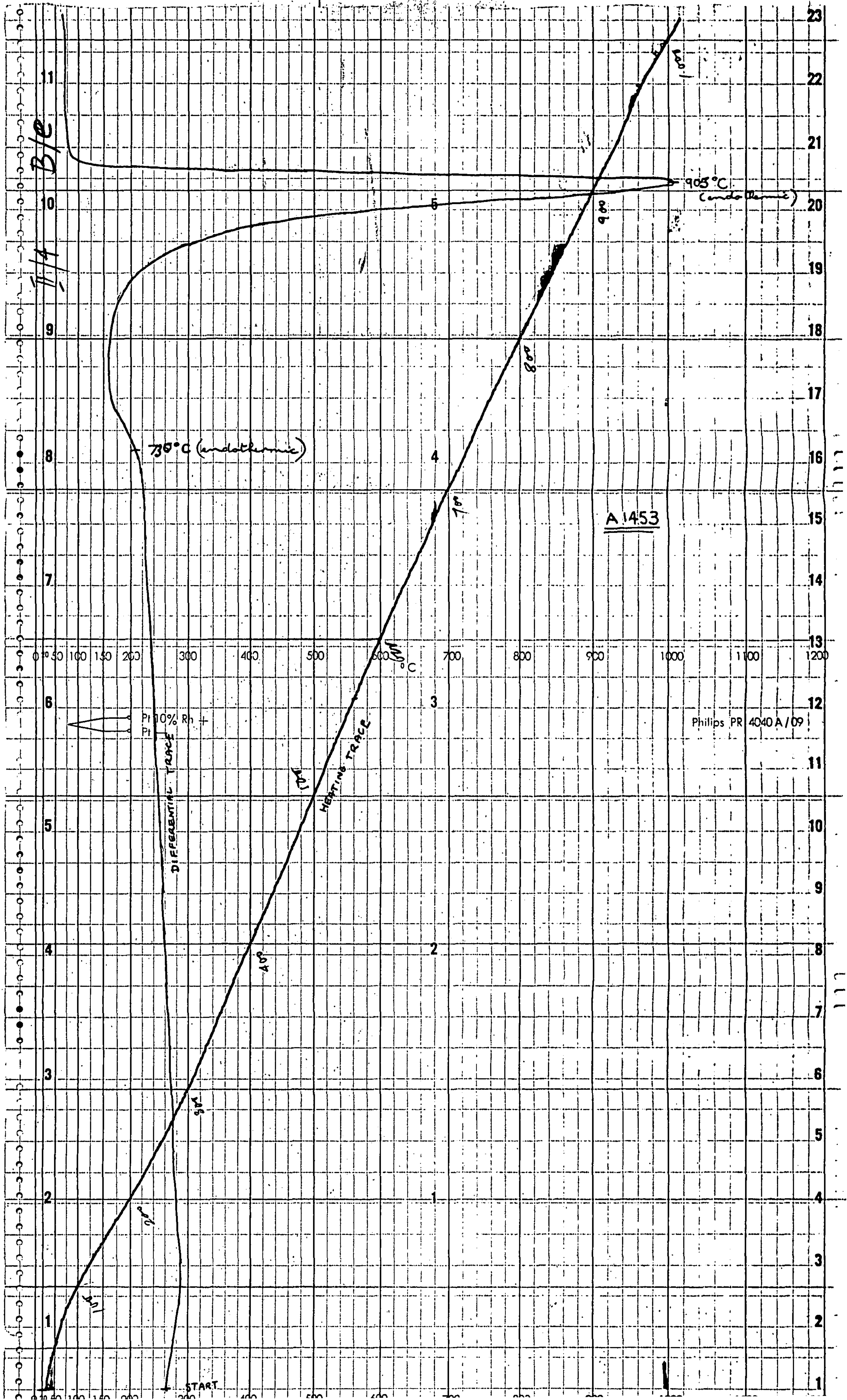
0 20 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200
°C
900°C (endothermic)
890°C (endothermic)
Pt 10% Rh +
Pt −
Philips PR 4040 A/09
715°C (endothermic)
A1451
DIFFERENTIAL TRACE
HEATING TRACE
140°C (endothermic)
START



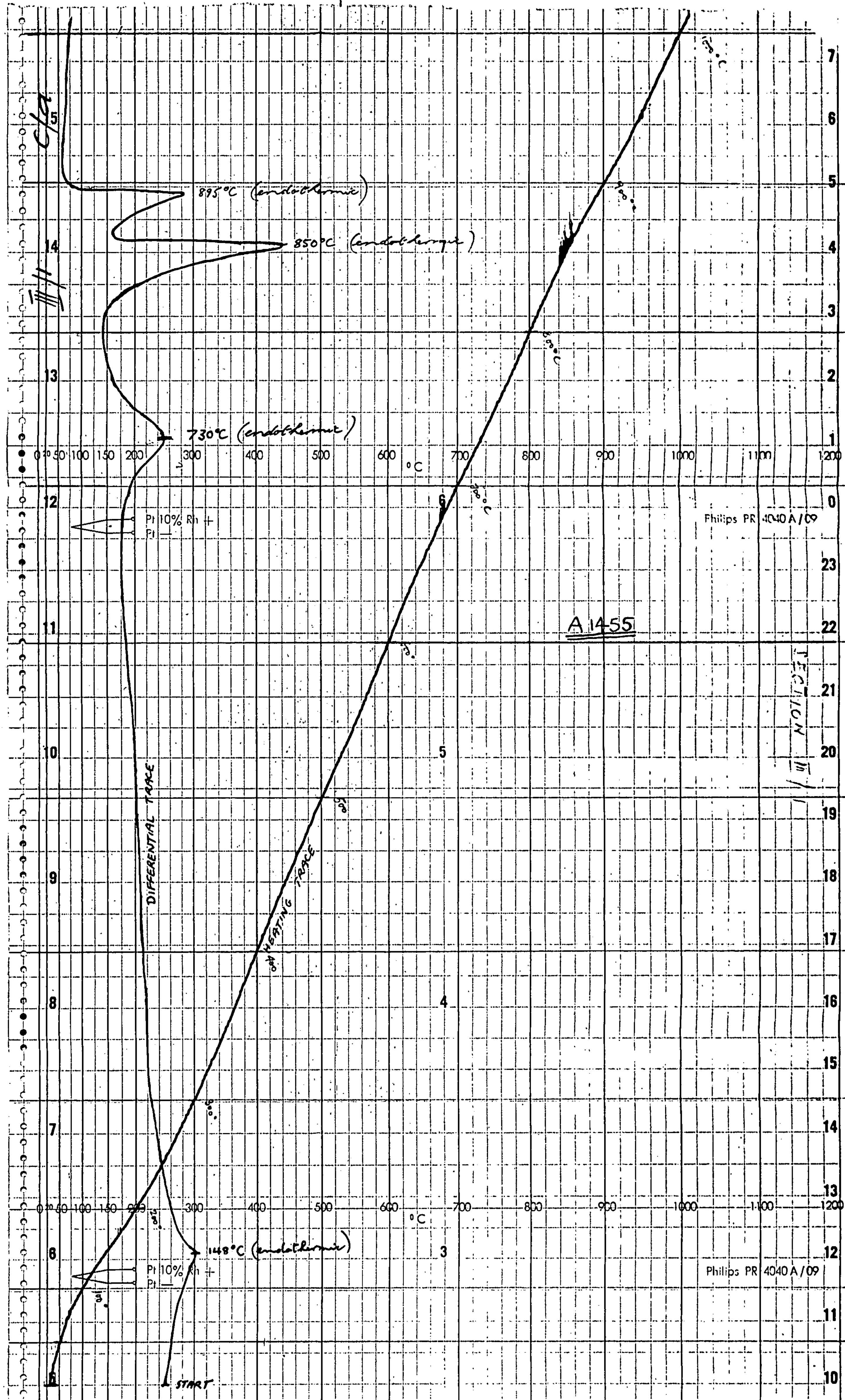
B/C
1/3
910°C (endothermic)
885°C (endothermic)
722°C (endothermic)
0 10 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200
°C
Pt 10% Rh +
Pt −
Philips PR 4040 A/09
A1452
DIFFERENTIAL TRACE
HEATING TRACE

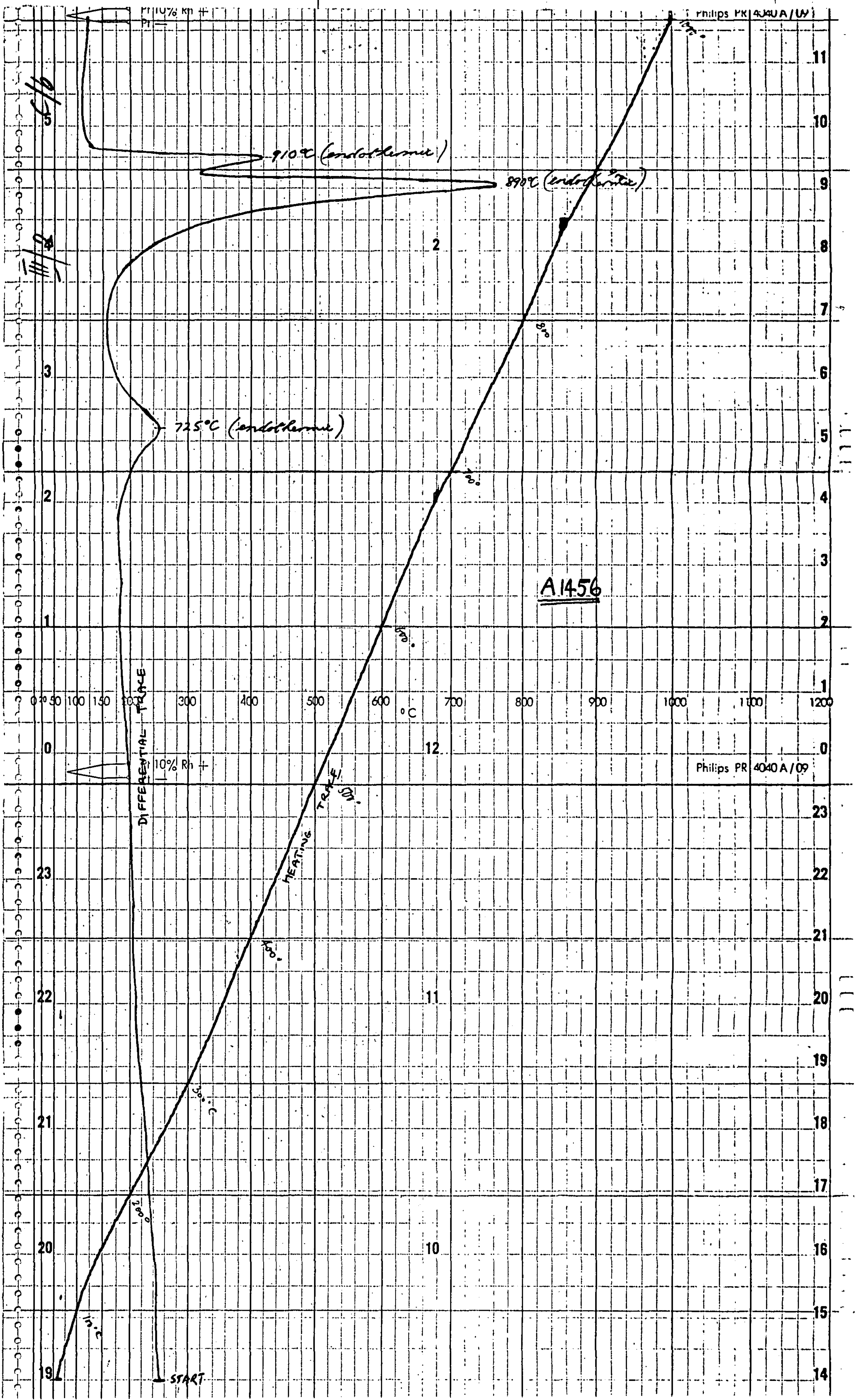


Pt 10% Rh +
Pt —
Philips PR 4040 A/09
B/dt
11/5
A1445
(54)
900°C (endothermic)
700°C (endothermic)
SECTION I/1
°C
DIFFERENTIAL TRACE
HEATING TRACE
START

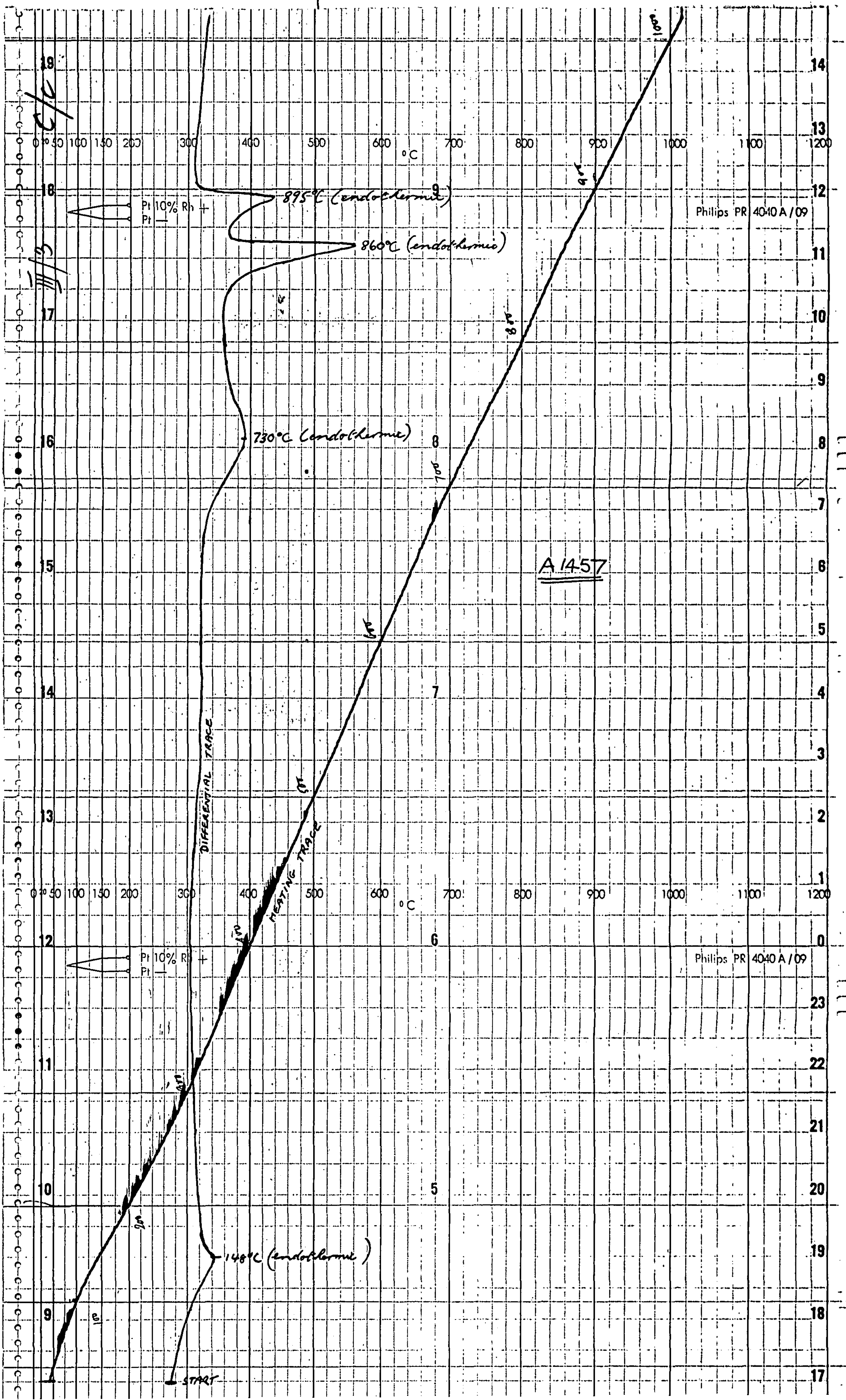


B/e
II/4
905°C (endothermic)
730°C (endothermic)
A 1453
DIFFERENTIAL TRACE
HEATING TRACE
Pt 10% Rh +
Pt
Philips PR 4040 A/09
START
°C

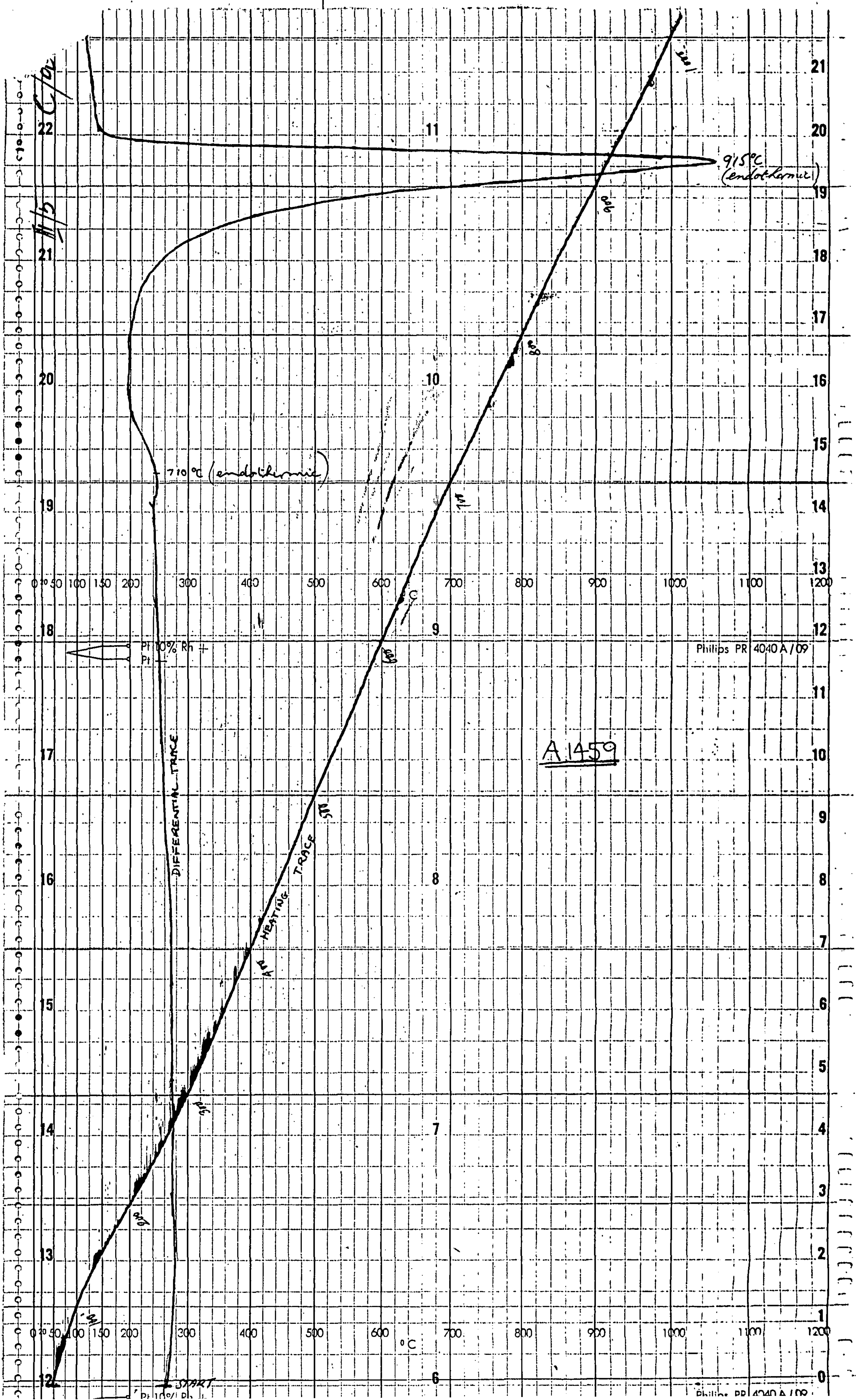

C/a
895°C (endothermic)
850°C (endothermique)
730°C (endothermic)
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
A 1455
SECTION III
DIFFERENTIAL TRACE
HEATING TRACE
148°C (endothermic)
START



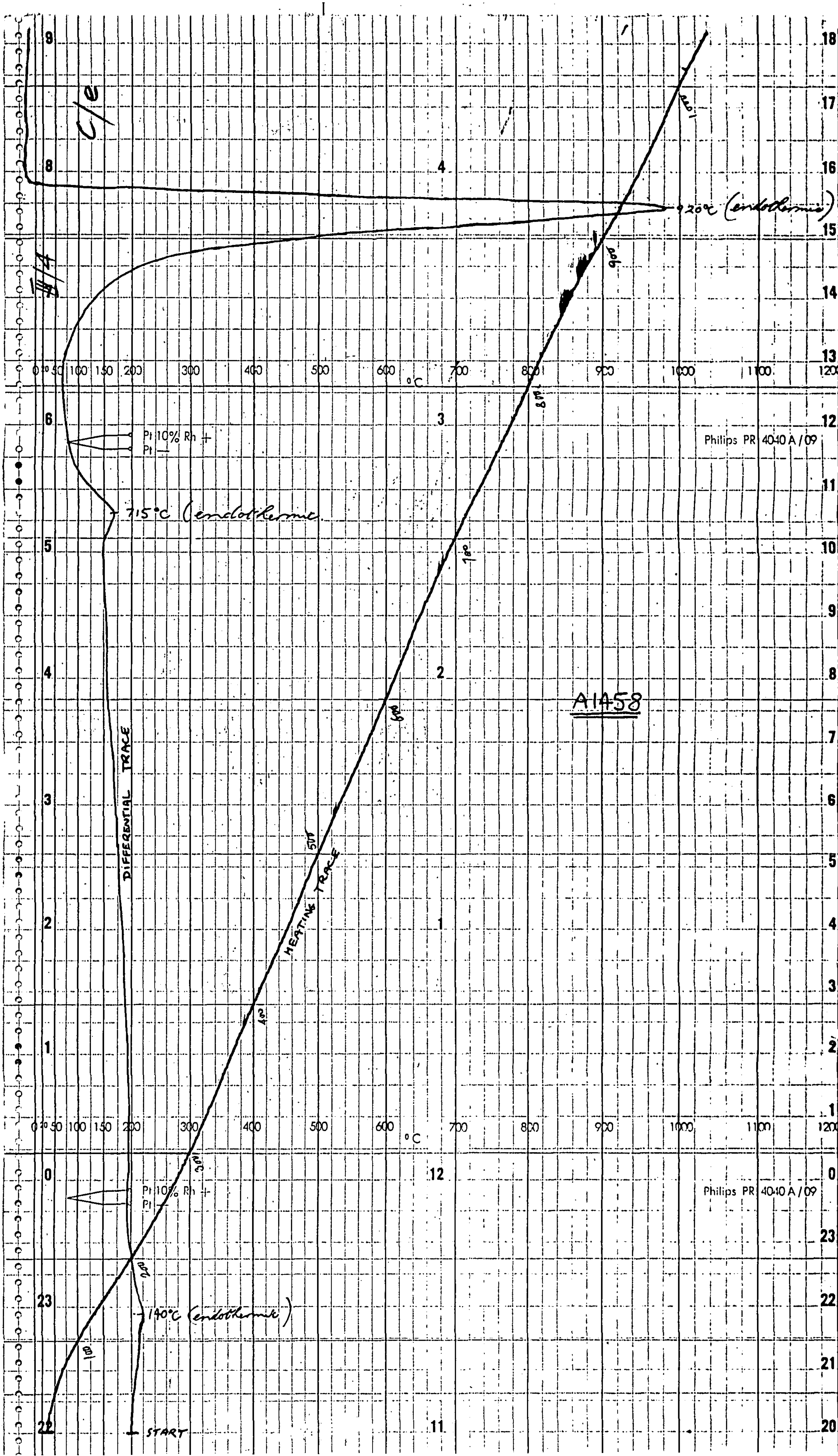
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
910°C (endothermic)
890°C (endothermic)
725°C (endothermic)
A1456
0 20 50 100 150 200 300 400 500 600 °C 700 800 900 1000 1100 1200
Philips PR 4040 A/09
DIFFERENTIAL TRACE
HEATING TRACE
START

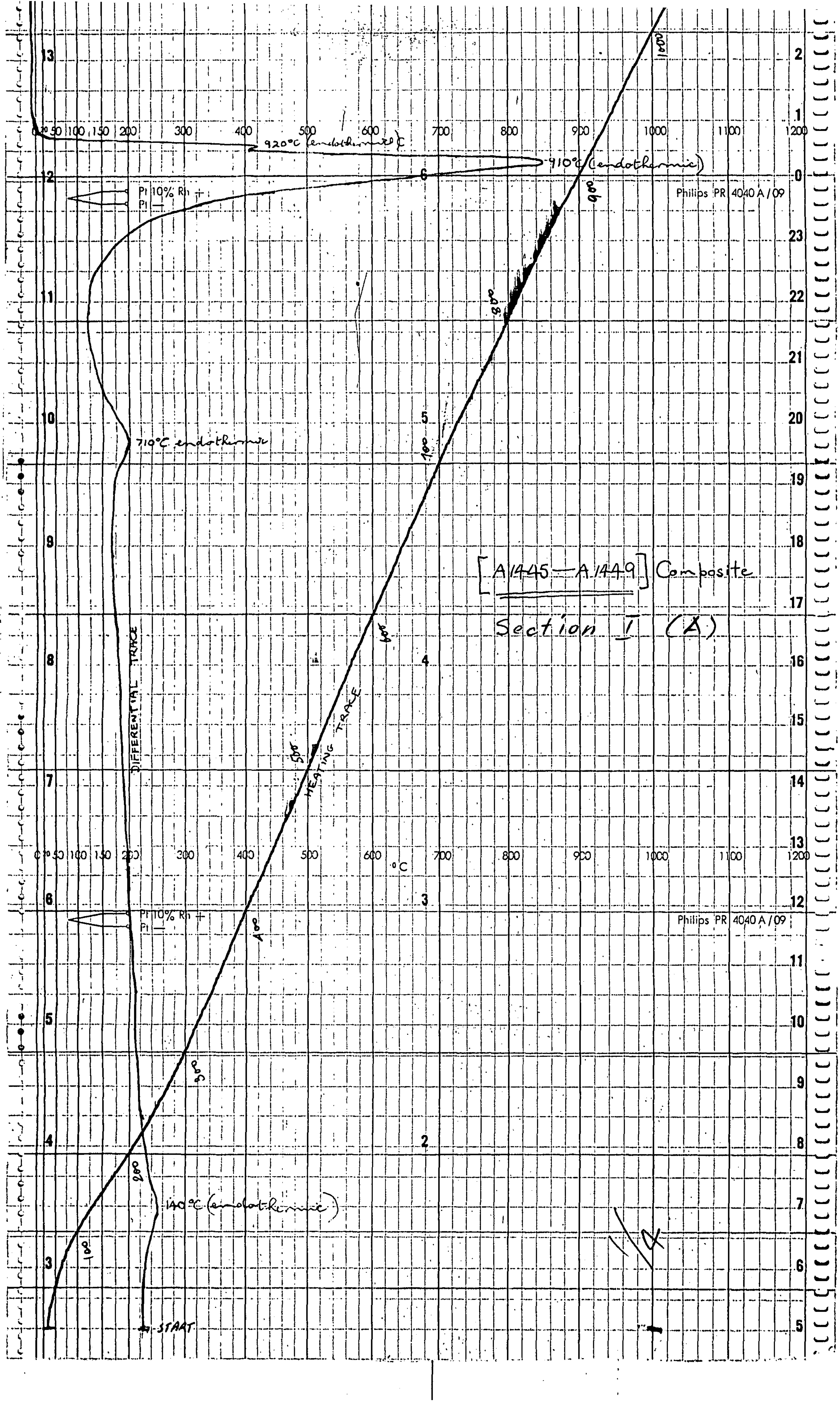


895°C (endothermic)
860°C (endothermic)
730°C (endothermic)
148°C (endothermic)
A 1457
DIFFERENTIAL TRACE
HEATING TRACE
START
Philips PR 4040 A/09
Pt 10% Rh +
Pt —
°C
0 20 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200

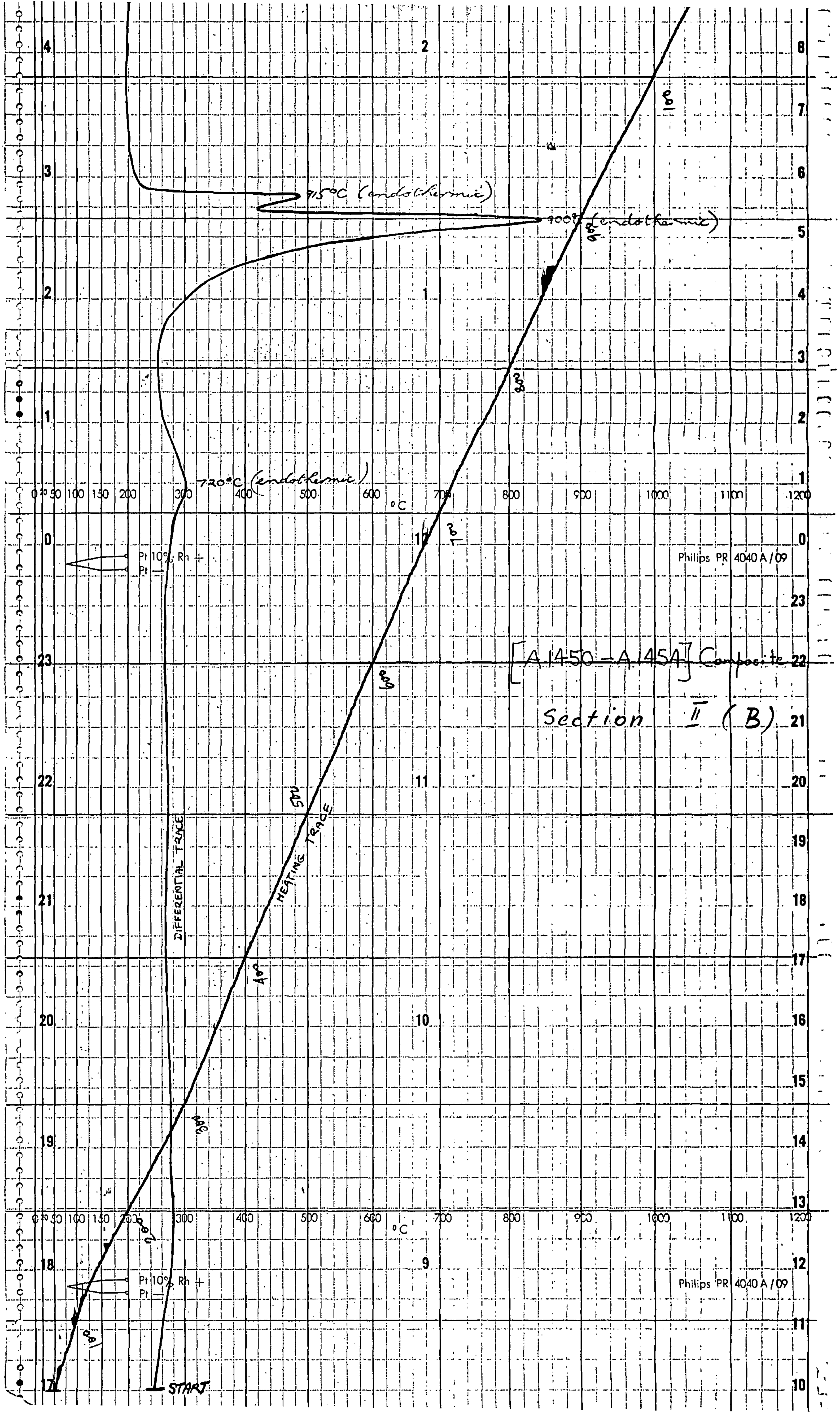


915°C (endothermic)
710°C (endothermic)
DIFFERENTIAL TRACE
HEATING TRACE
A.1459
Pt 10% Rh +
Pt −
Philips PR 4040 A / 09
START
°C
0 20 50 100 150 200 300 400 500 600 700 800 900 1000 1100 1200

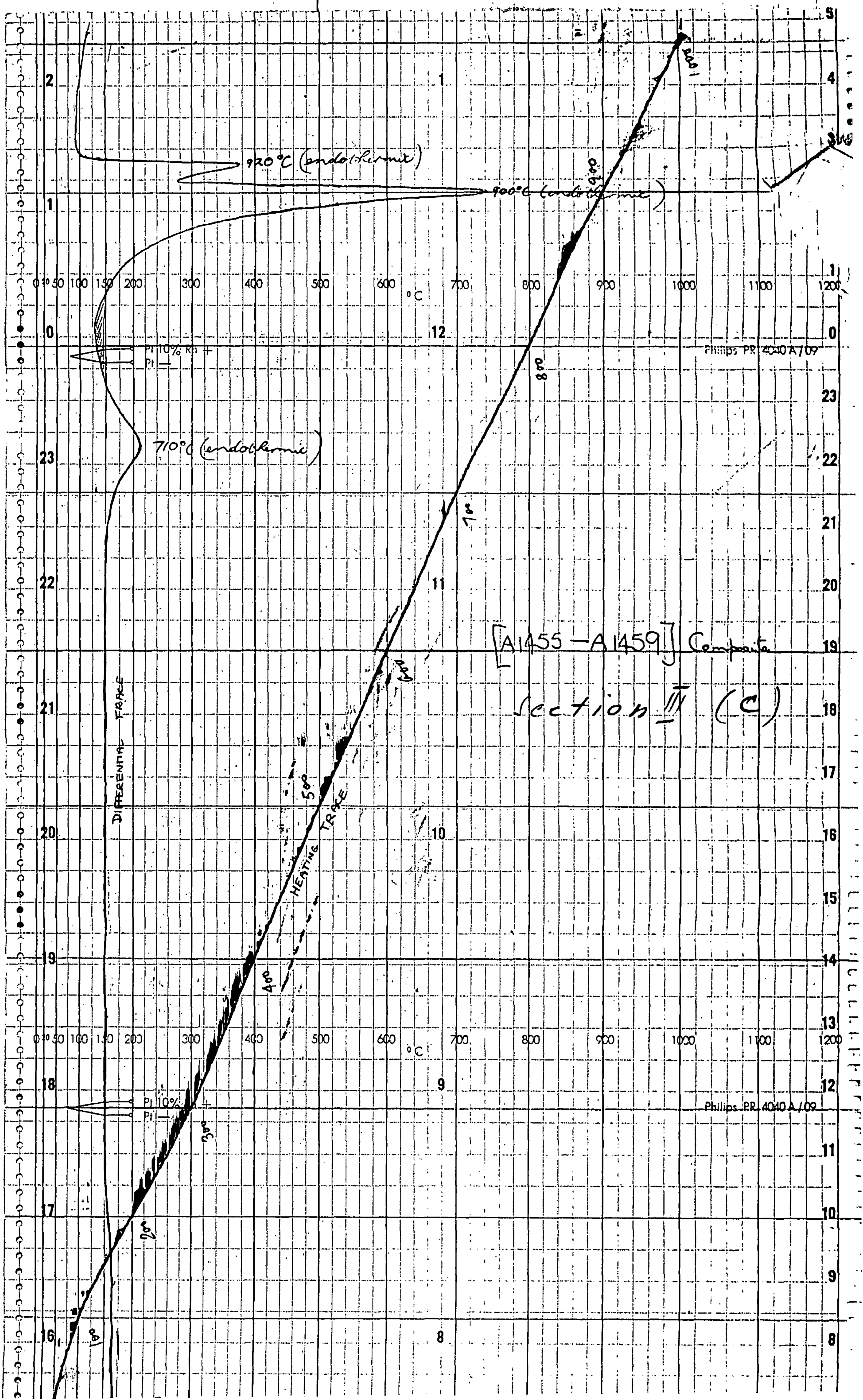

C/e
920°C (endothermic)
715°C (endothermic
140°C (endothermic)
DIFFERENTIAL TRACE
HEATING TRACE
A1458
Philips PR 4040 A / 09
Pt 10% Rh +
Pt −
°C
START



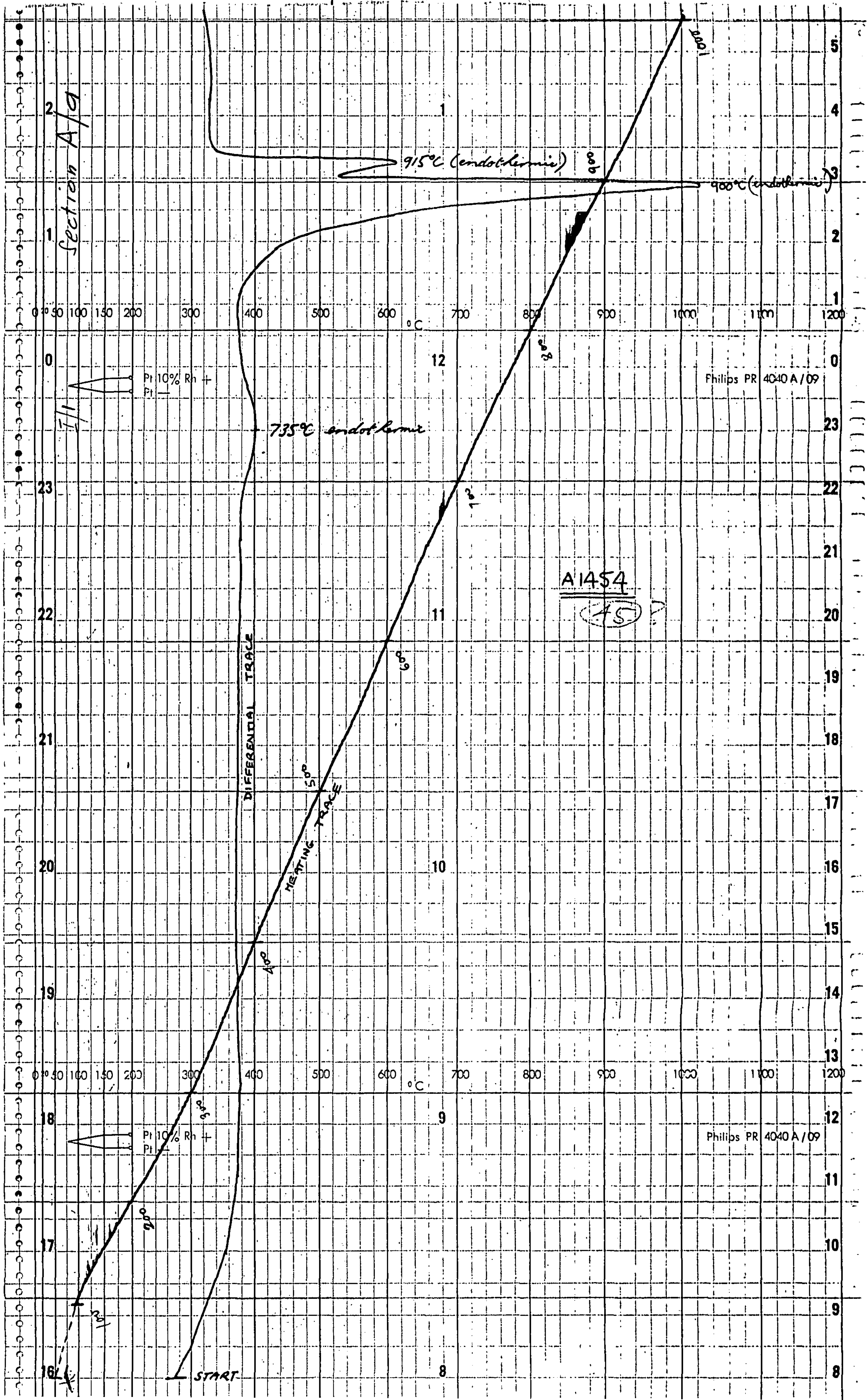
920°C (endothermic)
910°C (endothermic)
710°C endothermic
140°C (endothermic)
START
DIFFERENTIAL TRACE
HEATING TRACE
Pt 10% Rh +
Pt —
Philips PR 4040 A / 09
°C
[A1445 — A1449] Composite
Section I (A)



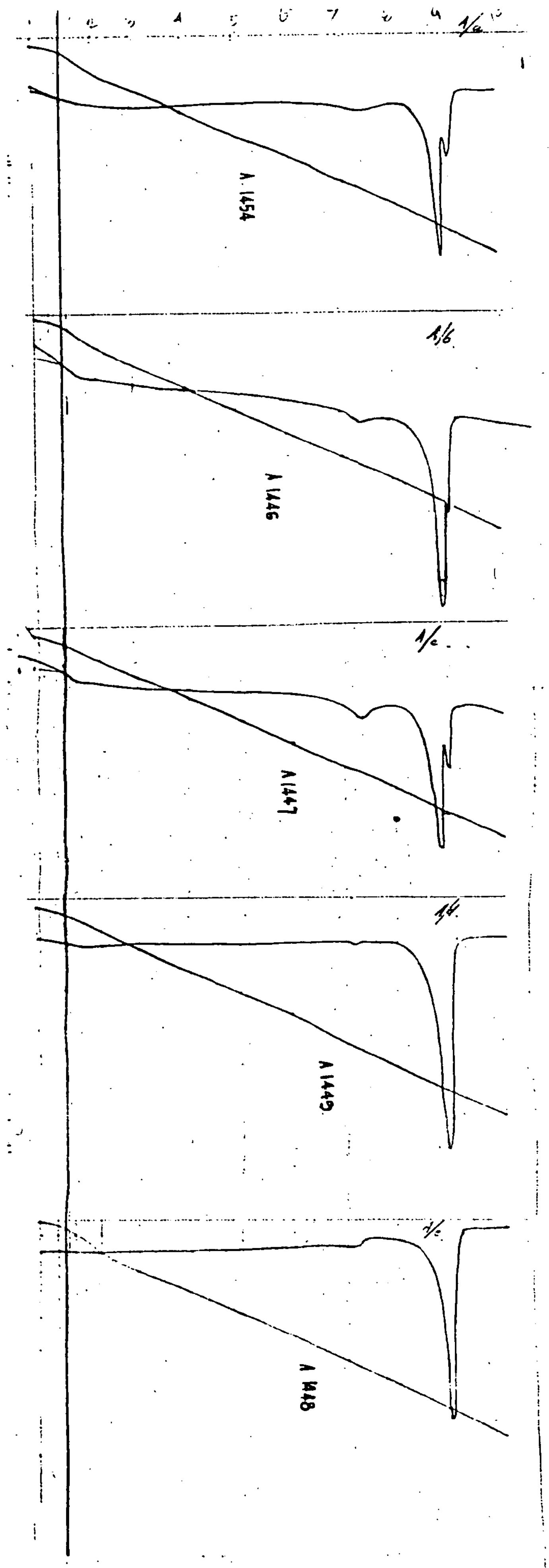
915°C (endothermic)
1000°C (endothermic)
720°C (endothermic)
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
[A1450 – A1454] Composite
Section II (B)
DIFFERENTIAL TRACE
HEATING TRACE
START



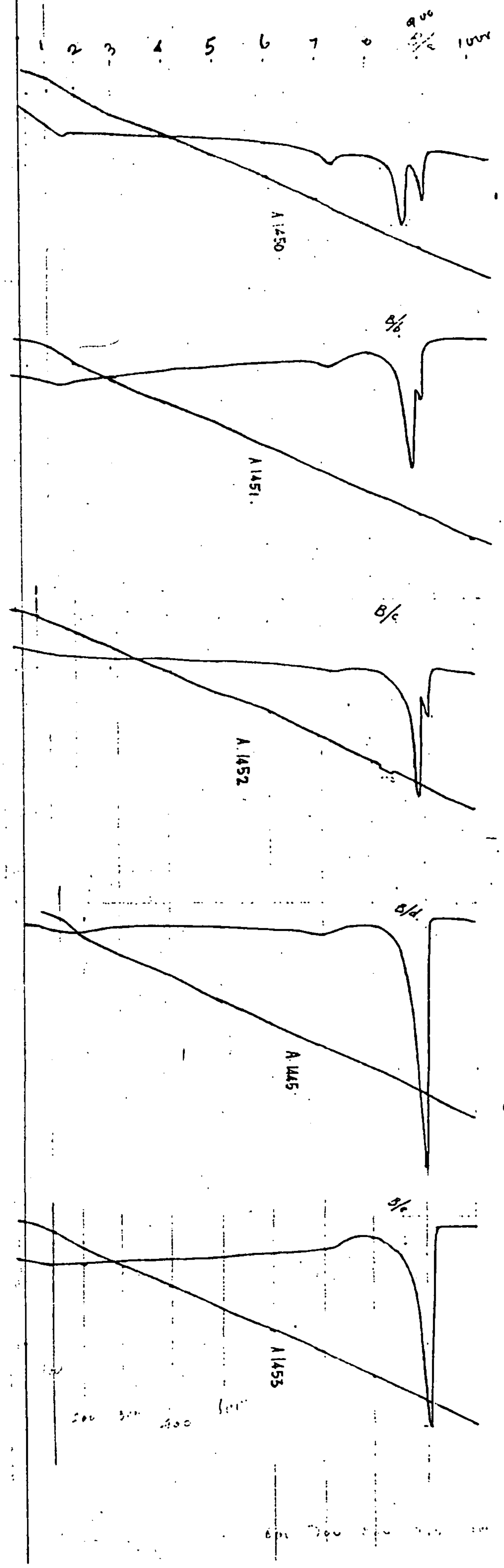
920°C (endothermic)
900°C (endothermic)
710°C (endothermic)
DIFFERENTIAL TRACE
HEATING TRACE
[A1455 — A1459] Composite
Section III (C)
Pt 10% Rh +
Pt —
Philips PR 4040 A/09
°C


Section A/9
915°C (endothermic)
900°C (endothermic)
735°C endothermic
A1454
(45)
DIFFERENTIAL TRACE
HEATING TRACE
START
°C
Pt 10% Rh +
Pt —
Philips PR 4040 A/09

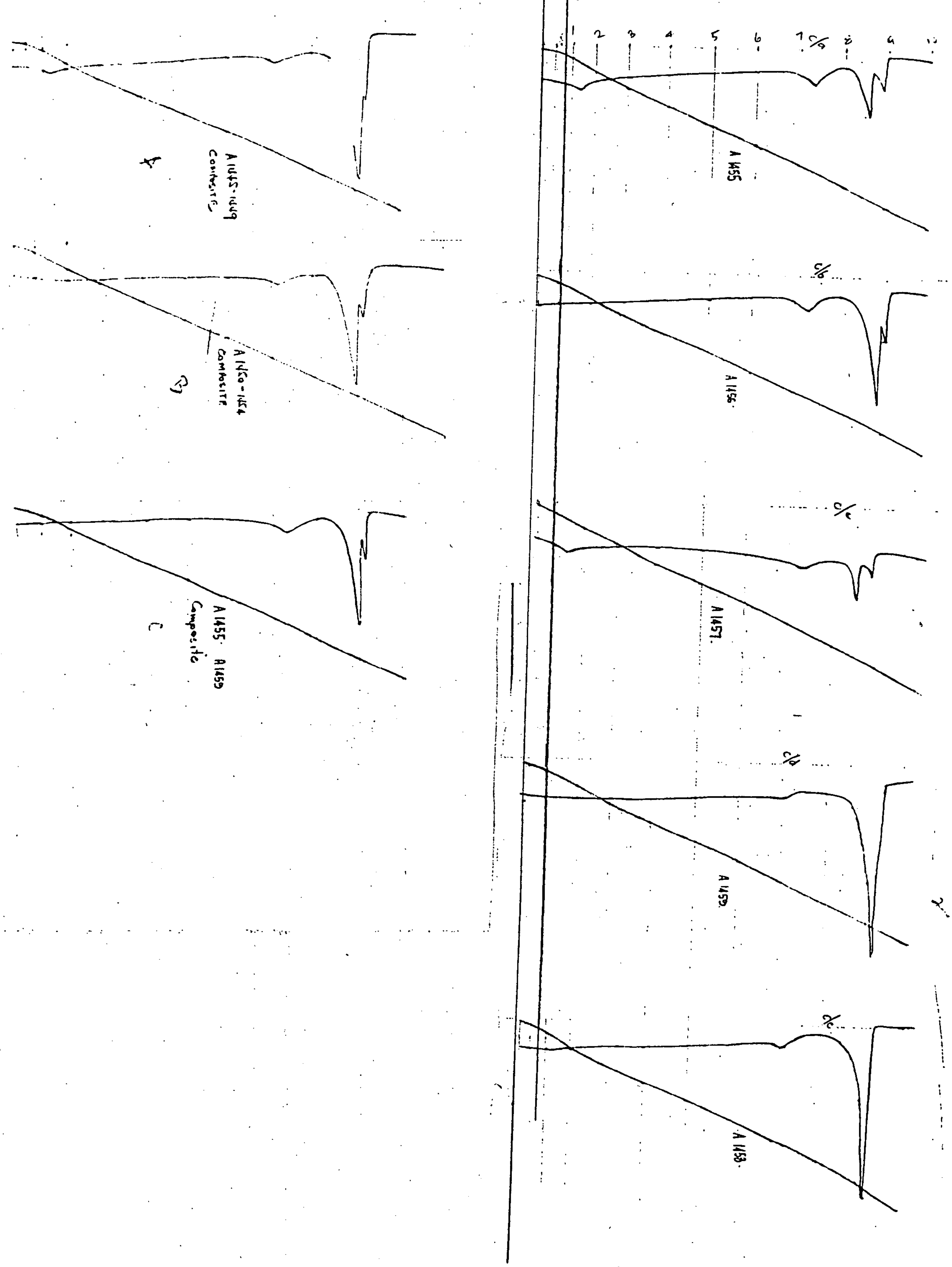
SECTION A



SECTION B



SECTION C



A 1445-1449 Composite
A 1450-1454 Composite
A 1455 - A 1459 Composite
A 1455
A 1456
A 1457
A 1459
A 1458

DEPARTMENT OF MINES—SOUTH AUSTRALIA D.M.—C 33

APPLICATION FOR EXAMINATION OF SPECIMENS OR SAMPLES

50bks100—4.60 7645

Applicant's Mark	Dept. Sample No.	Location: Hundred	Location: Sects.	Location: * Other Locality Information	Information Required
Section I sample 1–5 Section II sample 1–5 Section III sample 1–5				Morgan L. St. type loc.	Differential thermal anal. of each indiv. sample (15) and of compound sample from each section (3)

* Locality information includes distance, direction and name of nearest town or well known point; claim or lease number (if any); pastoral lease (if out of hundreds)—photo and run number or military sheet reference.

Disposal of Specimens

Method of Collection—Selected Specimens or Representative Sample—taken from surface, ~~open working, prospecting shaft, underground working, bore hole, etc.~~

Estimated Size of Deposit

Name of Applicant ? ¶. HEPNER

Address— Geys

Please forward to—
The Director,
Department of Mines,
Box 38, Rundle Street P.O.,
Adelaide.

Signed ? I. Hepner

Date 31/8/ 1960

OFFICE USE ONLY

Submitted to the Australian Mineral Development Laboratories for—

Analysis,
Petrological Laboratory Examination, as above.
Other —

Charge against Mines Department Account No.

Approved for submission to A.M.D.L.

Director of Mines

Copy 1—A.M.D.L. Copy (via head office).
Copy 2—Mines Department, Rundle Street (T.I. Section).
Copy 3—Originator (Mines Department only).
Copy 4—Thebarton (only when samples submitted through Core Room).

DIFFERENTIAL THERMAL CURVES FROM THREE SECTIONS OF PORTION OF MORGAN LIMESTONE

INTERVAL { SECTIONS A – B 60FT.
SECTIONS B – C 150FT.

61-322 H WOPFNER

R