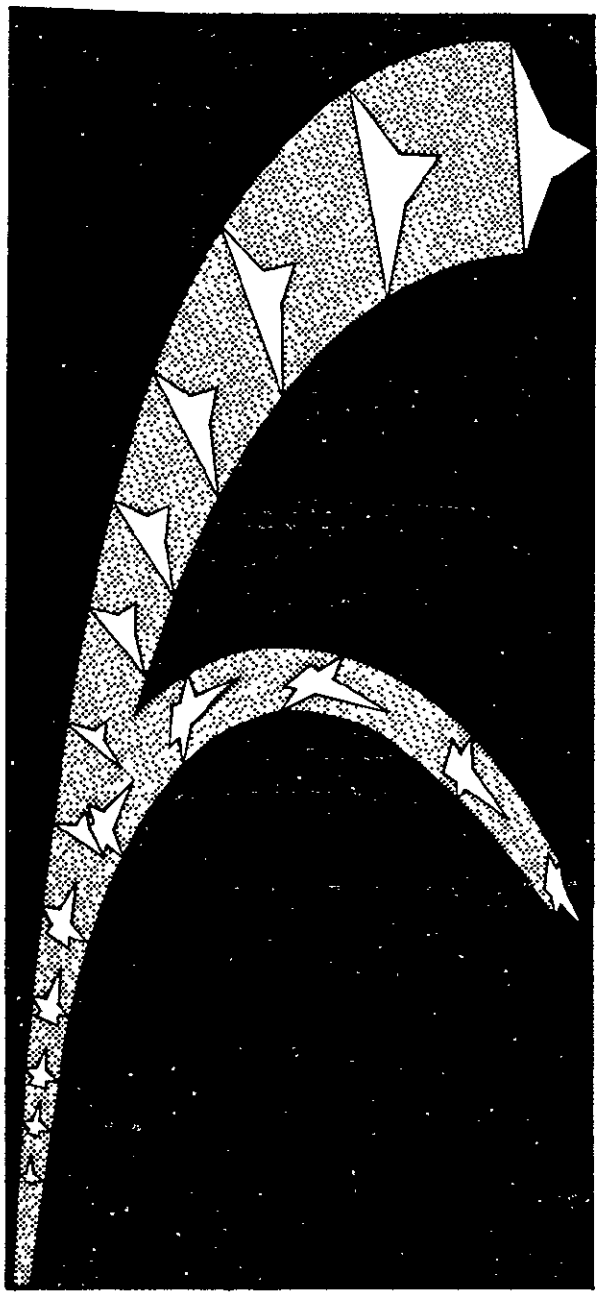
DMS-DR-1154

JULY, 1971



—SPACE SHUTTLE—

AERODYNAMIC HEATING TO THE GRUMMAN SPACE SHUTTLE ORBITERS (ROS-NB1 AND ROS-WB1) AT MACH NUMBER 8.0

by

A. D'Errico, GAC

GAC

HYPERSONIC WIND TUNNEL

SADSAC SPACE SHUTTLE
AEROTHERMODYNAMIC
DATA MANAGEMENT SYSTEM

CONTRACT NAS8-4016
MARSHALL SPACE FLIGHT CENTER

SPACE DIVISION CHRYSLER CORPORATION

DMS-DR-1154
JULY, 1971

SADSAC/SPACE SHUTTLE

WIND TUNNEL TEST DATA REPORT

CONFIGURATION: Grumman Delta-Wing Orbiters (ROS-NBl and ROS-WBl)

TEST PURPOSE: Aerodynamic heat transfer to the space shuttle orbiter at Mach number 8.0.

Test Hours - 80 (approx.)

TEST FACILITY: GAC Hypersonic Wind Tunnel

TESTING AGENCY: Grumman Aerospace Corporation

TEST NO. & DATE: GFHT-017, February 20 - March 22, 1971

FACILITY COORDINATOR: F. Woods

PROJECT ENGINEER(S): A. D'Errico

C. Osonitsch

DATA MANAGEMENT SERVICES

LIAISON: John E. Vaughn
John E. Vaughn

DATA OPERATIONS: A. D. Martin
A. D. Martin

RELEASE APPROVAL: J. L. Glynn
FOR N. D. Kemp, Supervisor
Aero Thermo Data Group

CONTRACT NAS8-4016 AMENDMENT 151 DRL 184 - 58

FACILITY COORDINATOR:

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SPACE SHUTTLE ORBITER
HEAT TRANSFER MODEL TEST RESULTS
DATA REPORT

TEST NUMBER:	GFHT-017
FACILITY:	GAC HYPERSONIC WIND TUNNEL
CONFIGURATION:	GRUMMAN DELTA WING ORBITERS (ROS-NB1 AND ROS-WB1)
MODEL SCALE:	0.0067
TEST PURPOSE:	AERODYNAMIC HEAT TRANSFER TO THE SPACE SHUTTLE ORBITER AT HYPERSONIC SPEEDS.
MACH NUMBER:	8.

TEST CONDUCTED BY: GRUMMAN AEROSPACE CORPORATION

TEST CONDUCTOR: A. D'ERRICO

PROJECT ENGINEER: C. OSONITSCH

TEST DATE: FEBRUARY 20 - MARCH 22, 1971

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ABSTRACT

This report presents the results of a heat transfer wind tunnel test conducted on 0.0067 scale models utilizing the phase-change paint technique. The GAC ROS-NB1 and ROS-WB1 delta wing orbiter configurations were investigated. The ROS-NB1 configuration was tested with a ventral fin on selected runs. Data were obtained for an angle of attack range from 0 to 50 degrees.

The test was conducted in the Grumman 36 inch Hypersonic Wind Tunnel, Farmingdale, New York at a Mach Number of 8.0 and nominal Reynolds numbers per foot of 5×10^5, 7×10^5 and 2.0×10^6.

CONFIGURATION DATA

Components of the Orbiter Configurations were designated as follows:

B_1 - Basic body, ROS-NB1

B_2 - Basic Body, ROS-WB1

W_{1H} - Delta Wing

V_{1H} - Centerline vertical tail

V_{2H} - Twin vertical tails

U_{1H} - Ventral fin

The geometric characteristics are tabulated on the model component sheets which follow. The configurations of the ROS-NB1 and ROS-WB1 delta-wing orbiter models and the ventral fin model are shown in Figures 1, 2 and 3 respectively.

MODEL COMPONENT: BODY - B_1

GENERAL DESCRIPTION: BASIC ROS-NR 1 BODY

DRAWING NUMBER:

DIMENSIONS:	FULL-SCALE	MODEL SCALE
Length	161 ft.	12.867 in.
Max. Width	28 ft.	2.240 in.
Max. Depth	28.7 ft.	2.296 in.
Fineness Ratio	5.61	5.61
Area		
Max. Cross-Sectional	616 $ft.^2$	3.94 $in.^2$
Planform	3990 $ft.^2$	25.54 $in.^2$
Wetted	12610 $ft.^2$	80.70 $in.^2$
Base	590 $ft.^2$	3.78 $in.^2$

MODEL COMPONENT: BODY - B_2

GENERAL DESCRIPTION: BASIC ROS-WB1 BODY

DRAWING NUMBER: _____

DIMENSIONS:	FULL-SCALE	MODEL SCALE
Length	161 ft.	12.867 in.
Max. Width	44.8 ft.	3.584 in.
Max. Depth	28.8 ft.	2.304 in.
Fineness Ratio	3.6	3.6
Area		
Max. Cross-Sectional	956 ft.^{2}	6.12 in.^{2}
Planform	5160 ft.^{2}	33.02 in.^{2}
Wetted	13,930 ft.^{2}	89.15 in.^{2}
Base	744 ft.^{2}	4.76 in.^{2}

MODEL COMPONENT: W_{TH}

GENERAL DESCRIPTION: BASIC ROS-IBI WING WITH MINIMUM TRAILING EDGE THICKNESS OF 0.200 INCHES MAINTAINED FOR HEAT TRANSFER PURPOSES. LOWER SURFACE CONTOURS WERE MAINTAINED WHILE UPPER SURFACE CONTOURS WERE BLENDED TO MEET TRAILING EDGE.

DRAWING NUMBER:

DIMENSIONS:	FULL-SCALE	MODEL SCALE
TOTAL DATA		
Area		
Planform	5747 ft.^{2}	36.78 in.^{2}
Wetted	7780 ft.^{2}	49.79 in.^{2}
Span (equivalent)	97.3 ft.	7.784 in.
Aspect Ratio	1.65	1.65
Rate of Taper		
Taper Ratio	.129	.129
Diehedral Angle, degrees	5°	5°
Incidence Angle, degrees	+2°@BODY, 0°@TIP	
Aerodynamic Twist, degrees		
Toe-In Angle		
Cant Angle		
Sweep Back Angles, degrees		
Leading Edge	60°	60°
Trailing Edge	-8.4°	-8.4°
0.25 Element Line	42.9°	42.9°
Chords:		
Root (Wing Sta. 0.0)	104.6 ft.	8.368 in.
Tip, (equivalent)	13.5 ft.	1.08 in.
MAC	59.0	4.720 in.
Fus. Sta. of .25 MAC		
W.P. of .25 MAC		
B.L. of .25 MAC		
Airfoil Section		
Root		
Tip		
EXPOSED DATA		
Area	3217 ft.^{2}	20.59 in.^{2}
Span, (equivalent)	69.3 ft.	5.541 in.
Aspect Ratio	1.5	1.5
Taper Ratio		
Chords		
Root	78.25 ft.	6.26 in.
Tip	13.5 ft.	1.08 in.
MAC	46.4 ft.	3.712 in.
Fus. Sta. of .25 MAC		
W.P. of .25 MAC		
B.L. of .25 MAC		

MODEL COMPONENT: V_{TH}

GENERAL DESCRIPTION: THE CENTERLINE MOUNTED VERTICAL TAIL IS SIMULATED FOR HEAT TRANSFER PURPOSES BY A FLAT PLATE 0.200 INCHES THICH WITH A MINIMUM LEADING EDGE RADIUS OF 0.10(INCHES AND A LEADING EDGE SWEEP of 45°.

DRAWING NUMBER: _____

DIMENSIONS:	FULL-SCALE	MODEL SCALE
Area	805 ft.^{2}	5.15 in.^{2}
Span (equivalent)	33.3 ft.	2.664 in.
Inb'd equivalent chord	34.6 ft.	2.768 in.
Outb'd equivalent chord	13.75 ft.	1.100 in.
Ratio Elevator chord/horizontal tail chord	(NO MOVABLE SURFACE)	
At Inb'd equiv. chord	-	-
At Outb'd equiv. chord	-	-
Sweep Back Angles, degrees		
Leading Edge	45°	45°
Tailing Edge	19.7°	19.7°
Hingeline	-	-
Area Moment (Normal to hinge line)	-	-

MODEL COMPONENT: V_{2H}

GENERAL DESCRIPTION: THE TWIN VERTICAL TAILS ARE SIMULATED FOR HEAT TRANSFER PURPOSES BY FLAT PLATES OF 0.200 INCH THICKNESS AND 0.100 INCH LEADING EDGE RADII.

DRAWING NUMBER: _____

DIMENSIONS:	FULL-SCALE	MODEL SCALE
Area	670 ft.^{2}	4.288 in.^{2}
Span (equivalent)	35.5 ft.	2.840 in.
Inb'd equivalent chord	33.2 ft.	2.656 in.
Outb'd equivalent chord	9.08 ft.	.726 in.
Ratio Elevator chord/horizontal tail chord	(NO MOVABLE SURFACE)	
At Inb'd equiv. chord	-	-
At Outb'd equiv. chord	-	-
Sweep Back Angles, degrees		
Leading Edge	40°	40°
Tailing Edge	8.5°	8.5°
Hingeline	-	-
Area Moment (Normal to hinge line)	-	-

TEST FACILITY DESCRIPTION

Grumman 36-Inch Hypersonic Tunnel

Description: This is an intermittent blowdown to vacuum type tunnel. The test section is 36 inches in diameter. High temperature air from a pebble bed heater is introduced to the test section through fixed contoured, axisymmetric nozzles.

Performance Parameters:

Mach Range:	8, 10, 14
Reynold's Number (x 10^6/ft):	0.2 to 4.5
Stagnation Pressure (psia):	200 to 2200
Dynamic Pressure (psf):	100 to 1200
Stagnation Temperature ($^\circ$R):	1000 to 3500
Run Time (sec):	30 to 60

Testing Capabilities: Model mounting consists of a water-cooled, sting balance sector rig which features a model injection system. Instrumentation for force, pressure, and heat transfer measurement is provided. A Schlieren System is available.

PHASE CHANGE PAINT DATA

The test results are shown in Figures 4 through 50 in the form of heating contours. These contours are correlated to heat transfer coefficient ratios (h/h_o), the ratios of local heat transfer coefficients on the model surface to the heat transfer coefficient at the stagnation point of a 1/150 foot radius sphere. The grid systems shown in Photographs 1 and 2 were permanently marked on each test model. The grid lines were positioned in a projected planform view one inch apart parallel to fuselage stations (from F.S. 200) and one half inch apart parallel to butt lines (from model centerline). The vertical tail grid lines are one half inch apart in a projected profile view parallel to water lines.

LIST OF NOMENCLATURE

h Heat transfer coefficient based on temperature (BTU/SEC-ft^2-$^\circ$R)

h_o Heat transfer coefficient at the stagnation point of a 1 foot radius sphere at model scale

RN Reynold's Number (non-dimensional)

α Angle of attack (degrees)

β Angle of sideslip (Degrees)

ϕ Angle of roll (Degrees)

TABLE 1

PHASE CHANGE COATING TEST DATA SUMMARY SHEET

TEST TITLE: SPACE SHUTTLE ORBITER HEAT TRANSFER MODEL TEST

TEST NUMBER: GFHT-017 TEST FACILITY: GAC HYPERSONIC TUNNEL

TEST DATE: FEBRUARY 20- MARCH 22,1971 TEST ENGINEER: A. D'ERRICO

Run No.	Model Configuration Identification	Model Scale	Free Stream Mach Number	Total Pressure (psia)	Total Temp. (^{o}R)	$\frac{T_{aw}*}{T_{total}}$	$\frac{RNX10^{6}}{Ft}$	Phase Change Temp. (^{o}F)	Model Position (degrees) α	β	ϕ	$h_{r=1'}$	T_w**
2	$B_1W_{1H}V_{1H}$	.0067	8.0	123.0	1417	1.0	.47	200	0	0	0	.0301	535^{o}R
5				123.2	1272		.57	200	20			.0297	
6				124.8	1405		.48	113	20			.0303	
7				123.6	1495		.43	200	30			.0304	
8				123.1	1259		.58	113	30			.0297	
9				125.9	1443		.47	113	0			.0306	
11				121.4	1435		.45	113	0		180	.0300	
14				123.7	1314		.54	113	20			.0299	
18				231.7	1560		.75	113	30			.0420	
19				237.5	1625		.72	200	50		0	.0427	
20				234.3	1617		.71	113	50			.0424	
21				227.9	1552		.74	113	50		180	.0416	
22	$B_2W_{1H}V_{2H}$			240.1	1604		.74	350	50		0	.0429	535^{o}R

** T_w = wall temperature assumed in $h_{r=1'}$ calculation * T_{aw} = adiabatic wall temperature

TABLE 2

PHASE CHANGE COATING TEST DATA SUMMARY SHEET

TEST TITLE: SPACE SHUTTLE ORBITER HEAT TRANSFER MODEL TEST

TEST NUMBER: GPHT-017 TEST FACILITY: GAC HYPERSONIC TUNNEL

TEST DATE: FEBRUARY 20-MARCH 22,1971 TEST ENGINEER: A. D'Errico

Run No.	Model Configuration Identification	Model Scale	Free Stream Mach Number	Total Pressure (psia)	Total Temp. (^{o}R)	$\frac{T_{aw}*}{T_{total}}$	$\frac{RNX10^{6}}{Ft}$	Phase Change Temp. (^{o}F)	Model Position (degrees) α	β	ϕ	$h_{r=1}$	T_w**
23	$B_2W_{1H}V_{2H}$	.0067	8.0	240.0	1560	1.0	.78	200	50	0	180	.0427	535^{o}R
24				241.6	1606		.74	113	50			.0430	
26				238.9	1614		.73	113	30			.0428	
28				244.0	1531		.82	113	20			.0430	
29				240.9	1579		.76	200	20			.0429	
30				242.9	1615		.74	200	0			.0431	
31				243.8	1707		.67	113	0			.0435	
32	$B_1W_{1H}V_{1H}$			536.9	1525		1.82	113	20			.0641	
66	$B_1W_{1H}V_{1H}U_{1H}$			239.4	1536		.80	113	20		0	.0426	
67				239.5	1496		.84	200	20		0	.0424	
68				243.1	1418		.93	200	0		0	.0425	
69				239.0	1299		1.06	113	0		0	.0416	
70				242.1	1452		.89	113	50		0	.0425	535^{o}R

** T_w = wall temperature assumed in $h_{r=1}$ calculation

* T_{aw} = adiabatic wall temperature

TABLE 3

PHASE CHANGE COATING TEST DATA SUMMARY SHEET

TEST TITLE: SPACE SHUTTLE ORBITER HEAT TRANSFER MODEL TEST

TEST NUMBER: GHT-017 TEST FACILITY: GAC HYPERSONIC TUNNEL

TEST DATE: FEB. 20 - MARCH 22,1971 TEST ENGINEER: A. D'Errico

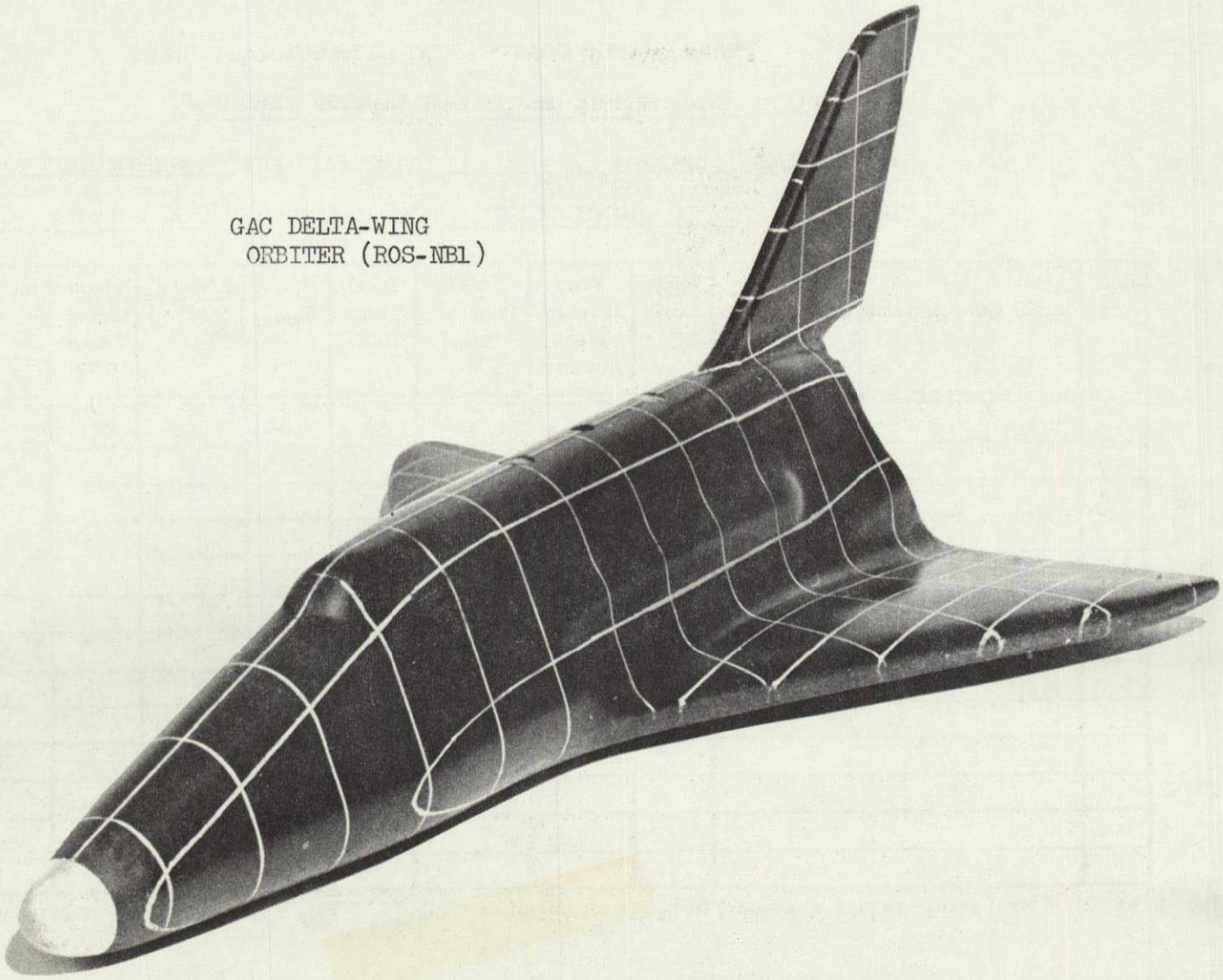
Run No.	Model Configuration Identification	Model Scale	Free Stream Mach Number	Total Pressure (psia)	Total Temp. (^{o}R)	$\frac{T_{aw}*}{T_{total}}$	$\frac{RNX10^{6}}{Ft}$	Phase Change Temp. (^{o}F)	Model Position (degrees)			$h_{r=1'}$	T_{w}**
									α	β	ϕ		
71	$B_1W_{1H}V_{1H}U_{1H}$	.0067	8.0	244.4	1382	1.0	.98	200	50	0	0	.0425	535^{o}R

** T_{w} = wall temperature assumed in $h_{r=1'}$ calculation

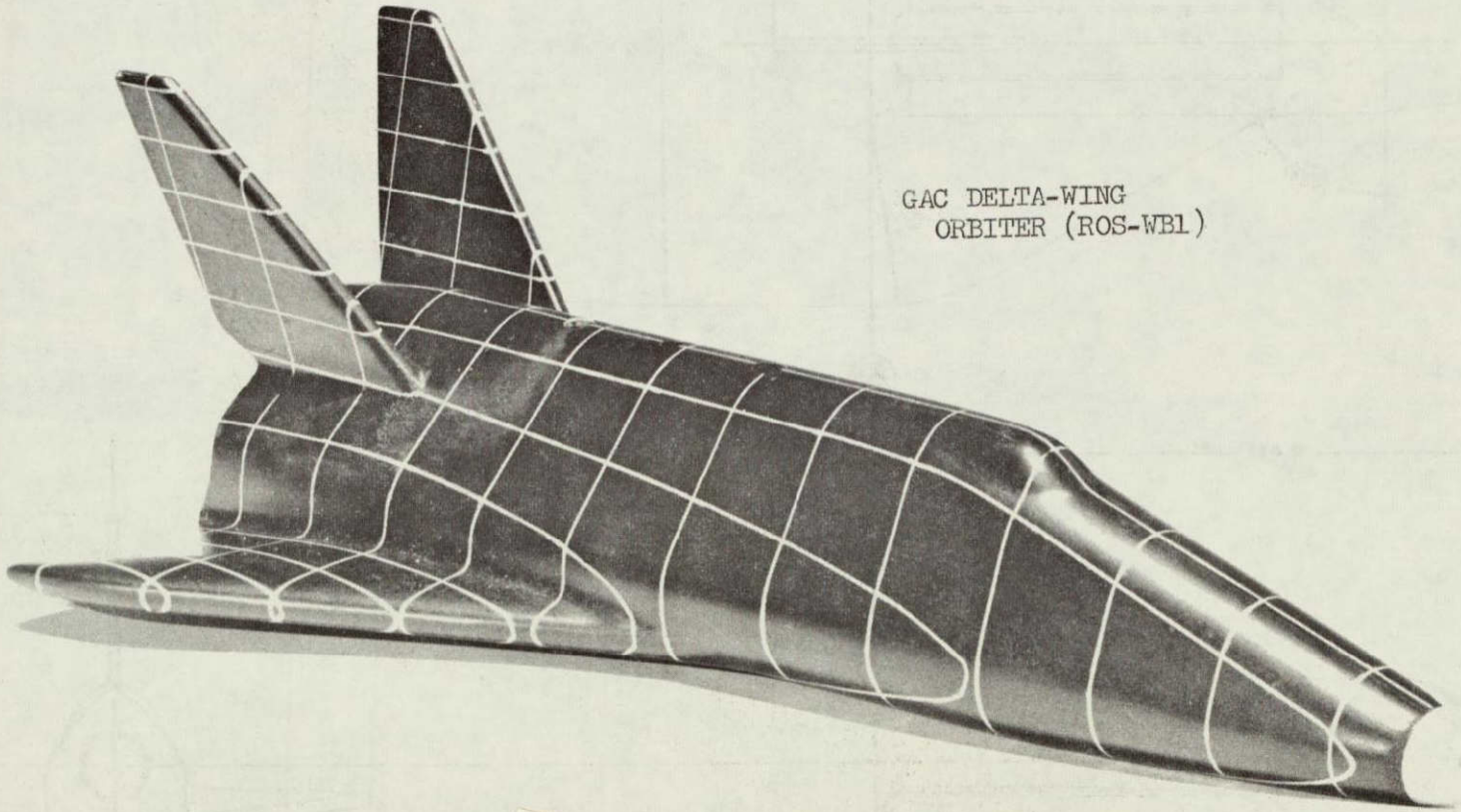
* T_{aw} = adiabatic wall temperature

PHOTOGRAPH 1

GAC DELTA-WING
ORBITER (ROS-NB1)

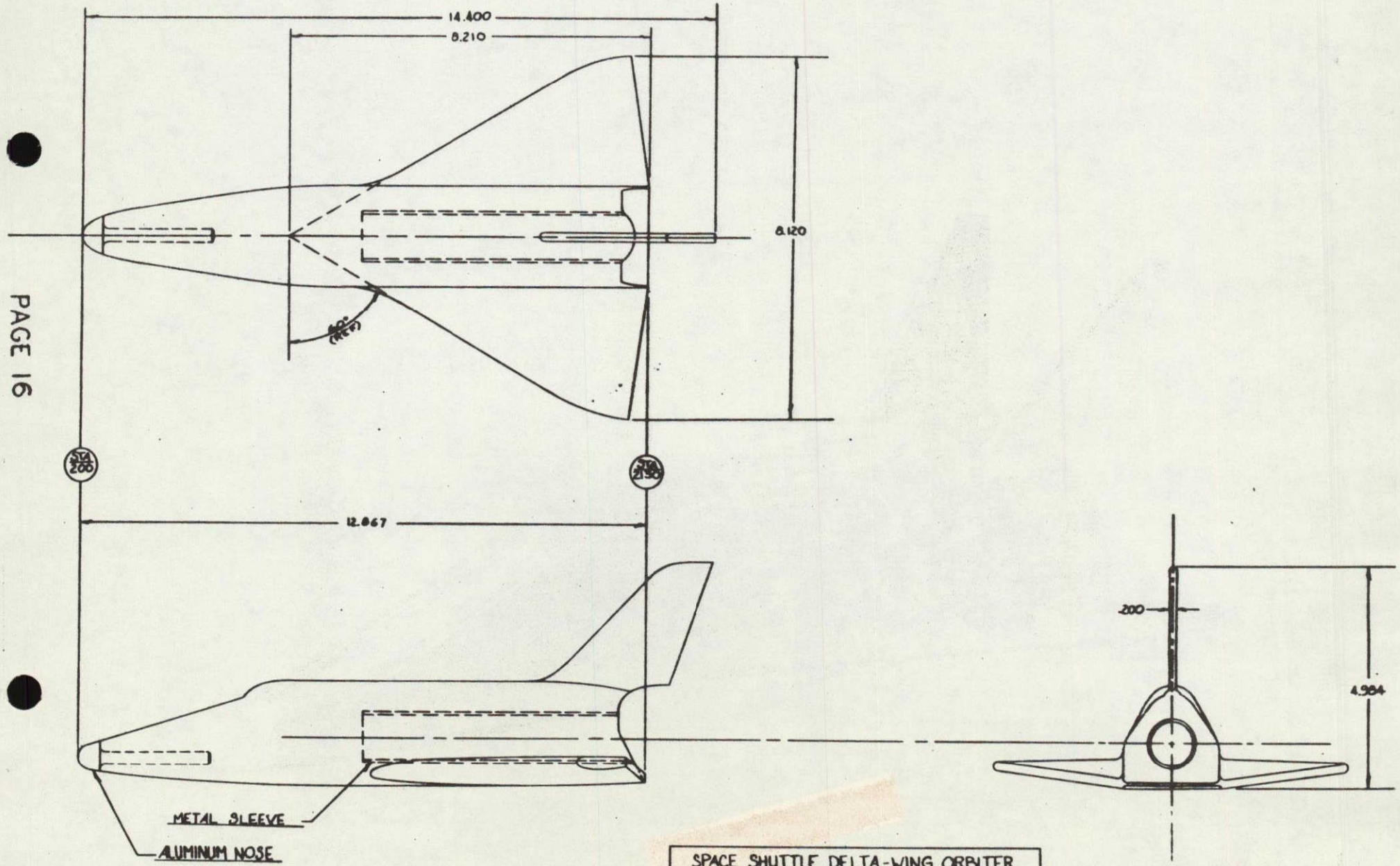


PHOTOGRAPH 2



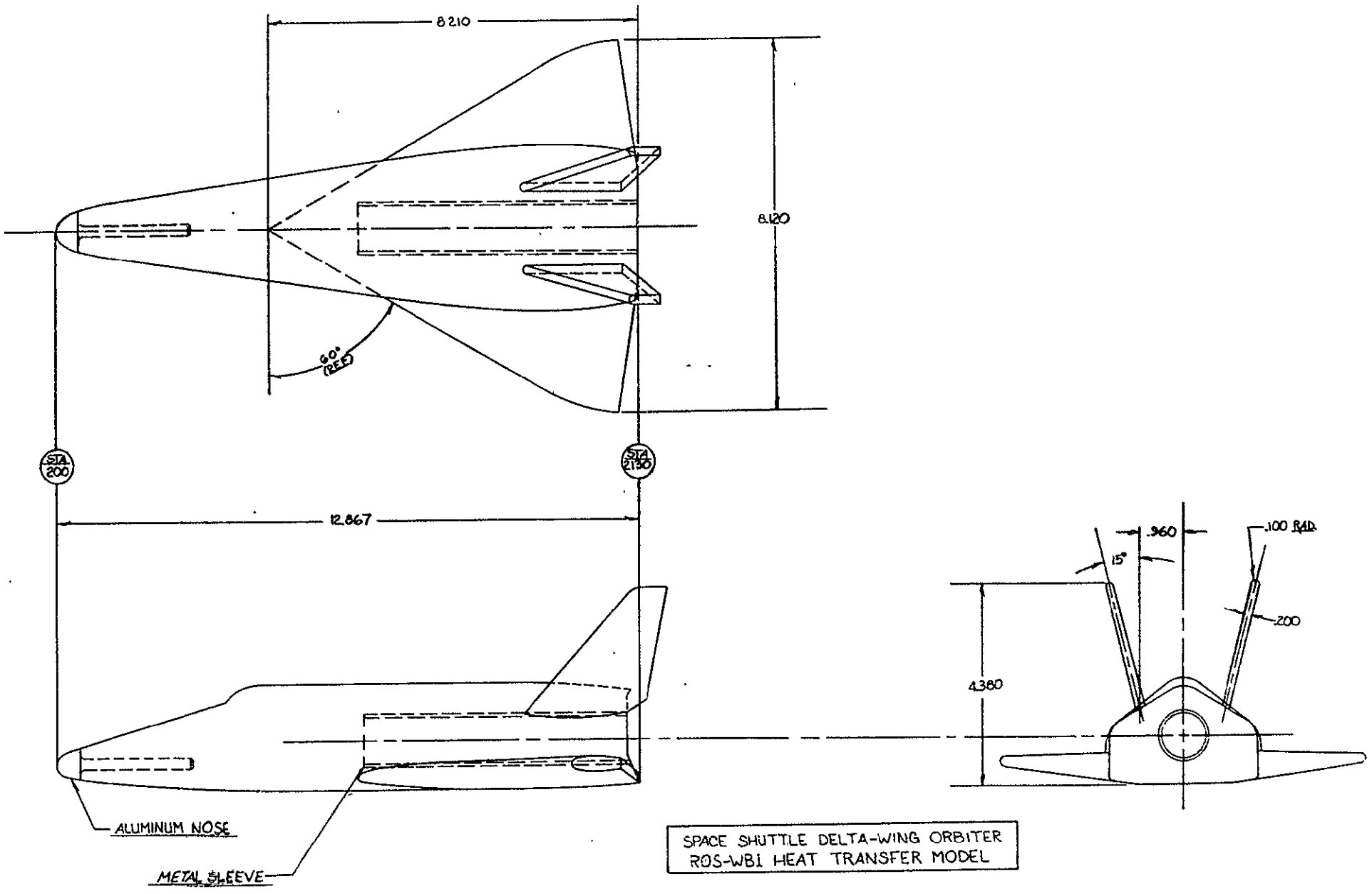
GAC DELTA-WING
ORBITER (ROS-WB1)

FIGURE 1



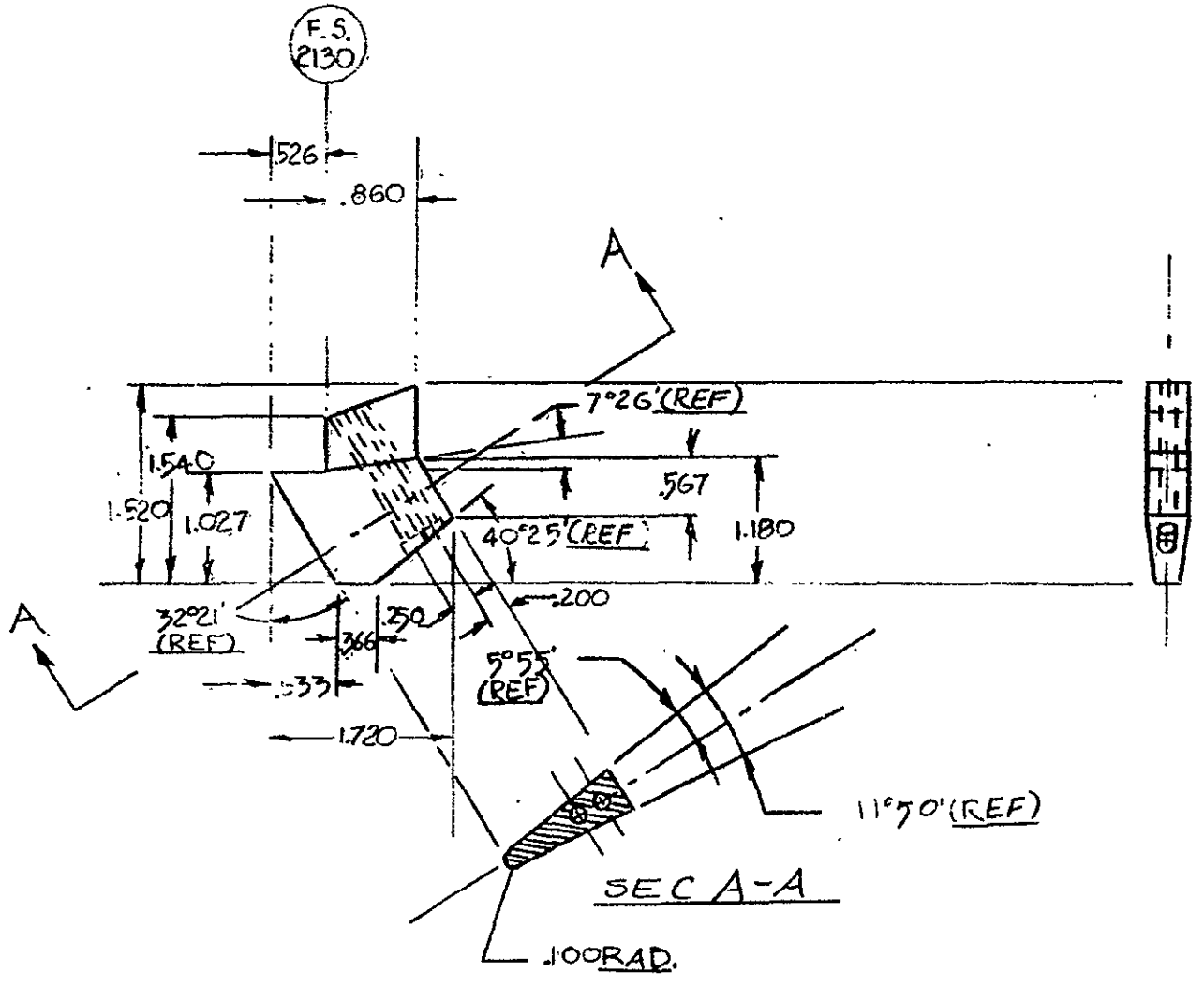
SPACE SHUTTLE DELTA-WING ORBITER
ROS-NB1 HEAT TRANSFER MODEL

FIGURE 2



SPACE SHUTTLE DELTA-WING ORBITER
ROS-WBI HEAT TRANSFER MODEL

FIGURE 3



VENTRAL FIN [U_{1H}]

1/150 SCALE HEAT TRANSFER MODEL

A.J.D.

SUMMARY OF HEATING CONTOURS

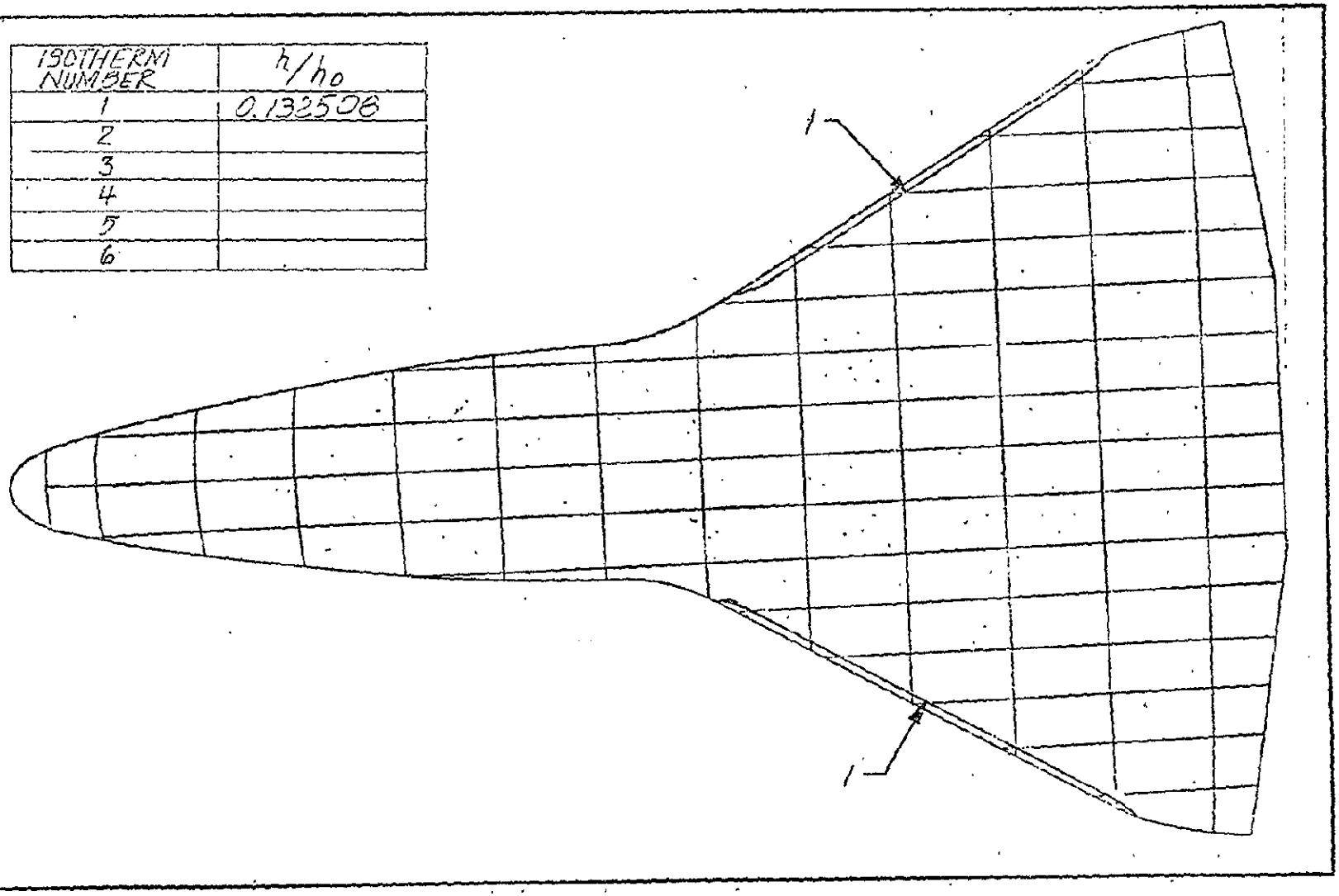
SUMMARY OF HEATING CONTOURS (Continued)

SUMMARY OF HEATING CONTOURS (Continued)

PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 002

ISOTHERM NUMBER	h/ho
1	0.132506
2	
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 009

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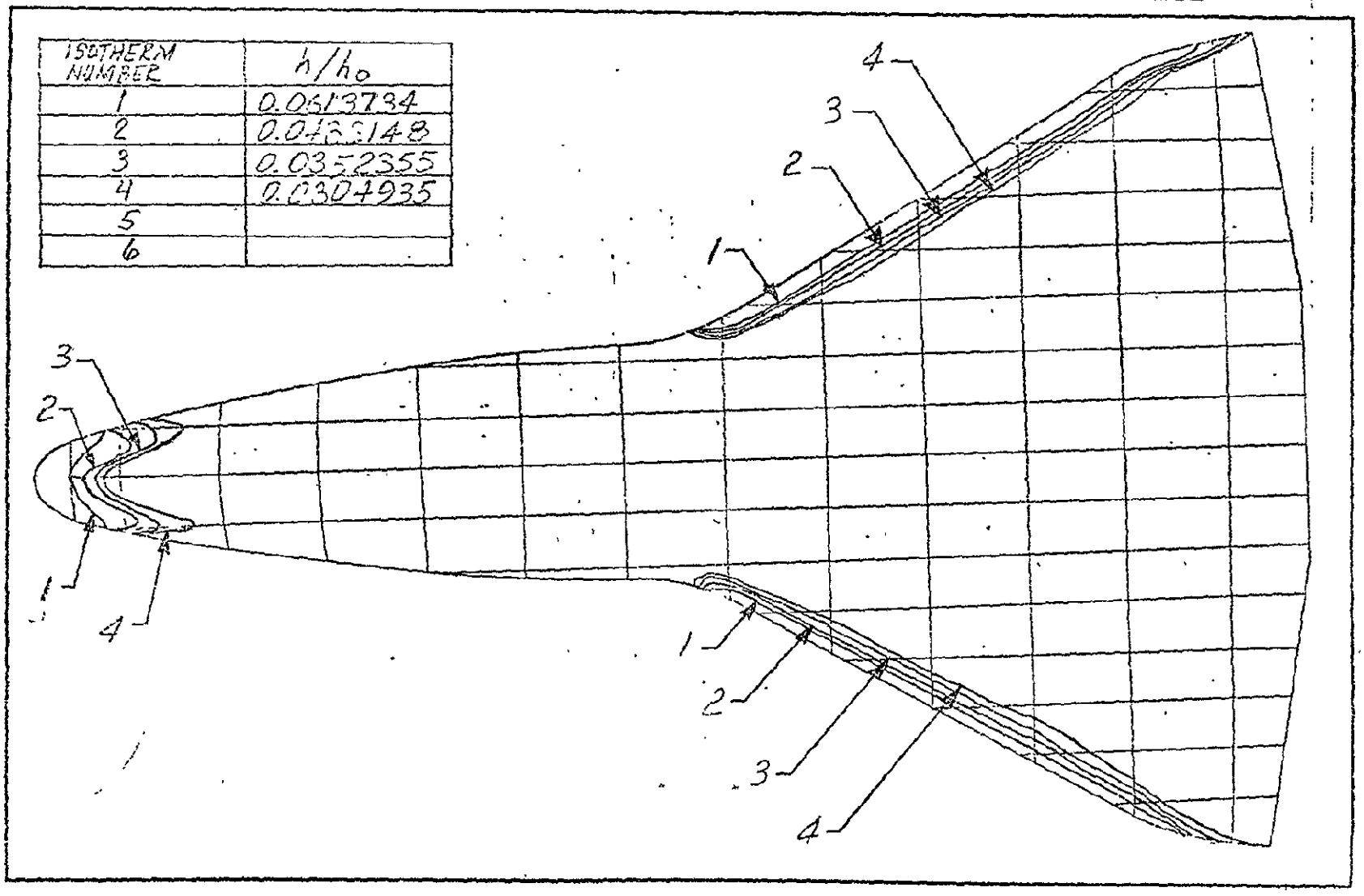
3	0.0352355
4	0.0304935
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 005

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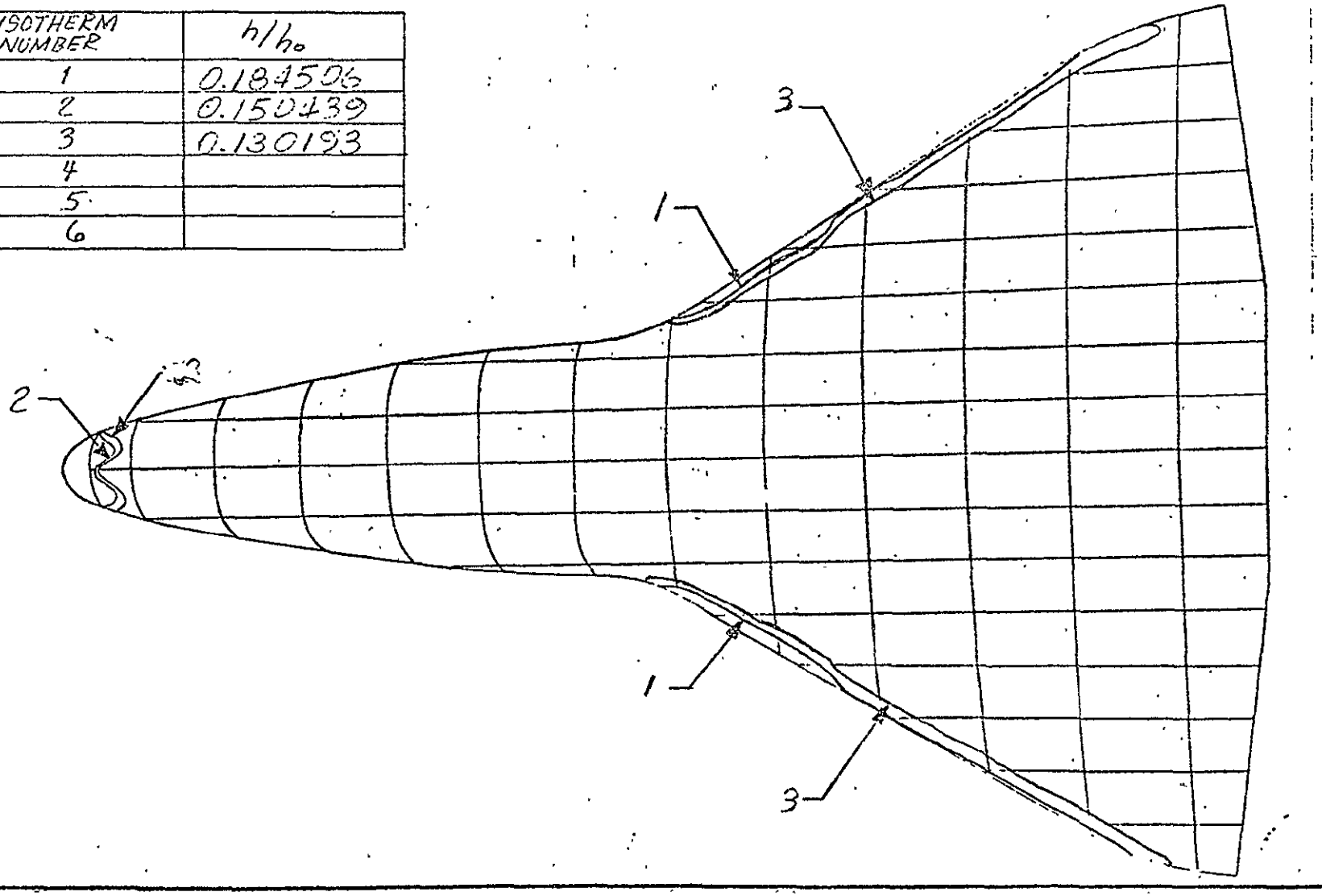
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 006

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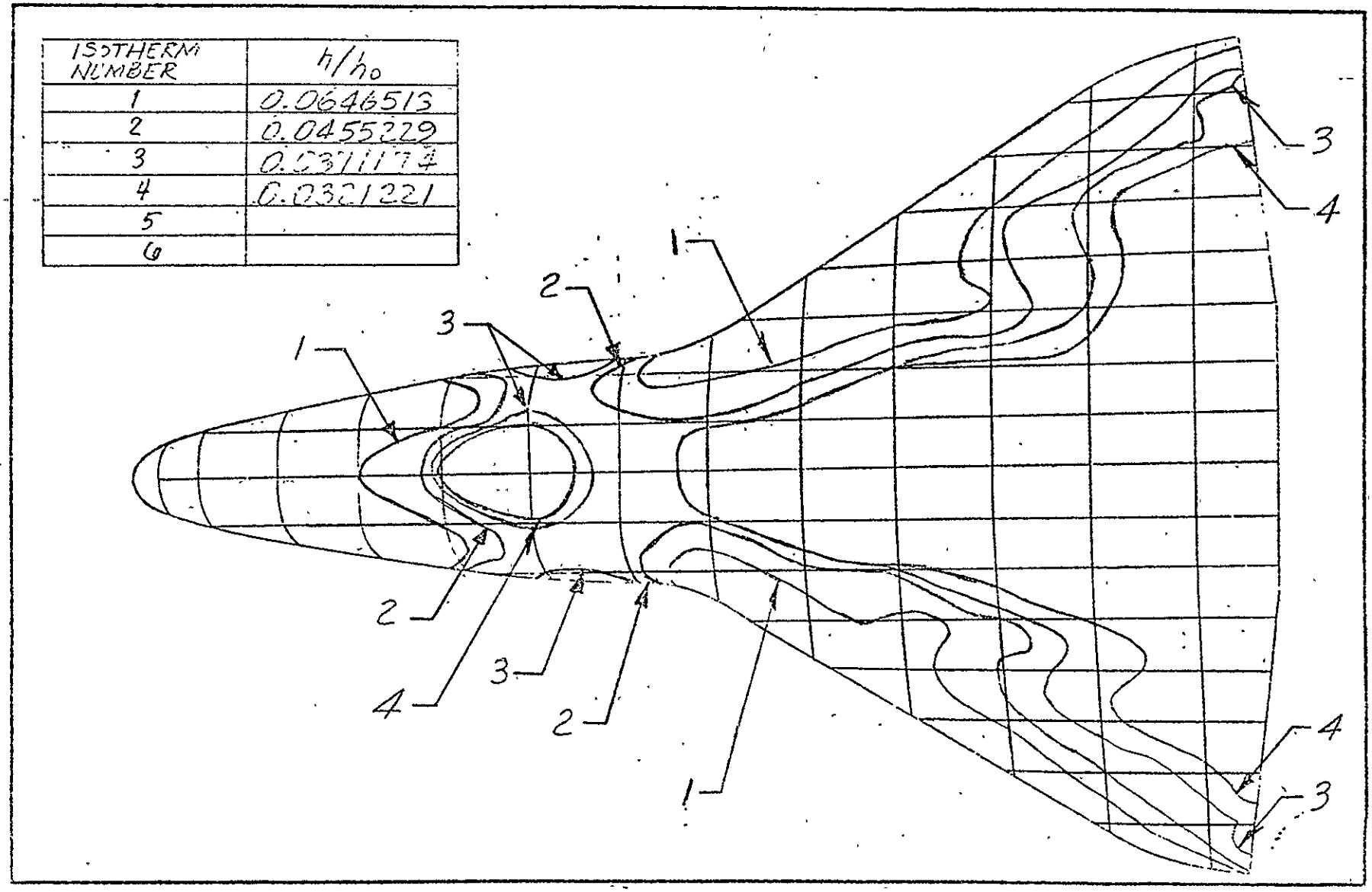
3	0.0371174
4	0.0321221
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 007

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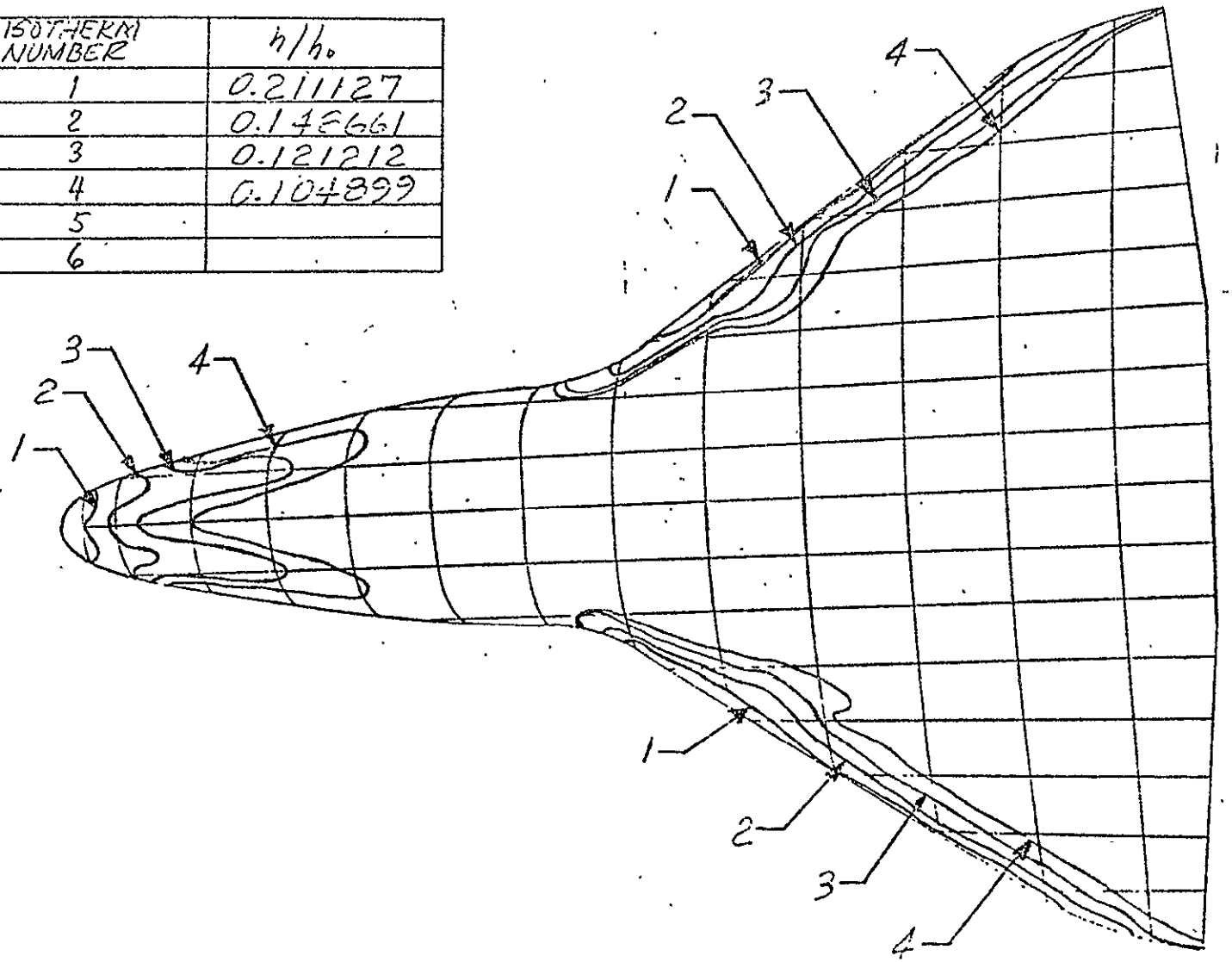
4	0.104899
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 008

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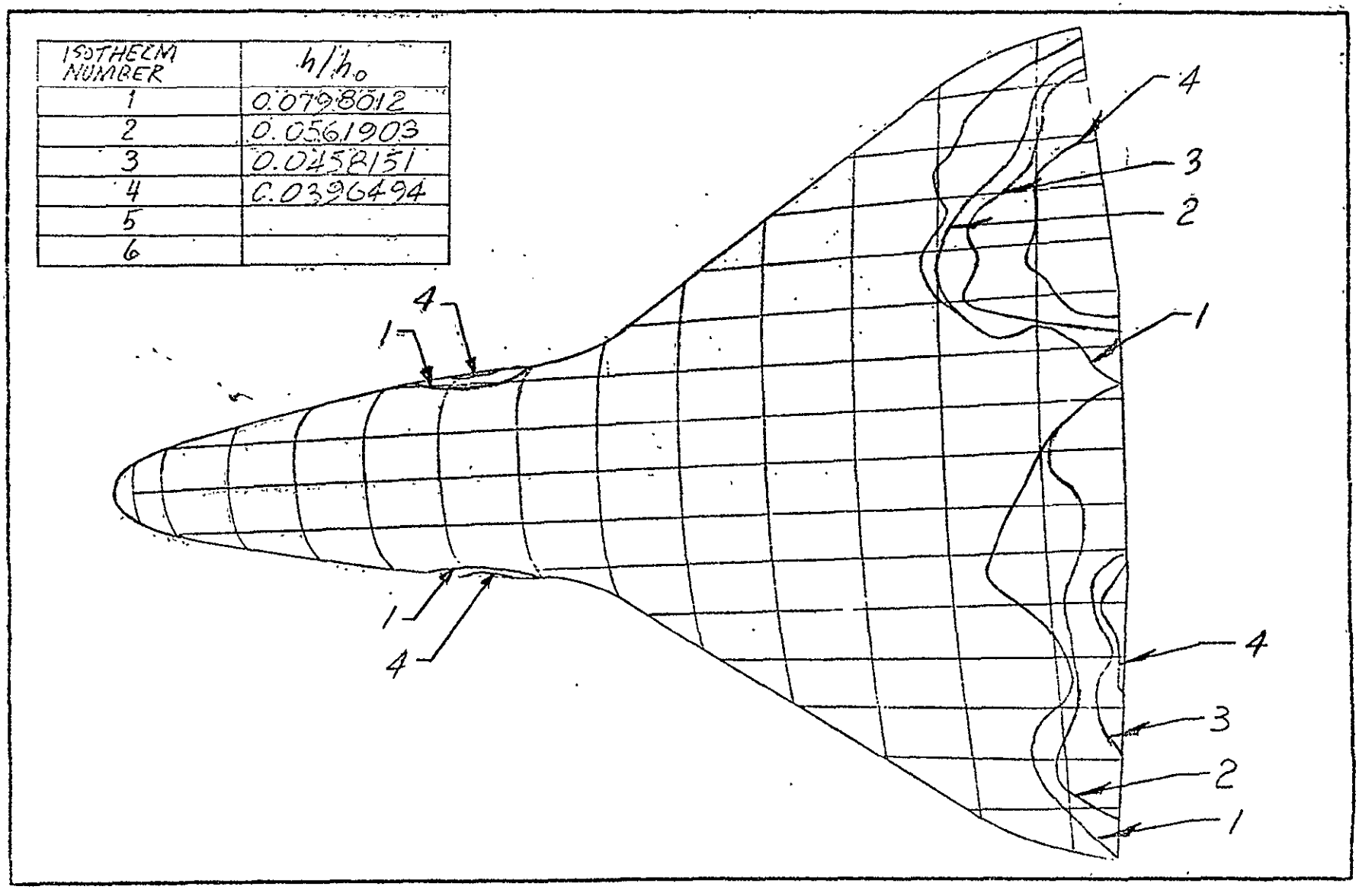
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 019

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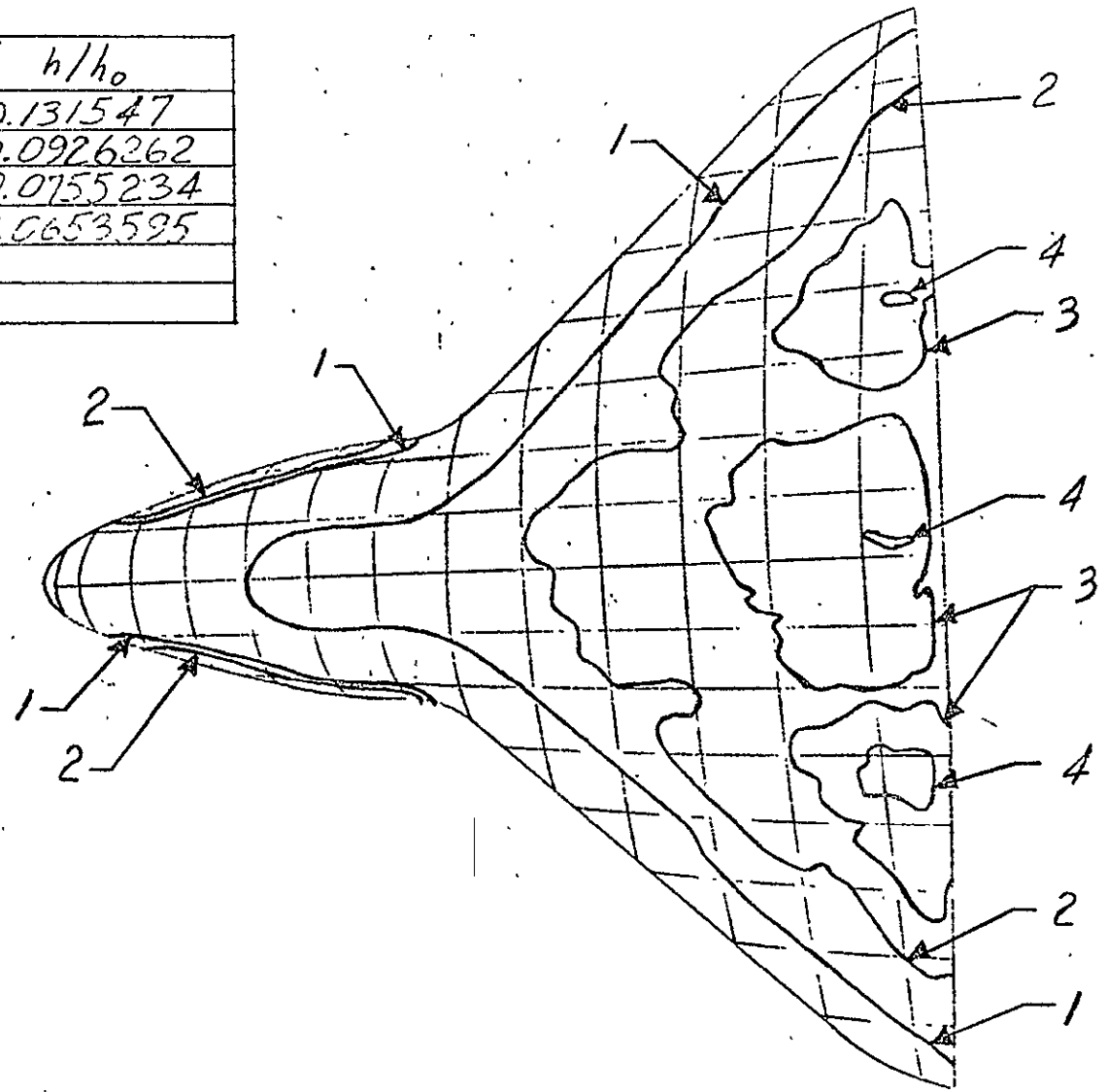

PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GEHT-017 TEST RUN NUMBER: 022

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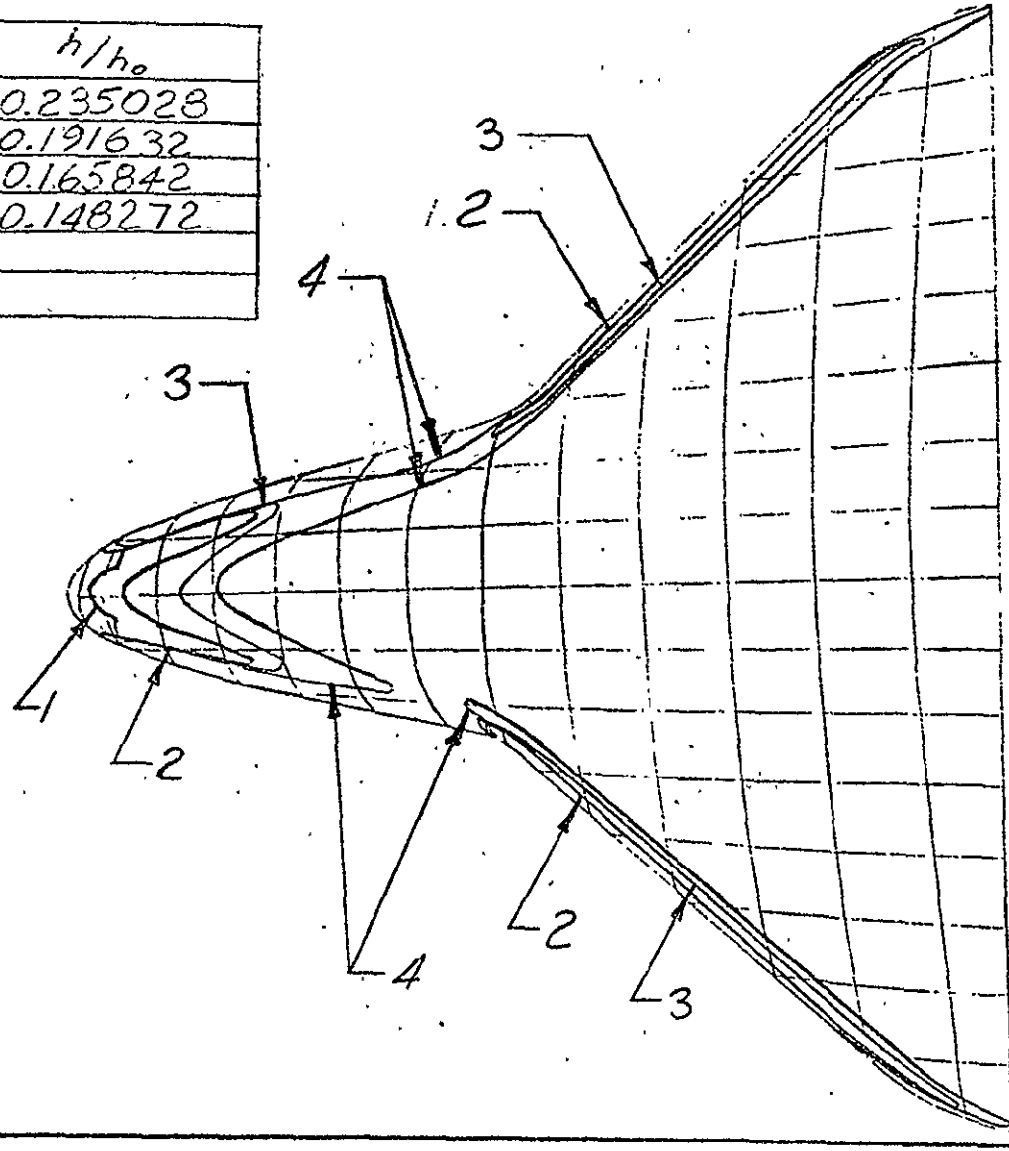
6	



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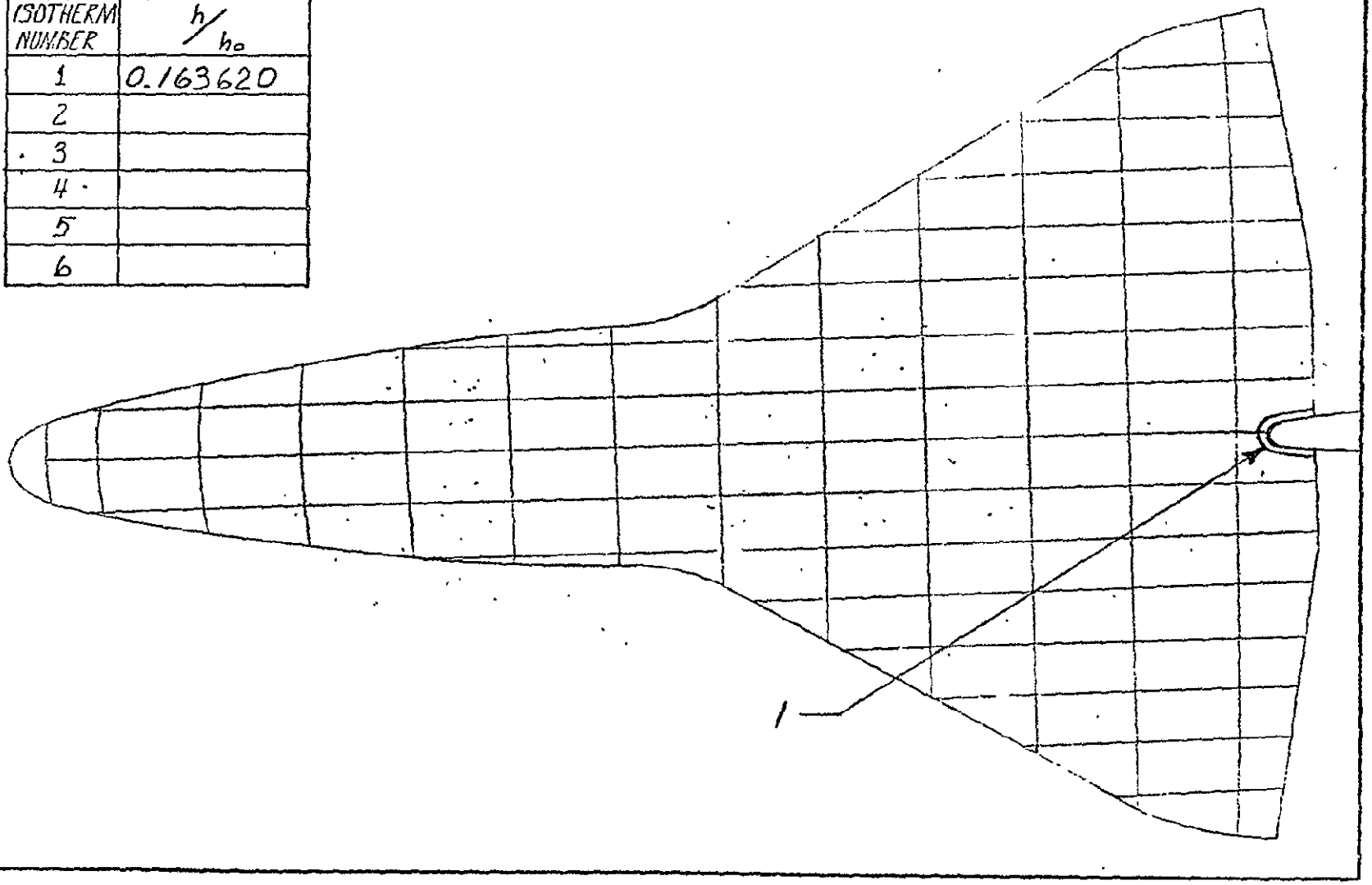
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST TEST TEST NUMBER: GFHT-017 TEST RUN NUMBER: 069

ISOTHERM NUMBER	h/h_o
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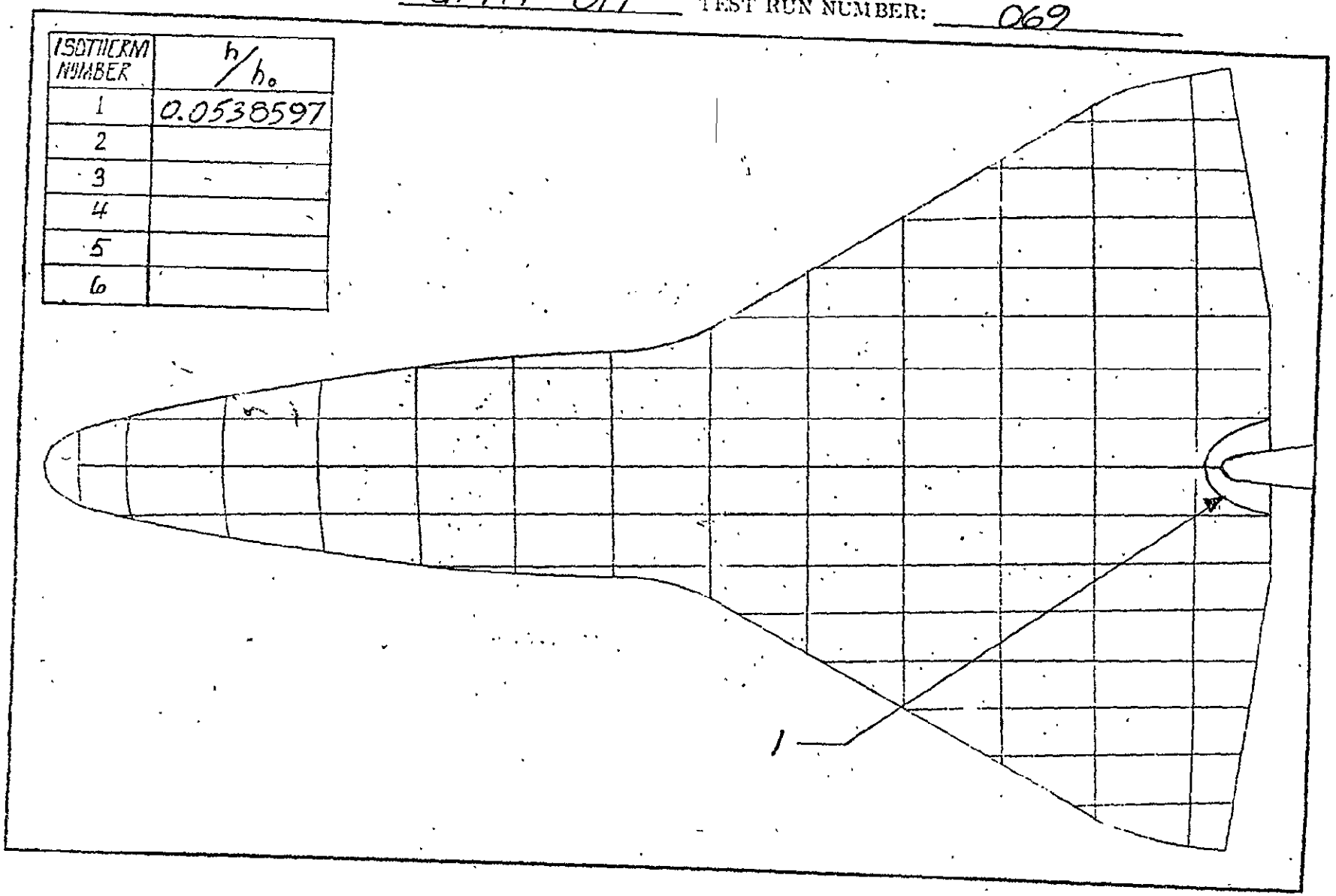
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GEHT-017 TEST RUN NUMBER: 067

ISOTHERM NUMBER	h/h_o
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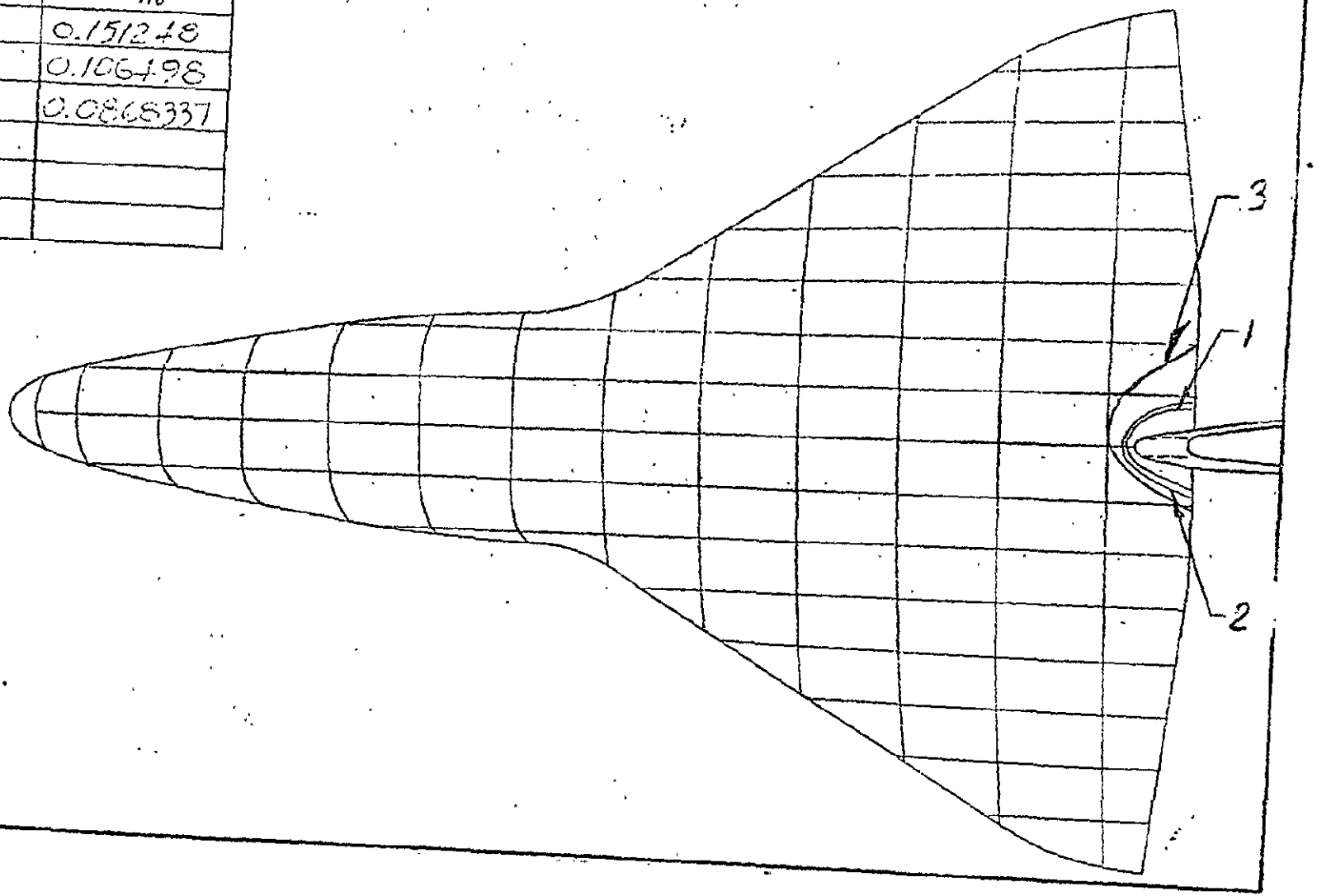
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 071

ISOTHERM NUMBER	h/h_o
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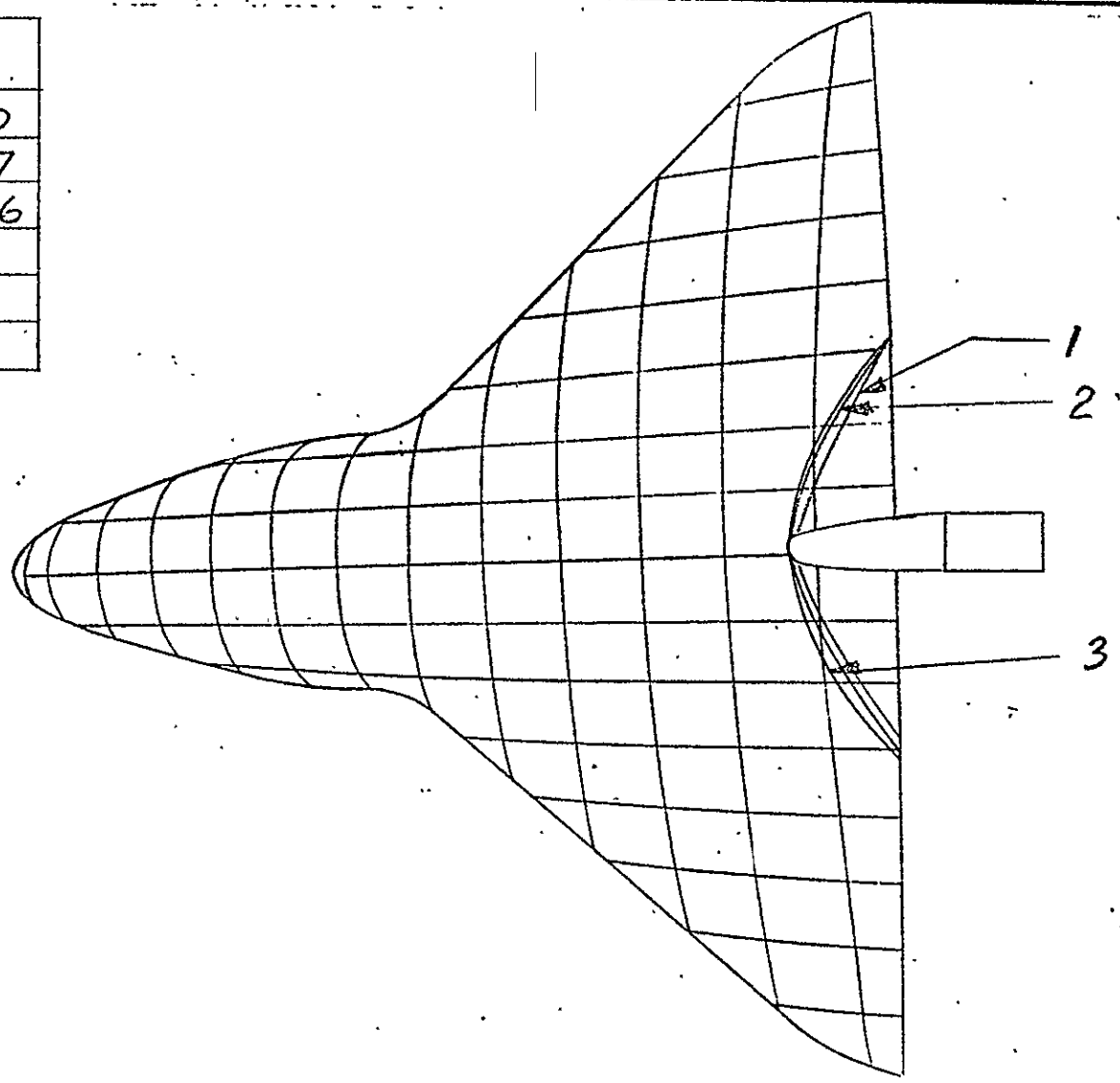
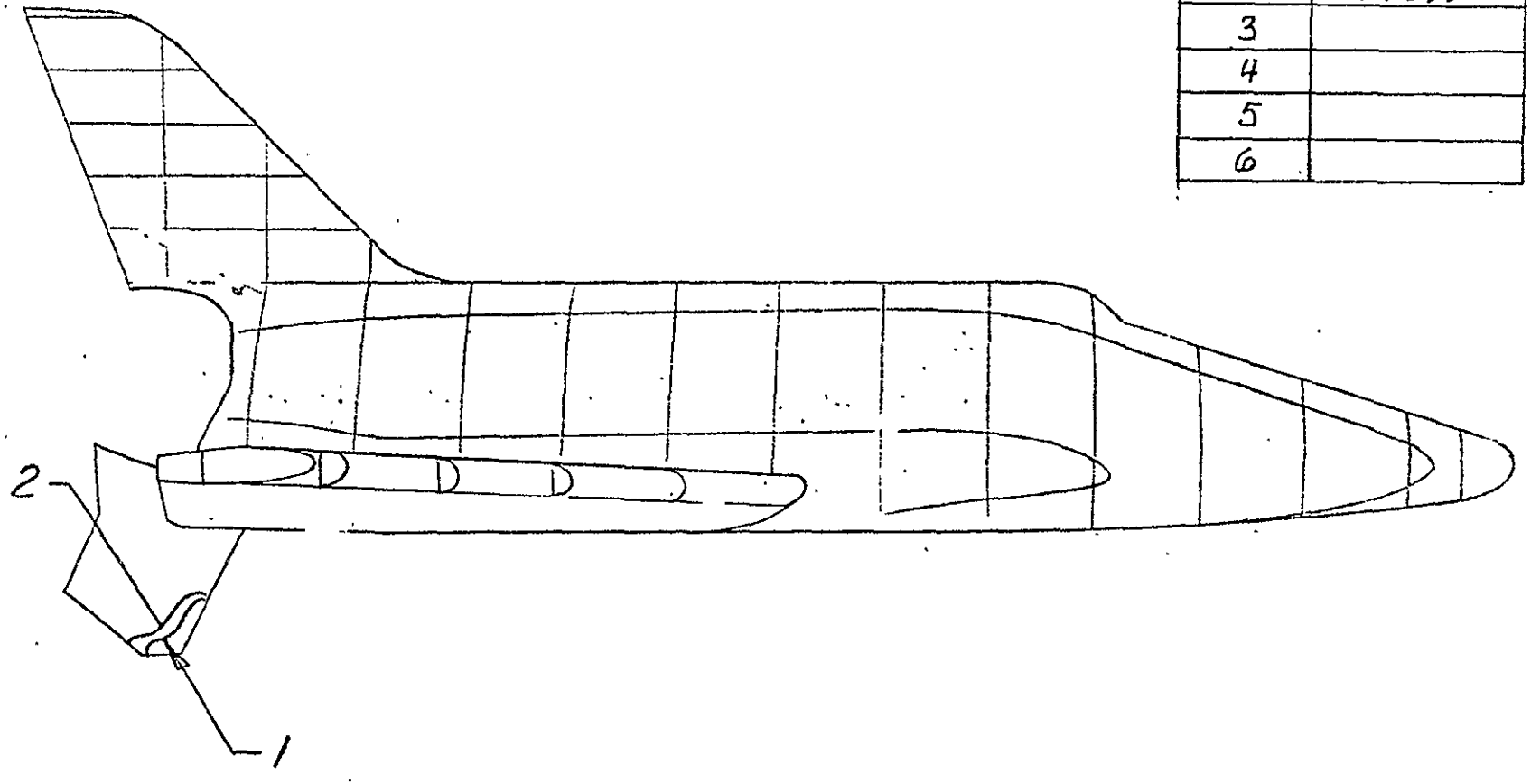
2	0.119357
3	0.0973186
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 068

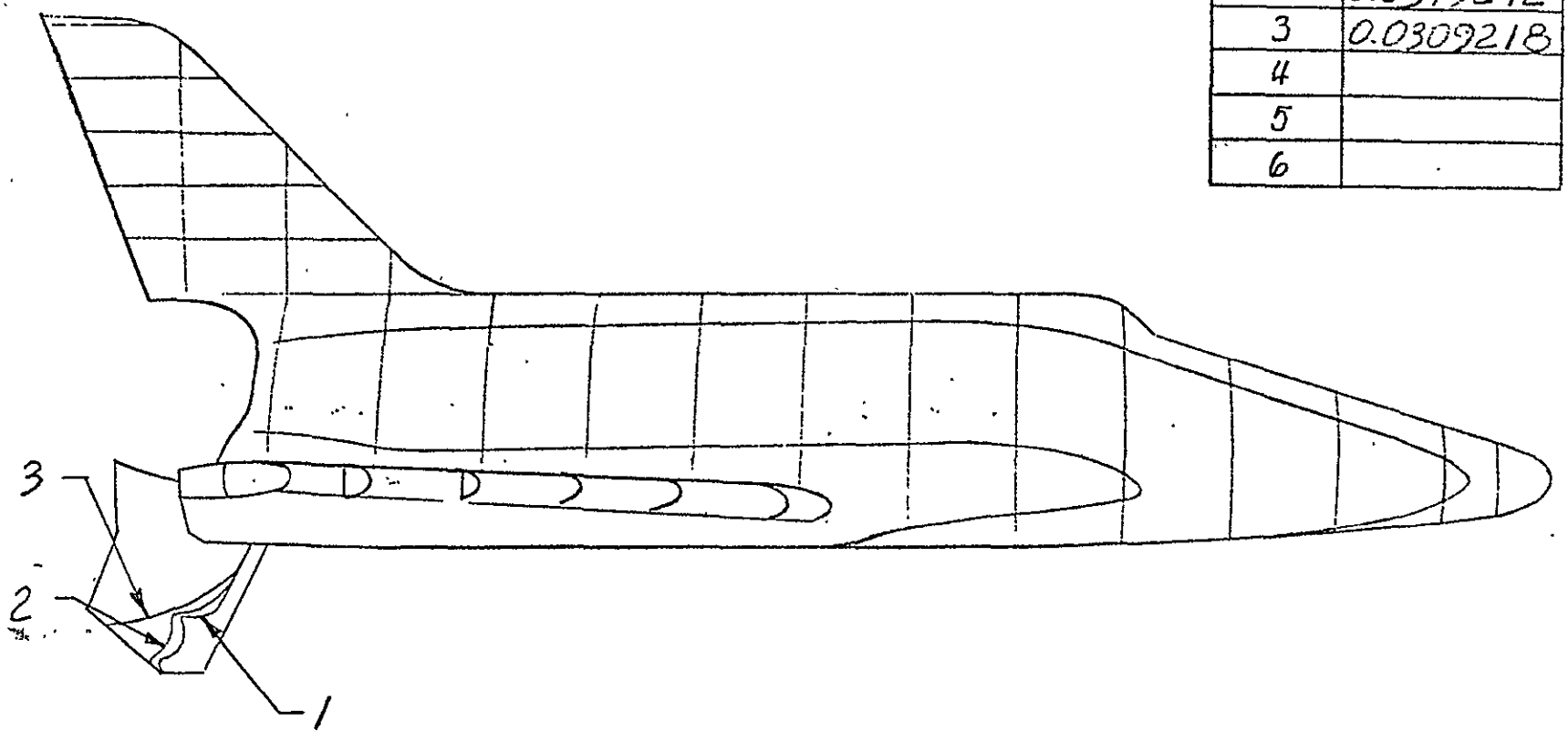
ISOTHERM NUMBER	h/h_o
1	0.115209
2	0.0939366
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 069

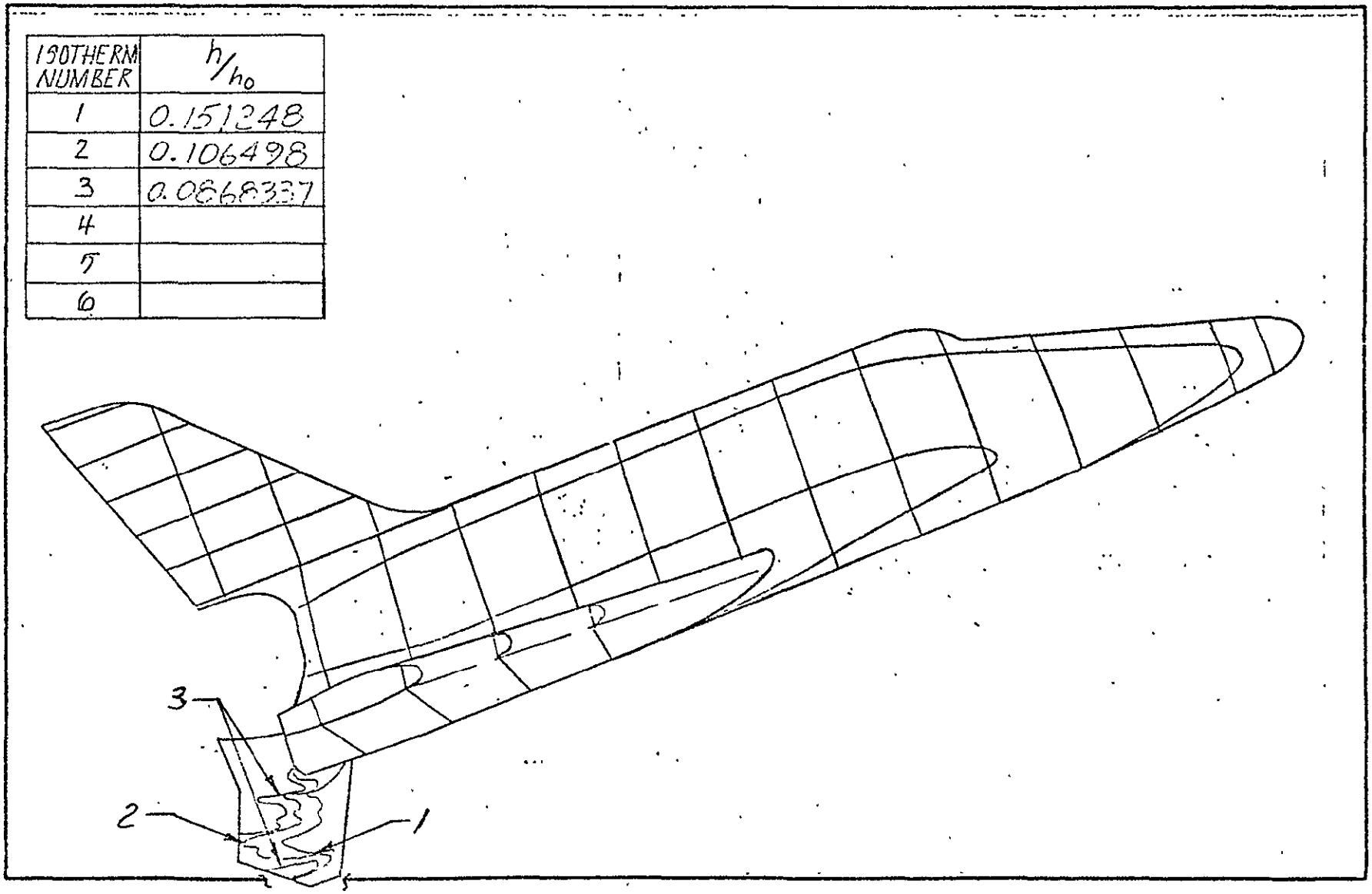
ISOTHERM NUMBER	h/h_o
1	0.0538597
2	0.0379242
3	0.0309218
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 067

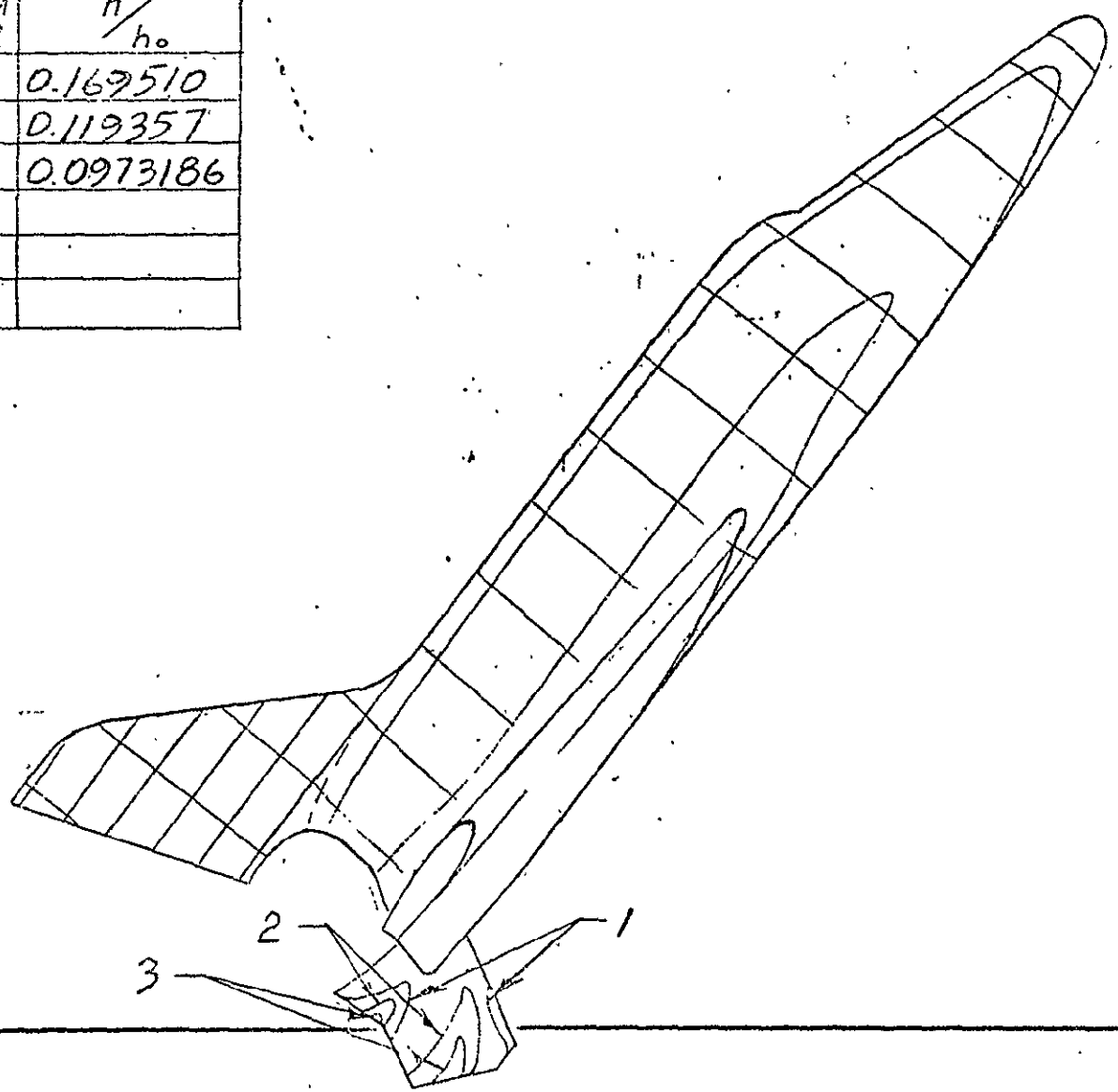
ISOTHERM NUMBER	h/h_o
1	0.151248
2	0.106498
3	0.0868337
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 071

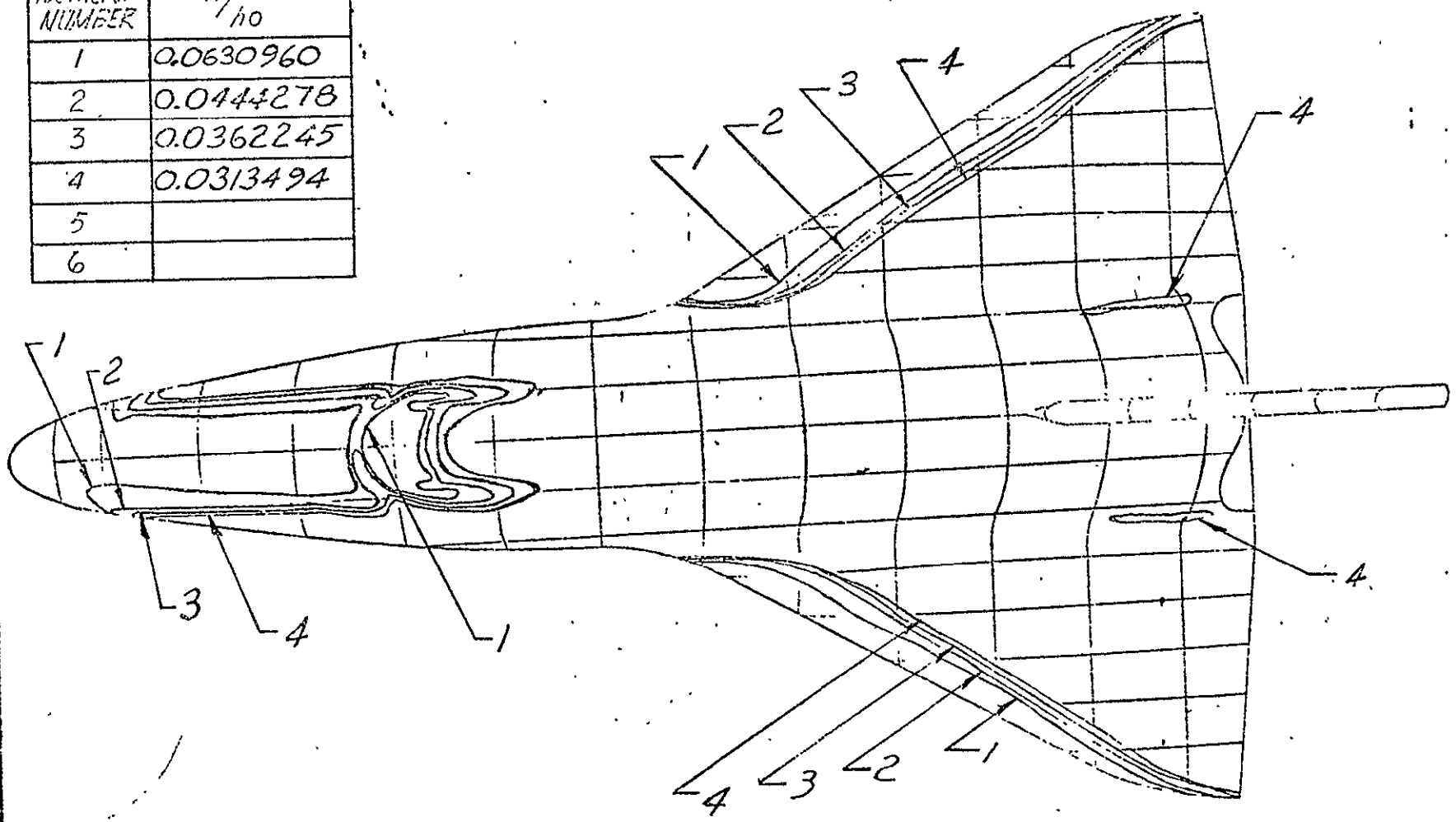
ISOTHERM NUMBER	h/h_o
1	0.169510
2	0.119357
3	0.0973186
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 011

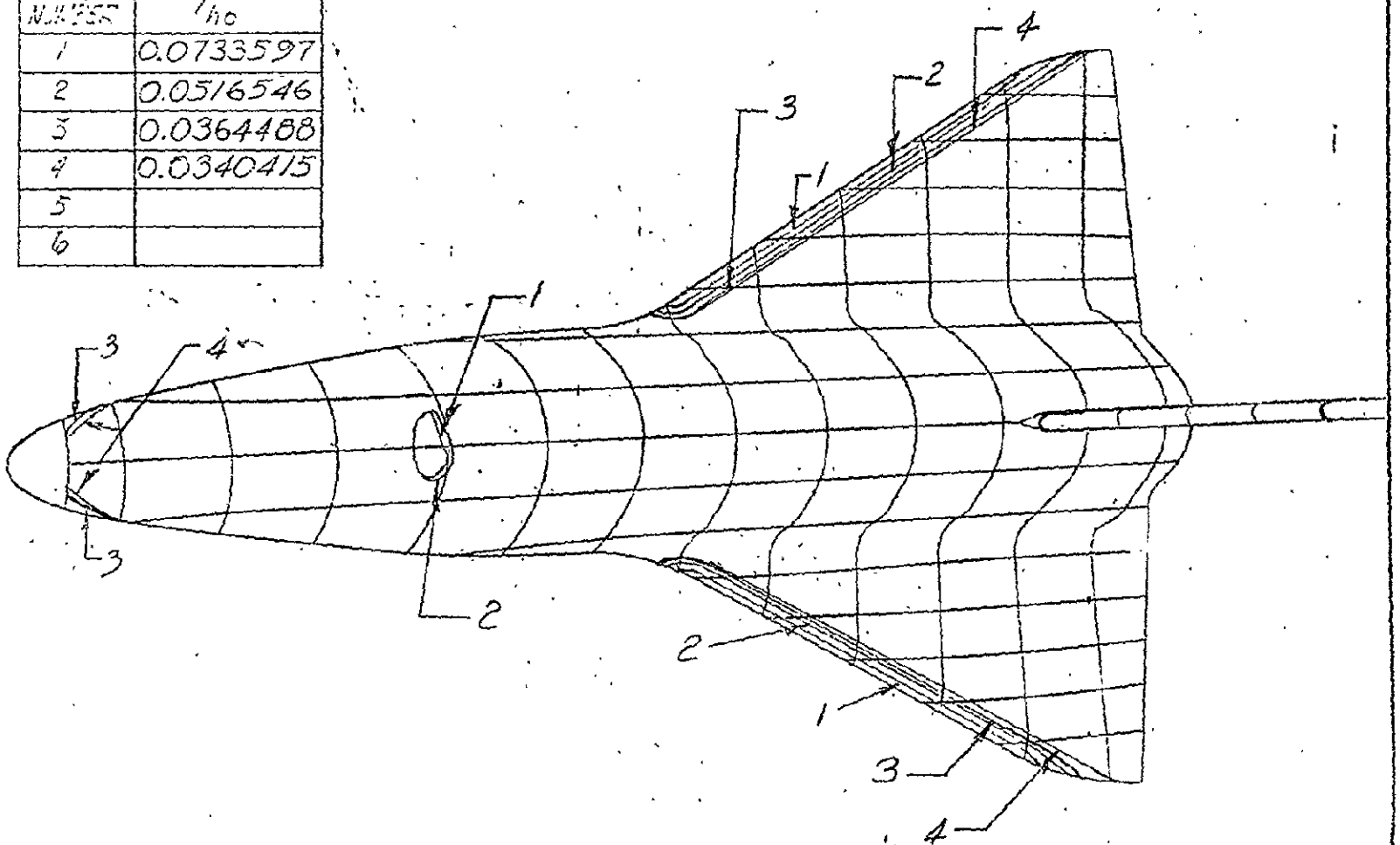
ISOTHERM NUMBER	h/h_0
1	0.0630960
2	0.0444278
3	0.0362245
4	0.0313494
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 014

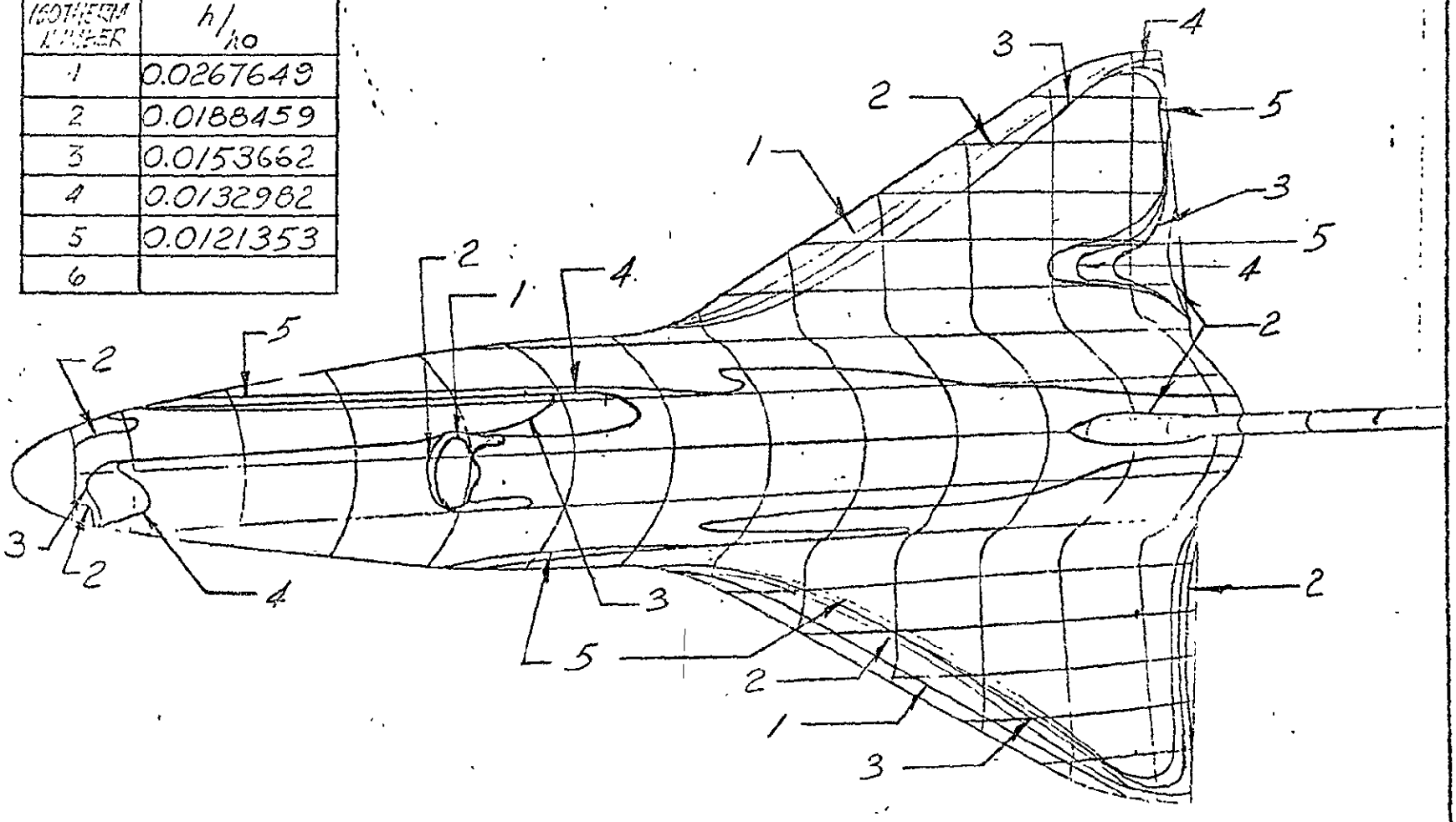
TEST ITEM NUMBER	η/h_0
1	0.0733597
2	0.0516546
3	0.0364488
4	0.0340415
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 032

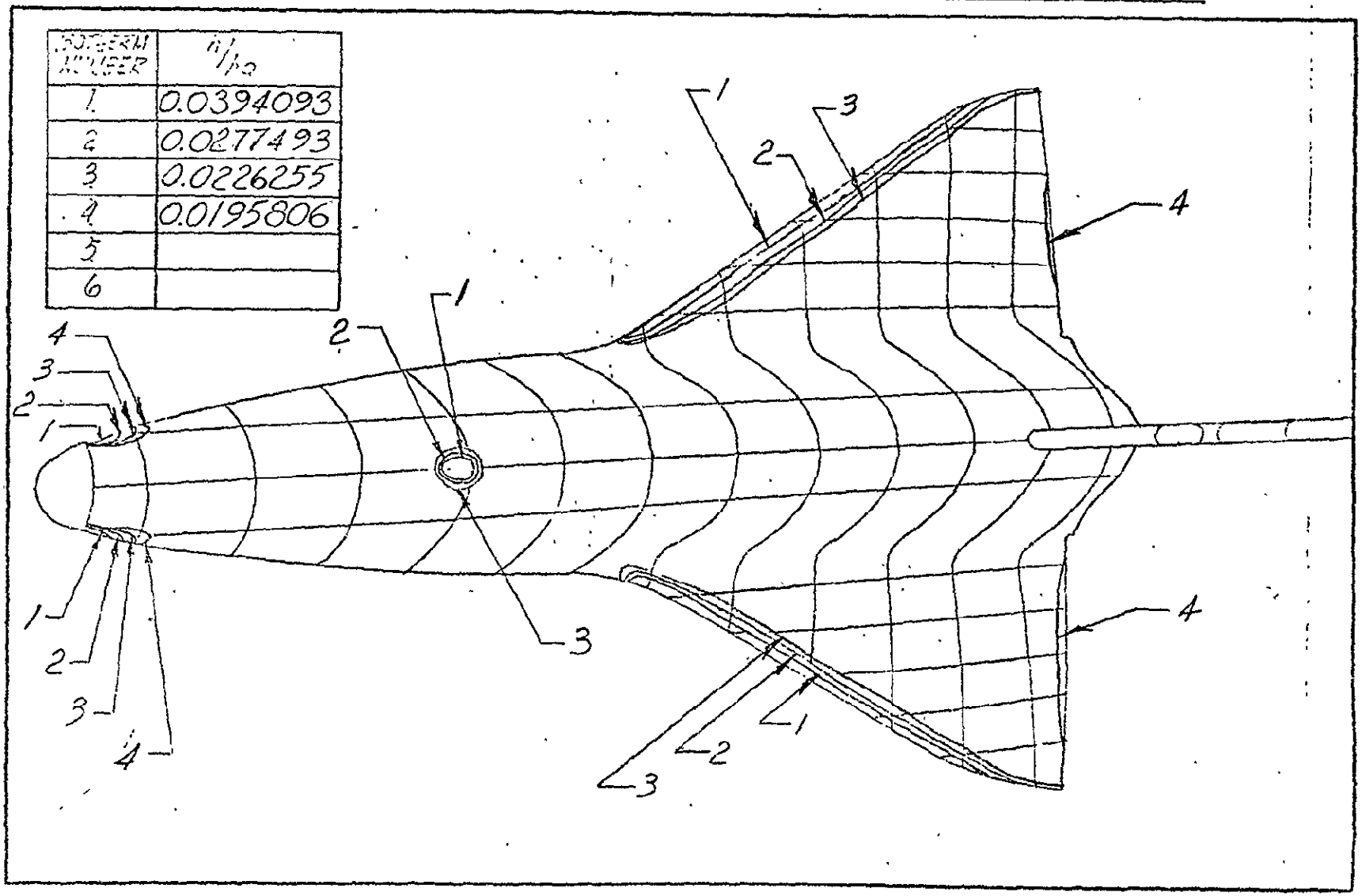
ISOTHERM NUMBER	h/h_0
1	0.0267649
2	0.0188459
3	0.0153662
4	0.0132982
5	0.0121353
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 018

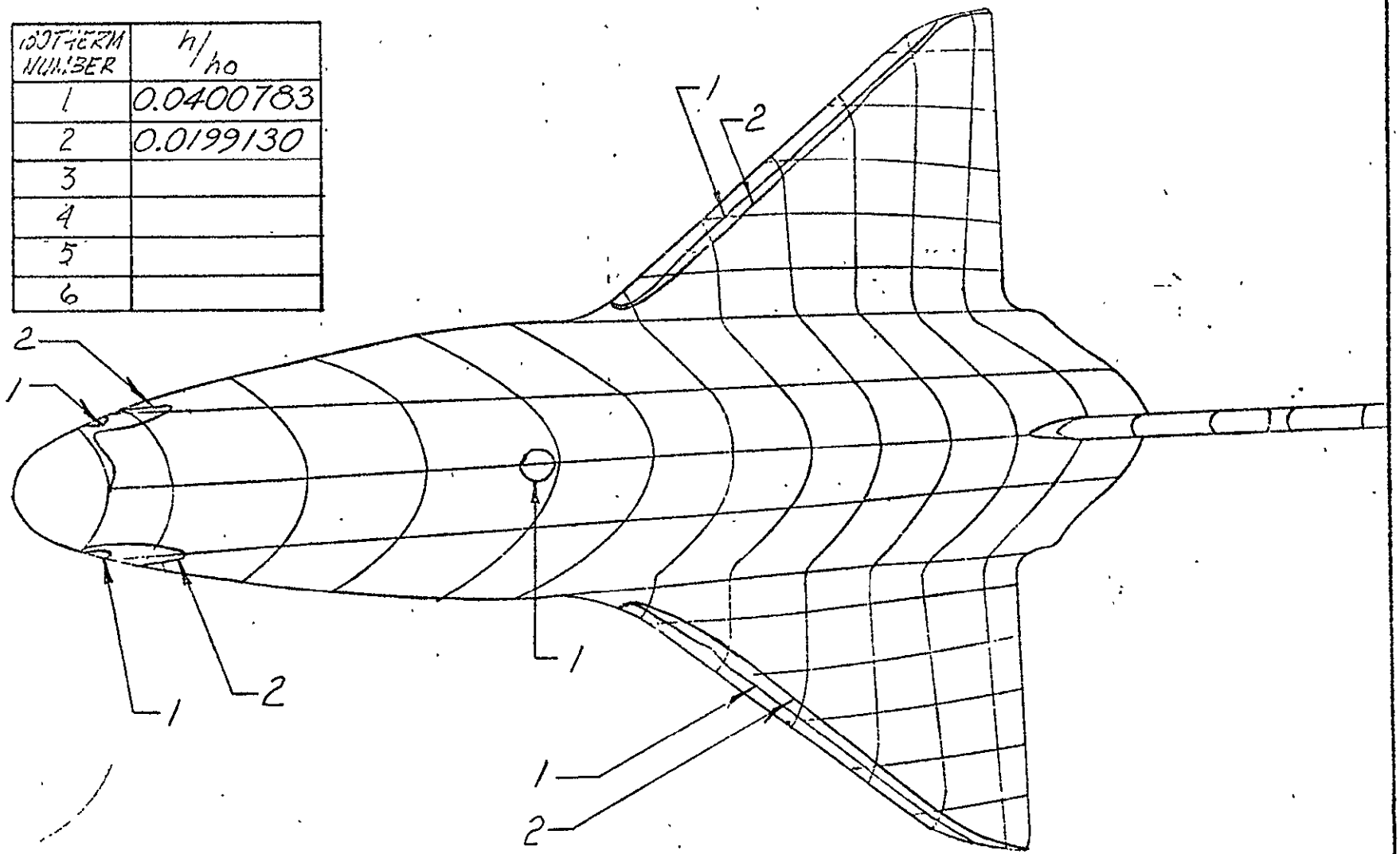
THERMOCOUPLE NUMBER	n/ft
1	0.0394093
2	0.0277493
3	0.0226255
4	0.0195806
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 021

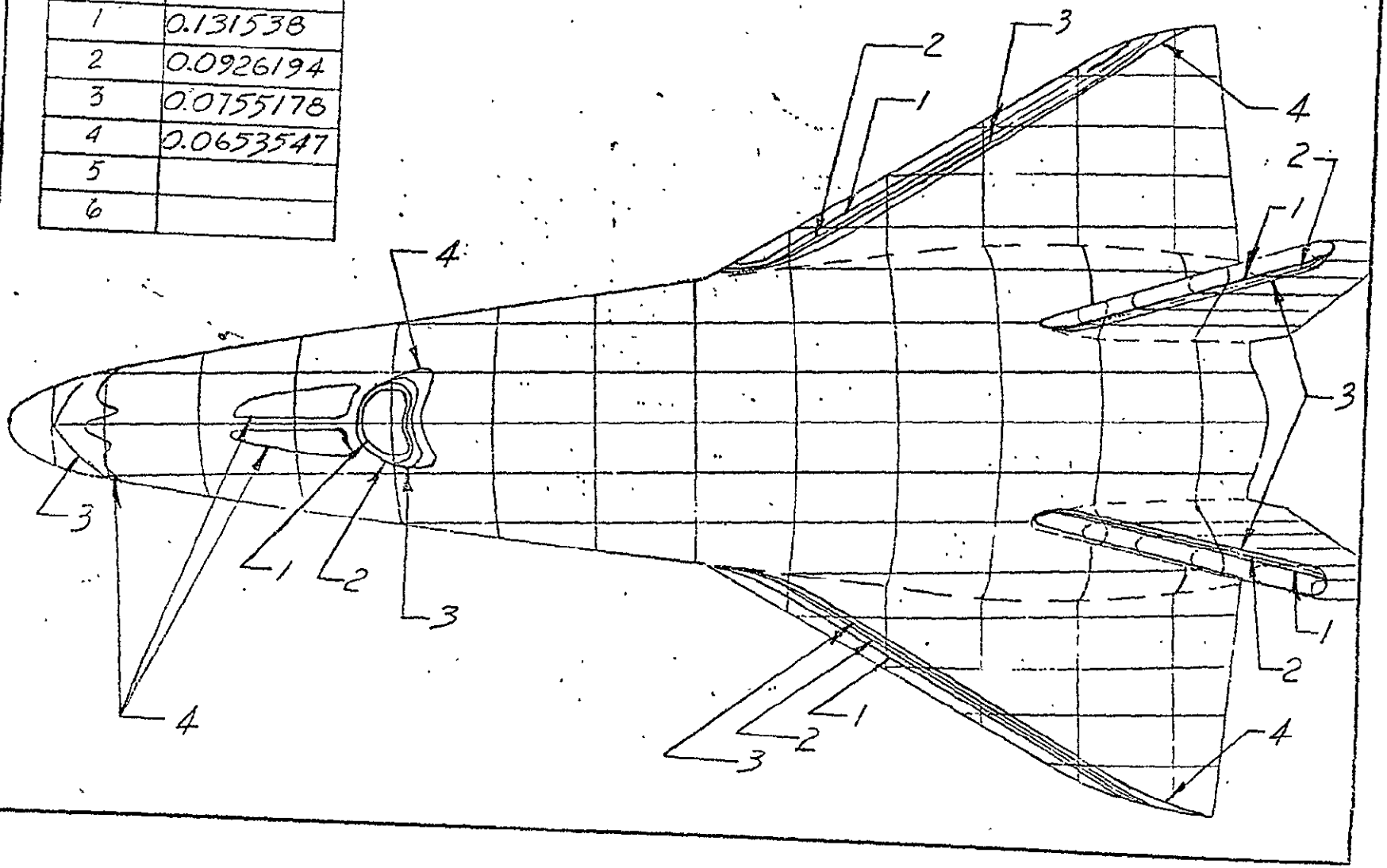
ISOTHERM NUMBER	h/h_o
1	0.0400783
2	0.0199130
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 030

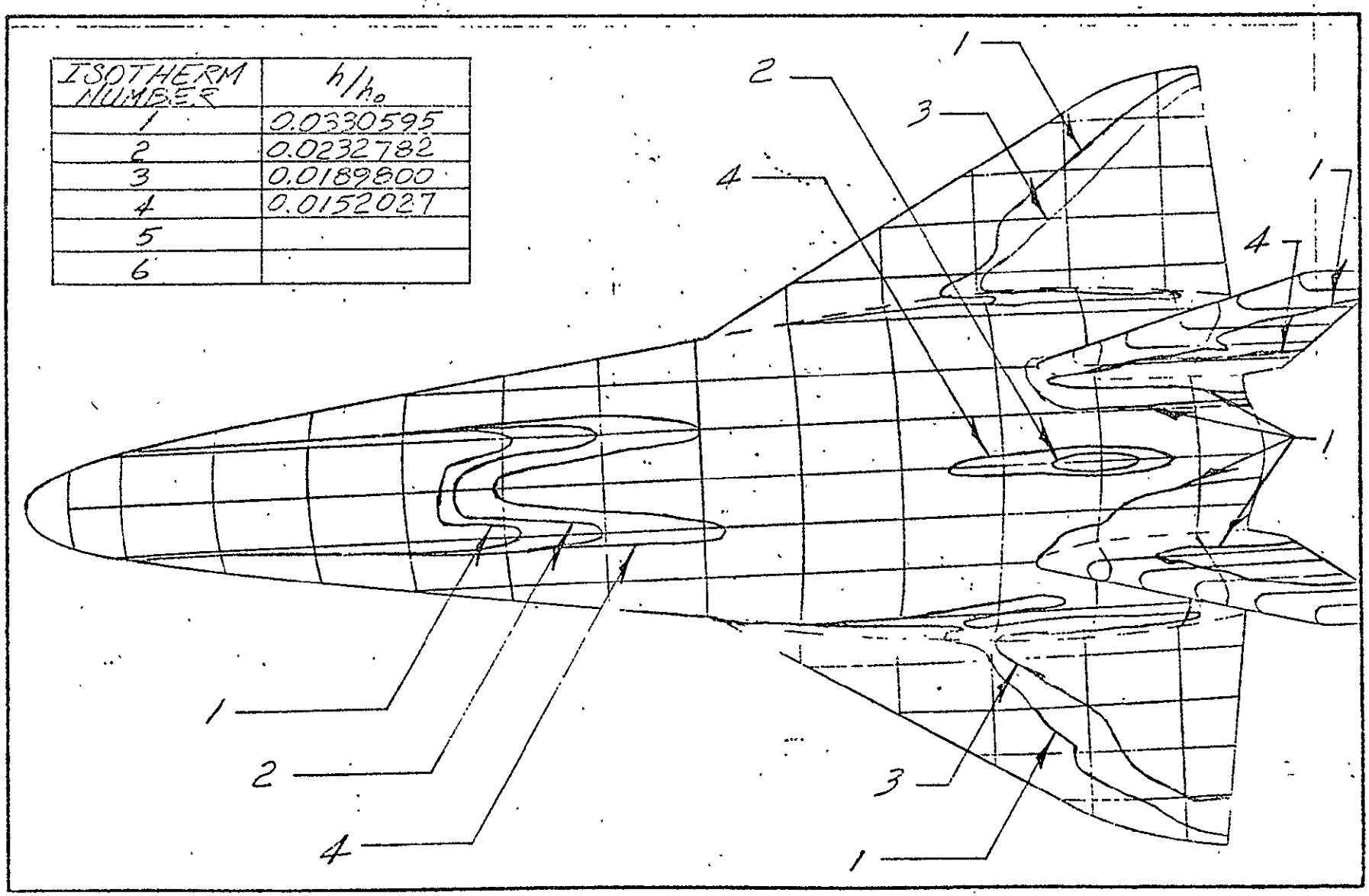
ISOTHERM NUMBER	r/r_0
1	0.131538
2	0.0926194
3	0.0755178
4	0.0653547
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 031

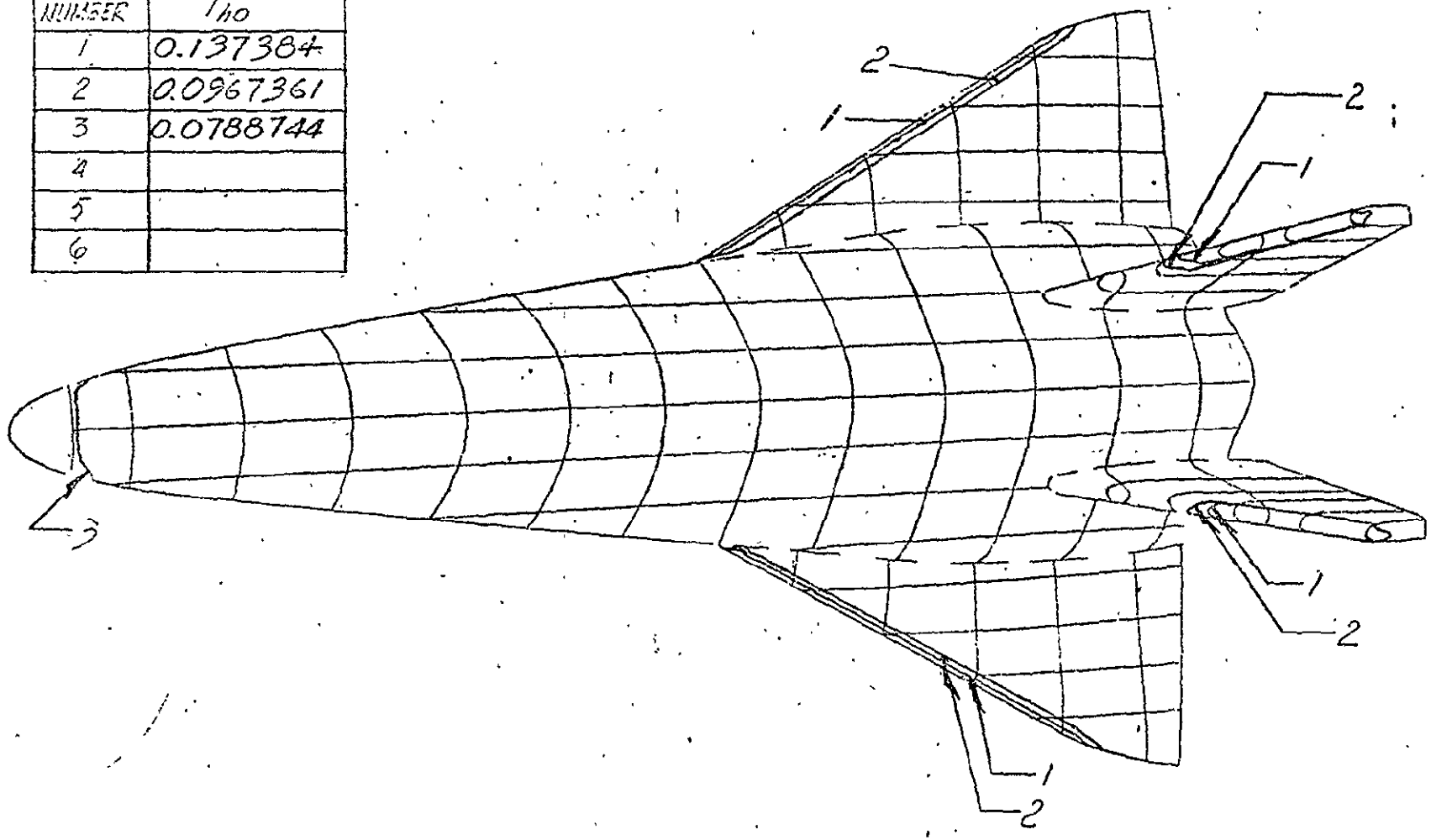
ISOTHERM NUMBER	h/h_o
1	0.0330595
2	0.0232782
3	0.0189800
4	0.0152027
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 029

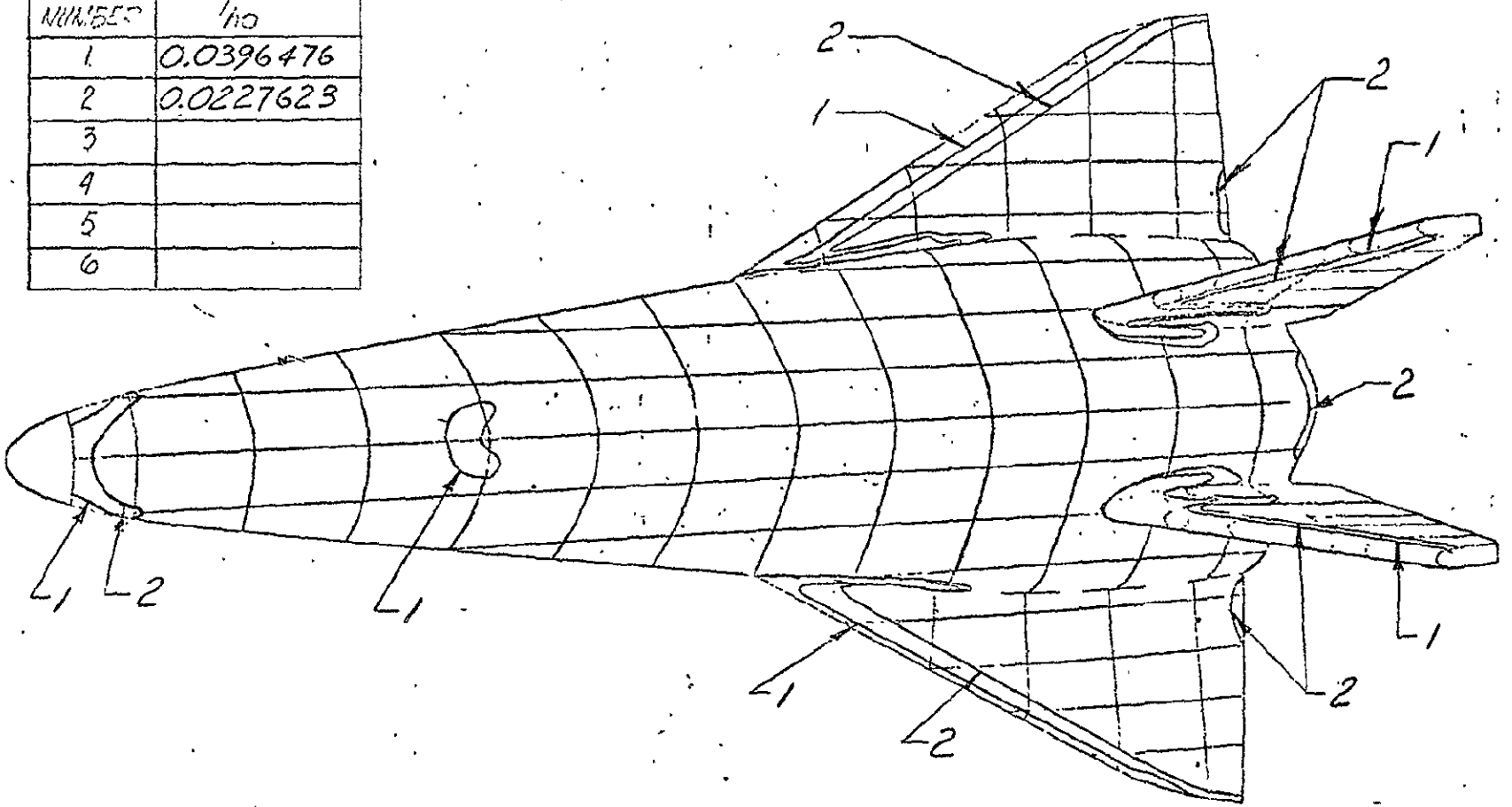
ISOTHERM NUMBER	h/h_0
1	0.137384
2	0.0967361
3	0.0788744
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 028

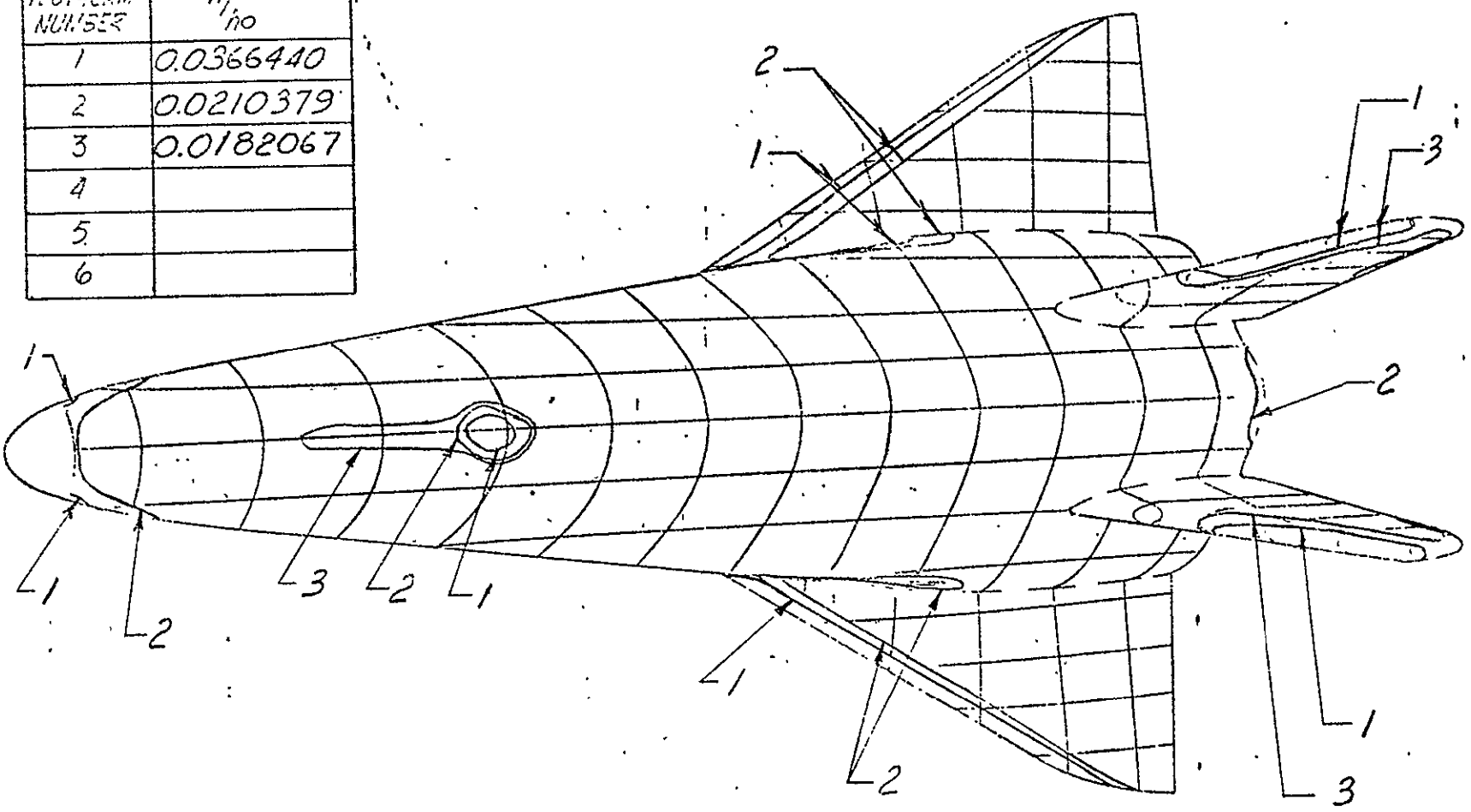
ISOTHERM NUMBER	h/h_0
1	0.0396476
2	0.0227623
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 026

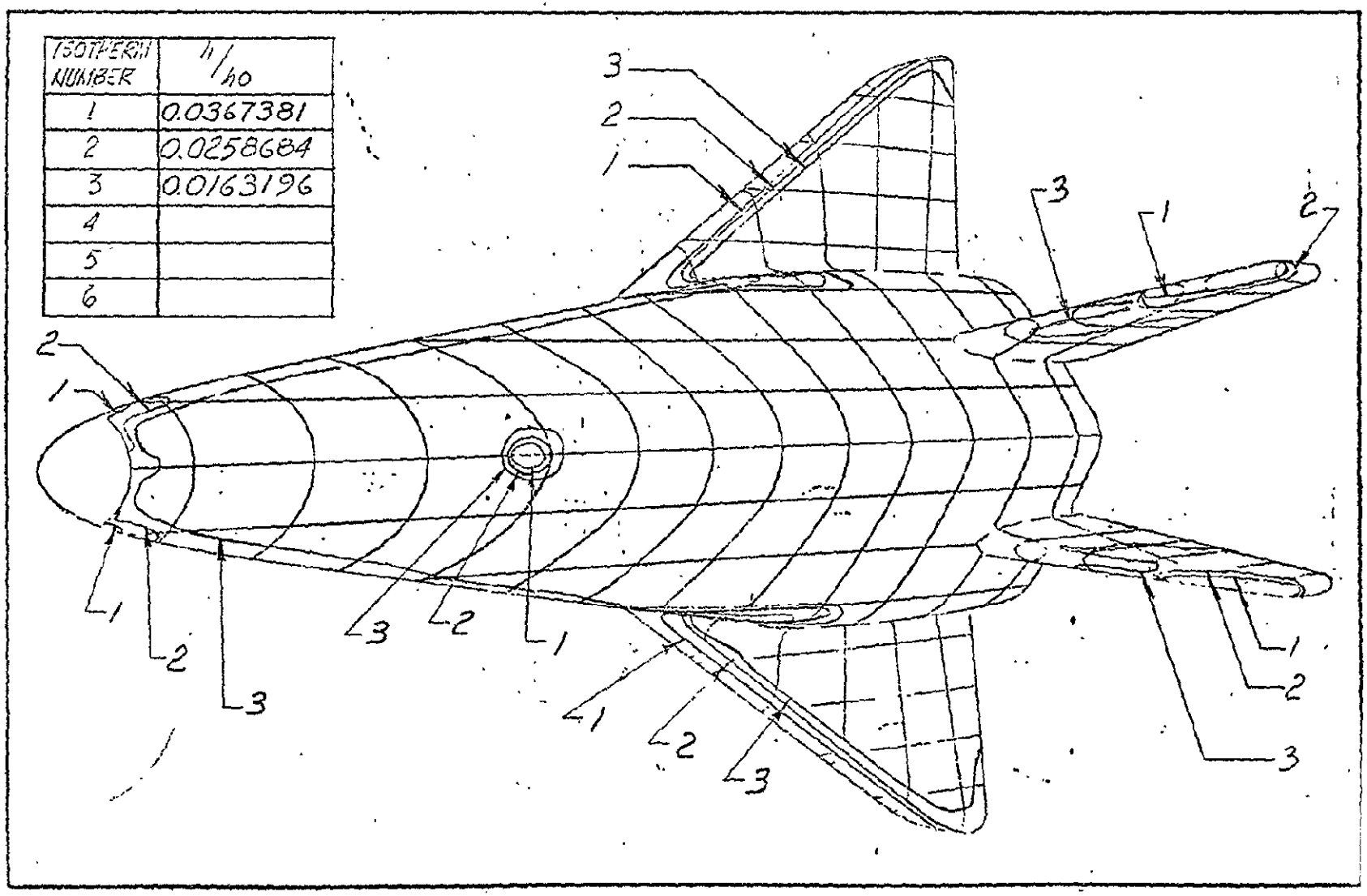
ISOTHERM NUMBER	$\dot{h}/\dot{h}_0$
1	0.0366440
2	0.0210379
3	0.0182067
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 024

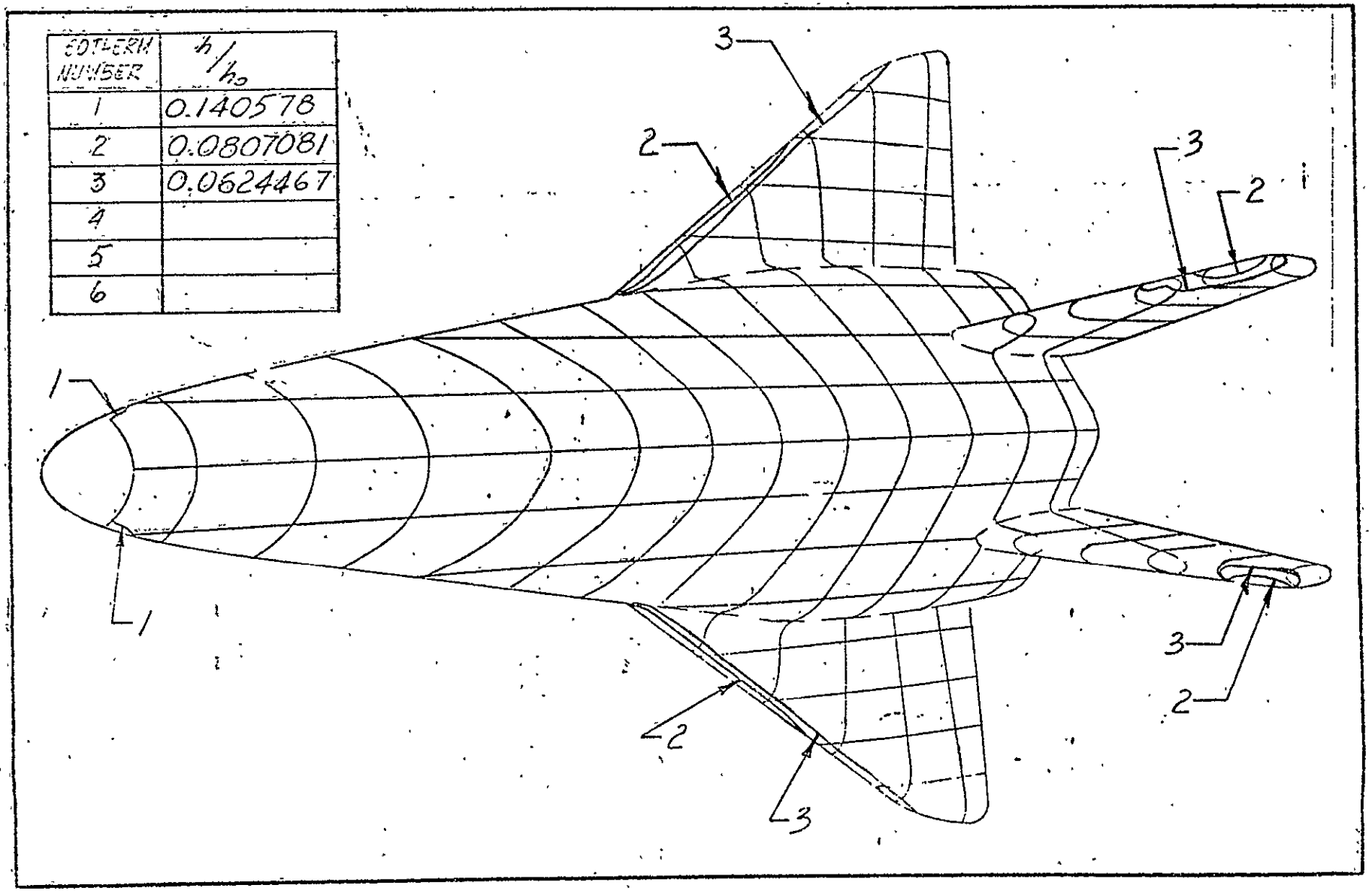
ISOTHERM NUMBER	h/h_0
1	0.0367381
2	0.0258684
3	0.0163196
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 023

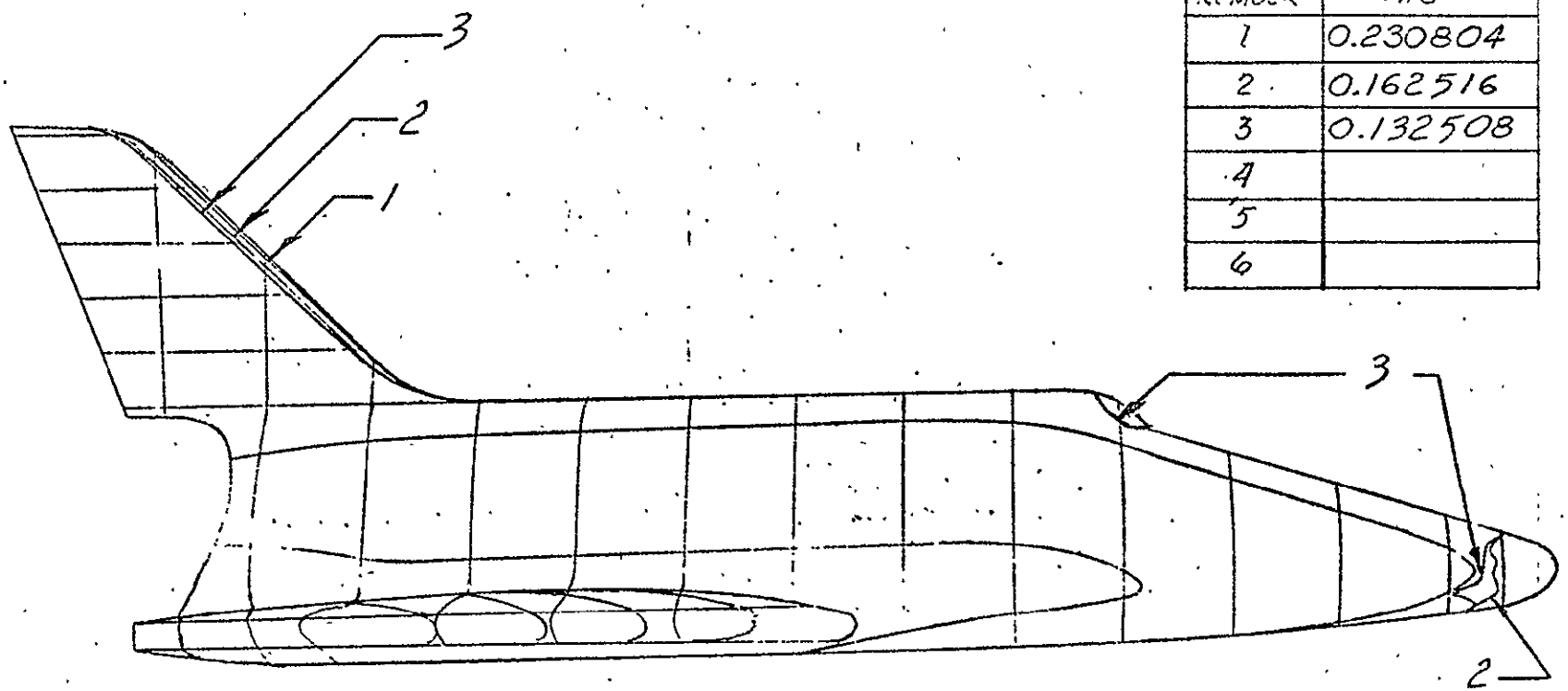
SOTLERN NUMBER	h/h_o
1	0.140578
2	0.0807081
3	0.0624467
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

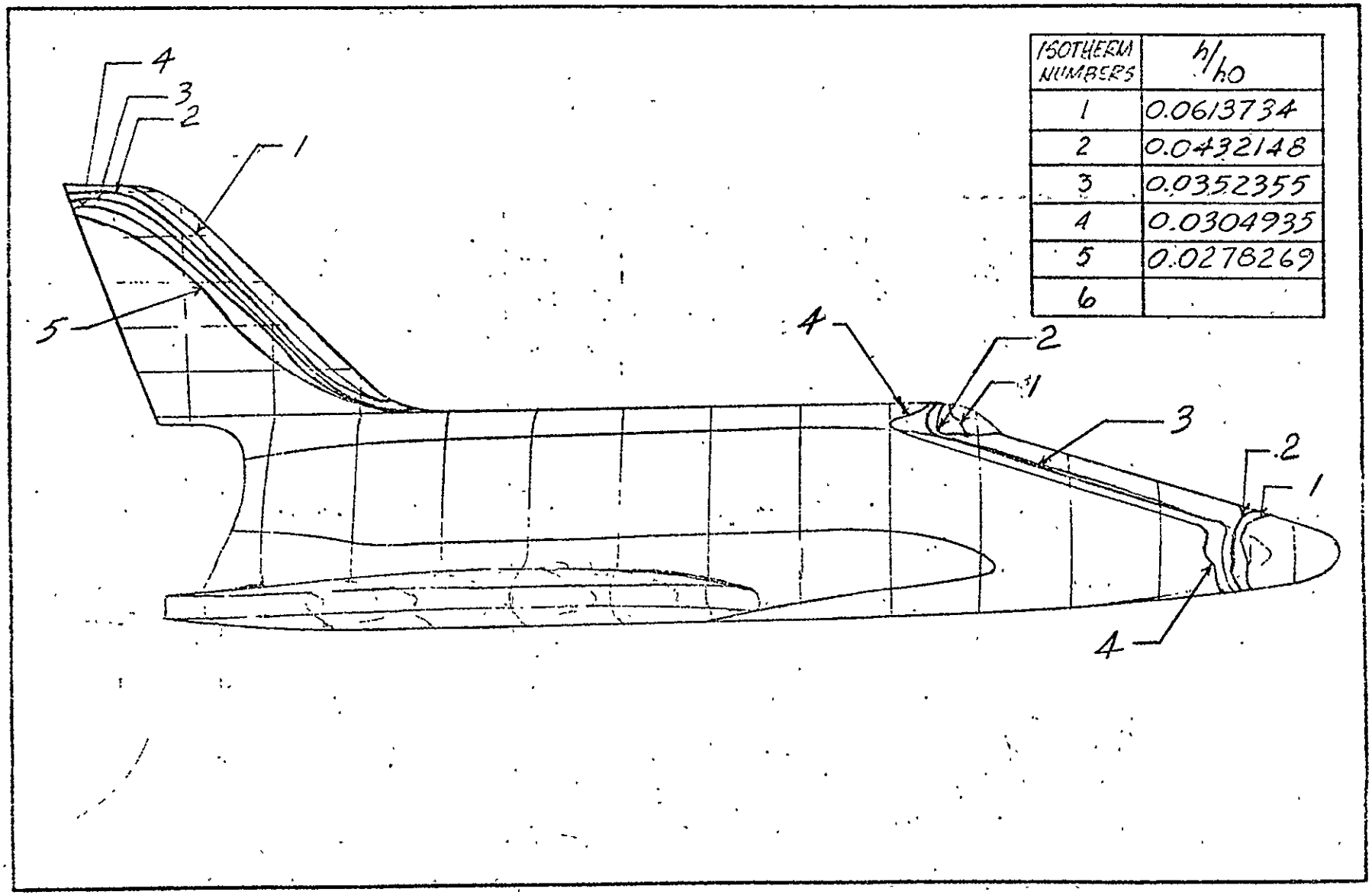
TEST NUMBER: GFHT-017 TEST RUN NUMBER: 002

ISOTHERM NUMBER	h/h_0
1	0.230804
2	0.162516
3	0.132508
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 009

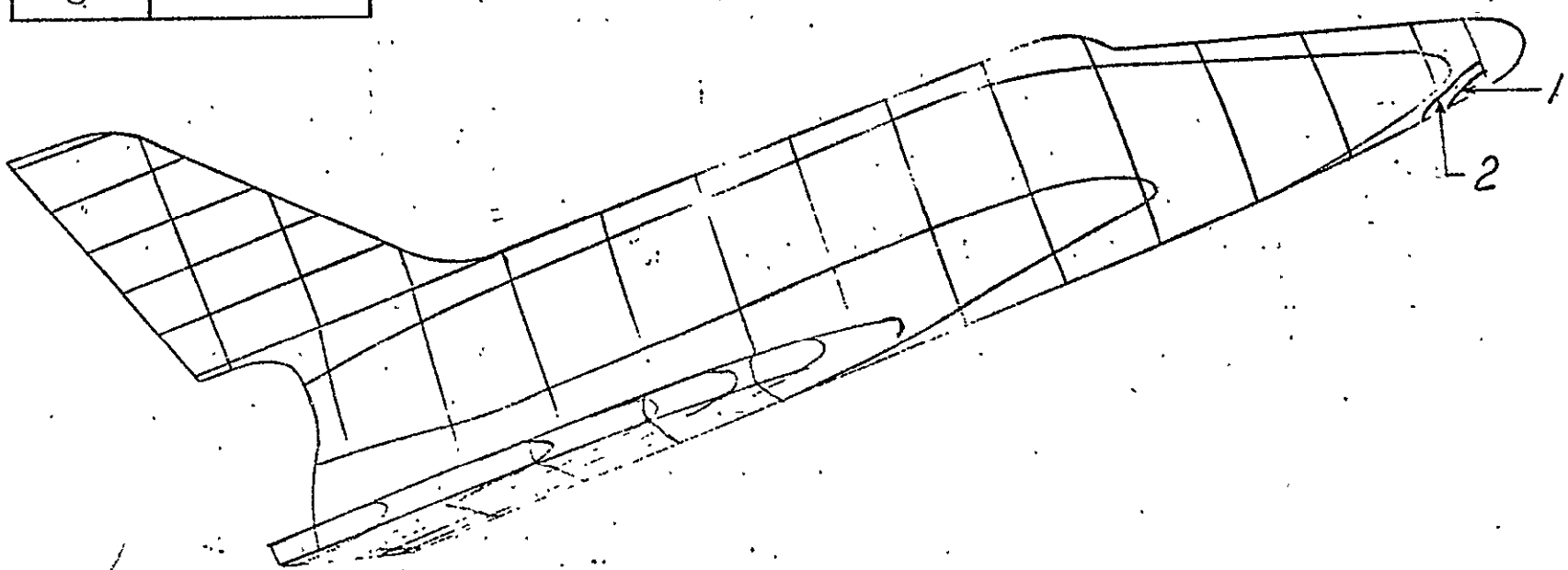


ISOTHERM NUMBERS	h/h_0
1	0.0613734
2	0.0432148
3	0.0352355
4	0.0304935
5	0.0278269
6	

PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT - 017 TEST RUN NUMBER: 005

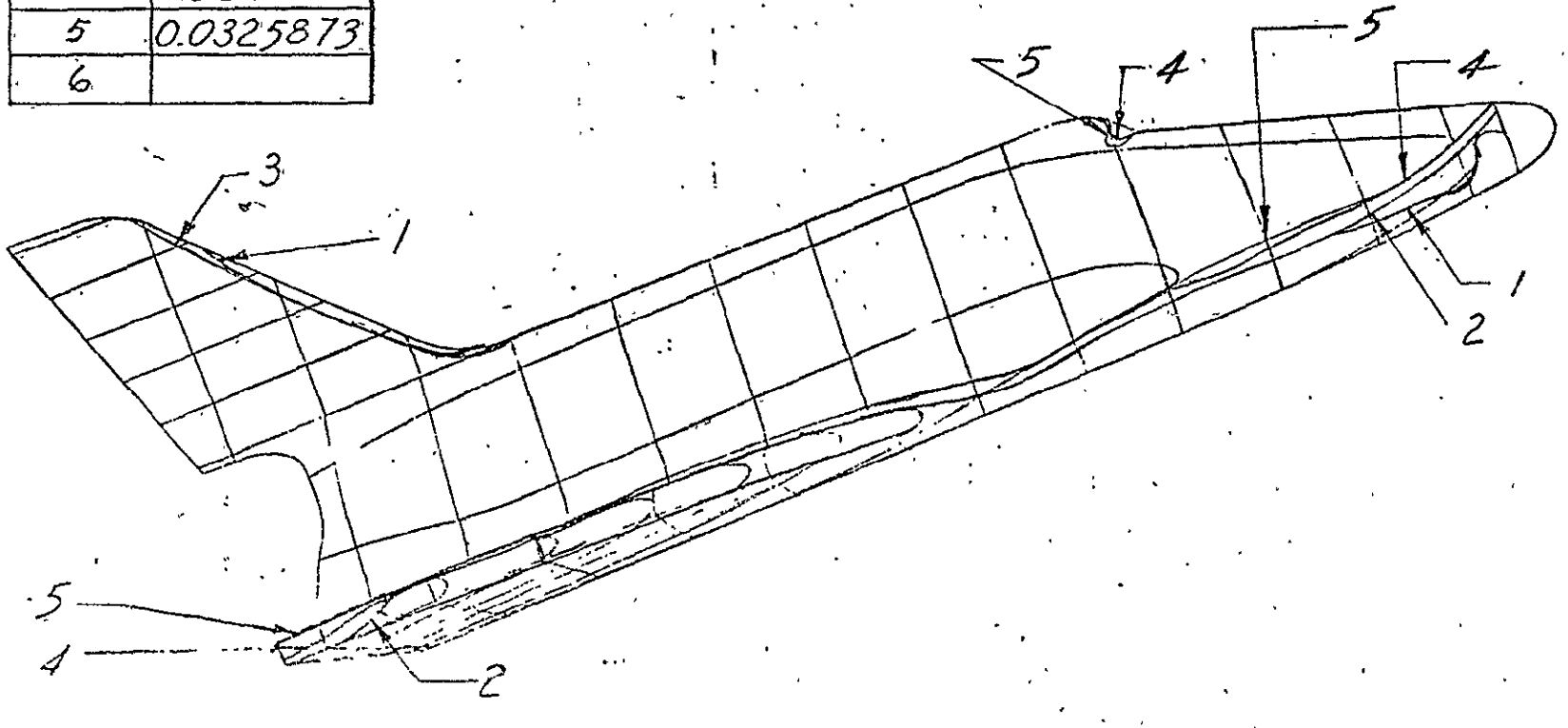
ISOTHERM NUMBER	l_i/h_0
1	0.130193
2	0.116400
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GEHT-017 TEST RUN NUMBER: 014

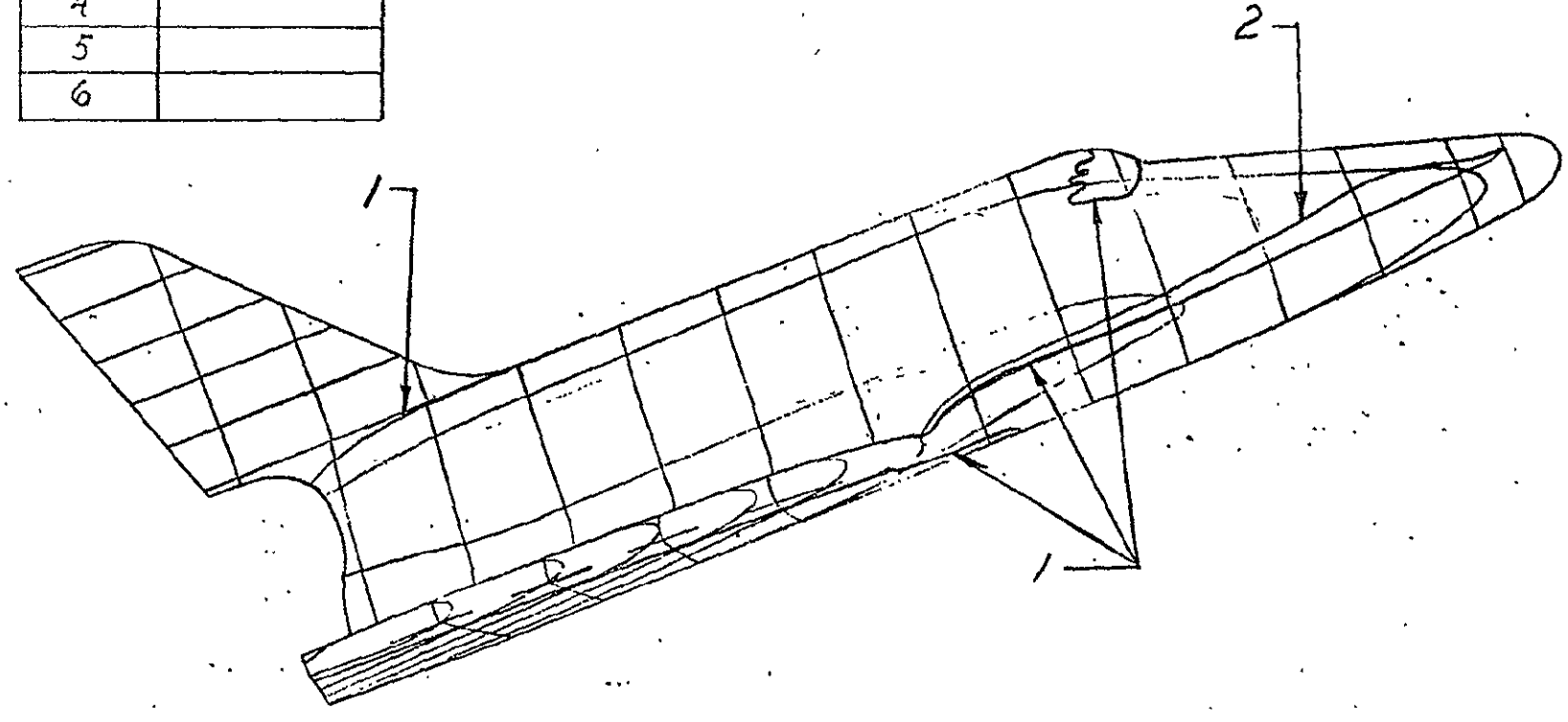
ISOTHERM NUMBERS	h/h_0
1	0.0733597
2	0.0515546
3	0.0421169
4	0.0364486
5	0.0325873
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT – 017 TEST RUN NUMBER: –032

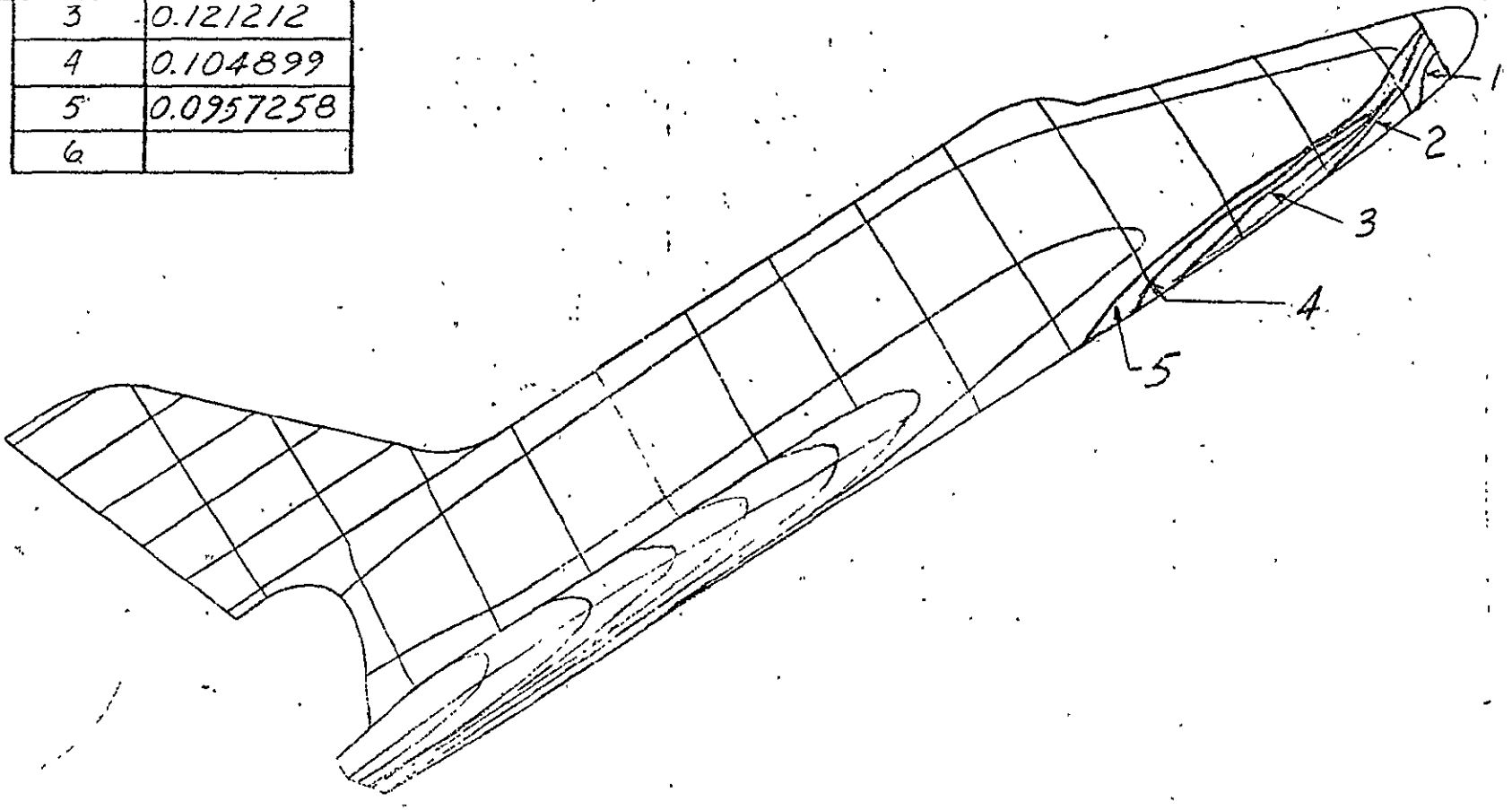
ISOTHERM NUMBERS	h/h.
1	0.0267649
2	0.0132982
3	
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 007

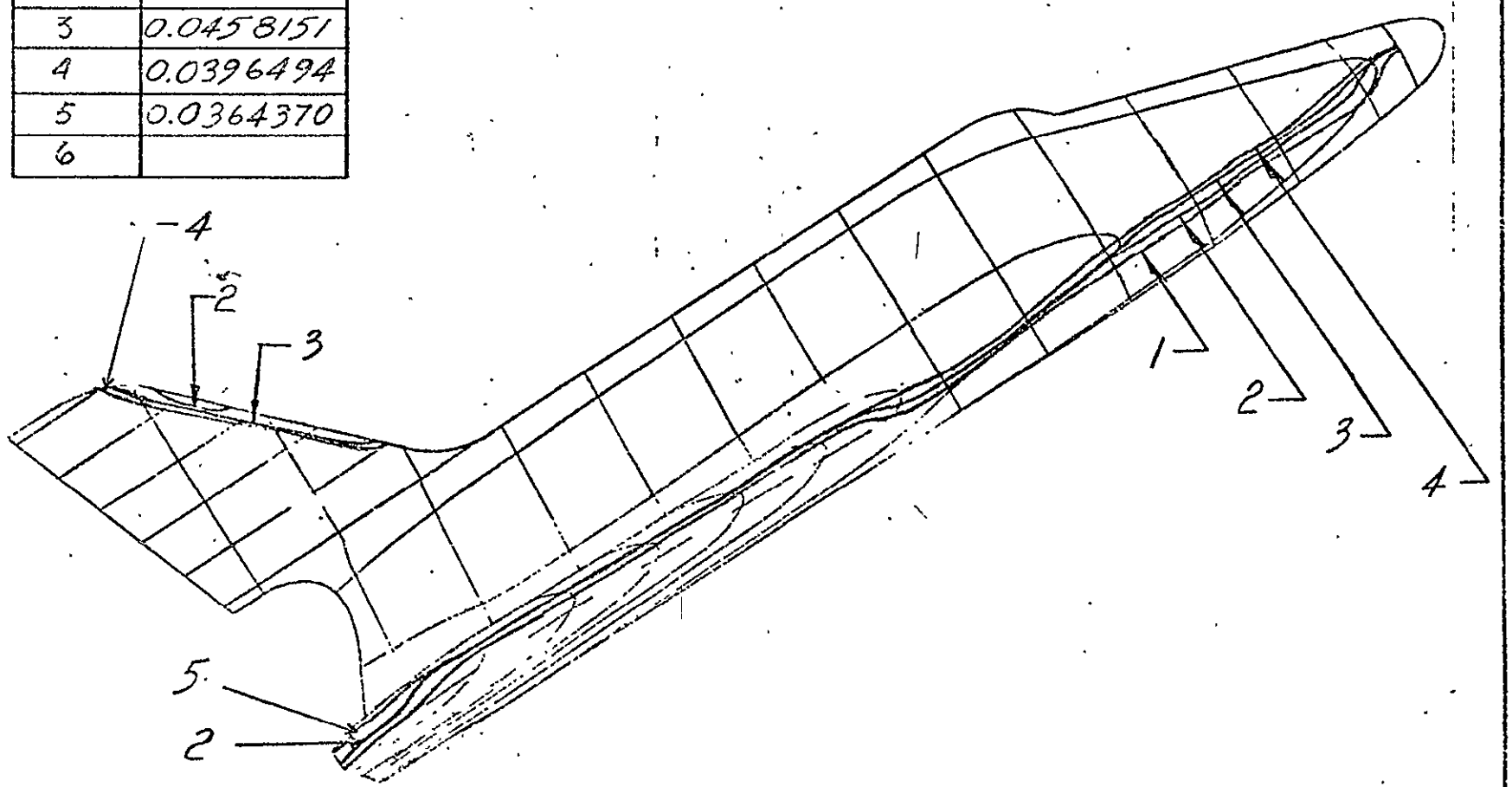
ISOTHERM NUMBER	l_1/l_{10}
1	0.211127
2	0.148661
3	0.121212
4	0.104899
5	0.0957258
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 008

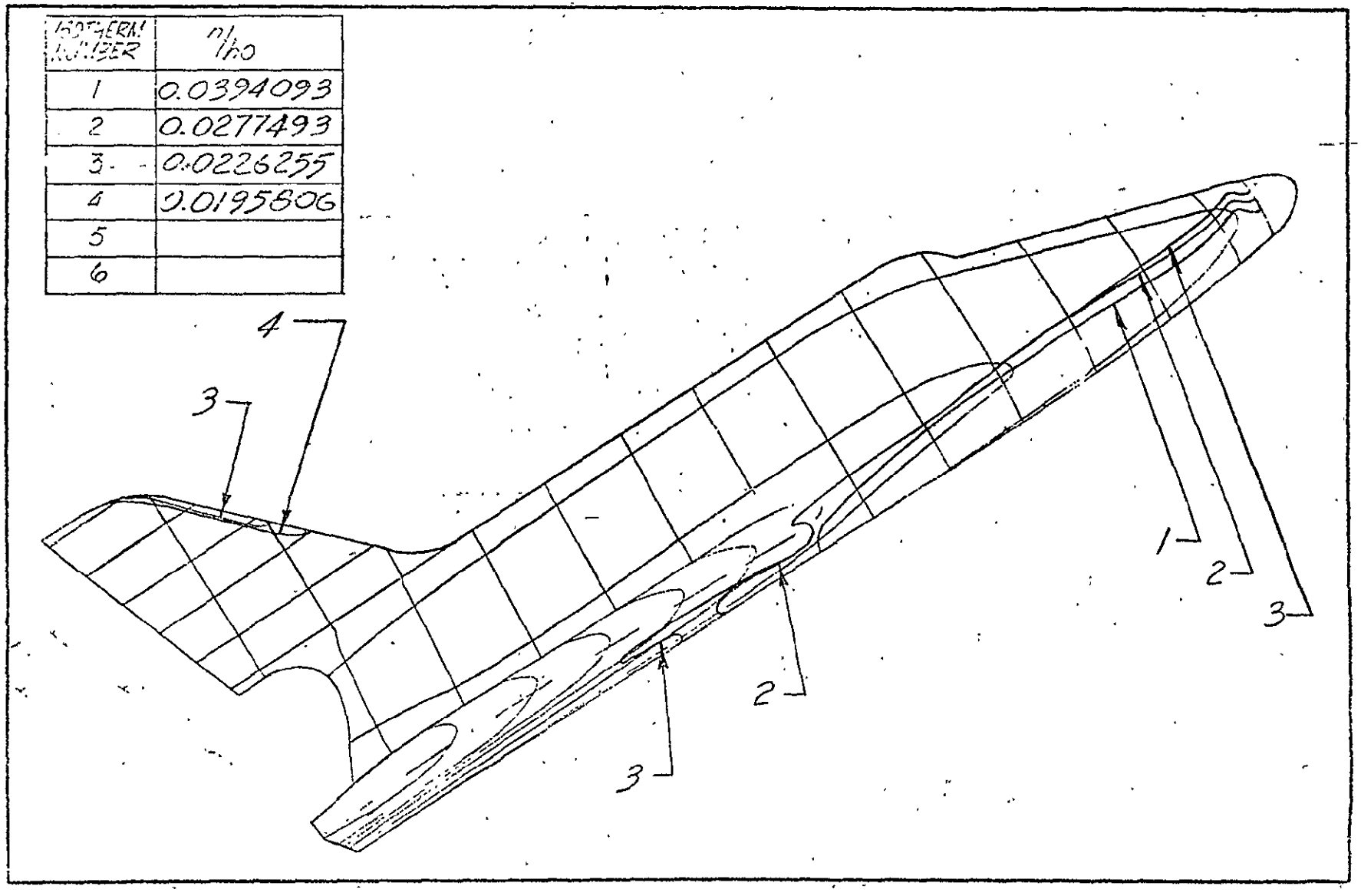
ISOTHERM NUMBERS	h/h_0
1	0.0798012
2	0.0561903
3	0.0458151
4	0.0396494
5	0.0364370
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST TYPE: TEST NUMBER: GFHT-017 TEST RUN NUMBER: 018

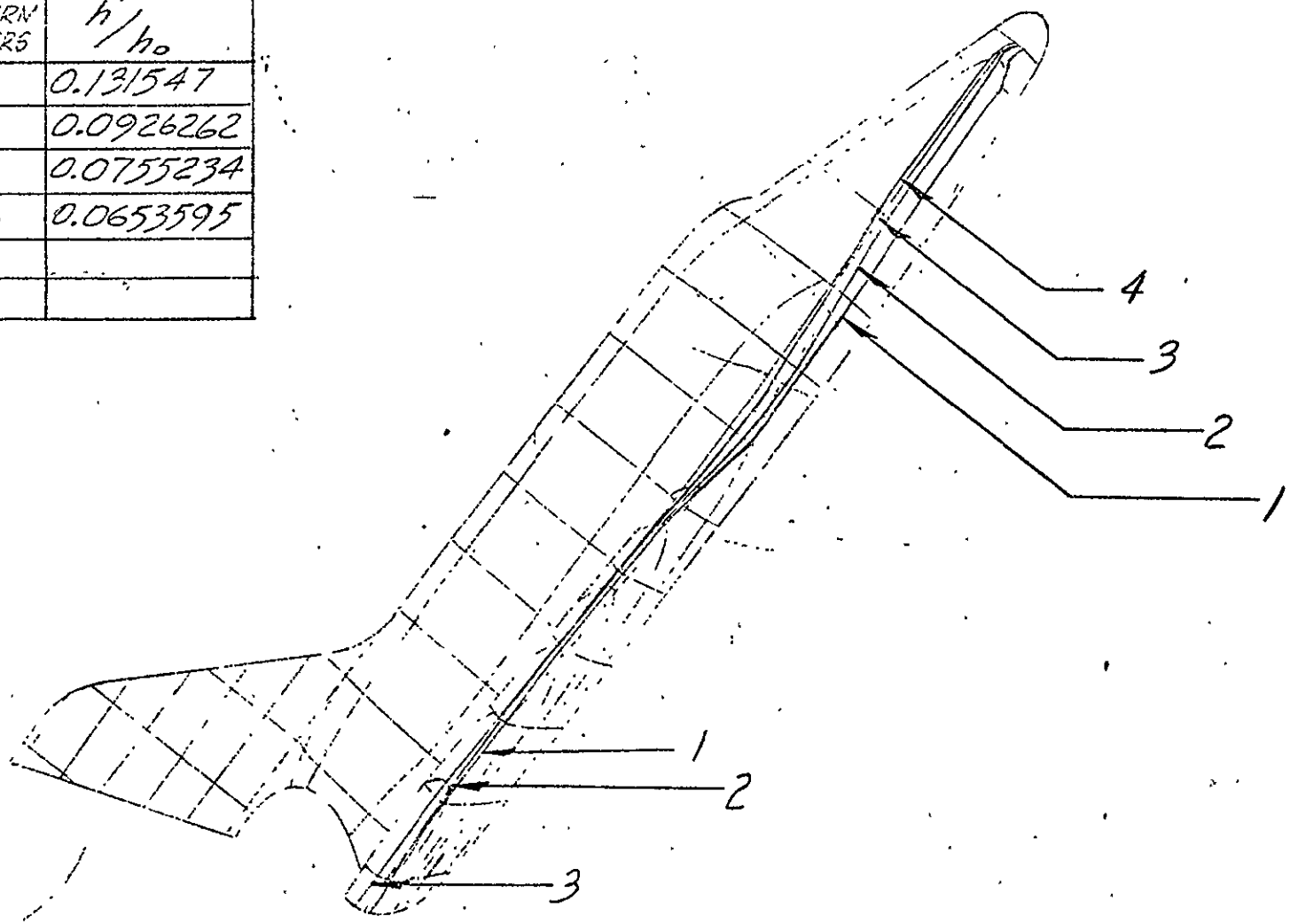
THERMOCOUPLE NUMBER	r/ho
1	0.0394093
2	0.0277493
3	0.0226255
4	0.0195806
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: - 019

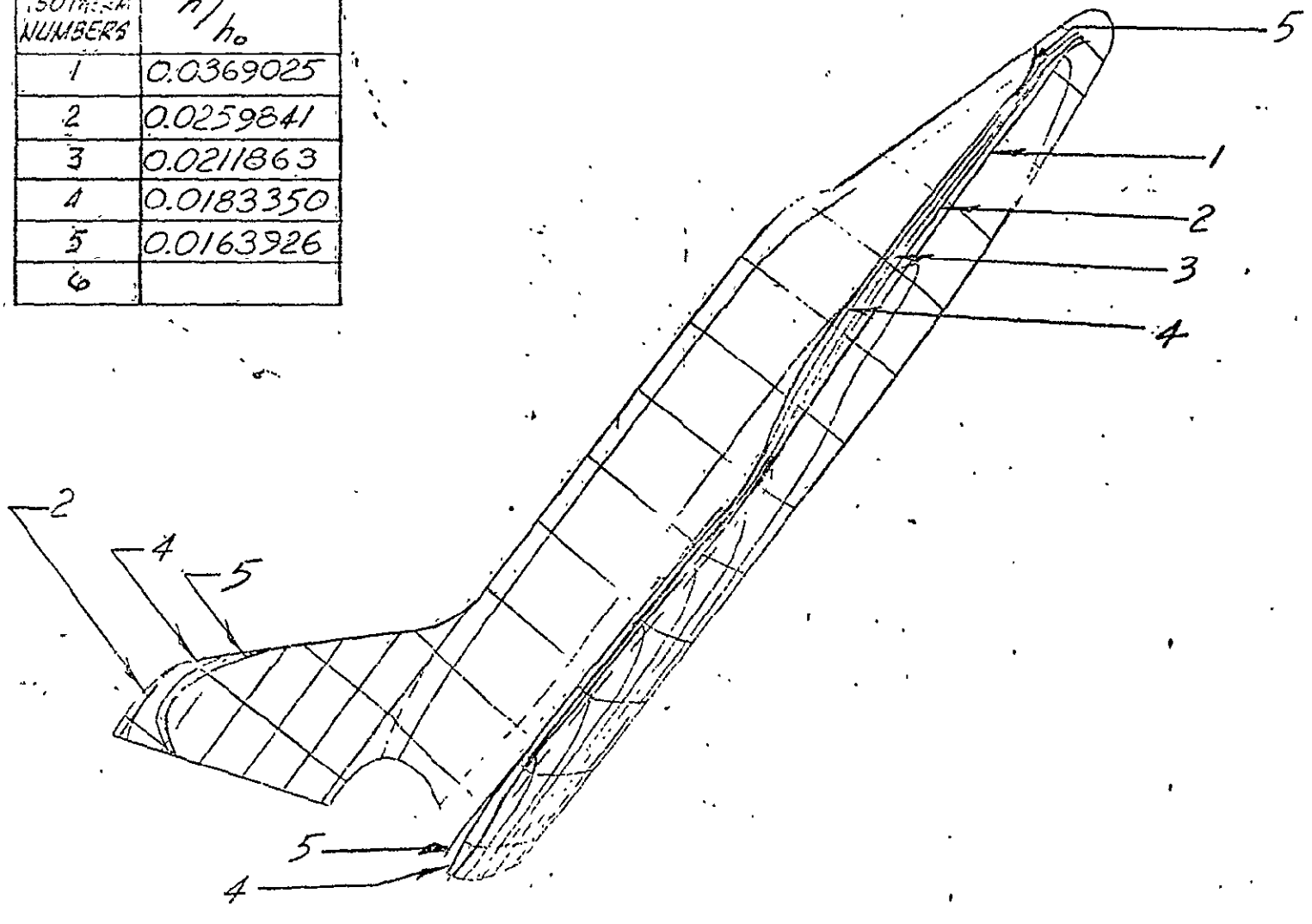
ISOTHERM NUMBERS	h/h_o
1	0.131547
2	0.0926262
3	0.0755234
4	0.0653595
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 020

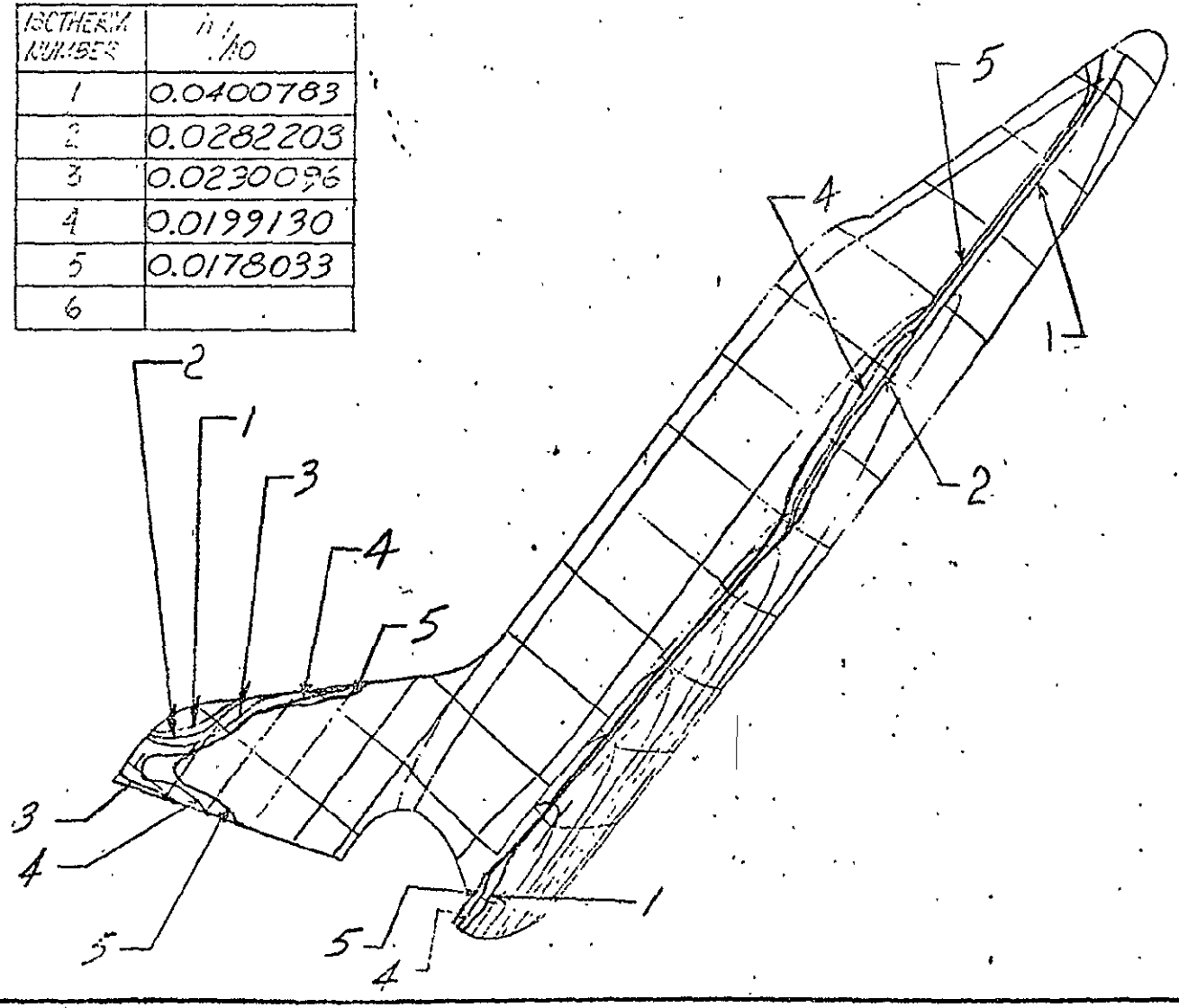
ISOTHERM NUMBERS	h/h_o
1	0.0369025
2	0.0259841
3	0.0211863
4	0.0183350
5	0.0163926
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 021

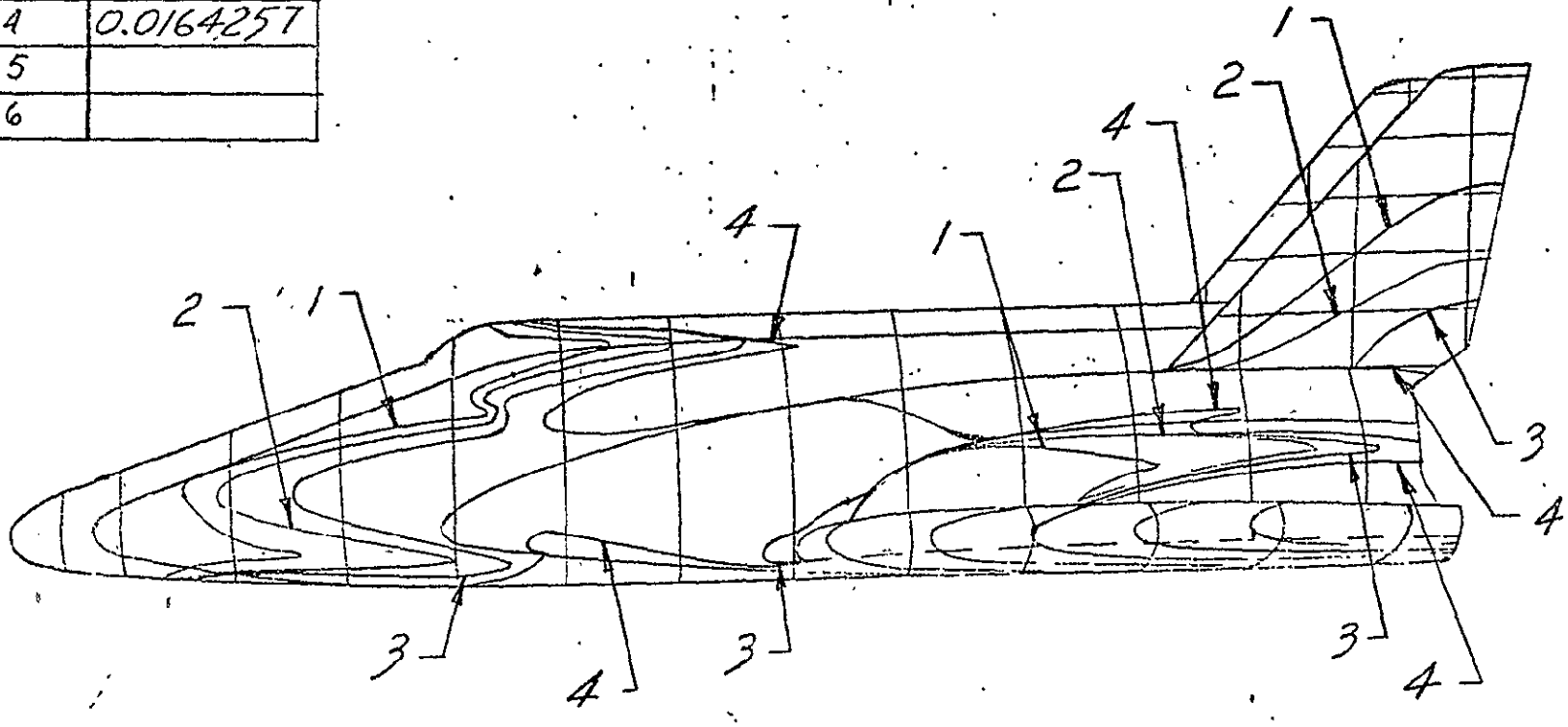
ISOTHERM NUMBER	h_i/h_0
1	0.0400783
2	0.0282203
3	0.0230096
4	0.0199130
5	0.0178033
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 031

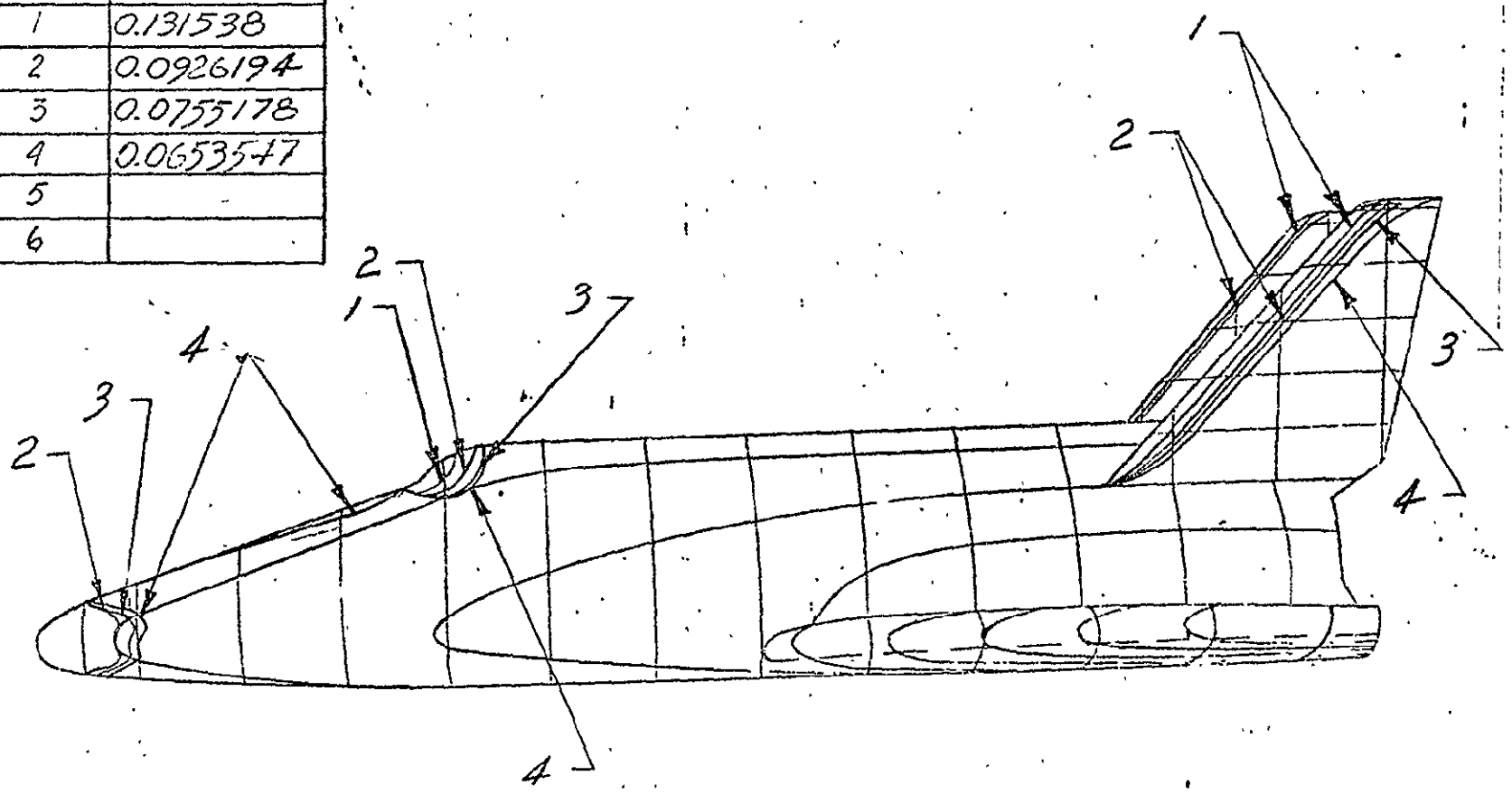
ISOTHERM NUMBERS	h/h_0
1	0.0330595
2	0.0232782
3	0.0189800
4	0.0164257
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 030

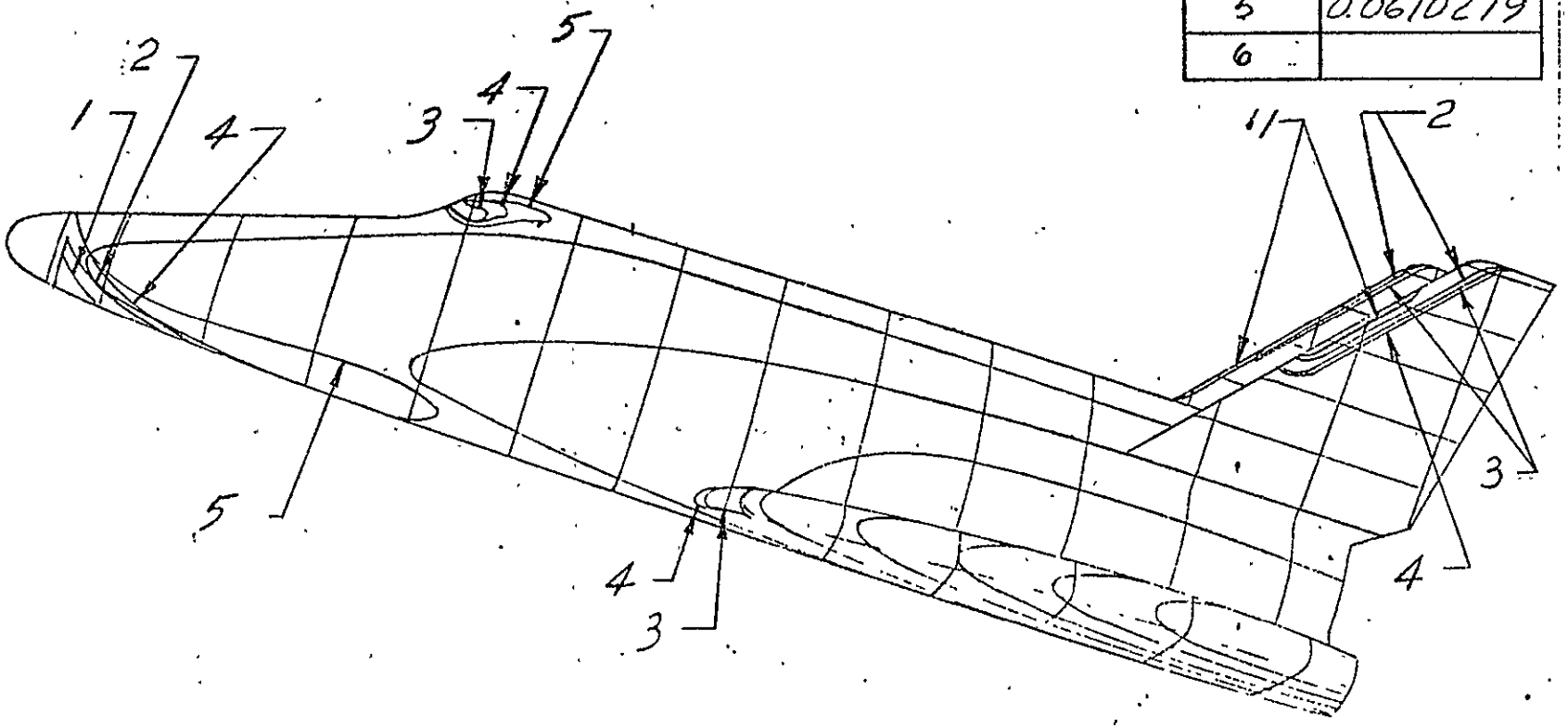
ISOTHERM NUMBERS	h/h_0
1	0.131538
2	0.0926194
3	0.0755178
4	0.0653547
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GEHT-017 TEST RUN NUMBER: 029

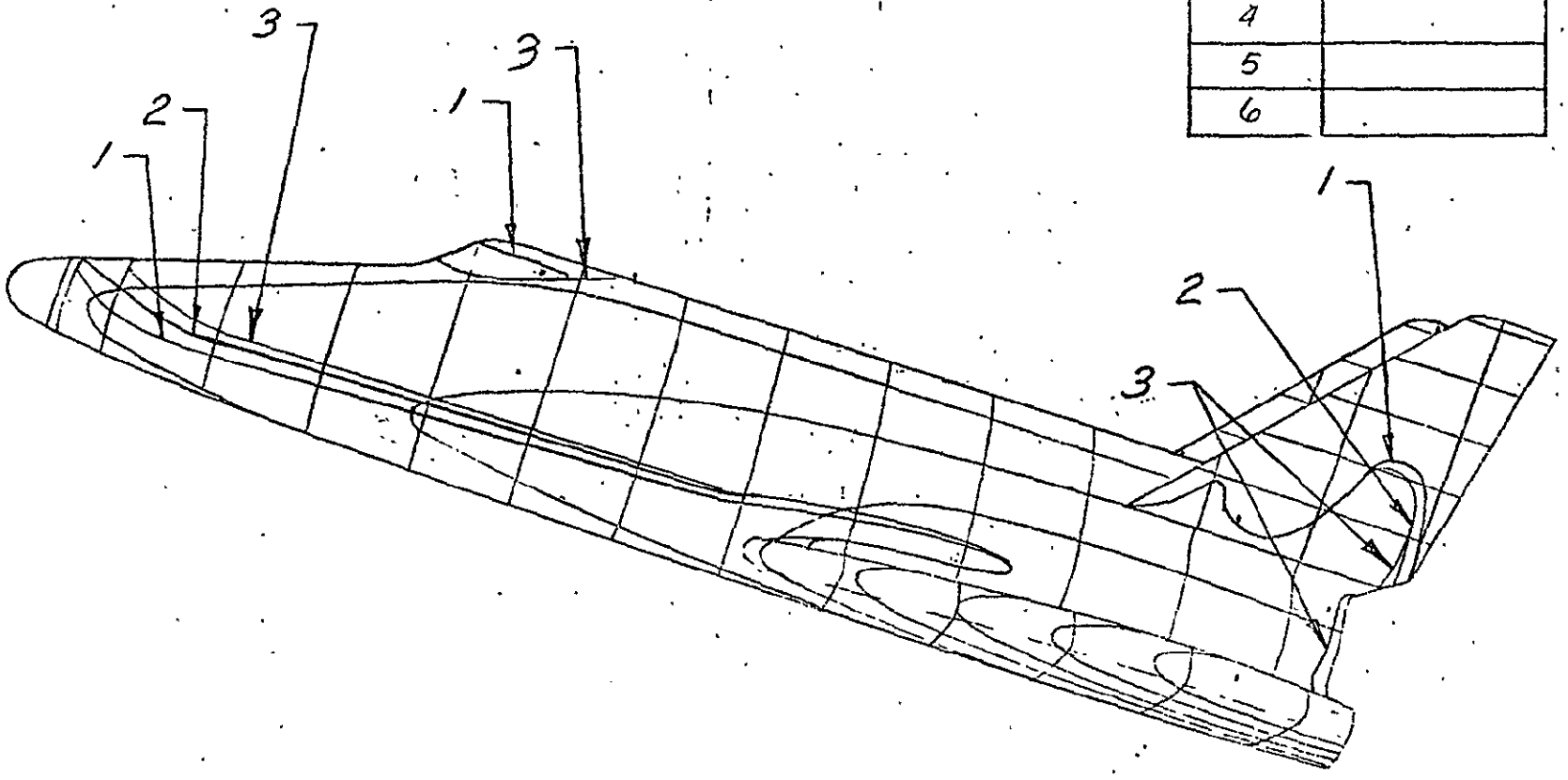
ISOTHERM NUMBERS	h/h_0
1	0.137364
2	0.0967361
3	0.0788744
4	0.0682595
5	0.0610279
6	



PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: 028

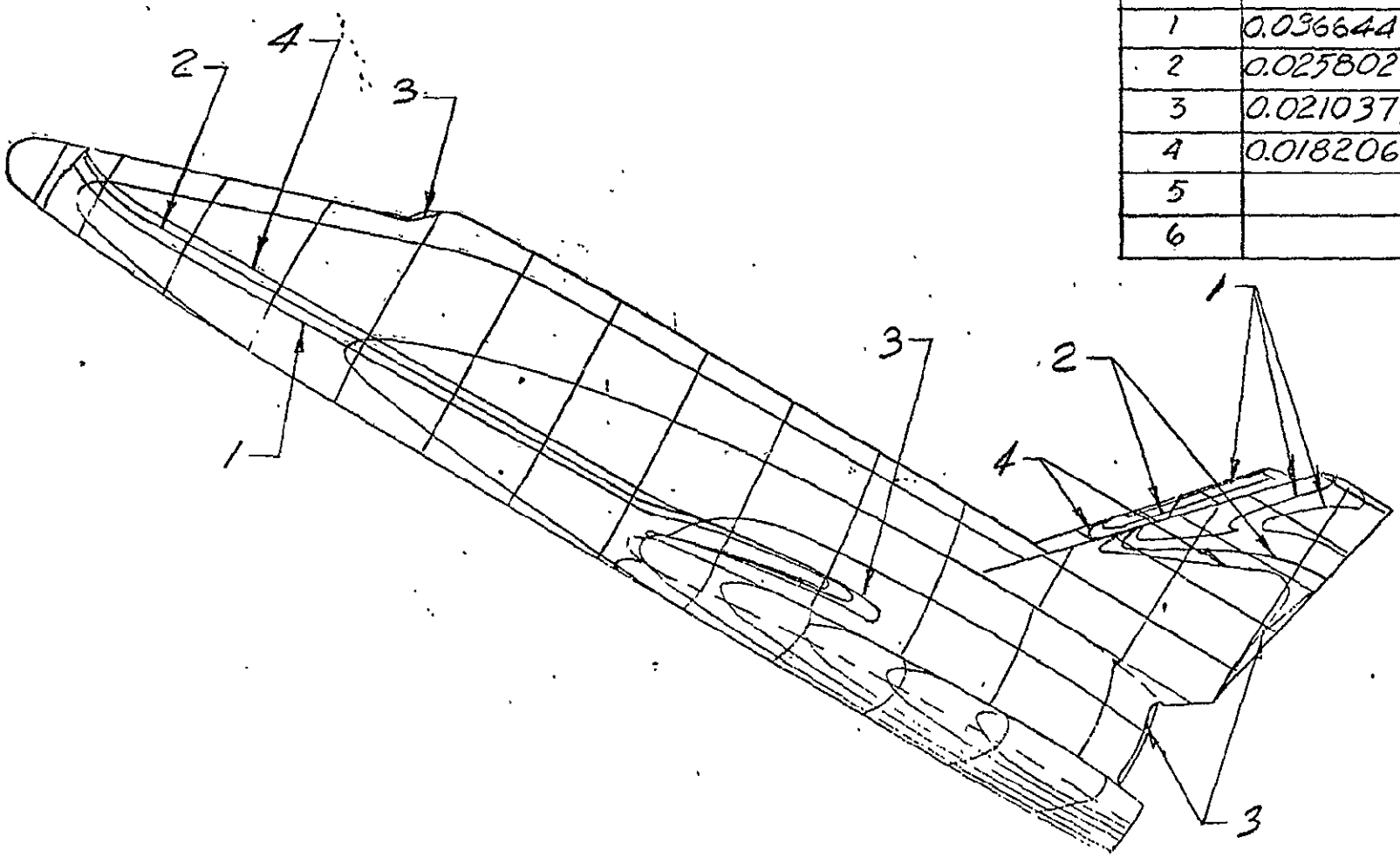
ISOTHERM NUMBERS	h/h_o
1	0.0396476
2	0.0279170
3	0.0183979
4	
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

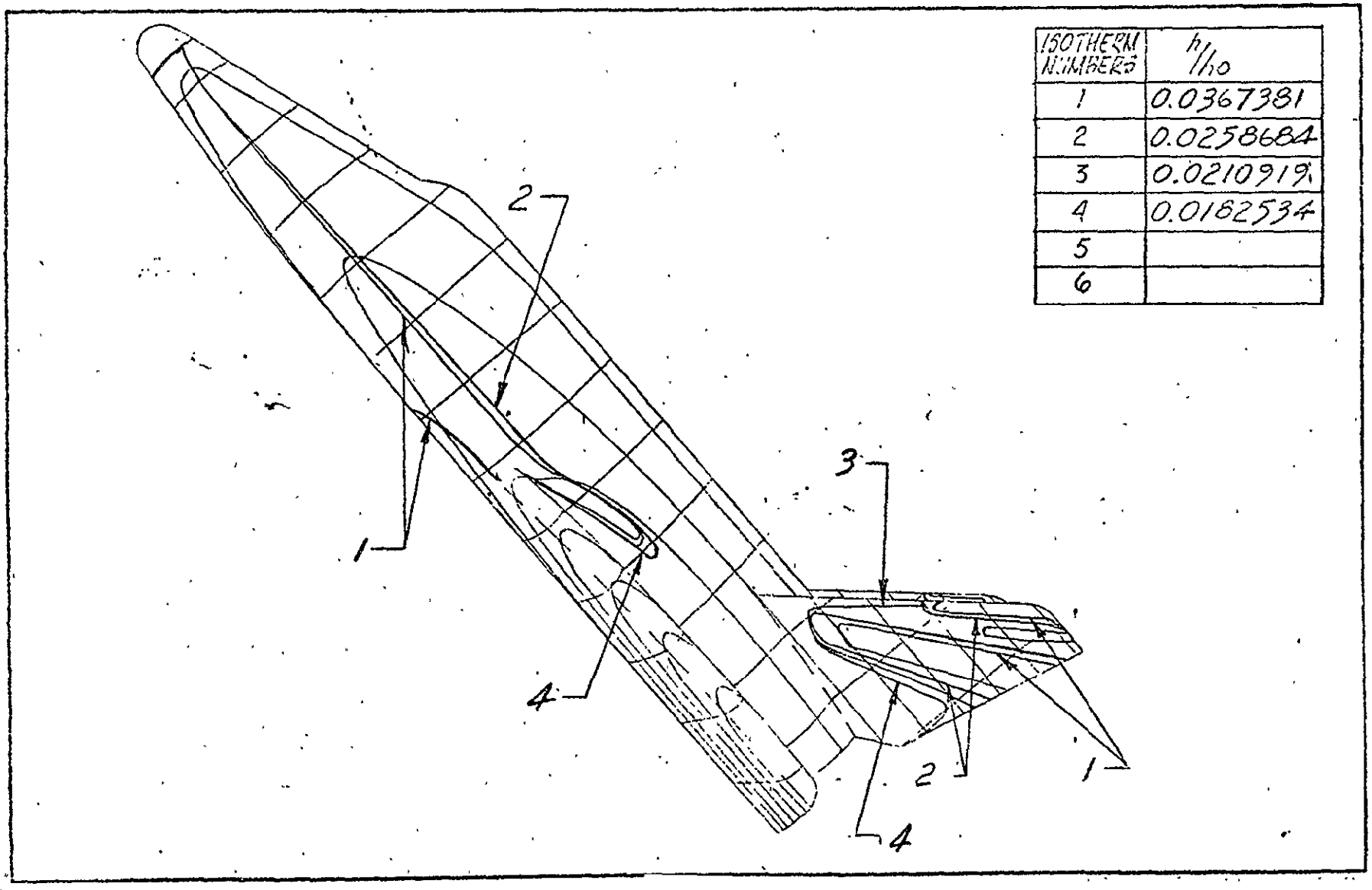
TEST NUMBER: GFHT-017 TEST RUN NUMBER: 026

ISOTHERM NUMBERS	h/h_0
1	0.0366440
2	0.0258021
3	0.0210379
4	0.0182067
5	
6	



PHASE CHANGE COATING TEST RUN SHEET

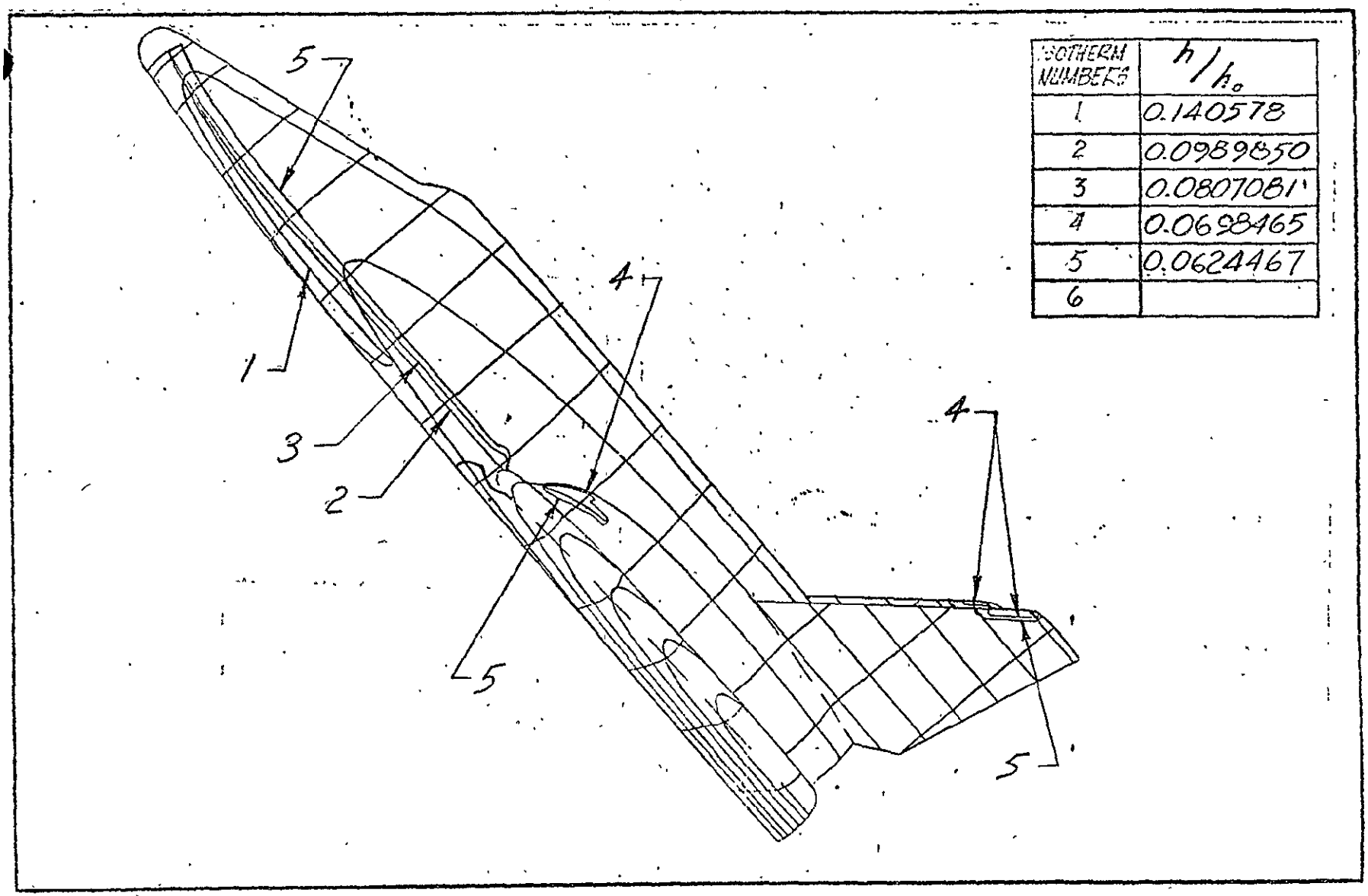
TEST NUMBER: GEHT-017 TEST RUN NUMBER: 029



ISOTHERM NUMBERS	h/h_o
1	0.0367381
2	0.0258684
3	0.0210919
4	0.0182534
5	
6	

PHASE CHANGE COATING TEST RUN SHEET

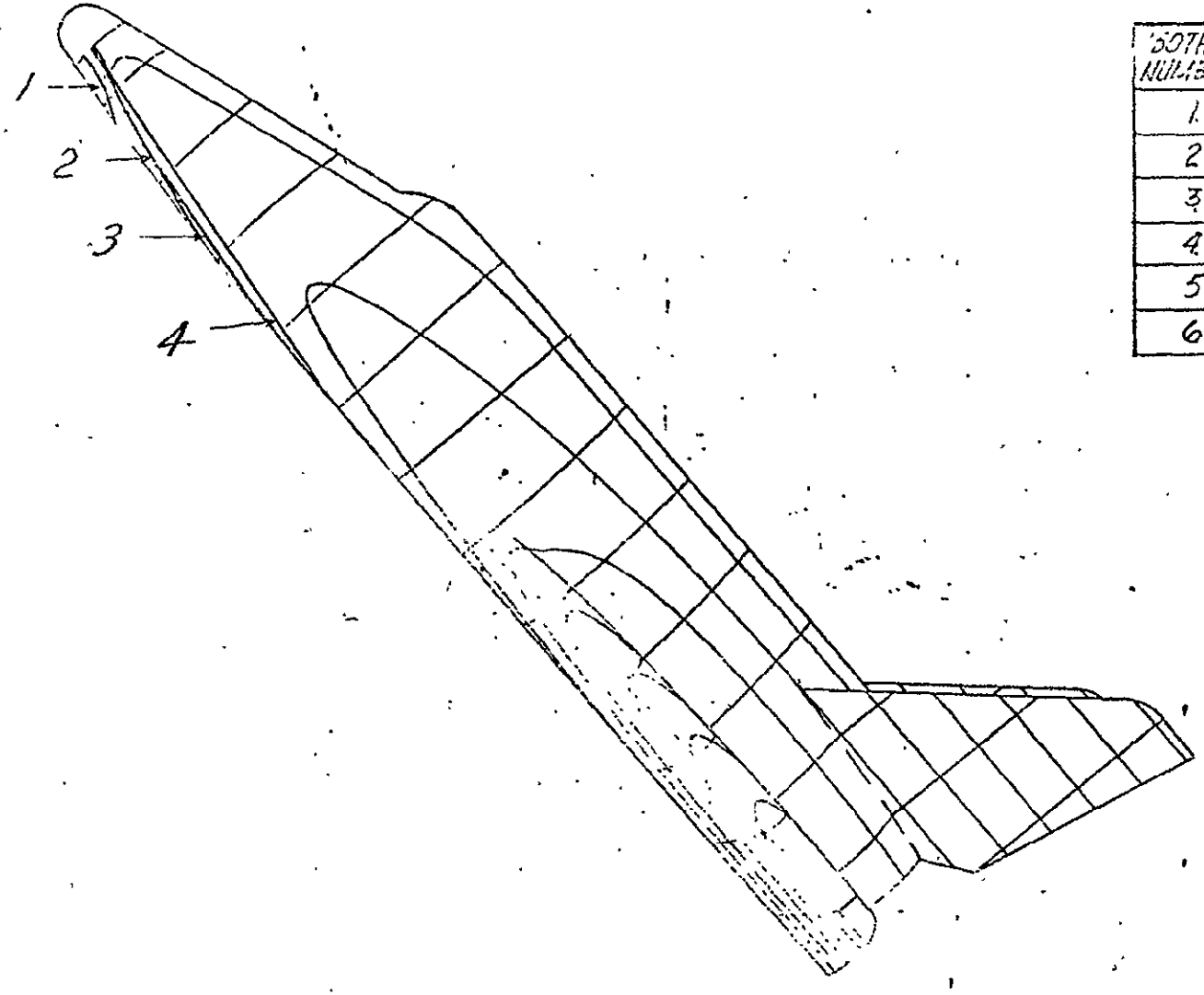
TEST NUMBER: GFHT-017 TEST RUN NUMBER: 023



ISOTHERM NUMBERS	h/h_o
1	0.140578
2	0.0989850
3	0.0807081
4	0.0698465
5	0.0624467
6	

PHASE CHANGE COATING TEST RUN SHEET

TEST NUMBER: GFHT-017 TEST RUN NUMBER: - 022



ISOTHERM NUMBERS	h/ho
1	0.235028
2	0.191632
3	0.165842
4	0.148272
5	
6	