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FOREBODY TEMPERATURES AND TOTAL HEATING RATES MEASURED DURING PROJECT FIRE 1 REENTRY AT 38 000 FEET PER SECOND

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FOREBODY TEMPERATURES AND TOTAL HEATING RATES MEASURED DURING PROJECT FIRE 1 REENTRY AT 38 000 FEET PER SECOND*

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SUMMARY

Calorimeter-type measurements of total heating have been obtained on an Apollo-shaped body reentering the earth's atmosphere at a speed of approximately 38 000 fps. The magnitude of the total-heat-flux time history was found to lie within estimates made by using available theoretical and empirical methods.

INTRODUCTION

Theoretical methods are currently available for predicting reentry heating at velocities representative of returns to earth from the moon or the near planets. However, these methods offer a variety of answers which may differ by as much as an order of magnitude. Considerable dispersion also exists among ground-facility measurements and their extrapolation, particularly with respect to the radiative heating component.

Because of these uncertainties and the fact that ground-test facilities cannot duplicate the full-scale reentry case in all important respects, the National Aeronautics and Space Administration undertook Project Fire to provide reentry-heating data at a nominal velocity of 37 000 fps.

On April 14, 1964, the first Project Fire experiment was launched from Cape Kennedy, Florida, and a successful reentry was accomplished approximately 4500 nautical miles down the Eastern test range near Ascension Island. A large amount of useful data was acquired during the reentry. These data involve measurements of the trajectory variables, thermal radiation, forebody and afterbody heating, afterbody pressures, and radio signal attenuation or "blackout." The preliminary results derived from the principal onboard experiments are reported in reference 1.

The primary purpose of this report is to make available the results of the forebody temperature-time history measurements and to present calculated total heating rates derived from these measurements. This report does not attempt to

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define the convective and radiative heating rates individually. However, by an analysis of the flight-test data, limiting "benchmark" values of the total (convective plus absorbed radiative) heating rates experienced during the Fire 1 reentry are defined.

SYMBOLS

A,B,C,d,E,F	polynomial coefficients
c	specific-heat capacity of beryllium, Btu/lb-°R
D	diameter of forebody calorimeter shield, in.
i,j	integers
k	thermal conductivity of beryllium, Btu/ft-sec-°R
L	total thickness of beryllium calorimeter plug (0.20 in.)
Q	total heat absorbed by forebody during the entire reentry, $2\pi\int_0^R q_m s'\,ds'$, Btu
q	local accumulative heat load, $\int_{t=1650}^{t} (\dot{q}_c + \alpha\dot{q}_r)\,dt$, Btu/ft^2
$\dot{q}$	local heat rate, Btu/ft^2-sec
q_m	local accumulated heat load during entire reentry, Btu/ft^2
R	radius of forebody calorimeter shield measured perpendicular to axis of symmetry, in. (See fig. 8.)
R_C	corner radius of calorimeter shield, in.
R_N	forebody nose radius, in.
s	radial distance measured perpendicularly from axis of symmetry, in. (See fig. 8.)
s'	radial distance measured along surface of forebody calorimeter shield, in. (See fig. 8.)
T	temperature, °R
t	time, sec
x	distance into calorimeter measured normal to heated surface, in.

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α	total hemispherical absorptance of beryllium, dimensionless
ϵ	total hemispherical emittance of beryllium, dimensionless
ρ	density of beryllium, 116 lb/cu ft
σ	Stefan-Boltzmann constant, 0.4761×10^{-12} Btu/ft^2-sec-($^\circ$R)^4
ϕ	azimuth angle, deg

Subscripts:

c	convective
e	exposure
em	emitted from front
i	summation index
j,k	range indices
0	heated surface
ob	emitted out back
r	radiative
s	stored

DESCRIPTION OF REENTRY EXPERIMENT

A detailed description of the Fire 1 reentry experiment is given in reference 2. The experiment was designed so that data were collected in three experimental periods during reentry as shown in figure 1.

A sketch of the complete vehicle used for Project Fire is shown in figure 2. The various phases of the trajectory and sequence of major events prior to reentry are depicted in figure 3 and the reentry trajectory is defined in figure 4. A velocity of 37 971 fps at an altitude of 400 000 ft and a reentry angle of -14.6° was achieved. The local atmospheric conditions during reentry were essentially those of the 1962 Standard Atmosphere as indicated by sounding data presented in reference 2.

Reentry Package

A basic requirement of the Project Fire reentry experiment was that the forebody heating measurements be made in a contamination-free atmosphere; that is, the flow field in front of the reentry package should not contain or be

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perturbed by gaseous products resulting from a subliming or charring ablation type of heat shield. This type of contamination could greatly influence the heat-transfer rates and gas cap total and spectral radiation measurements. It was therefore considered necessary to utilize a relatively "clean" metallic calorimeter shield.

At hyperbolic reentry velocities, no known calorimeter material can survive the heat load of the entire reentry without losing mass. It was therefore necessary to devise a means of utilizing a metallic calorimeter shield until it began to melt and then to expose a new cool shield that would provide additional clean experiment time. The Fire reentry package was designed with a layered heat shield so that additional cool calorimeters were exposed by ejection of the protecting ablation material layers just prior to and after peak heating. This procedure provided a total of three distinct experimental or data-gathering periods as shown in figure 1.

Physical description.- The general shape and external dimensions of the reentry package (subsequently referred to in figures as the R/P) are shown in figure 5. It consisted of a very blunt forebody (large nose radius of curvature) and a conical afterbody (total included angle of 66°). The forebody and afterbody structures were joined with a pressure cooker type of seal joint. The external shape of the reentry package was symmetric about its longitudinal axis. The reentry package was designed to reenter the atmosphere with its blunt face foremost and with its longitudinal axis at an angle of attack of 0°. The forebody nose radius and maximum diameter varied during reentry because of the periodic ejection of heat-shield layers. Pertinent dimensions are indicated in the table shown in figure 5. At the beginning of the reentry, the maximum diameter of the reentry package was slightly greater than 2 feet and its total weight was approximately 185 pounds.

A sketch of the reentry package and its adapter is shown in figure 6. The dishlike forebody consisted of a thin aluminum substructure which was covered on the forward side with a composite multilayered heat shield and reinforced on the inside with a welded instrument mounting grid. The composite forebody heat shield was formed by using alternate layers of pure beryllium metal and phenolic-asbestos ablation material. The three beryllium layers served as heat sink type of calorimeters, and the phenolic asbestos provided the needed protection between and after the calorimeter experiment periods.

The first and third beryllium layers were 0.12 inch thick and the second layer, which was designed to be exposed during the peak of the heat pulse, was 0.20 inch thick. Each beryllium shield was machined from the same hot-pressed beryllium block. The 98.5-percent pure beryllium material was produced by a process of sintering beryllium powder. The exposed surface of each of the beryllium shields was polished to a surface finish of approximately 8 micro-inches root-mean-square roughness height.

In order to protect succeeding beryllium calorimeter layers until the desired exposure time, they were separated from each other by 0.20-inch-thick thermal insulation layers. These layers were fabricated from a phenolic resin which was impregnated with asbestos fiber and compression molded into the

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desired shape. Details concerning their composition, fabrication, and thermal properties can be found in reference 3.

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The conical afterbody shell was formed from an aluminum sheet and covered with a laminate of insulative batting and phenolic asbestos. The insulative batting was encapsulated in woven glass fabric to form a flexible blanket which was then bonded to the aluminum-alloy shell. This combination was then overlaid with a phenolic-asbestos sheet which was bonded to the insulation blanket. In order to minimize the formation of an electrically conductive char layer on the afterbody, the afterbody surface was coated with a very thin layer of a cellular-silicone composition. This material was composed of 75 percent by weight silicone elastomer and 25-percent high-silica microballoons. Teflon-covered VHF antennas were located on the afterbody within the band shown in the side view of the reentry package in figure 7.

Data sensing and reentry package instrumentation.- Data sensing was accomplished by a variety of sensors located onboard the reentry package. The purpose of the sensors was to (1) measure the temperatures resulting from the heat flux incident upon the exterior of the reentry package, (2) to measure the energy radiated from the heat shock layer, (3) sense reentry package motions during flight, (4) measure external static pressures on the afterbody, and (5) measure internal pressure and temperature for diagnostic purposes. The location of the primary sensors on the external surface of the reentry package is shown in figure 7.

The forebody temperatures, which constitute the only measurements to be discussed in this paper, were obtained from 12 "plugs" (temperature measuring stations) located along three radial rays in each of three beryllium calorimeter shields as shown in figure 8. All the plugs were small circular cylinders which were machined from the same batch of material as the sleeves and calorimeter layers into which they were shrink-fitted. A sketch of the beryllium plug installations is shown in figure 9. The diameter of all plugs was approximately 0.125 inch and that of the sleeves was 0.375 inch. Although the thickness of the first and third beryllium layers was only 0.12 inch, the depth of all plugs was 0.20 inch. This depth was obtained by providing the thinner shields with 2-inch-diameter bosses on their rearward surface to accommodate the full plug depth as shown in figure 9(a).

Each plug was instrumented with four thermocouples whose hot junctions were located at the nominal depths of 0.01, 0.07, 0.13, and 0.20 inch from the heated surface. The actual measured thermocouple depths are given in table I. In order to establish the thermocouple junctions, the two wires were crossed and spotwelded to the beryllium plug material. Each plug containing four thermocouples was then press-fitted into a protecting sleeve. This assembly was then checked and shrink-fitted into the beryllium calorimeter layer. With this technique, 144 thermocouples were installed in the three beryllium calorimeter shields. Approximately 66 percent of these thermocouples functioned properly during the reentry.

A sketch of a typical thermocouple installation is shown in figure 10. The thermocouples were made from premium grade, 1-mil diameter, chromel-alumel wire. This unusually small gage wire was used to provide rapid response,

negligible conduction heat loss along the wire, minimum disturbance to the homogeneity of the plug, and small thermocouple-junction size. The thermocouple leads were insulated from the beryllium plug and shield by encasing them in a double-bore quartz sheath whose diameter was approximately 3.5 to 4.0 mils. They were then routed directly out the back of the plug through a groove milled along the surface of the plug. The width of the groove was approximately 5 mils and its depth was such that the quartz sheath was just flush with the plug surface as shown in figure 10. A more complete discussion of the considerations and philosophy involved in the design of the Project Fire beryllium calorimeters and forebody shielding is presented in reference 4.

The thermocouple outputs were sampled sequentially at the rate of 10 samples per second by use of a 90 × 10 pulse duration modulation (PDM) commutator. The signals from the commutator were telemetered to the ground in real time by a real-time transmitter. They were also recorded on a tape loop in a tape recorder. After about a 45-second delay, the data from the tape were telemetered by a second or delay-time transmitter system, and the tape was erased. On emergence from radio-frequency blackout, the "erase-record" function of the tape recorder was canceled and the delay transmitter transmitted repeatedly the 45-second cycle of data obtained prior to emergence from blackout. By these means, the data for the heat-pulse period (most of which occurs during blackout) were obtained.

The extent of the data coverage during the Fire 1 reentry is shown schematically in figure 11. It is noted that portions of four playbacks of the reentry data acquired during blackout were provided by a delay-time telemetry link. The intermittent dropouts or gaps in the playback data are due to a progressive deterioration of the antenna system for the delay-time telemetry transmitter. Although the data dropouts necessitated the use of some time-consuming manual data-reduction procedures, the final superposition of the four playbacks, shown as the "sum of playbacks" in figure 11, resulted in approximately two-thirds total data coverage during the crucial blackout period.

It is indicated on the time scale in figure 11 that the reentry package experienced body motions beginning at approximately 1666 seconds after launch. Accelerometer data obtained during reentry indicate that the angular excursions produced by the disturbance at 1666 seconds were probably relatively large. An analysis of the body motions and derivation of the body attitudes is beyond the scope of this paper.

Beryllium Material Properties

The thermophysical properties of the beryllium material which are considered to be the most applicable to the Fire reentry package are presented in figures 12 to 14. The values of specific-heat capacity and thermal conductivity shown in figures 12 and 13, respectively, were determined from a survey of the literature. The variation of specific-heat capacity with temperature is identical to that recommended in reference 5. In order to expedite the use of the specific-heat capacity values in a machine calculation program, the curve shown in figure 12 was fitted with a fourth-degree polynomial. The resulting equation shown in figure 12 fits the given curve with a maximum error of 1 percent.

The variation of total hemispherical emittance of beryllium with temperature is shown in figure 14. This curve was estimated from measured values of total normal emittance by the use of theoretical conversion ratios calculated from equations derived in reference 6. These total normal emittance measurements were made by the National Bureau of Standards on specimens of the beryllium used in the Fire reentry package.

DATA REDUCTION AND SMOOTHING

Reduction of Forebody Temperature Data

As noted in a preceding section, the reentry package forebody temperatures were sensed during reentry by thermocouples located in the three beryllium calorimeter layers. The hot junctions of the thermocouple circuits were located at four depthwise positions in each plug as shown in figure 9. The plugs in each shield were located as shown in figure 8. The cold junctions of the thermocouple circuits were established at a point inside the reentry package and remained at an essentially constant reference temperature of 525° R as indicated by reference thermistors.

The so-called "real-time" data are those which were transmitted immediately as they were being sensed by the reentry package. These data which were obtained prior to and after telemetry blackout were of excellent quality. They exhibited a relatively low noise content, essentially no dropout, and could be machine converted directly to discrete temperature-time values.

The more important "delay-time" or "playback" data were sensed by the reentry package during the main portion of the reentry heating period and were transmitted to the ground after radio-frequency blackout by way of a separate delay-time telemetry link. Unfortunately, an intermittent loss of the delay-time telemetry signal occurred because of progressive deterioration of this transmission system. This signal loss is shown schematically in figure 11 by the gaps in the various playbacks. The gaps proved to be large enough to cause the loss of time synchronization in the planned machine-data-reduction procedure.

In order to reduce the delay-time data obtained during blackout, it was necessary to resort to a time-consuming partially manual procedure. The pulse duration modulation (PDM) signal from the various playbacks of the data was converted to a 90 × 10 pulse amplitude modulation (PAM) signal and reproduced along with the time-code-generator signal on a continuous oscillograph trace. The pulse amplitudes on the oscillograph traces were then converted to digital counts in punched cards with the use of manually operated telereader equipment. The thermocouple wire calibration allowed the final conversion to temperature-time values. The time correlation was established by the use of the signal from the onboard time code generator.

The position or timewise location of the individual thermocouple segments in each commutator frame is given in table I. The time values shown in tables II, III, and IV are those corresponding to the first segment in each

90-segment frame. Minor corrections to these time values could be made for a given thermocouple by increasing them by the number of $\frac{1}{900}$th second indicated in table I. Since each thermocouple was sampled at the rate of 10 readings per second, these minor time corrections, which involved hundredths of a second, were considered unnecessary.

Data Smoothing

The basic temperature-time data acquired by the delay-time telemetry link exhibited considerable random scatter. The scatter band was generally on the order of $\pm 50^{\circ}$ R and became greater during periods of rapid temperature rise. The scatter, which appeared to be randomly distributed, is believed to be primarily due to (1) sporadic signal distortions near data dropout periods, (2) inaccuracies involved in machine conversion from a pulse duration modulation to a pulse amplitude modulation signal, and (3) noise generated by manual data reduction procedures. The resulting high-frequency scatter was not associated with relatively low frequency body motions.

It is emphasized that the data dropouts, combined with the scatter, precluded a highly accurate forebody heating analysis. In order to utilize the temperature-time data in any heating analysis program, it was necessary that considerable smoothing and interpolation be performed. Because of the continuous thermal properties of the calorimeter material, the temperature-time history at a given depth should be reasonably smooth and continuous in both magnitude and first derivative until melting begins. This fact was considered to justify the smoothing and interpolation procedures used on the data. Several data-smoothing methods (primarily curve-fitting techniques) were investigated. These included (1) least-squares curve fitting using polynomials of degree 3 to 9, (2) Chebyshev polynomial curve fits, and (3) polynomial curve fits based on a method of chosen points. It was desired to obtain an equation for the local temperature as a function of time which would apply for the entire useful life of the given thermocouple and in which the coefficients were constant.

The data-smoothing procedure finally chosen was a modified hand-smoothing technique. The procedure consisted of manually fairing a smooth curve through the scattered temperature-time data points and then fitting this curve with a sixth-degree polynomial equation whose coefficients were determined by the method of Chebyshev polynomials. (See, for example, ref. 7.) The criterion for "goodness of fit" in the Chebyshev method was that the coefficients should be determined so that the maximum residual was minimized. The residual, in this case, was the difference between the temperature calculated for a given time from the curve-fit equation and that determined directly from the manually faired curve for the same time. By using a sixth-degree polynomial, all fits of the faired Fire 1 data for the three data periods were obtained with maximum residuals less than $\pm 10^{\circ}$ R. The resultant polynomial expressions for the local temperature T as a function of time t were of the form

$$T = A_0 + A_1 t + A_2 t^2 + A_3 t^3 + A_4 t^4 + A_5 t^5 + A_6 t^6$$

where the coefficients A_i were constant with respect to time for each data period. These algebraic expressions have been used in the forebody heating analysis in lieu of the actual scattered data points.

TOTAL HEATING ANALYSIS

Heat-Transfer Modes and Basic Assumptions

During the Fire 1 reentry, the three recognized heat-transfer modes were significantly involved. Heat was transferred into the exposed forebody heat shield by two modes, convection from the viscous boundary layer and radiation from the hot gas cap. Some of this absorbed heat was stored in each of the volume elements of the shield, some was transferred rearward by conduction, and a relatively small amount was transferred out the front and back surfaces by radiant emission, convection, and conduction.

In the limited analysis of the temperature-time data reported herein, it has been assumed that the heat conduction in any beryllium plug was essentially one-dimensional, depthwise, from the forward heated surface to the rearward insulated surface. This assumption implies that the local temperature gradient in any lateral direction (parallel to the exposed surface) was negligible compared with that in the direction x, measured normal to the exposed surface. In addition, the thermal response of a beryllium shield in the vicinity of any given plug was taken to be essentially that of an infinite slab heated uniformly at one surface. This assumption was justified in the present case by the uniformity of the input heating distribution over the blunt forebody and the thinness of the beryllium calorimeter layers. An analysis presented in reference 4 indicates that the diameter of the bosses on the rear surface of the first and third beryllium layers was sufficiently large (2 inches) to ensure that their influence on the one-dimensional characteristic of the heat flow in the vicinity of the plugs was negligible.

Derivation of Heat-Balance Equation

If one assumes that the transient heat conduction is one dimensional, then the governing second-order partial differential equation is

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) = \rho c\frac{\partial T}{\partial t} \tag{1}$$

where the local temperature $T(x,t)$ is a function of both position x and time t. The properties of the beryllium material are represented by the specific mass density ρ, the specific-heat capacity c, and the thermal conductivity k.

According to Fourier's law of heat conduction, the one-dimensional heat flux $\dot{q}(x,t)$ at any depth x and time t is given by

$$\dot{q}(x,t) = -k\frac{\partial T}{\partial x} \tag{2}$$

where the minus sign indicates that a positive heat flux takes place in the direction of decreasing temperature.

If equation (2) is substituted into equation (1), the governing differential equation involving the heat flux becomes

$$-\frac{\partial \dot{q}}{\partial x} = \rho c\frac{\partial T}{\partial t} \tag{3}$$

The time-dependent boundary conditions (local heating rates) at the exposed surface ($x = 0$) and rear surface ($x = L$) are schematically indicated in the sketch of figure 15. They can be written

$$\left.\begin{aligned} \dot{q}(0,t) &= \dot{q}_c(t) + \alpha\dot{q}_r(t) - \dot{q}_{em}(t) \\ \dot{q}(L,t) &= \dot{q}_{ob}(t) = -k\left(\frac{\partial T}{\partial x}\right)_{x=L} \end{aligned}\right\} \tag{4}$$

where $\dot{q}_c(t)$ is the convective heating rate, $\dot{q}_r(t)$ is the radiative heating rate, $\dot{q}_{em}(t)$ is the rate at which heat is reradiated or emitted from the front beryllium surface, and $\dot{q}_{ob}(t)$ is the rate at which heat leaves the rearward surface. In equation (4), α is the total hemispherical absorptance of the beryllium surface. It should be noted that any material other than a theoretically "black" body will reflect back to space a portion of the thermal radiation which is incident upon its surface. Thus α is that fraction of the incident radiative heat flux $\dot{q}_r$ which was absorbed into the beryllium material. The numerical value of α is dependent upon the spectral gas radiation intensity and the spectral absorptance characteristics of the local surface.

The initial condition for a given plug was taken to be the temperature distribution, $T(x,t_e) = T_e(x)$. It can also be expressed as the local heat flux distribution

$$\dot{q}(x,t_e) = -k\frac{\partial T_e(x)}{\partial x} \tag{5}$$

through the plug at the initial exposure time $t = t_e$.

It is considered worthwhile to point out here the distinction between the so-called "direct" and "inverse" heat conduction problems. The most common type of conduction problem encountered involves the determination of the local temperatures within a body when the initial and boundary conditions are known.

This problem would involve the solution of equation (1) for $T = T(x,t)$ subject to the known set of boundary and initial conditions and is sometimes referred to as the "direct" problem. In the present case, however, the problem was to determine the local boundary condition (surface heating rate) which produced the known temperatures in the beryllium plug. This problem is generally referred to as the "inverse" problem or a "temperature-to-heat flux inversion." Since the desired solution is the surface heat flux, equations (3), (4), and (5) have been written in terms of $\dot{q}$.

In the analysis of the Fire 1 data, a transient solution, which relies heavily on techniques of curve fitting the basic temperature data, has been obtained. The solution accounts for variable material properties and yields a closed-form analytical expression for the local surface heat flux at a given instant of time.

If at any time t, the differential equation (3) is partially integrated with respect to x between the limits $x = 0$ and $x = L$,

$$\dot{q}(0,t) - \dot{q}(L,t) = \int_0^L \rho c \frac{\partial T}{\partial t}\, dx$$

Application of the boundary conditions (eqs. (4)) yields a general heat balance equation which can be written in terms of the instantaneous heating rates as

$$\left.\begin{array}{l} \text{Heat in} = \text{Heat stored} + \text{Heat out} \\ \dot{q}_c(t) + \alpha\dot{q}_r(t) = \dot{q}_s(t) + \dot{q}_{em}(t) + \dot{q}_{ob}(t) \end{array}\right\} \qquad (6)$$

where

$$\dot{q}_s(t) = \int_0^L \rho c \frac{\partial T}{\partial t}\, dx \qquad (7)$$

is the rate of heat storage in the plug.

Equation (6) indicates that in order to maintain a heat balance, the total heat input $\dot{q}_c + \alpha\dot{q}_r$ must equal the heat stored in the plug $\dot{q}_s$ plus the total heat output $\dot{q}_{em} + \dot{q}_{ob}$. Since equation (6) is the result of a partial integration with respect to x, the terms in equation (6) are functions of t only. It can be seen that the evaluation of the instantaneous total heating rate at a given plug location consists simply of the evaluation and summation of the individual terms on the right-hand side of equation (6) for the given instant of time. The source of the data used to evaluate each of the terms is indicated in figure 15. The important point to note here is that only the terms on the right-hand side of the equation can be evaluated from the local temperature-time history data; that is, the calorimetric measurements yield not

the individual convective and radiative heating rates but the sum of the convective plus that fraction of the incident radiative flux which is absorbed. It is emphasized that the primary function of this paper is limited to the presentation of the forebody temperature-time history data and the total (convective plus absorbed radiative) input heating rates inferred from these data. As used here, the term "total" refers to the instantaneous input heat flux $\dot{q}_c + \alpha\dot{q}_r$ through a unit area of the exposed surface.

Rate of Heat Storage $\dot{q}_s(t)$

As given by equation (7), the rate of heat storage in the calorimeter $\dot{q}_s(t)$ was determined by the rate of increase of internal energy. This rate was indirectly measured by the four thermocouples embedded in each plug. As previously discussed, the temperature-time data for each given thermocouple location were smoothed by replacing the actual data points with a sixth-degree polynomial equation for the temperature as a function of time. For a given calorimeter plug, the temperature time history curves for the four thermocouples located at the depths x_j are given by

$$T(x_j,t) = \sum_{i=0}^{i=6} A_{ij}t^i \qquad (j = 1,2,3,4) \qquad (8)$$

In these equations, the coefficients A_{ij} are constant with respect to time t for each data period but vary with thermocouple depth x_j.

For any chosen instant of time $t = t_k$, equations (8) can be used to calculate four values of temperature $T(x_j,t_k)$ corresponding to the thermocouple depths x_j. An analytical expression for the temperature distribution through the plug at time $t = t_k$ can then be obtained by curve fitting the four points $T(x_j,t_k)$, x_j with a cubic polynomial of the form

$$T(x,t_k) = \sum_{i=0}^{i=3} B_{ik}x^i \qquad (9)$$

In a similar manner, equations (8) can be partially differentiated with respect to time to obtain the fifth-degree polynomial expressions

$$\frac{\partial}{\partial t}\left[T(x_j,t_k)\right] = \sum_{i=0}^{i=6} iA_{ij}t^{i-1} \qquad (j = 1,2,3,4) \qquad (10)$$

Equations (10) can be used to calculate the four sets of values $\frac{\partial}{\partial t}\left[T(x_j,t_k)\right]$, x_j for $t = t_k$ and $j = 1,2,3,4$. These four points can also be fitted with a

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cubic polynomial of the form

$$\frac{\partial}{\partial t}\left[T\left(x,t_k\right)\right] = \sum_{i=0}^{i=3} C_{ik}x^i \tag{11}$$

In equations (9) and (11), the polynomial coefficients B_{ik} and C_{ik} are constant with respect to x but vary with the chosen time $t = t_k$. It is now noted that equation (11) provides a convenient analytical expression for the time rate of change of temperature as a function of x. This expression can be utilized in the integrand of equation (7) in order to evaluate $\dot{q}_s\left(t_k\right)$.

For beryllium, the variation of the specific mass density with temperature is so small that ρ can be considered constant (116 lb/cu ft) and taken out from under the integral sign in equation (7) with little error. However, both the specific-heat capacity c and the thermal conductivity k are relatively strong functions of temperature as indicated in figures 12 and 13. Thus, the variation of these properties should be accounted for in any accurate analysis.

In order to account for the variation of c with temperature, the same curve-fitting techniques were again utilized. After a survey of the literature on beryllium, the data recommended in reference 5 and shown in figure 12 were fitted with the fourth-degree polynomial

$$c(T) = \sum_{i=0}^{i=4} d_i T^i \tag{12}$$

The constant coefficients d_i are given in figure 12. Equation (12) represented the given data over the temperature range from 400° R to 2805° R (melting point) with a maximum error of approximately 1 percent. An expression for the specific-heat capacity which could be used in the solution of equation (7) was obtained by substituting the expression for the temperature $T\left(x,t_k\right)$ given by equation (9) into equation (12). This substitution resulted in the twelfth-degree polynomial for $c\left(x,t_k\right)$

$$c\left(x,t_k\right) = \sum_{i=0}^{i=12} E_{ik}x^i \tag{13}$$

The integrand of equation (7) was then formed by multiplying $c\left(x,t_k\right)$ as given by equation (13) by the expression for the time rate of change of temperature given by equation (11).

$$c\left(x,t_k\right)\frac{\partial}{\partial t}\left[T\left(x,t_k\right)\right] = \sum_{i=0}^{i=15} F_{ik}x^i \tag{14}$$

Since the expression for the integrand was a simple fifteenth-degree polynomial in x, the integration indicated in equation (7) could be easily performed. The resulting closed-form analytical expression for the instantaneous rate of heat storage at time $t = t_k$ was

$$\dot{q}_s(t_k) = \rho \sum_{i=0}^{i=15} \frac{F_{ik}(L)^{i+1}}{i + 1} \tag{15}$$

where the coefficients F_{ik} were functions of t_k only and could be readily computed.

Rate of Heat Emission $\dot{q}_{em}(t)$

The rate at which heat was emitted to space from the exposed surface $\dot{q}_{em}(t)$ was a function of the local surface temperature $T_0 = T(0,t)$. It is given by the Stefan-Boltzmann equation

$$\dot{q}_{em}(0,t) = \epsilon\sigma(T_0)^4 \tag{16}$$

where σ is the Stefan-Boltzmann constant $\left(0.4761 \times 10^{-12}\ \text{Btu/ft}^2\text{-sec-}(^\circ\text{R})^4\right)$. In equation (16), $\epsilon = \epsilon(T_0)$ is the total hemispherical emittance of the beryllium surface. The variation of ϵ with temperature was estimated from laboratory measurements made on beryllium specimens similar to the forebody calorimeter shields. The variation of ϵ believed to be the most applicable to the reentry conditions of the Fire 1 experiment is shown in figure 14.

The local surface temperature at $t = t_k$ was obtained by setting x equal to zero in equation (9) to give

$$T_0(t_k) = B_{0k} \tag{17}$$

The surface temperature given by equation (17) was then used to evaluate $\epsilon(T_0)$ and, finally, $\dot{q}_{em}(t_k)$ from equation (16).

Rate of Heat Transfer From Rear Surface $\dot{q}_{ob}(t)$

The heat flux through the rear surface of a given plug can be determined by evaluating equation (2) at $x = L$. This fact is indicated in the rear surface boundary condition of equations (4). At the time $t = t_k$,

$$\dot{q}_{ob}(t_k) = -k\left(\frac{\partial T}{\partial x}\right)_{x=L} \tag{18}$$

[redacted]

where the thermal conductivity k is a function of the rear surface temperature $T(x_4,t_k)$. The slope of the depthwise temperature distribution at $t = t_k$ could be determined by differentiating equation (9) with respect to x and evaluating the resulting expression at $x = L$. However, since small residuals in the curve fit indicated by equation (9) could produce relatively large errors in the calculated derivative at $x = L$, this method was not used to determine the slope. In the calculations reported herein, the slope at $x = L$ was arbitrarily approximated by the expression $\frac{T_4 - T_3}{3(x_4 - x_3)}$. Since the rear surface of any beryllium plug was essentially insulated, the heat flux out the back was very small relative to that stored in the plug and could have been neglected with little error.

It can now be seen that the total heating rate at $t = t_k$ is determined by the sum of the values obtained from equations (15), (16), and (18).

RESULTS AND DISCUSSION

Basic Temperature Data

The forebody temperature-time data measured during the three experimental periods of the Fire 1 reentry are presented in tables II, III, and IV. The real-time data obtained prior to blackout (see fig. 11) indicated no temperature rise and was used simply to verify a zero heat flux and a uniform temperature over the first heat shield prior to the main part of the reentry. Therefore, only the delay-time data are presented. It is noted that data are presented for only 4 of the 12 plugs (temperature-measuring stations) in each of the three beryllium calorimeter layers because of the loss or malfunction of one or more of the four thermocouples in each of the remaining plugs and the fact that the reliable data for the remaining plugs were essentially a repetition of those which are presented.

The plugs for which data are presented are shown as cross-hatched circles in figure 8. They include one plug at each of the four radial stations. These particular plugs were chosen because all four thermocouples in depth, or at least the three thermocouples closest to the heated surface, functioned properly during the useful lifetime of the particular beryllium shield. Accurate measurements of the depthwise locations of the four thermocouples in each of these plugs are given in table I.

In order to illustrate the quality of the basic data, the temperature-time histories are also plotted in figures 16 to 21. Figures 16 to 18 show the data from all four thermocouples in a given plug on one plot for comparison whereas figures 19 to 21 show the temperature-time histories of the thermocouples individually. Some data points are shown for times after the beryllium reached melt temperature. These points are included merely to substantiate melt and are not considered to be reliable data for analysis purposes. The gaps in the

[redacted]

data indicate time periods where no intelligible signal was received from the delay-time telemetry link as shown in figure 11.

The general shape of the temperature-time history of the first beryllium layer is illustrated in figure 16. It can be seen that the temperature rise during the early part of the reentry was very gradual. However, as the heating rate increased because of the higher atmospheric density at the lower altitudes, the temperature rose very rapidly. The data indicate that the surface of the first beryllium layer reached its melting temperature (2805° R) approximately 20 seconds after the start of the reentry (altitude, 400 000 ft; t, 1647.4 sec). Calculations performed subsequent to the Fire 1 reentry and utilizing the approximate heating rate experienced by the reentry package indicated that the thinner portions of the first beryllium shield would reach its melting temperature at approximately $t = 1666$ seconds. The data obtained from the plugs on the first shield were therefore considered to be useful only up to this time. The relatively low temperatures shown in figure 16(d) were typical of all the plugs located on the rim of the beryllium shield. These plugs were downstream of the corner, as shown in figure 8.

At approximately $t = 1670.4$ seconds, any molten beryllium residue from the first layer and the first phenolic-asbestos heat shield were ejected and the second beryllium layer was exposed. The data shown in figure 17 for the second beryllium layer indicate that its surface was uniformly cool when it was exposed. However, since it was exposed near the peak of the heat pulse, its lifetime was very short. The exposed surface reached its melting temperature in slightly over 2 seconds. Because of the data dropout and scatter indicated in figures 17 and 20 for this second experiment period, the generally steep slopes of the temperature-time curves could not be determined with a high degree of accuracy. This condition was particularly true for the times early in the experiment period immediately after exposure. It is also noted in figure 17(d) that a definite, low-heating-rate temperature rise was indicated for the plugs located on the rim.

At approximately $t = 1677$ seconds, the remnants of the second beryllium layer and its backup phenolic-asbestos insulation shield were ejected to expose the third beryllium layer. Since the third beryllium layer was exposed shortly after peak heating, its temperature rose rather rapidly for approximately 3.5 seconds as indicated in figure 18. After this time the thermocouple readings became erratic and the beryllium no longer functioned as a true calorimeter.

Although the scatter precludes direct cross plots of the temperature data, the depthwise temperature variation through the thickness of any given plug can generally be seen in the comparisons shown in figures 16 to 18. Because of the relatively high thermal conductivity of beryllium, heat was transferred through the plugs very rapidly. In some cases the exposed surface temperature rose at the rate of approximately 1000° per second and the temperature lag at the rear surface was only about 500°.

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In order to utilize the scattered temperature data in a heating analysis program, it was necessary that considerable smoothing and interpolation be performed. The method of handling these data in the total heating analysis reported herein is discussed in the previous sections. It consisted of manually fairing a smooth curve through the data for each thermocouple and then fitting this curve with a sixth-degree polynomial. This provided an expression for the local temperature as a function of time, which was then used in the heating calculations in lieu of the actual data points. The smooth curves used to represent the data are shown in figures 19 to 24. Figures 19, 20, and 21 illustrate the fairing used for each individual thermocouple. Figures 22, 23, and 24 show a comparison of the fairings for the four thermocouples in the plug near the stagnation region for each of the three experimental periods.

Circumferential temperature distribution.- The circumferential temperature distribution on the forebody would be indicated by the variation of temperature with azimuth angle ϕ, for any given time t, radial station s/R, and thermocouple depth x. Since the reentry package was axisymmetric and was designed to reenter at an angle of attack of 0° and with spin, it was anticipated that the circumferential temperature variation would be small.

A direct comparison of corresponding temperature-time histories measured at different azimuth angles indicated that the heating rate did not vary significantly with ϕ. The only two exceptions which should be noted were an apparently low heating rate for the plug located at $s/R = 0.55$ and $\phi = 146.25^{\circ}$ on the first beryllium shield and a somewhat high response for the plug located at $s/R = 0.90$ and $\phi = 146.25^{\circ}$ on the second shield. These variations from plug to plug in a given ring amounted to approximately 10 percent and are illustrated in the comparisons shown in figures 25 and 26. For the remaining thermocouples which performed satisfactorily during reentry, the circumferential distribution as determined from the smooth fairings of the data was generally very flat with variations of less than 5 percent. The general invariance of thermal response with azimuth angle must be attributed to the masking or averaging effects of spin stabilization and "thermal inertia" or conduction time lag.

Radial temperature distribution.- The radial distribution of temperature is indicated by the variation of T with s/R for any given time t, azimuth angle ϕ, and thermocouple depth x. The maximum variation of temperature with s/R measured during the first experimental period is shown in figure 27. Figure 27(a) shows a comparison of the corresponding temperature-time histories for the different radial locations. This comparison was made for the individual thermocouples located nearest the exposed surface ($x = 0.01$ in.).

Figure 27(b) shows the radial temperature distribution along two rays for three representative times. The solid curves are direct cross plots of the curves shown in figure 27(a). They emphasize the previously mentioned low temperature rise of the plug located at $s/R = 0.55$ and $\phi = 146.25^{\circ}$. However, the distributions observed were generally flat and the dashed curves shown for the ray $\phi = 258.75^{\circ}$ are typical.

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Similar comparisons for the second and third experimental periods are shown in figures 28 and 29, respectively. During the second experimental period, the maximum temperature rise was indicated by the plug located nearest to the geometric center (theoretical stagnation point) of the beryllium shield. This result was anticipated from theoretical predictions of the heating distribution. Figure 29 indicates that the temperature distribution over the forebody was generally very flat during the third experimental period. For all three experimental periods, the temperature dropped abruptly to a very low value as the observer moved from the exposed face of the shields around the corner to the plugs located on the rim at $s/R = 1.0$.

In general, the temperature distribution over the forebody was indicated to be relatively flat with a maximum deviation of approximately 15 percent. The maximum temperature rise was indicated near the geometric center ($s/R = 0$) of the forebody heat shield. It is noteworthy that the radial distributions shown in figures 27 to 29 are generally of the shape associated with predictions of convective heating on a blunt body.

Forebody Total Heating Rate

Experimental total heating rates which were inferred from the basic temperature-time data are shown in figure 30. The solid and dashed curves shown represent the difference in calculated total heating rate that can be obtained by two different fairings of the same basic data. The corresponding fairings of the temperature-time data are shown as solid and dashed curves in figures 19(a) to 19(d), 20(a) to 20(d), and 21(a) to 21(d). The low values of total heating rate indicated at the beginning of the second and third experimental periods can be increased considerably by fairing slightly steeper initial slopes on the temperature-time history curves. The crosshatched bands shown illustrate the latitude afforded by various possible fairings of the data and are considered to be the region in which the result would lie if accurate and definitive fairings could be made. The calculated heating rates are unreliable for a short time immediately after exposure of a calorimeter. This unreliability is due to inaccurate definition of the steep slopes of the temperature-time curves from the basic data.

A comparison of the total heating rates at the various radial locations on the forebody is shown in figure 31. These results indicate little variation in the total heating rate over the forebody for the entire reentry.

A comparison of the experimental and theoretically predicted total heating rates for the forebody stagnation region is shown in figure 32. It can be seen in figure 32 that the significant portion of the reentry heat pulse occurred over a relatively short time period of approximately 35 seconds. Figure 32 also indicates that the total heating rate increased to a maximum of approximately 1100 Btu/ft^2-sec as the reentry package penetrated the more dense atmosphere at the lower altitudes. The maximum heating rate apparently occurred between the second and third experimental periods at a time of approximately 1674 seconds after launch. This time corresponds to an altitude of 164 000 ft and a velocity of 33 800 fps as shown in figure 4.

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The theoretically predicted heating-rate curves shown in figure 32 are th results of calculations using the Fire 1 trajectory data shown in figure 4 and the local atmospheric conditions at the time of reentry. The curves differ only in the sources used to calculate the convective heating rate and the equilibrium component of the radiative heating rate. The various sources used are indicated in figure 32 and are given in references 8 to 13. In the theoretica calculations, the temperature and density ratio in the homogeneous radiating gas cap were determined from the conservation equations and the use of the gas tables given in reference 12. The values of temperature and density ratio behind the shock were then used in conjunction with references 10 and 11 to estimate the equilibrium component of the radiative heating rate. In all cases, the nonequilibrium component of the radiative heating was estimated fro results presented in reference 13. The average total hemispherical absorptanc of the beryllium calorimeter material was taken to be equal to 0.55.

A one-dimensional, depthwise, heat balance for any given beryllium plug requires that the total heat input $\dot{q}_c + \alpha\dot{q}_r$ equal that stored in the plug $\dot{q}$ plus any heat transferred out of the front surface $\dot{q}_{em}$ and out of the back surface $\dot{q}_{ob}$. The rate at which heat was emitted from the forward exposed sur face of a typical plug is shown in figure 33(a). The estimated rate of heat transfer out the rear surface is shown in figure 33(b). By comparing the heat loss rates shown in figure 33 with the total heating rates shown in figure 32, it is readily apparent that the rate of the heat loss was indeed negligible compared with the rate of heat storage in the plug. This low rate of heat los from the beryllium shields, coupled with their relatively large heat-storage capacity, emphasized their typical heat-sink characteristic.

The accumulative heat load experienced by the entire forebody of the Fire 1 reentry package is illustrated in figure 34. The two curves shown repr sent a running time integration of the approximate heating rate at the stagnation region as indicated by the experimental bands shown in figure 32. The "total" heating rates used were obtained by fairing curves through the higher and lower parts of the experimental bands shown in figure 32. The two curves thus represented estimated maximum and minimum values.

CONCLUDING REMARKS

Calorimeter-type measurements of total heating have been obtained on an Apollo-shaped body reentering the earth's atmosphere at a speed of approximately 38 000 fps. During the 35-second reentry heat pulse, the forebody tota heating rate increased to a maximum of approximately 1100 Btu/ft^2-sec at an altitude of 164 000 ft and a velocity of 33 800 fps. The magnitude of the total heat flux time history lies within estimates made by using available theoretical and empirical methods.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., April 20, 1965.

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REFERENCES

1. Dingeldein, Richard C.: Flight Measurements of Reentry Heating at Hyperbolic Velocity (Project Fire). NASA TM X-1053, 1965.

2. SLV Test Evaluation and Guidance Software Groups: Project Fire Integrated Post Flight Evaluation Report. Flight No. 1. NASA CR 57017, 1964.

3. Doyle, Harry J.: Development of Design Data for the Application of Phenolic Asbestos Laminates on Fire Vehicle Heat Protective Systems. RAC 970-A (ARD 965-250A), Republic Aviation Corp., June 18, 1963.

4. Linzer, F. D.; and Kaplan, Eli: Considerations in Design of Calorimeters for the Project FIRE Superorbital Re-Entry Test Vehicle. [Preprint] 750L, Soc. Automotive Engrs., Sept. 1963.

5. Anon.: Beryllium in Aero/Space Structures. The Brush Beryllium Co., 1963.

6. Jakob, Max: Heat Transfer. Vol I. John Wiley & Sons, Inc., c.1949.

7. Hamming, R. W.: Numerical Methods for Scientists and Engineers. McGraw-Hill Book Co., Inc., c.1962.

8. Cohen, Nathaniel B.: Boundary-Layer Similar Solutions and Correlation Equations for Laminar Heat-Transfer Distribution in Equilibrium Air at Velocities up to 41,100 Feet Per Second. NASA TR R-118, 1961.

9. Fay, J. A.; and Riddell, F. R.: Theory of Stagnation Point Heat Transfer in Dissociated Air. J. Aeron. Sci., vol. 25, no. 2, Feb. 1958, pp. 73-85, 121.

10. Meyerott, R. E.; Sokoloff, J.; and Nicholls, R. A.: Absorption Coefficients of Air. AFCRC-TR-59-296, U.S. Air Force, Sept. 1959.

11. Kivel, B.; and Bailey, K.: Tables of Radiation From High Temperature Air. Res. Rept. 21 (Contracts AF 04(645)-18 and AF 49(638)-61), AVCO Res. Lab., Dec. 1957.

12. Hilsenrath, Joseph; Klein, Max; and Woolley, Harold W.: Tables of Thermodynamic Properties of Air Including Dissociation and Ionization From 1500° K to 15,000° K. AEDC-TR-59-20, Arnold Eng. Dev. Center, Dec. 1959.

13. Page, William A.; and Arnold, James O.: Shock-Layer Radiation of Blunt Bodies at Reentry Velocities. NASA TR R-193, 1964.

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TABLE I. - DEPTH OF THERMOCOUPLES IN THE BERYLLIUM CALORIMETER PLUGS AND THERMOCOUPLE POSITION IN COMMUTATOR FRAME

Beryllium layer No.	Radial location, s/R	Azimuth angle, ϕ, deg	Thermocouple depth, x, in.	Thermocouple position in 90 × 10 commutator frame, (given in 1/900ths second from frame reference time, t)
1	0.09	146.25	0.0096	15
			.0728	16
			.1318	17
			.2000	18
1	.55	33.75	.0111	12
			.0726	44
			.1318	45
			.2000	—
1	.89	146.25	.0110	7
			.0712	8
			.1324	9
			.2000	10
1	1.00	242.00	.0111	19
			.0719	20
			.1313	21
			.2000	22
2	0.10	258.75	0.0126	31
			.0709	32
			.1311	33
			.2000	34
2	.54	258.75	.0132	27
			.0715	28
			.1312	29
			.2000	30
2	.90	258.75	.0138	23
			.0736	24
			.1317	25
			.2000	26
2	1.00	242.00	.0120	19
			.0705	20
			.1318	21
			.2000	—
3	0.10	146.25	0.0122	15
			.0704	16
			.1310	17
			.2000	18
3	.57	146.25	.0125	11
			.0723	12
			.1323	13
			.2000	14
3	.87	242.00	.0133	23
			.0735	24
			.1335	25
			.2000	26
3	1.00	242.00	.0137	19
			.0730	20
			.1322	21
			.2000	22

[redacted]

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD

(a) $s/R = 0.09$; $\phi = 146.25^{\circ}$; $x = 0.0096$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	555.1	1653.59	558.7	1660.96	762.8
1647.11	531.0	1653.69	519.3	1661.16	905.3
1647.21	546.8	1653.79	566.1	1661.26	894.8
1647.31	497.0	1654.09	603.2	1661.56	1094.4
1647.41	500.2	1654.19	542.9	1662.86	1057.1
1647.51	519.3	1654.29	531.1	1662.86	1029.7
1647.71	534.9	1655.28	623.4	1663.06	1103.3
1647.81	576.2	1655.38	619.8	1663.26	1265.2
1649.10	507.5	1655.48	580.9	1663.36	1175.1
1649.20	527.1	1655.78	621.8	1663.46	1092.6
1649.30	530.7	1655.88	543.1	1663.56	1220.2
1649.80	523.3	1655.98	580.8	1663.56	1195.9
1649.90	519.4	1656.08	592.3	1663.66	1299.7
1650.00	550.4	1656.18	581.6	1664.36	1361.3
1650.10	546.5	1656.28	607.9	1664.46	1386.9
1650.20	565.8	1656.48	618.4	1664.56	1419.1
1650.30	542.5	1657.17	566.2	1664.66	1365.6
1650.40	538.7	1657.27	592.4	1664.76	1457.7
1650.50	527.2	1657.47	636.8	1664.86	1499.6
1650.60	561.9	1657.57	609.7	1665.06	1567.2
1650.70	535.1	1657.77	680.8	1665.16	1569.0
1650.80	491.6	1657.77	598.6	1665.26	1614.8
1650.90	484.2	1657.87	596.8	1665.26	1604.2
1651.30	443.6	1657.97	627.8	1665.36	1629.9
1651.40	573.0	1658.07	673.6	1665.36	1624.1
1651.45	523.3	1658.07	714.3	1665.45	1608.7
1651.79	542.7	1658.17	650.7	1665.45	1667.2
1651.89	572.9	1658.17	632.1	1665.55	1733.7
1651.99	531.1	1658.17	618.4	1665.55	1697.4
1652.09	562.1	1658.37	731.9	1665.65	1665.1
1652.19	527.3	1658.47	637.5	1665.65	1747.4
1652.19	558.2	1658.57	697.5	1665.75	1749.6
1652.29	519.4	1658.57	617.8	1665.75	1692.7
1652.29	534.9	1658.67	623.2	1665.85	1825.0
1652.59	539.1	1658.97	716.4	1666.05	1743.3
1652.69	562.1	1659.17	750.7	1666.15	1706.3
1652.99	527.2	1659.27	713.3	1666.25	1771.2
1653.09	499.6	1659.37	741.6	1666.35	1821.6
1653.09	515.5	1659.47	724.9	1666.45	1790.0
1653.19	554.6	1659.57	692.9	1667.05	2418.1
1653.29	542.9	1659.67	783.1	1667.15	2216.5
1653.39	569.6	1659.77	714.0	1667.65	2695.1
1653.39	581.4	1659.87	760.3	1667.75	2648.4
1653.49	550.3	1660.07	830.3	1667.95	2900.5

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TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(b) $s/R = 0.09$; $\phi = 146.25^{\circ}$; $x = 0.0728$ in.

Time, sec	Temp., °R
1647.01	551.1
1647.11	538.7
1647.41	492.5
1647.51	503.6
1647.71	531.1
1647.81	538.6
1649.10	503.5
1649.20	523.3
1649.30	512.1
1649.80	500.4
1649.80	519.3
1650.00	584.2
1650.10	531.0
1650.20	538.8
1650.30	534.8
1650.40	527.2
1650.50	535.1
1650.60	561.9
1650.70	535.1
1650.80	503.5
1650.90	554.6
1651.30	474.0
1651.40	542.6
1651.45	499.5
1651.79	507.8
1651.89	558.0
1652.09	554.5
1652.19	527.3
1652.19	534.9
1652.29	507.8
1652.29	538.8
1652.39	463.1
1652.59	527.2
1652.69	546.7
1652.99	479.9
1653.09	519.3
1653.09	507.7
1653.19	523.3
1653.29	542.9
1653.39	546.6
1653.39	581.4
1653.59	554.8
1653.69	566.3
1653.79	577.4

Time, sec	Temp., °R
1654.09	562.0
1654.29	558.6
1655.38	558.9
1655.48	519.4
1655.78	584.4
1655.88	612.3
1656.08	611.1
1656.18	596.8
1656.28	600.3
1656.48	592.2
1656.58	622.7
1656.68	551.1
1656.78	649.8
1657.07	613.3
1657.27	554.6
1657.47	610.6
1657.57	609.7
1657.67	613.6
1657.77	628.2
1657.87	612.0
1657.97	640.9
1657.97	616.8
1658.07	673.6
1658.07	627.1
1658.17	606.2
1658.17	652.2
1658.47	583.0
1658.57	644.9
1658.57	714.7
1658.67	668.8
1658.97	731.9
1659.17	750.7
1659.27	698.2
1659.47	690.6
1659.57	692.9
1659.67	763.7
1661.06	767.3
1661.16	832.5
1661.26	944.8
1661.36	867.8
1661.46	899.1
1662.86	1134.9
1662.86	1029.7
1662.96	1052.5

Time, sec	Temp., °R
1663.06	1057.2
1663.16	1097.1
1663.26	1143.8
1663.26	1083.1
1663.36	1122.6
1663.46	1114.5
1663.56	1093.6
1663.66	1118.4
1664.26	1229.9
1664.46	1273.7
1664.56	1346.9
1664.66	1317.6
1664.76	1304.3
1664.86	1296.6
1665.06	1477.3
1665.16	1462.6
1665.26	1567.2
1665.26	1526.4
1665.36	1544.0
1665.36	1491.9
1665.45	1464.5
1665.45	1548.7
1665.55	1639.6
1665.55	1616.4
1665.65	1668.8
1665.65	1654.0
1665.75	1697.2
1665.75	1656.5
1665.85	1718.5
1665.95	1633.1
1666.05	1654.7
1666.15	1683.9
1666.25	1721.9
1666.35	1716.4
1666.45	1775.0
1666.55	1784.5
1667.05	2082.3
1667.15	2224.4
1667.65	2847.9
1667.85	2963.6
1667.95	2785.1
1668.05	3011.2
1668.15	3145.1
1668.25	2767.6

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TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(c) $s/R = 0.09$; $\phi = 146.25^{\circ}$; $x = 0.1318$ in.

Time, sec	Temp., °R
1647.01	539.2
1647.11	519.4
1647.21	577.4
1647.31	549.6
1647.41	523.3
1647.51	527.2
1647.71	546.6
1647.81	572.5
1649.20	523.3
1649.30	512.1
1649.80	523.3
1649.80	503.5
1650.00	561.9
1650.10	531.0
1650.20	554.4
1650.30	561.7
1650.40	554.3
1650.50	539.0
1650.60	561.9
1650.70	511.4
1650.90	515.5
1651.20	579.6
1651.45	499.5
1651.79	496.1
1651.89	554.1
1651.99	535.0
1652.19	523.3
1652.19	523.3
1652.29	531.0
1652.29	562.1
1652.39	479.5
1652.59	535.1
1652.69	527.2
1652.99	495.6
1653.09	476.0
1653.09	519.4
1653.29	566.1
1653.39	565.8
1653.39	604.1
1653.49	546.5
1653.59	550.8
1653.69	527.2
1653.79	581.2

Time, sec	Temp., °R
1654.09	554.4
1654.29	573.7
1654.39	547.0
1655.38	596.9
1655.78	569.5
1655.88	608.5
1656.08	581.0
1656.18	570.2
1656.28	554.8
1656.48	580.9
1656.58	622.7
1656.68	547.2
1657.07	609.6
1657.27	538.9
1657.47	554.4
1657.67	605.9
1657.77	680.8
1657.77	602.3
1657.87	627.2
1657.97	644.7
1657.97	627.8
1658.07	634.6
1658.17	608.7
1658.17	650.6
1658.17	663.5
1658.37	697.5
1658.37	670.5
1658.47	602.5
1658.57	626.1
1658.67	646.0
1658.97	720.3
1659.17	754.6
1659.27	694.4
1659.37	714.3
1659.47	709.5
1659.67	763.7
1659.87	760.3
1660.07	814.9
1661.06	794.9
1661.16	793.8
1661.26	863.9
1661.36	875.5
1661.56	919.5

Time, sec	Temp., °R
1662.76	1033.6
1662.86	1057.1
1662.86	1066.1
1662.96	1014.4
1662.96	1150.3
1663.06	986.4
1663.16	1112.1
1663.26	1070.0
1663.26	1131.2
1663.36	1074.0
1663.46	1092.6
1663.56	1176.2
1663.66	1148.2
1664.36	1321.2
1664.46	1256.0
1664.56	1299.9
1664.66	1284.3
1664.76	1293.4
1665.06	1413.6
1665.16	1462.6
1665.26	1501.2
1665.26	1496.8
1665.36	1544.0
1665.36	1521.3
1665.45	1493.3
1665.45	1478.6
1665.55	1531.9
1665.55	1547.2
1665.65	1563.6
1665.65	1565.4
1665.75	1574.4
1665.85	1608.8
1665.95	1650.6
1666.05	1684.2
1666.15	1654.0
1666.25	1702.9
1666.35	1697.6
1666.45	1704.2
1666.55	1682.6
1667.05	1951.7
1667.65	2063.3
1667.85	2720.4
1667.95	2810.8

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TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(d) $s/R = 0.09$; $\phi = 146.25^{\circ}$; $x = 0.2000$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	566.7	1653.69	507.5	1662.86	977.5
1647.11	519.4	1653.79	554.6	1662.86	970.8
1647.21	577.4	1654.19	566.2	1662.96	983.8
1647.31	504.5	1654.29	546.8	1662.96	1125.0
1647.41	488.7	1654.39	566.5	1663.06	986.4
1647.51	543.0	1655.38	566.5	1663.16	1041.1
1647.71	546.6	1655.78	569.5	1663.26	1103.3
1647.81	557.7	1655.88	578.0	1663.36	1111.4
1649.10	539.1	1655.98	584.6	1663.46	1067.1
1649.20	519.5	1656.08	554.5	1663.56	1025.4
1649.30	523.3	1656.18	570.2	1663.66	1144.5
1649.80	511.4	1656.28	543.0	1664.36	1226.3
1649.90	511.6	1656.48	592.2	1664.46	1256.0
1650.10	569.3	1656.58	619.0	1664.56	1249.3
1650.20	534.9	1656.68	543.2	1664.66	1202.5
1650.30	557.9	1656.78	627.1	1664.76	1238.6
1650.40	531.0	1657.07	587.4	1665.06	1353.7
1650.50	531.1	1657.47	554.4	1665.16	1356.1
1650.60	580.5	1657.57	602.3	1665.26	1428.0
1650.70	527.2	1657.67	559.4	1665.26	1433.8
1650.80	519.3	1657.77	662.2	1665.36	1447.3
1650.90	515.5	1657.87	634.8	1665.36	1418.5
1651.30	452.4	1657.97	644.7	1665.45	1395.9
1651.40	519.4	1657.97	576.2	1665.45	1430.6
1651.45	539.1	1658.17	643.2	1665.55	1546.7
1651.79	500.0	1658.17	644.7	1665.55	1518.0
1651.89	515.5	1658.37	663.7	1665.65	1543.2
1651.99	554.5	1658.37	696.6	1665.75	1559.8
1652.09	542.8	1658.47	637.5	1665.75	1538.8
1652.19	511.4	1658.57	678.7	1665.85	1522.0
1652.19	554.3	1658.57	614.0	1665.95	1554.7
1652.29	507.8	1658.67	661.2	1666.05	1629.1
1652.29	538.8	1658.97	690.0	1666.15	1613.3
1652.39	499.4	1659.17	711.5	1666.25	1634.6
1652.59	539.1	1659.27	664.2	1666.35	1735.2
1652.69	546.7	1659.57	677.9	1666.45	1685.5
1652.99	451.0	1659.67	736.5	1666.55	1729.9
1653.09	523.3	1659.87	764.1	1667.05	1901.8
1653.09	519.4	1660.96	817.0	1667.15	1856.3
1653.19	543.0	1661.06	861.8	1667.65	1956.5
1653.39	546.6	1661.16	848.0	1667.75	2550.9
1653.39	581.4	1661.26	773.8	1667.85	2733.1
1653.49	558.1	1661.36	890.9	1668.05	2955.1
1653.59	531.1	1661.56	850.3	1668.15	2853.9

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TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(e) $s/R = 0.55$; $\phi = 33.75^{\circ}$; $x = 0.0111$ in.

Time, sec	Temp., °R
1647.01	551.1
1647.11	515.5
1647.21	503.7
1647.31	485.7
1647.41	507.9
1647.51	519.3
1647.71	527.2
1647.81	523.3
1649.10	503.5
1649.20	493.0
1649.30	538.2
1649.80	523.3
1649.80	515.4
1649.90	511.6
1649.90	527.2
1650.00	550.1
1650.00	565.6
1650.10	507.8
1650.20	523.3
1650.30	515.6
1650.40	519.4
1650.50	523.3
1650.60	542.6
1650.70	519.3
1650.80	503.5
1651.20	572.3
1651.30	456.8
1651.40	534.9
1651.79	519.4
1651.89	580.3
1651.99	588.4
1652.09	550.6
1652.19	547.1
1652.19	573.2
1652.29	511.7
1652.29	515.5
1652.39	601.3
1652.59	539.1
1652.69	558.4
1652.99	495.6
1653.09	519.4
1653.19	562.3

Time, sec	Temp., °R
1653.39	554.4
1653.39	615.5
1653.49	523.3
1653.69	519.3
1653.79	588.7
1654.09	538.8
1654.19	566.2
1654.29	550.7
1655.38	604.5
1655.78	580.7
1655.88	620.0
1655.98	603.3
1656.18	577.8
1656.28	630.6
1656.68	578.2
1656.78	646.0
1657.07	554.0
1657.27	554.6
1657.47	565.8
1657.57	624.5
1657.77	651.1
1657.77	609.7
1657.87	738.1
1657.97	667.2
1657.97	605.7
1658.07	646.0
1658.17	628.4
1658.17	659.7
1658.37	648.7
1658.37	746.1
1658.67	661.2
1658.87	714.0
1658.97	697.5
1659.17	684.8
1659.27	728.8
1659.37	706.7
1659.47	721.0
1659.57	815.4
1659.67	713.3
1660.07	791.8
1660.86	757.2
1660.96	820.8

Time, sec	Temp., °R
1661.06	881.3
1661.16	890.1
1661.26	929.4
1661.36	944.8
1661.56	858.1
1662.56	998.2
1662.86	1097.9
1662.86	1130.6
1662.96	1134.4
1663.06	1087.9
1663.26	1166.0
1663.36	1223.7
1663.46	1212.9
1663.66	1111.0
1664.36	1357.7
1664.46	1418.7
1664.56	1386.6
1664.66	1365.6
1664.86	1496.0
1665.06	1541.0
1665.16	1602.1
1665.26	1603.8
1665.26	1596.8
1665.36	1669.7
1665.36	1646.2
1665.45	1728.9
1665.45	1689.7
1665.55	1760.0
1665.55	1793.5
1665.65	1738.4
1665.65	1713.8
1665.75	1750.5
1665.85	1656.1
1666.05	1750.7
1666.15	1751.1
1666.25	1782.6
1666.35	1817.9
1666.45	1782.5
1667.05	2504.8
1667.15	2311.5
1667.65	2222.8
1668.25	2767.6

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(f) $s/R = 0.55$; $\phi = 33.75^{\circ}$; $x = 0.0726$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	551.1	1656.87	577.4	1663.06	994.3
1647.11	531.0	1657.07	624.3	1663.06	1114.9
1647.21	527.2	1657.17	656.9	1663.16	1141.8
1647.31	512.0	1657.27	558.5	1663.26	1084.8
1647.41	481.0	1657.37	666.5	1663.26	1094.2
1647.51	523.3	1657.47	588.2	1663.46	1191.1
1647.71	546.6	1657.57	628.2	1663.56	1146.9
1647.81	594.7	1657.67	598.1	1663.56	1152.0
1648.51	515.5	1657.77	624.5	1664.36	1288.4
1650.10	569.3	1657.87	604.4	1664.46	1284.3
1650.20	538.8	1657.97	682.2	1664.56	1458.8
1650.30	546.4	1657.97	594.7	1664.66	1288.0
1650.40	538.7	1658.07	601.0	1665.06	1511.1
1650.50	558.7	1658.07	615.6	1665.06	1481.0
1650.60	576.8	1658.17	677.5	1665.16	1517.7
1650.70	519.3	1658.17	629.7	1665.16	1502.9
1650.90	499.8	1658.37	696.6	1665.26	1485.7
1651.79	542.7	1658.57	671.2	1665.36	1533.2
1651.89	569.1	1658.57	741.5	1665.36	1521.3
1652.19	546.5	1658.67	665.0	1665.45	1590.7
1652.29	538.8	1658.77	728.7	1665.45	1570.9
1652.29	527.2	1658.87	702.6	1665.55	1580.1
1652.59	515.4	1658.97	751.2	1665.55	1594.5
1652.69	550.6	1659.17	715.4	1665.65	1570.8
1652.99	503.6	1659.27	717.1	1665.65	1594.8
1653.09	495.7	1659.37	676.3	1665.75	1611.5
1653.19	550.7	1659.67	732.6	1665.75	1642.1
1653.19	562.6	1659.77	721.8	1665.85	1762.6
1653.29	523.3	1659.87	709.8	1665.95	1703.3
1653.39	534.9	1660.07	707.5	1665.95	1681.0
1653.39	581.4	1660.86	788.5	1666.05	1713.8
1653.49	527.1	1660.96	874.9	1666.15	1736.2
1653.59	554.8	1661.06	834.2	1666.25	1744.6
1653.69	531.1	1661.16	901.5	1666.35	1746.5
1654.19	585.1	1661.26	860.0	1666.45	1763.8
1654.29	611.4	1661.36	956.3	1666.55	1755.4
1655.08	603.3	1661.46	880.0	1666.95	2013.2
1655.68	615.0	1661.56	846.4	1667.05	2001.6
1655.88	555.0	1662.36	938.1	1667.15	2015.9
1655.98	562.1	1662.66	955.5	1667.55	2691.0
1656.08	592.3	1662.76	1056.2	1667.65	2979.4
1656.18	581.6	1662.86	988.9	1667.75	2887.3
1656.68	562.9	1662.96	1022.0	1667.85	2809.4
1656.78	618.8	1662.96	1067.1	1667.95	3011.7

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(g) $s/R = 0.55$; $\phi = 33.75^{\circ}$; $x = 0.1318$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	574.4	1656.68	551.1	1663.06	954.9
1647.11	554.3	1656.78	542.9	1663.06	1011.2
1647.21	562.4	1656.87	577.4	1663.16	1059.9
1647.31	512.0	1657.07	620.7	1663.26	1084.8
1647.41	484.8	1657.17	611.6	1663.26	1057.1
1647.51	515.4	1657.27	599.9	1663.46	1136.4
1647.71	546.6	1657.37	670.2	1663.56	1099.2
1647.81	530.9	1657.57	606.0	1663.56	1152.0
1648.51	531.1	1657.67	563.3	1663.66	1144.5
1650.10	531.0	1657.77	635.6	1664.36	1193.0
1650.20	519.4	1657.87	562.6	1664.46	1245.4
1650.30	565.4	1657.87	650.6	1664.56	1285.4
1650.40	534.9	1657.97	625.9	1664.66	1265.8
1650.50	550.8	1657.97	572.5	1665.06	1342.5
1650.60	546.5	1658.07	642.2	1665.16	1392.8
1650.70	547.0	1658.17	608.7	1665.26	1376.6
1650.90	499.8	1658.17	659.7	1665.26	1411.6
1651.45	531.2	1658.37	648.7	1665.36	1572.6
1651.79	515.5	1658.37	674.2	1665.36	1400.1
1651.89	587.7	1658.57	686.3	1665.45	1432.0
1652.19	527.3	1658.57	666.2	1665.45	1415.9
1652.19	546.5	1658.67	638.4	1665.55	1517.1
1652.29	573.3	1658.77	640.9	1665.55	1426.9
1652.59	511.5	1658.87	653.4	1665.65	1487.8
1652.69	523.3	1658.97	693.8	1665.65	1462.2
1652.99	515.4	1659.17	654.3	1665.75	1526.6
1653.09	535.1	1659.27	709.5	1665.75	1414.1
1653.19	538.9	1659.37	695.3	1665.85	1543.7
1653.19	531.2	1659.67	790.9	1665.95	1664.7
1653.29	573.6	1659.77	721.8	1665.95	1479.2
1653.39	577.1	1659.87	698.5	1666.05	1599.9
1653.49	565.5	1660.07	707.5	1666.15	1613.3
1653.59	581.4	1660.86	691.5	1666.25	1593.4
1653.69	562.5	1660.96	774.4	1666.35	1622.7
1654.19	570.0	1661.06	775.2	1666.45	1622.3
1654.29	558.6	1661.26	809.0	1666.55	1660.8
1654.39	566.5	1661.36	879.4	1666.95	1787.6
1655.28	574.0	1661.46	818.1	1667.05	1807.2
1655.68	581.1	1661.56	815.3	1667.15	1886.7
1655.78	591.9	1662.36	972.1	1667.25	2444.9
1655.88	555.0	1662.66	913.6	1667.55	2771.9
1655.98	507.7	1662.76	1026.0	1667.85	2720.8
1656.08	577.2	1662.86	988.9	1667.85	2690.8
1656.18	566.4	1662.96	1008.1	1667.95	2836.4

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(h) $s/R = 0.89$; $\phi = 146.25^{\circ}$; $x = 0.0110$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	551.1	1654.29	585.0	1662.86	1066.1
1647.11	542.6	1655.28	566.4	1662.96	1112.1
1647.21	519.3	1655.38	562.7	1663.06	958.8
1647.31	534.5	1655.48	618.4	1663.16	1108.3
1647.41	511.7	1655.98	546.6	1663.16	1140.6
1647.51	531.1	1656.18	593.0	1663.26	1114.3
1647.71	546.6	1656.28	535.1	1663.36	1182.5
1647.81	561.5	1656.48	607.2	1663.46	1125.4
1649.10	475.8	1656.58	558.6	1663.56	1201.8
1649.20	527.1	1656.78	554.8	1663.56	1093.6
1649.30	527.0	1657.17	622.9	1663.66	1185.4
1649.80	492.7	1657.27	535.0	1664.36	1317.5
1649.90	534.9	1657.37	666.5	1664.46	1273.7
1649.90	511.7	1657.77	617.6	1664.56	1350.5
1650.00	565.2	1657.77	613.4	1664.66	1269.5
1650.00	534.9	1657.87	531.2	1665.06	1391.1
1650.10	496.2	1657.97	622.2	1665.16	1514.0
1650.20	542.7	1657.97	605.7	1665.26	1507.9
1650.30	538.7	1658.07	658.4	1665.36	1493.8
1650.40	511.7	1658.07	619.4	1665.36	1447.9
1650.50	543.0	1658.17	696.5	1665.45	1496.9
1650.60	565.6	1658.17	674.7	1665.45	1563.5
1650.70	515.4	1658.37	659.2	1665.55	1643.3
1650.80	570.4	1658.57	503.9	1665.55	1587.3
1651.30	434.8	1658.67	638.4	1665.65	1588.9
1651.40	523.3	1658.87	778.9	1665.65	1594.8
1651.45	531.2	1658.97	667.5	1665.75	1606.4
1651.79	519.4	1659.17	711.5	1665.85	1762.6
1651.89	538.7	1659.27	724.9	1665.95	1612.3
1652.29	554.3	1659.37	695.3	1666.05	1610.8
1652.29	546.6	1659.47	686.8	1666.15	1631.7
1652.69	546.7	1659.57	711.6	1666.25	1623.3
1652.99	495.6	1659.67	759.8	1666.35	1720.2
1653.09	527.2	1659.77	764.6	1666.45	1659.4
1653.19	562.3	1660.96	855.7	1666.95	2162.7
1653.39	546.6	1661.16	878.7	1667.05	2271.9
1653.49	527.1	1661.26	890.9	1667.15	2154.1
1653.59	577.6	1661.36	871.6	1667.85	2997.6
1653.79	519.3	1661.56	977.0	1667.95	2797.9
1654.09	558.2	1662.76	988.1	1668.05	2764.9
1654.19	546.8	1662.86	1049.7	1668.15	2738.2

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(i) $s/R = 0.89$; $\phi = 146.25^{\circ}$; $x = 0.0712$ in.

Time, sec	Temp., °R
1647.01	566.7
1647.11	515.5
1647.21	519.3
1647.31	530.8
1647.41	519.4
1647.51	535.1
1647.71	554.4
1647.81	542.4
1649.10	499.5
1649.20	504.4
1649.30	545.6
1649.80	542.4
1649.80	515.4
1649.90	519.4
1649.90	503.9
1650.00	515.6
1650.10	542.6
1650.20	531.1
1650.30	538.7
1650.40	538.7
1650.50	511.5
1650.60	531.0
1650.70	519.3
1650.80	491.6
1650.90	566.1
1651.20	527.1
1651.30	407.7
1651.40	546.5
1651.45	495.6
1651.79	531.0
1651.89	542.5
1651.99	542.8
1652.19	542.7
1652.29	569.4
1652.29	538.8
1652.59	550.9
1652.69	562.1
1652.99	547.0
1653.09	519.4
1653.39	577.1
1653.39	596.5
1653.49	523.3

Time, sec	Temp., °R
1653.59	507.5
1653.69	495.7
1653.79	531.1
1654.09	584.4
1654.19	573.8
1654.29	550.7
1654.39	623.6
1655.38	535.1
1655.78	610.6
1655.88	543.1
1655.98	558.3
1656.18	581.6
1656.28	577.6
1656.48	569.6
1656.58	600.1
1657.27	584.9
1657.37	606.7
1657.57	542.5
1657.77	617.6
1657.77	646.7
1657.87	566.4
1657.97	637.2
1657.97	602.0
1658.07	654.5
1658.07	638.4
1658.17	704.2
1658.17	632.1
1658.17	701.0
1658.37	633.6
1658.37	666.7
1658.57	633.6
1658.57	515.5
1658.67	668.8
1658.87	710.2
1658.97	690.0
1659.17	646.6
1659.27	701.9
1659.37	714.3
1659.47	698.2
1659.57	711.6
1659.67	686.8
1659.77	807.5

Time, sec	Temp., °R
1659.87	779.7
1660.86	788.5
1661.06	818.5
1661.16	886.3
1661.26	902.5
1661.36	875.5
1661.46	763.7
1662.86	1019.3
1662.96	1123.2
1663.06	990.3
1663.16	1111.2
1663.26	1070.0
1663.36	1141.3
1663.46	1132.7
1663.56	1069.9
1663.56	1126.5
1663.66	1085.0
1664.26	1226.3
1664.36	1230.0
1664.46	1231.1
1664.56	1289.1
1664.76	1443.1
1665.06	1402.4
1665.16	1458.9
1665.26	1424.3
1665.26	1444.9
1665.36	1522.5
1665.36	1480.9
1665.45	1450.0
1665.45	1430.6
1665.55	1517.1
1665.55	1496.1
1665.65	1527.5
1665.65	1558.0
1665.75	1524.5
1666.05	1585.4
1666.15	1598.5
1666.25	1623.3
1666.35	1660.1
1666.45	1648.2
1667.05	2101.7
1667.15	2042.5

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(j) $s/R = 0.89$; $\phi = 146.25^{\circ}$; $x = 0.1324$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	555.1	1655.38	539.1	1661.56	858.1
1647.11	558.1	1655.78	633.1	1662.56	1051.5
1647.31	568.0	1655.88	570.4	1662.86	996.5
1647.41	523.3	1656.18	596.8	1662.86	1014.9
1647.71	558.3	1656.28	550.8	1662.96	1059.9
1647.81	557.7	1656.48	603.4	1663.06	954.9
1649.20	504.4	1656.58	596.3	1663.16	1140.6
1649.30	512.1	1656.78	589.1	1663.26	1125.4
1649.80	492.7	1657.07	568.9	1663.36	1088.9
1649.80	531.2	1657.27	611.3	1663.46	1125.4
1649.90	527.2	1657.37	625.4	1663.56	1124.9
1649.90	503.9	1657.57	587.5	1663.56	1155.7
1650.00	515.6	1657.67	598.1	1663.66	1062.7
1650.00	546.5	1657.77	617.6	1664.26	1219.0
1650.10	523.3	1657.77	617.1	1664.36	1230.0
1650.20	531.1	1657.87	615.8	1664.46	1202.4
1650.30	531.0	1657.97	624.1	1664.56	1231.2
1650.40	511.7	1658.07	657.4	1664.66	1273.2
1650.50	539.0	1658.17	631.6	1664.76	1315.3
1650.60	565.6	1658.17	595.1	1665.06	1342.5
1650.70	515.4	1658.17	607.2	1665.26	1380.3
1651.20	553.8	1658.37	629.9	1665.26	1396.8
1651.30	417.0	1658.37	707.9	1665.36	1440.1
1651.45	547.0	1658.57	648.7	1665.36	1411.2
1651.79	503.9	1658.57	696.0	1665.45	1349.1
1651.89	534.9	1658.67	638.4	1665.45	1397.4
1651.99	565.9	1658.87	714.0	1665.55	1424.3
1652.19	546.5	1658.97	675.0	1665.55	1532.6
1652.29	534.9	1659.17	681.0	1665.65	1523.9
1652.29	515.5	1659.27	683.1	1665.65	1436.4
1652.69	558.4	1659.37	649.8	1665.75	1426.9
1652.99	471.9	1659.47	675.5	1665.75	1410.5
1653.09	500.0	1659.57	689.1	1666.05	1570.8
1653.39	550.5	1659.67	690.6	1666.15	1580.1
1653.39	577.6	1659.77	756.8	1666.25	1582.1
1653.49	523.3	1659.87	698.5	1666.35	1582.0
1653.69	495.7	1660.07	834.1	1666.45	1615.0
1653.79	535.0	1660.86	788.5	1667.05	1890.2
1654.09	584.4	1661.06	755.4	1667.15	1928.5
1654.19	539.0	1661.16	824.7	1667.75	2610.0
1654.29	550.7	1661.26	840.4	1667.95	2810.8
1654.39	566.5	1661.36	925.5	1668.25	2840.0

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(k) $s/R = 0.89$; $\phi = 146.25^{\circ}$; $x = 0.2000$ in.

Time, sec	Temp., °R
1647.01	555.1
1647.11	538.7
1647.21	562.4
1647.31	545.8
1647.41	523.3
1647.51	519.3
1647.71	531.1
1647.81	553.9
1649.10	531.2
1649.20	523.3
1649.30	512.1
1649.80	499.5
1649.90	503.8
1649.90	511.7
1650.00	554.0
1650.10	531.0
1650.20	534.9
1650.30	531.0
1650.40	538.7
1650.50	511.5
1650.60	542.6
1650.70	495.6
1650.80	519.3
1651.40	531.0
1651.79	527.2
1651.89	534.9
1651.99	531.1
1652.09	577.2
1652.19	515.5
1652.29	538.8
1652.29	499.9
1652.59	535.1
1652.69	550.6
1652.99	483.8
1653.09	511.6
1653.59	539.0
1653.69	495.7
1653.79	531.1
1654.19	519.3
1654.29	523.3
1654.39	527.2

Time, sec	Temp., °R
1655.28	574.0
1655.38	515.4
1655.48	595.9
1655.78	580.7
1655.98	573.3
1656.58	562.4
1656.68	515.3
1656.78	562.5
1657.07	538.6
1657.17	638.0
1657.27	531.1
1657.37	617.9
1657.47	606.9
1657.57	565.3
1657.77	617.6
1657.77	650.4
1657.87	642.4
1657.97	622.2
1657.97	620.5
1658.07	677.5
1658.17	677.5
1658.17	617.3
1658.17	633.5
1658.37	719.2
1658.57	686.3
1658.57	658.8
1658.87	714.0
1658.97	667.5
1659.17	669.6
1659.27	660.5
1659.37	683.9
1659.47	649.1
1659.57	670.5
1659.67	705.7
1659.77	642.0
1660.07	784.2
1660.86	823.6
1660.96	867.3
1661.06	779.1
1661.26	840.4
1661.36	828.6

Time, sec	Temp., °R
1661.56	819.1
1662.86	947.1
1662.86	978.2
1662.96	922.7
1663.16	1074.8
1663.26	1166.0
1663.36	1017.0
1663.46	1099.9
1663.56	1084.6
1663.56	1079.0
1663.66	1047.8
1664.26	1182.4
1664.36	1207.8
1664.46	1173.7
1664.56	1242.1
1664.66	1210.0
1664.76	1322.6
1665.06	1334.9
1665.16	1359.8
1665.26	1376.6
1665.26	1359.7
1665.36	1386.4
1665.36	1363.4
1665.45	1309.4
1665.45	1408.5
1665.55	1461.4
1665.55	1386.8
1665.65	1581.7
1665.65	1392.2
1665.75	1414.1
1665.85	1525.6
1666.05	1538.1
1666.15	1528.5
1666.25	1559.7
1666.35	1567.2
1666.45	1567.2
1667.05	1769.8
1667.15	1771.3
1668.05	2639.6
1668.15	2793.9
1668.25	2784.7

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(ℓ) s/R = 1.00; ϕ = 242.00°; x = 0.0111 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	547.2	1653.79	531.1	1661.46	523.3
1647.11	519.4	1654.19	566.2	1662.76	588.4
1647.21	539.0	1654.29	531.1	1662.86	569.7
1647.31	508.3	1655.28	558.8	1662.86	561.1
1647.41	534.8	1655.38	535.1	1662.96	562.4
1647.51	511.5	1655.48	569.6	1662.96	609.1
1647.71	542.7	1655.78	588.2	1663.06	547.6
1647.81	557.7	1655.88	539.1	1663.16	611.6
1649.20	508.1	1655.98	538.8	1663.26	569.6
1649.80	511.8	1656.08	515.5	1663.36	574.0
1649.80	511.4	1656.18	503.6	1663.46	613.4
1649.90	546.6	1656.28	491.8	1663.56	599.0
1650.10	542.6	1656.68	527.3	1663.66	622.7
1650.20	538.8	1656.78	581.5	1664.36	584.6
1650.30	550.2	1657.07	587.4	1664.46	615.6
1650.40	527.2	1657.17	611.6	1664.56	591.6
1650.50	546.9	1657.27	550.7	1664.66	503.5
1650.60	542.6	1657.57	527.1	1665.06	565.6
1650.70	535.1	1657.67	535.4	1665.06	582.5
1650.80	467.7	1657.77	542.6	1665.16	626.7
1650.90	511.5	1657.77	534.8	1665.16	615.3
1651.20	575.9	1657.87	491.7	1665.26	615.2
1651.30	430.4	1657.97	527.2	1665.26	639.0
1651.40	558.1	1657.97	500.3	1665.36	664.7
1651.45	511.4	1658.07	539.2	1665.36	607.8
1651.79	503.9	1658.07	535.1	1665.45	643.4
1651.89	542.5	1658.17	538.7	1665.45	581.6
1651.99	546.7	1658.17	542.8	1665.55	643.1
1652.09	546.7	1658.37	542.8	1665.55	629.7
1652.19	511.4	1658.37	558.2	1665.65	615.6
1652.19	569.4	1658.47	466.5	1665.75	646.2
1652.29	523.3	1658.57	573.5	1665.75	645.6
1652.29	531.1	1658.67	546.9	1665.85	696.0
1652.39	499.4	1658.87	511.5	1665.95	683.7
1652.59	527.2	1658.97	592.3	1666.05	625.8
1652.69	554.5	1659.17	562.7	1666.15	627.1
1652.99	471.9	1659.27	531.1	1666.25	624.9
1653.09	476.0	1659.37	535.1	1666.35	639.0
1653.09	500.0	1659.47	507.6	1666.45	645.8
1653.19	539.1	1659.67	585.0	1667.15	2974.1
1653.29	542.9	1660.86	543.0	1667.65	2903.0
1653.39	542.7	1660.96	675.0	1667.75	2938.5
1653.39	558.7	1661.16	566.0	1667.85	2894.1
1653.59	527.2	1661.26	558.9	1667.95	2827.9
1653.69	527.2	1661.36	570.3	1668.05	2773.6

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(m) $s/R = 1.00$; $\phi = 242.00^{\circ}$; $x = 0.0719$ in.

Time, sec	Temp., °R
1647.01	543.2
1647.11	519.4
1647.21	566.1
1647.31	508.3
1647.41	496.4
1647.51	507.5
1647.71	523.3
1647.81	550.1
1649.10	487.7
1649.20	538.4
1649.80	519.3
1649.90	515.5
1650.10	546.5
1650.20	527.2
1650.30	554.1
1650.40	542.6
1650.50	554.8
1650.60	558.1
1650.70	515.4
1650.80	483.7
1650.90	495.9
1651.20	557.6
1651.30	456.8
1651.40	554.2
1651.45	511.4
1651.79	488.4
1651.89	531.0
1651.99	562.1
1652.09	531.1
1652.19	511.4
1652.19	523.3
1652.29	538.8
1652.29	538.8
1652.39	475.5
1652.59	535.1
1652.69	531.1
1652.99	491.7
1653.09	480.0
1653.09	507.7
1653.19	519.3
1653.29	546.8
1653.39	542.7
1653.39	562.5
1653.49	534.9
1653.59	523.3

Time, sec	Temp., °R
1653.69	527.2
1654.09	554.4
1654.19	531.1
1654.29	607.6
1655.38	507.5
1655.68	542.9
1655.78	534.9
1655.88	539.1
1655.98	515.5
1656.08	542.8
1656.18	531.2
1656.28	523.3
1656.48	546.7
1656.58	519.3
1656.68	491.5
1656.78	558.7
1657.47	531.1
1657.57	534.8
1657.67	519.3
1657.77	534.8
1657.87	495.6
1657.97	546.7
1657.97	507.9
1658.07	555.0
1658.07	531.1
1658.17	527.3
1658.17	538.7
1658.17	562.1
1658.37	550.6
1658.37	562.0
1658.67	511.5
1658.87	519.3
1658.97	584.8
1659.17	539.1
1659.27	542.9
1659.37	483.9
1659.47	503.7
1659.67	546.8
1659.77	539.0
1659.87	577.5
1660.86	491.8
1661.06	562.9
1661.16	573.5
1661.26	562.7
1661.36	547.0

Time, sec	Temp., °R
1661.46	539.0
1662.86	562.2
1662.96	527.2
1663.06	527.4
1663.16	592.7
1663.26	584.6
1663.36	577.8
1663.46	620.8
1663.56	602.7
1663.66	622.7
1664.36	618.4
1664.46	586.5
1664.56	621.3
1664.66	455.1
1664.76	577.2
1665.06	599.1
1665.06	586.3
1665.16	581.3
1665.16	615.3
1665.26	592.5
1665.26	608.5
1665.36	642.6
1665.36	588.9
1665.45	613.7
1665.45	612.0
1665.55	677.5
1665.55	614.7
1665.65	632.5
1665.65	623.2
1665.75	616.3
1665.85	625.2
1665.95	694.8
1666.05	625.8
1666.25	636.4
1666.35	669.6
1666.45	664.7
1666.55	705.6
1666.65	691.2
1667.05	661.2
1667.15	1163.4
1667.75	2853.2
1667.85	2391.7
1667.95	2866.3
1668.05	2877.3
1668.15	2802.5

[redacted]

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Continued

(n) $s/R = 1.00$; $\phi = 242.00^{\circ}$; $x = 0.1313$ in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	578.2	1654.19	588.9	1662.76	569.6
1647.11	542.6	1654.39	515.4	1662.86	542.8
1647.21	507.6	1655.68	566.1	1662.86	549.8
1647.31	534.5	1655.78	562.0	1662.96	558.6
1647.41	538.7	1655.88	515.4	1662.96	598.1
1647.51	554.8	1655.98	511.6	1663.06	559.7
1647.71	542.7	1656.08	542.8	1663.16	592.7
1647.81	565.2	1656.18	507.5	1663.26	614.5
1648.51	511.5	1656.28	507.5	1663.26	562.2
1649.10	543.0	1656.48	515.5	1663.36	593.0
1649.20	530.8	1656.68	491.5	1663.56	628.8
1649.80	523.3	1656.78	535.1	1663.56	591.3
1649.90	542.7	1657.27	492.0	1663.66	615.2
1650.10	538.7	1657.57	542.5	1664.36	603.4
1650.20	531.1	1657.67	495.1	1664.46	582.9
1650.30	554.1	1657.77	565.5	1664.56	602.7
1650.40	538.7	1657.77	542.5	1664.66	523.3
1650.50	550.8	1657.87	495.6	1664.86	579.6
1650.60	558.1	1657.97	546.7	1665.06	550.4
1650.70	515.4	1657.97	481.1	1665.06	582.5
1650.80	483.7	1658.07	535.2	1665.16	615.3
1651.20	534.7	1658.07	531.1	1665.26	592.5
1651.30	417.0	1658.17	515.3	1665.26	608.5
1651.40	546.5	1658.17	565.4	1665.36	626.7
1651.79	503.9	1658.17	550.6	1665.45	623.4
1651.89	538.7	1658.37	542.8	1665.55	654.5
1652.09	573.4	1658.37	550.5	1665.55	640.9
1652.19	511.4	1658.47	482.8	1665.65	591.6
1652.19	542.7	1658.57	554.3	1665.65	642.2
1652.29	500.0	1658.67	539.1	1665.75	593.0
1652.29	523.3	1658.87	519.3	1665.75	634.6
1652.39	499.4	1658.97	569.7	1665.85	643.9
1652.59	507.5	1659.17	600.9	1665.95	695.9
1652.69	550.6	1659.27	539.0	1665.95	587.5
1652.99	499.6	1659.37	523.3	1666.05	640.7
1653.09	499.6	1659.47	531.1	1666.15	611.9
1653.09	519.4	1659.57	550.5	1666.25	624.9
1653.19	523.3	1659.67	546.8	1666.35	669.6
1653.19	550.9	1659.77	543.0	1666.45	672.3
1653.29	535.0	1659.87	535.0	1666.55	653.9
1653.39	527.2	1660.07	561.9	1666.65	710.2
1653.39	581.4	1660.86	523.3	1667.05	665.0
1653.49	507.8	1661.16	569.7	1667.15	2893.7
1653.59	550.8	1661.26	596.9	1667.65	3191.6
1653.69	527.2	1661.36	547.0	1667.85	2733.1
1653.79	523.3	1661.46	499.8	1668.05	2825.4
1654.09	546.6	1661.56	566.3	1668.25	2708.0

TABLE II. - TEMPERATURES RECORDED IN THE FIRST BERYLLIUM CALORIMETER SHIELD - Concluded

(o) s/R = 1.00; ϕ = 242.00°; x = 0.2000 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1647.01	539.2	1653.69	511.5	1662.86	562.2
1647.11	538.7	1653.79	499.8	1662.86	568.3
1647.21	511.5	1654.09	531.1	1662.96	531.1
1647.31	500.8	1654.39	511.4	1663.06	503.0
1647.41	492.5	1655.38	551.0	1663.16	577.5
1647.51	531.1	1655.48	507.7	1663.26	565.8
1647.71	531.1	1655.68	566.1	1663.26	562.2
1647.81	561.5	1655.78	527.2	1663.36	585.4
1648.51	488.0	1655.88	499.5	1663.46	591.2
1649.10	507.5	1655.98	499.9	1663.56	606.5
1649.20	511.9	1656.08	531.1	1663.56	583.9
1649.80	499.5	1656.18	519.3	1663.66	566.1
1649.90	503.8	1656.48	538.9	1664.26	628.6
1650.10	531.0	1656.58	527.2	1664.36	588.4
1650.20	515.5	1656.68	499.4	1664.46	582.9
1650.30	515.6	1656.78	503.6	1664.56	587.8
1650.40	561.9	1657.07	550.1	1664.66	491.6
1650.50	523.3	1657.27	535.0	1664.76	618.6
1650.60	558.1	1657.57	504.1	1664.86	627.3
1650.70	515.4	1657.67	495.1	1665.06	588.0
1650.80	515.4	1657.77	561.8	1665.06	597.9
1650.90	566.1	1657.77	538.7	1665.16	562.4
1651.30	417.0	1657.87	531.2	1665.16	615.3
1651.40	558.1	1657.97	527.2	1665.26	566.1
1651.45	511.4	1657.97	488.8	1665.26	585.7
1651.79	503.9	1658.07	523.3	1665.36	587.3
1651.89	550.3	1658.17	507.4	1665.36	607.8
1651.99	562.1	1658.17	519.4	1665.45	617.4
1652.19	499.5	1658.17	550.6	1665.45	585.4
1652.19	527.2	1658.37	531.1	1665.55	631.6
1652.29	511.7	1658.37	569.5	1665.55	637.2
1652.29	523.3	1658.47	431.8	1665.65	621.3
1652.39	479.5	1658.57	546.5	1665.65	615.6
1652.59	511.5	1658.67	527.2	1665.75	574.0
1652.69	523.3	1658.87	519.3	1665.75	623.7
1652.99	577.8	1658.97	531.1	1665.85	666.2
1653.09	476.0	1659.17	531.2	1665.95	609.7
1653.09	511.6	1659.27	519.3	1666.05	663.2
1653.19	531.1	1659.47	511.5	1666.15	608.1
1653.19	511.4	1659.57	550.5	1666.25	624.9
1653.29	511.5	1659.67	531.1	1666.35	623.8
1653.39	527.2	1661.16	588.5	1666.45	634.4
1653.39	562.5	1661.26	585.5	1666.55	646.5
1653.49	500.1	1661.36	566.5	1667.05	699.1
1653.59	531.1	1661.56	527.2	1667.35	2890.3

[redacted] ASSIFIED

TABLE III. - TEMPERATURES RECORDED IN THE SECOND BERYLLIUM CALORIMETER SHIELD

(a) s/R = 0.10; ϕ = 258.75°; x = 0.0126 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	542.7	1672.74	2374.9	1673.84	2761.5
1670.15	576.9	1672.84	2339.9	1675.24	2368.4
1670.25	554.6	1672.84	2357.3	1675.34	2758.4
1670.35	523.3	1672.94	2547.1	1675.43	2832.8
1670.45	587.8	1673.04	2571.0	1675.53	2794.1
1670.55	681.6	1673.14	2584.5	1675.63	2783.3
1670.65	725.1	1673.24	2619.2	1675.73	2601.0
1670.75	818.2	1673.34	2452.7	1675.93	2682.0
1670.85	990.7	1673.44	2873.0	1676.03	2787.1
1670.95	953.2	1673.54	2726.6	1676.13	2648.6
1671.94	1683.0	1673.64	2695.5	1676.23	2640.3
1672.04	1653.2	1673.74	2640.2	1676.33	2726.8

(b) s/R = 0.10; ϕ = 258.75°; x = 0.0709 in.

1670.05	476.7	1672.84	2050.7	1673.84	2495.8
1670.15	569.4	1672.84	1985.1	1675.24	2859.5
1670.25	554.6	1672.94	2222.8	1675.34	2800.7
1670.35	523.3	1672.94	2124.1	1675.43	2798.5
1670.45	542.6	1673.04	2170.4	1675.53	2887.1
1670.55	559.0	1673.04	2173.8	1675.63	2762.2
1670.65	676.6	1673.14	2233.3	1675.73	2846.0
1670.75	610.3	1673.24	2224.9	1675.83	2761.9
1670.95	840.1	1673.34	2314.9	1675.93	2615.2
1671.94	1459.3	1673.44	2411.4	1676.03	2766.1
1672.04	1567.3	1673.54	2384.6	1676.13	2669.4
1672.74	1947.1	1673.64	2487.5	1676.23	2639.5

(c) s/R = 0.10; ϕ = 258.75°; x = 0.1311 in.

1670.05	519.4	1672.84	1893.3	1675.24	2648.5
1670.15	527.2	1672.94	1998.5	1675.34	2661.1
1670.25	554.6	1673.04	2005.6	1675.43	2525.2
1670.35	531.1	1673.04	1994.4	1675.53	2696.7
1670.45	542.6	1673.14	2030.6	1675.63	2576.8
1670.55	562.9	1673.24	2014.8	1675.73	2665.5
1670.65	576.5	1673.34	2188.2	1675.83	2732.5
1670.75	595.4	1673.44	2251.6	1676.03	2532.0
1670.85	695.4	1673.54	2256.9	1676.13	2764.7
1670.95	771.3	1673.64	2335.0	1676.23	2809.0
1671.94	1355.2	1673.74	2296.7	1676.23	2677.6
1672.04	1342.1	1673.84	2487.6	1676.33	2796.7
1672.74	1794.8	1675.14	3007.3	1676.33	2661.1

(d) s/R = 0.10; ϕ = 258.75°; x = 0.2000 in.

1670.05	503.9	1672.74	1699.7	1675.14	2906.0
1670.15	565.7	1672.84	1823.2	1675.24	2779.3
1670.25	558.6	1672.84	1875.5	1675.34	2851.4
1670.35	562.5	1672.94	1867.4	1675.43	2867.1
1670.45	542.6	1673.04	1846.6	1675.53	2887.1
1670.55	562.9	1673.04	1866.9	1675.63	2749.6
1670.65	572.8	1673.24	1935.9	1675.73	2717.1
1670.75	580.5	1673.34	2110.4	1675.83	2732.5
1670.85	680.6	1673.44	2171.3	1675.93	2757.1
1670.95	798.0	1673.54	2131.9	1676.03	2782.9
1671.94	1236.3	1673.64	2214.3	1676.13	2681.8
1672.04	1242.0	1673.74	2122.5	1676.23	2756.8
1672.54	1599.9	1673.84	2244.5	1676.23	2656.9

[redacted]

TABLE III. - TEMPERATURES RECORDED IN THE SECOND BERYLLIUM CALORIMETER SHIELD - Continued

(e) s/R = 0.54; ϕ = 258.75°; x = 0.0132 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	496.1	1672.74	2124.5	1675.24	2749.8
1670.15	519.4	1672.84	2091.9	1675.34	2783.8
1670.25	550.7	1672.84	2187.5	1675.43	3025.8
1670.35	515.4	1673.04	2245.7	1675.53	2918.0
1670.45	546.5	1673.14	2386.2	1675.73	2772.9
1670.55	597.4	1673.24	2451.1	1675.83	2644.3
1670.65	687.7	1673.34	2551.6	1676.03	2640.1
1670.75	745.4	1673.44	2665.5	1676.23	2778.6
1670.85	786.6	1673.54	2587.2	1676.23	2636.2
1670.95	851.5	1673.64	2656.9	1676.33	2866.6
1671.05	908.2	1673.84	2690.4	1676.33	2673.7
1671.94	1530.0	1674.04	2682.1	1676.43	2861.9

(f) s/R = 0.54; ϕ = 258.75°; x = 0.0715 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	488.4	1672.74	1816.7	1673.84	2354.8
1670.15	550.4	1672.84	1932.2	1675.24	2728.7
1670.25	523.3	1673.04	2058.7	1675.34	2749.9
1670.35	554.8	1673.04	2017.6	1675.43	2755.6
1670.45	531.0	1673.14	2107.5	1675.53	2834.0
1670.55	559.0	1673.24	2067.5	1675.63	2766.5
1670.65	527.1	1673.34	2239.5	1675.83	2719.9
1670.95	813.3	1673.44	2320.4	1676.13	2652.7
1671.05	919.2	1673.54	2359.5	1676.23	2895.9
1671.94	1381.3	1673.64	2396.6	1676.23	2685.9
1672.04	1413.6	1673.74	2443.8	1676.33	2792.4

(g) s/R = 0.54; ϕ = 258.75°; x = 0.1312 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	550.4	1672.74	1754.5	1673.74	2222.5
1670.25	550.7	1672.84	1764.7	1673.84	2143.8
1670.35	519.3	1672.94	1783.2	1674.04	2401.6
1670.45	531.0	1672.94	1789.1	1675.24	2779.3
1670.55	547.2	1673.04	1835.5	1675.34	2800.7
1670.65	572.8	1673.04	1866.9	1675.43	2747.0
1670.75	580.5	1673.14	1904.3	1675.53	2873.8
1670.95	717.8	1673.24	1943.4	1675.83	2749.3
1671.05	766.5	1673.34	1999.6	1676.03	2787.1
1671.94	1228.7	1673.44	2068.6	1676.23	2835.0
1672.04	1281.3	1673.54	2171.9	1676.23	2648.6
1672.54	1607.1	1673.64	2226.3	1676.33	2783.6

(h) s/R = 0.54; ϕ = 258.75°; x = 0.2000 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	492.3	1672.74	1655.8	1675.34	2762.6
1670.15	538.8	1673.04	1675.1	1675.43	2738.4
1670.25	531.1	1673.14	1824.9	1675.53	2913.6
1670.35	519.3	1673.24	1772.8	1675.63	2543.9
1670.45	546.5	1673.34	1896.8	1675.73	2644.0
1670.55	562.9	1673.44	2014.2	1675.93	2602.6
1670.65	561.7	1673.54	1998.0	1676.13	2731.6
1670.75	561.9	1673.64	2115.5	1676.23	2904.5
1670.95	710.3	1673.74	1994.5	1676.23	2594.8
1671.05	695.8	1673.84	2147.6	1676.33	2783.6
1671.94	1213.6	1674.04	2106.4	1676.33	2665.3
1672.04	1231.1	1675.24	2855.3	1676.43	2779.0

TABLE III. - TEMPERATURES RECORDED IN THE SECOND BERYLLIUM CALORIMETER SHIELD - Continued

(i) s/R = 0.90; ϕ = 258.75°; x = 0.0138 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	496.1	1672.84	1757.5	1675.34	2775.3
1670.15	554.3	1672.84	2121.8	1675.43	2781.3
1670.25	585.0	1673.04	1603.6	1675.53	2851.7
1670.35	511.5	1673.04	1626.4	1675.63	2635.9
1670.45	546.5	1673.14	1784.0	1675.73	2734.3
1670.55	551.1	1673.14	2298.2	1675.83	2698.9
1670.65	609.9	1673.24	1842.3	1675.93	2623.5
1670.75	714.7	1673.34	1934.9	1676.03	2661.1
1670.85	896.9	1673.44	2037.5	1676.13	2706.7
1670.95	874.3	1673.54	2434.6	1676.23	2709.1
1671.94	1537.4	1673.64	2978.6	1676.23	2586.5
1672.04	1656.8	1675.24	2732.9	1676.33	2905.9

(j) s/R = 0.90; ϕ = 258.75°; x = 0.0736 in.

1670.05	496.1	1672.94	1945.1	1675.34	2796.4
1670.15	531.0	1673.04	1907.0	1675.43	2841.4
1670.25	535.0	1673.14	2049.8	1675.53	2940.2
1670.35	511.5	1673.14	2073.1	1675.63	2715.9
1670.45	527.1	1673.24	2086.3	1675.73	2764.3
1670.55	566.7	1673.34	2164.9	1675.83	2656.9
1670.65	561.7	1673.44	2255.7	1675.93	2536.8
1670.75	573.1	1673.54	2305.8	1676.03	2426.2
1671.94	1284.6	1673.64	2376.1	1676.13	2509.3
1672.54	1389.6	1673.74	2347.9	1676.23	2917.6
1672.84	1735.7	1673.84	2256.3	1676.23	2669.3
1672.84	1805.2	1675.24	2825.8	1676.33	2849.2

(k) s/R = 0.90; ϕ = 258.75°; x = 0.1317 in.

1670.15	580.6	1672.84	1753.7	1675.43	2918.6
1670.25	569.9	1672.94	1701.6	1675.53	2931.3
1670.35	511.5	1673.04	1713.8	1675.63	2602.1
1670.45	558.1	1673.04	1836.7	1675.73	2708.5
1670.55	562.9	1673.14	1866.1	1675.83	2787.1
1670.65	580.2	1673.24	1856.9	1675.93	2611.0
1670.75	554.3	1673.34	1885.4	1676.03	2711.5
1670.85	736.9	1673.44	1975.4	1676.13	2723.3
1670.95	801.9	1673.54	2147.9	1676.23	2878.5
1671.94	1254.9	1673.64	2158.9	1676.23	2665.2
1672.04	1223.9	1673.84	2163.0	1676.33	2770.5
1672.74	1699.7	1675.24	2855.3	1676.33	2640.1
1672.84	1710.2	1675.34	2783.8	1676.43	2818.3

(ℓ) s/R = 0.90; ϕ = 258.75°; x = 0.2000 in.

1670.05	472.9	1672.84	1643.4	1675.24	2821.5
1670.15	580.6	1672.94	1653.4	1675.34	2783.8
1670.25	523.3	1673.04	1691.6	1675.43	2832.8
1670.35	515.4	1673.04	1701.4	1675.53	2834.0
1670.45	580.4	1673.14	1728.1	1675.63	2707.5
1670.55	574.4	1673.14	1663.4	1675.73	2699.9
1670.65	527.1	1673.24	1798.5	1675.83	2770.3
1670.75	534.9	1673.34	1814.3	1675.93	2427.5
1670.95	717.8	1673.44	1940.4	1676.03	2631.7
1671.94	1134.4	1673.54	1966.7	1676.13	2681.8
1672.04	1256.3	1673.64	2045.6	1676.23	2926.3
1672.74	1576.3	1673.74	1964.5	1676.23	2648.6
1672.84	1710.2	1673.84	2071.2	1676.33	2774.9

[redacted]

TABLE III. - TEMPERATURES RECORDED IN THE SECOND BERYLLIUM CALORIMETER SHIELD - Concluded

(m) s/R = 1.00; ϕ = 242.00°; x = 0.0120 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	527.2	1670.95	591.4	1673.04	892.6
1670.15	546.5	1671.05	630.2	1673.04	945.5
1670.25	531.1	1671.94	739.7	1673.14	915.0
1670.35	507.5	1672.04	746.4	1673.14	883.1
1670.45	558.1	1672.54	845.6	1673.24	915.6
1670.55	551.1	1672.74	771.3	1673.34	931.9
1670.65	523.3	1672.84	800.9	1673.44	1097.7
1670.75	496.2	1672.84	872.4	1673.54	1032.9
1670.85	602.6	1672.94	844.6	1673.64	1006.4

(n) s/R = 1.00; ϕ = 242.00°; x = 0.0705 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	503.9	1672.84	800.9	1675.43	2832.8
1670.15	538.8	1672.84	814.9	1675.63	2943.4
1670.25	531.1	1672.94	836.9	1675.73	2897.6
1670.35	503.6	1673.04	883.8	1675.83	2837.4
1670.45	554.2	1673.14	857.5	1675.93	2769.7
1670.55	566.7	1673.24	870.6	1676.03	2757.7
1670.65	632.1	1673.34	973.7	1676.13	2793.8
1670.75	527.2	1673.44	975.0	1676.23	2856.8
1670.85	554.1	1673.54	1063.8	1676.23	2839.1
1670.95	628.6	1673.64	1006.4	1676.33	2949.6
1671.05	633.9	1675.24	3074.8	1676.33	2891.6
1672.74	851.5	1675.34	2817.6	1676.43	2914.2

(o) s/R = 1.00; ϕ = 242.00°; x = 0.1318 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1670.05	496.1	1672.84	778.0	1675.34	2720.3
1670.15	527.2	1672.84	841.8	1675.43	2845.7
1670.25	554.6	1672.94	740.0	1675.53	2807.4
1670.35	527.2	1673.04	742.8	1675.63	2762.2
1670.45	550.3	1673.14	756.4	1675.73	2730.0
1670.55	566.7	1673.14	779.9	1675.83	2782.9
1670.65	554.1	1673.24	817.1	1675.93	2665.2
1670.75	507.8	1673.34	824.7	1676.03	2707.3
1670.85	542.5	1673.44	924.6	1676.13	2706.7
1670.95	598.9	1673.54	915.8	1676.23	2813.3
1671.05	608.4	1673.64	956.3	1676.23	2623.8
1671.94	666.2	1673.74	888.1	1676.33	2726.8
1672.04	814.5	1673.84	908.1	1676.33	2736.5
1672.74	778.9	1675.24	2787.7	1676.43	2787.7

[redacted]

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD

(a) s/R = 0.10; ϕ = 146.25°; x = 0.0122 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	541.8	1678.95	1774.3	1680.14	2119.8
1676.75	557.3	1679.05	1865.2	1680.14	2221.6
1676.85	526.9	1679.15	1885.8	1680.24	2163.5
1676.95	508.4	1679.25	1956.5	1680.24	2113.0
1677.05	658.7	1679.25	1902.5	1680.24	2216.9
1677.15	731.7	1679.35	1917.1	1680.34	2178.4
1677.25	802.9	1679.35	2035.6	1680.34	2144.4
1677.35	893.0	1679.45	1959.1	1680.34	2251.2
1677.45	986.8	1679.54	2014.2	1680.44	2092.9
1677.55	1069.3	1679.54	2068.1	1680.44	2203.9
1677.65	1159.7	1679.54	2205.1	1680.44	2236.7
1677.75	1145.5	1679.64	2036.5	1680.54	2250.9
1677.85	1315.6	1679.64	1984.8	1680.54	2354.5
1677.95	1307.0	1679.74	2058.2	1680.74	2868.0
1678.05	1400.1	1679.74	2068.4	1680.84	2752.6
1678.15	1429.2	1679.74	2103.3	1681.94	3009.7
1678.35	1541.6	1679.84	2109.3	1682.04	3127.2
1678.45	1534.5	1679.84	2033.9	1682.23	2891.7
1678.45	1565.6	1679.84	2111.7	1682.33	3092.2
1678.55	1550.7	1679.94	2149.7	1682.34	2862.1
1678.55	1657.7	1679.94	2223.5	1682.43	2910.6
1678.65	1700.5	1680.04	2109.6	1682.53	2886.2
1678.65	1754.0	1680.04	2236.2	1682.63	2926.5
1678.75	1688.0	1680.14	2138.1	1682.73	2980.8

(b) s/R = 0.10; ϕ = 146.25°; x = 0.0704 in.

1676.65	545.5	1679.05	1738.5	1680.24	1973.5
1676.75	549.8	1679.15	1723.9	1680.24	2136.7
1676.85	537.9	1679.25	1742.4	1680.34	2130.7
1676.95	493.5	1679.25	1782.1	1680.34	2104.7
1677.05	582.6	1679.35	1810.9	1680.34	2200.7
1677.15	624.4	1679.35	1944.8	1680.44	2026.0
1677.25	702.6	1679.45	1789.1	1680.44	2123.9
1677.35	769.9	1679.54	1983.6	1680.44	2109.2
1677.45	834.7	1679.54	1885.5	1680.54	2592.0
1677.55	894.3	1679.54	1945.5	1680.54	2673.4
1677.65	1021.0	1679.64	1927.5	1680.74	2909.5
1677.75	987.9	1679.64	1915.7	1680.84	2744.3
1677.85	1116.0	1679.74	1904.3	1680.94	2804.9
1677.95	1136.6	1679.74	1923.7	1681.04	2694.1
1678.05	1203.1	1679.74	1934.5	1681.14	2777.5
1678.15	1273.8	1679.84	1995.8	1681.34	2993.4
1678.25	1328.8	1679.84	1996.9	1681.44	2851.1
1678.35	1360.1	1679.94	1929.6	1681.64	2826.4
1678.45	1385.3	1679.94	1943.8	1681.74	2791.9
1678.45	1401.8	1679.94	2077.3	1682.23	2844.0
1678.55	1433.2	1680.04	2070.6	1682.33	2976.4
1678.55	1508.4	1680.04	1984.4	1682.34	2840.7
1678.65	1427.5	1680.14	2082.1	1682.43	2826.1
1678.65	1506.7	1680.14	2021.3	1682.53	2941.5
1678.75	1580.1	1680.14	2051.0	1682.63	2893.3
1678.95	1672.9	1680.24	2031.7	1682.73	2955.5

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(c) s/R = 0.10; ϕ = 146.25°; x = 0.1310 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	538.1	1678.95	1555.2	1680.14	1961.7
1676.75	542.2	1679.05	1602.0	1680.24	1893.5
1676.85	530.6	1679.15	1667.9	1680.24	1813.1
1676.95	500.9	1679.25	1612.9	1680.24	2016.5
1677.05	560.8	1679.25	1725.9	1680.34	1958.6
1677.15	588.7	1679.35	1687.6	1680.34	1949.4
1677.25	678.2	1679.45	1729.7	1680.34	2075.1
1677.35	680.0	1679.54	1696.7	1680.44	1903.4
1677.45	737.9	1679.54	1822.9	1680.44	2041.1
1677.55	818.2	1679.54	1741.7	1680.44	2052.4
1677.65	886.4	1679.64	1717.0	1680.54	2036.5
1677.75	916.7	1679.64	1728.8	1680.54	2127.0
1677.85	998.6	1679.64	1705.8	1680.74	2855.6
1677.95	1024.1	1679.74	1802.0	1680.84	2631.9
1678.05	1105.2	1679.74	1819.2	1681.94	2908.3
1678.15	1162.2	1679.74	1934.5	1682.04	3102.7
1678.25	1253.8	1679.84	1800.1	1682.23	2899.7
1678.35	1260.8	1679.84	1893.0	1682.24	2885.4
1678.45	1276.2	1679.84	1978.5	1682.33	3076.2
1678.45	1292.6	1679.94	1861.7	1682.34	2951.8
1678.55	1334.1	1679.94	1807.8	1682.43	2878.4
1678.55	1407.9	1679.94	1941.5	1682.53	3099.6
1678.65	1438.5	1680.04	2020.3	1682.63	2922.3
1678.65	1423.7	1680.14	1952.5	1682.73	2812.5
1678.75	1458.1	1680.14	1830.0	1682.83	2735.4

(d) s/R = 0.10; ϕ = 146.25°; x = 0.2000 in.

1676.65	545.5	1679.15	1584.6	1680.34	1935.3
1676.75	542.2	1679.25	1587.3	1680.34	1961.1
1676.85	526.9	1679.25	1648.7	1680.34	2026.6
1676.95	504.6	1679.35	1594.8	1680.44	1888.5
1677.05	557.2	1679.35	1836.5	1680.44	1966.7
1677.15	560.2	1679.45	1651.7	1680.44	1999.8
1677.25	608.4	1679.54	1714.8	1680.54	2361.1
1677.35	637.6	1679.54	1734.8	1680.54	2505.8
1677.45	698.9	1679.64	1642.5	1680.74	2988.1
1677.55	763.5	1679.64	1725.1	1680.84	2698.5
1677.65	868.7	1679.64	1691.7	1680.94	2903.6
1677.75	848.8	1679.74	1700.9	1681.04	2814.2
1677.85	958.8	1679.74	1697.4	1681.14	2898.1
1677.95	941.5	1679.74	1794.0	1681.34	3064.0
1678.05	1006.1	1679.84	1785.3	1681.44	2965.0
1678.15	1081.6	1679.84	1732.8	1681.64	2921.4
1678.25	1146.9	1679.84	1886.3	1681.74	2984.1
1678.35	1212.5	1679.94	1762.6	1681.94	2908.3
1678.45	1136.5	1679.94	1733.4	1682.23	2844.0
1678.45	1196.4	1679.94	1857.1	1682.24	2789.9
1678.55	1264.3	1680.04	1846.6	1682.33	3004.3
1678.55	1321.2	1680.14	1917.2	1682.34	2887.7
1678.65	1269.3	1680.14	1786.0	1682.43	2874.4
1678.65	1347.6	1680.14	1928.2	1682.53	3000.8
1678.75	1347.2	1680.24	1873.8	1682.63	2918.2
1678.95	1479.4	1680.24	1842.3	1682.73	2926.1
1679.05	1511.9	1680.24	1979.2	1682.83	2780.9

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(e) s/R = 0.57; ϕ = 146.25°; x = 0.0125 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	541.8	1679.05	1872.4	1680.34	2259.0
1676.75	534.6	1679.15	2001.0	1680.34	2228.1
1676.85	523.3	1679.25	1857.4	1680.34	2325.1
1676.95	504.6	1679.25	1967.5	1680.44	2195.4
1677.05	662.3	1679.35	1897.9	1680.44	2228.3
1677.15	695.6	1679.35	1959.4	1680.44	2139.9
1677.25	810.1	1679.45	1905.7	1680.54	2275.2
1677.35	893.0	1679.54	1996.6	1680.54	2354.5
1677.45	937.5	1679.54	1856.3	1680.74	2690.0
1677.55	1012.5	1679.64	1935.0	1680.84	2452.1
1677.65	1187.3	1679.64	1985.9	1680.94	2681.6
1677.75	1124.7	1679.64	1875.8	1681.04	2632.1
1677.85	1298.3	1679.74	2042.9	1681.14	2733.3
1677.95	1255.3	1679.74	2084.1	1681.34	2719.2
1678.05	1355.3	1679.74	2343.9	1681.44	2808.9
1678.15	1411.9	1679.84	2071.1	1681.54	2767.9
1678.25	1427.6	1679.84	2091.0	1681.64	2513.8
1678.35	1490.3	1679.84	2271.3	1681.74	2563.2
1678.45	1512.6	1679.94	2024.0	1681.94	2884.0
1678.45	1511.0	1679.94	1989.7	1682.04	3106.8
1678.55	1591.1	1679.94	2080.9	1682.23	2875.8
1678.55	1643.6	1680.04	2125.5	1682.24	1981.8
1678.65	1604.0	1680.04	2140.4	1682.33	2796.7
1678.65	1694.3	1680.14	2092.9	1682.34	2887.7
1678.75	1631.9	1680.14	2295.2	1682.43	2878.4
1678.75	1655.4	1680.24	2107.0	1682.53	2917.8
1678.85	1785.5	1680.24	2139.9	1682.63	2951.3
1678.95	1837.3	1680.24	2209.2	1682.73	2867.2

(f) s/R = 0.57; ϕ = 146.25°; x = 0.0723 in.

1676.65	552.9	1679.25	1705.3	1680.34	2067.6
1676.75	542.2	1679.25	1838.2	1680.34	2042.5
1676.85	519.6	1679.35	1751.1	1680.34	2116.7
1676.95	500.9	1679.35	1801.2	1680.44	2026.0
1677.05	564.4	1679.45	1826.3	1680.44	2107.8
1677.15	620.8	1679.45	1975.0	1680.44	2101.5
1677.25	699.2	1679.54	1861.6	1680.54	2059.8
1677.35	769.9	1679.54	1713.9	1680.54	2157.4
1677.45	791.7	1679.64	1869.9	1680.74	2350.0
1677.55	876.4	1679.64	1827.3	1680.84	2048.0
1677.75	991.4	1679.64	1758.8	1680.94	2220.6
1677.85	1116.0	1679.74	1888.9	1681.14	2502.0
1677.95	1136.6	1679.74	1830.6	1681.34	2533.3
1678.05	1171.6	1679.74	2091.9	1681.44	2572.5
1678.15	1211.2	1679.84	1919.6	1681.54	2632.2
1678.25	1287.9	1679.84	1912.0	1681.64	2628.0
1678.35	1346.4	1679.84	2056.0	1681.74	2738.7
1678.45	1384.7	1679.94	1910.8	1681.94	2798.8
1678.55	1400.1	1679.94	1833.7	1682.04	3029.1
1678.55	1473.7	1679.94	1963.5	1682.23	2716.6
1678.65	1508.4	1680.04	2016.5	1682.33	2589.0
1678.65	1517.1	1680.04	1984.4	1682.34	2674.0
1678.75	1472.9	1680.14	1987.8	1682.43	2525.3
1678.75	1548.4	1680.14	1946.0	1682.53	2981.1
1678.85	1676.8	1680.14	2133.7	1682.63	2951.3
1678.95	1672.9	1680.24	2047.5	1682.73	2917.7
1679.05	1717.4	1680.24	2044.9	1682.83	2826.4
1679.15	1843.0	1680.24	2079.8	1682.93	2786.0

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(g) s/R = 0.57; ϕ = 146.25°; x = 0.1323 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	552.9	1679.15	1713.4	1680.24	2035.1
1676.75	542.2	1679.25	1638.5	1680.34	1962.5
1676.85	508.7	1679.25	1708.4	1680.34	1945.6
1676.95	489.8	1679.35	1646.5	1680.34	2052.7
1677.05	553.4	1679.45	1666.5	1680.44	1970.3
1677.15	574.5	1679.45	1813.1	1680.44	2013.7
1677.25	639.8	1679.54	1768.9	1680.44	2026.1
1677.35	687.1	1679.54	1634.1	1680.54	1927.5
1677.45	716.4	1679.64	1646.2	1680.54	2115.6
1677.55	825.5	1679.64	1725.1	1680.74	2272.0
1677.65	936.0	1679.64	1666.9	1680.84	2192.2
1677.75	906.0	1679.74	1835.7	1680.94	2270.7
1677.85	1005.8	1679.74	1781.1	1681.14	2354.9
1677.95	1027.7	1679.74	1957.0	1681.34	2392.8
1678.05	1098.2	1679.84	1818.5	1681.44	2429.1
1678.15	1158.6	1679.84	1881.6	1681.54	2498.5
1678.25	1178.0	1679.84	2015.4	1681.64	2465.5
1678.35	1240.3	1679.94	1806.6	1681.74	2475.4
1678.45	1268.9	1679.94	1778.0	1682.04	3037.2
1678.45	1265.3	1679.94	1857.1	1682.23	2768.4
1678.55	1257.0	1680.04	1915.8	1682.33	2816.6
1678.55	1345.5	1680.04	1803.7	1682.34	2785.1
1678.65	1353.9	1680.14	1948.6	1682.43	2914.7
1678.65	1416.8	1680.14	1811.7	1682.53	2996.9
1678.75	1421.1	1680.14	1954.2	1682.63	2943.1
1678.95	1541.5	1680.24	2047.5	1682.73	2913.5
1679.05	1591.6	1680.24	1958.4	1682.83	1888.5

(h) s/R = 0.57; ϕ = 146.25°; x = 0.2000 in.

1676.65	545.5	1679.15	1477.5	1680.34	1762.2
1676.75	542.2	1679.25	1510.2	1680.34	1884.7
1676.85	516.0	1679.35	1454.8	1680.44	1732.4
1676.95	515.8	1679.45	1493.9	1680.44	1861.1
1677.05	549.6	1679.45	1588.1	1680.44	1871.9
1677.15	578.0	1679.54	1600.3	1680.54	1815.9
1677.25	632.8	1679.54	1584.3	1680.54	1940.6
1677.35	683.6	1679.54	1480.0	1680.74	3108.1
1677.45	688.4	1679.64	1521.3	1680.84	2761.0
1677.55	767.1	1679.64	1507.5	1680.94	2969.4
1677.65	861.5	1679.64	1523.7	1681.04	2748.0
1677.75	866.9	1679.74	1576.5	1681.14	2874.0
1677.85	951.6	1679.74	1717.4	1681.34	2972.6
1677.95	952.3	1679.84	1719.0	1681.44	2863.7
1678.05	1020.5	1679.84	1622.0	1681.64	2723.0
1678.15	1060.6	1679.84	1792.3	1681.74	2628.3
1678.25	1126.2	1679.94	1645.1	1681.94	2426.2
1678.35	1146.5	1679.94	1614.8	1682.04	2685.6
1678.45	1210.3	1679.94	1717.9	1682.23	2308.7
1678.45	1179.1	1680.04	1741.2	1682.24	2305.7
1678.55	1264.3	1680.14	1801.0	1682.33	2418.1
1678.55	1293.6	1680.14	1654.1	1682.34	2263.9
1678.65	1295.1	1680.14	1803.3	1682.43	2389.1
1678.65	1313.0	1680.24	1819.6	1682.53	2416.7
1678.75	1310.2	1680.24	1754.5	1682.63	2337.6
1678.95	1400.1	1680.24	1827.2	1682.73	2266.0
1679.05	1456.4	1680.34	1725.1	1682.83	2183.9

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(i) s/R = 0.87; ϕ = 242.00°; x = 0.0133 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	560.2	1678.75	1576.4	1680.14	2028.8
1676.75	549.8	1678.85	1690.8	1680.14	2187.0
1676.85	545.2	1678.95	1700.9	1680.24	2224.5
1676.95	523.3	1679.05	1752.6	1680.24	2209.2
1677.05	589.8	1679.15	1885.8	1680.24	2220.8
1677.15	688.4	1679.25	1872.6	1680.34	2154.5
1677.25	774.2	1679.25	1888.1	1680.34	2180.1
1677.35	820.8	1679.35	1818.4	1680.44	2388.7
1677.45	881.1	1679.45	1875.1	1680.44	2398.9
1677.55	1001.7	1679.54	1980.7	1681.34	2985.1
1677.65	1101.0	1679.54	2186.8	1681.44	2846.9
1677.75	1086.5	1679.64	1904.3	1681.54	2948.8
1677.85	1193.5	1679.64	1974.2	1681.64	2566.2
1677.95	1251.9	1679.64	1915.7	1682.04	3012.7
1678.05	1324.3	1679.74	2132.2	1682.23	2847.9
1678.15	1335.9	1679.84	1965.0	1682.24	2748.3
1678.25	1417.4	1679.94	2054.2	1682.33	2844.6
1678.35	1473.1	1679.94	1970.6	1682.34	2780.9
1678.45	1504.2	1679.94	2385.5	1682.43	2789.8
1678.55	1502.9	1680.04	2086.1	1682.53	2585.7
1678.55	1546.5	1680.04	2015.3	1682.63	3050.9
1678.65	1556.2	1680.04	2168.2	1682.73	2955.5
1678.65	1631.3	1680.14	2190.2	1682.83	2875.9

(j) s/R = 0.87; ϕ = 242.00°; x = 0.0735 in.

1676.65	560.2	1678.85	1531.0	1680.24	1973.5
1676.75	568.3	1678.95	1676.4	1680.24	2005.3
1676.85	523.3	1679.05	1629.7	1680.34	2083.2
1676.95	530.7	1679.15	1741.4	1680.34	2096.8
1677.05	564.4	1679.25	1675.6	1680.44	1955.4
1677.15	588.7	1679.25	1743.5	1680.44	2088.0
1677.25	713.1	1679.35	1668.9	1680.44	2136.1
1677.35	722.7	1679.45	1740.9	1680.64	2924.1
1677.45	809.6	1679.45	1975.0	1680.74	2863.9
1677.55	908.6	1679.54	1807.5	1680.84	2910.8
1677.65	964.3	1679.54	1974.1	1680.94	2907.7
1677.75	941.6	1679.64	1735.6	1681.04	2921.9
1677.85	1077.3	1679.64	1834.8	1681.54	2809.0
1677.95	1112.1	1679.64	1790.6	1681.64	3008.2
1678.05	1147.1	1679.74	1784.9	1681.74	2922.7
1678.15	1193.7	1679.84	1870.4	1681.84	2997.6
1678.25	1243.6	1679.84	1927.3	1681.94	2928.6
1678.35	1332.8	1679.94	1925.9	1682.23	2975.3
1678.45	1319.8	1679.94	1928.6	1682.24	2764.9
1678.45	1326.7	1679.94	1912.1	1682.33	2844.6
1678.55	1403.8	1680.04	1943.0	1682.34	2708.2
1678.55	1397.5	1680.04	1988.9	1682.43	2814.0
1678.65	1434.8	1680.14	2007.5	1682.53	2593.7
1678.65	1461.8	1680.14	1915.8	1682.73	2942.9
1678.75	1521.0	1680.14	1987.7	1682.83	2838.8
1678.75	1472.5	1680.24	2023.8	1682.93	2834.4

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(k) s/R = 0.87; ϕ = 242.00°; x = 0.1335 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	541.8	1678.95	1503.5	1680.34	1927.5
1676.75	568.3	1679.05	1556.9	1680.34	2065.7
1676.85	545.2	1679.15	1678.4	1680.34	2112.9
1676.95	549.4	1679.25	1623.9	1680.44	1862.6
1677.05	527.0	1679.25	1743.5	1680.44	1958.9
1677.15	570.9	1679.35	1594.8	1680.44	2026.1
1677.25	660.8	1679.45	1611.2	1680.54	2747.8
1677.35	683.6	1679.45	1714.4	1680.64	2891.7
1677.45	734.3	1679.54	1745.7	1680.74	2872.2
1677.55	803.6	1679.54	1804.2	1680.84	2885.8
1677.65	918.3	1679.64	1747.8	1680.94	2804.9
1677.75	863.2	1679.74	1794.5	1681.04	2810.1
1677.85	987.7	1679.74	1750.7	1681.24	2853.9
1677.95	1049.2	1679.84	1822.2	1681.34	3014.2
1678.05	1063.2	1679.84	1755.1	1681.44	2981.9
1678.15	1116.6	1679.94	1821.3	1681.54	2874.8
1678.25	1178.0	1679.94	1826.3	1681.74	2947.3
1678.35	1274.5	1679.94	1864.4	1681.84	3078.6
1678.45	1282.3	1680.04	2019.2	1682.23	2832.0
1678.55	1312.1	1680.04	1898.2	1682.24	2752.5
1678.55	1349.0	1680.14	1881.8	1682.33	2784.7
1678.65	1320.8	1680.14	1844.6	1682.34	2789.4
1678.65	1396.0	1680.14	1894.7	1682.43	2818.0
1678.75	1410.0	1680.24	1905.3	1682.53	2791.3
1678.75	1469.0	1680.24	1860.7	1682.73	2825.1
1678.85	1468.7	1680.24	1904.6	1682.83	2797.4

(ℓ) s/R = 0.87; ϕ = 242.00°; x = 0.2000 in.

1676.65	541.8	1678.85	1413.3	1680.14	1835.8
1676.75	549.8	1678.95	1489.7	1680.24	1849.7
1676.85	526.9	1679.05	1477.2	1680.24	1863.6
1676.95	523.3	1679.15	1619.1	1680.34	1884.7
1677.05	538.3	1679.25	1569.0	1680.34	1906.8
1677.15	527.0	1679.25	1659.2	1680.54	2747.8
1677.25	650.3	1679.35	1594.8	1680.64	2826.9
1677.35	651.8	1679.45	1611.2	1680.74	2818.4
1677.45	695.4	1679.45	1672.1	1680.84	2802.6
1677.55	778.0	1679.54	1730.2	1680.94	2780.2
1677.65	843.5	1679.54	1804.2	1681.04	2797.7
1677.75	812.5	1679.64	1731.9	1681.24	3030.4
1677.85	919.1	1679.64	1691.0	1681.34	3113.9
1677.95	955.9	1679.64	1688.2	1681.44	3019.9
1678.05	1009.8	1679.74	1749.6	1681.54	2209.1
1678.15	1050.1	1679.74	1697.4	1681.64	2276.5
1678.25	1115.8	1679.84	1825.9	1682.23	2855.9
1678.35	1184.7	1679.94	1766.2	1682.24	2715.1
1678.45	1168.7	1679.94	1748.3	1682.33	2728.8
1678.55	1242.3	1679.94	1721.5	1682.34	2797.9
1678.55	1269.3	1680.04	1950.7	1682.43	2846.2
1678.65	1287.7	1680.04	1928.4	1682.53	2664.8
1678.65	1333.8	1680.14	1889.7	1682.73	2879.8
1678.75	1382.9	1680.14	1771.4	1682.83	2842.9

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Continued

(m) s/R = 1.00; ϕ = 242.00°; x = 0.0137 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	545.5	1678.75	661.7	1680.14	3037.8
1676.75	582.9	1678.95	695.0	1680.14	2837.1
1676.85	534.3	1679.05	685.2	1680.34	2596.3
1676.95	553.1	1679.15	738.7	1680.34	2752.5
1677.05	582.6	1679.25	759.4	1680.34	2605.2
1677.15	552.9	1679.25	735.4	1680.54	2929.7
1677.25	604.9	1679.35	710.5	1680.54	2886.3
1677.35	595.3	1679.45	736.5	1680.94	2636.4
1677.45	583.9	1679.54	801.5	1681.04	2851.5
1677.55	630.9	1679.54	809.4	1681.14	2862.0
1677.65	608.7	1679.64	736.9	1681.44	2901.7
1677.75	570.4	1679.64	714.7	1681.94	2908.3
1677.85	628.3	1679.64	748.4	1682.04	2963.7
1677.95	599.1	1679.74	738.1	1682.23	2472.5
1678.05	627.6	1679.74	759.0	1682.24	2333.0
1678.15	659.8	1679.74	789.4	1682.33	2928.4
1678.35	655.1	1679.84	769.2	1682.34	2751.0
1678.45	637.0	1679.84	755.1	1682.43	2878.4
1678.45	668.7	1679.94	814.4	1682.53	2779.5
1678.55	660.7	1679.94	832.3	1682.63	3042.6
1678.55	674.5	1679.94	763.7	1682.73	2980.8
1678.65	664.7	1680.04	723.6	1682.83	2855.3
1678.65	709.8	1680.14	2967.1	1682.93	2850.5

(n) s/R = 1.00; ϕ = 242.00°; x = 0.0730 in.

1676.65	560.2	1679.05	703.0	1680.34	2873.3
1676.75	572.0	1679.15	753.3	1680.34	3030.8
1676.85	530.6	1679.25	717.1	1680.34	2954.5
1676.95	578.4	1679.25	675.3	1680.44	1888.5
1677.05	578.9	1679.35	676.3	1680.44	2018.6
1677.15	578.0	1679.45	686.8	1680.44	1994.1
1677.25	594.4	1679.54	773.1	1680.74	2095.7
1677.35	570.5	1679.54	769.2	1681.04	2743.8
1677.45	580.4	1679.64	656.9	1681.14	2789.6
1677.55	599.0	1679.64	729.5	1681.34	3089.0
1677.65	629.7	1679.64	720.7	1681.44	2834.2
1677.75	570.4	1679.74	718.6	1681.54	2506.5
1677.85	606.8	1679.74	728.5	1681.64	2933.8
1677.95	599.1	1679.74	702.3	1681.74	3008.6
1678.05	592.1	1679.84	761.5	1681.84	2933.7
1678.15	595.8	1679.84	739.6	1681.94	2952.9
1678.25	622.8	1679.94	710.9	1682.04	3074.1
1678.35	619.8	1679.94	735.4	1682.23	3042.9
1678.45	633.5	1679.94	755.9	1682.24	2827.2
1678.45	625.8	1680.04	727.5	1682.33	2960.4
1678.55	624.5	1680.14	706.9	1682.34	2815.1
1678.55	653.1	1680.14	656.9	1682.43	2866.3
1678.65	670.6	1680.14	669.7	1682.53	2716.2
1678.65	638.2	1680.24	816.0	1682.63	3017.7
1678.75	638.8	1680.24	822.1	1682.73	2997.6
1678.95	670.2	1680.24	1969.7	1682.83	2731.3

TABLE IV. - TEMPERATURES RECORDED IN THE THIRD BERYLLIUM CALORIMETER SHIELD - Concluded

(o) s/R = 1.00; ϕ = 242.00°; x = 0.1322 in.

Time, sec	Temp., °R	Time, sec	Temp., °R	Time, sec	Temp., °R
1676.65	560.2	1678.65	670.6	1680.14	3137.5
1676.75	564.7	1678.65	630.6	1680.14	2996.4
1676.85	570.4	1678.75	638.8	1680.14	2895.8
1676.95	519.6	1678.95	698.5	1680.24	2960.0
1677.05	549.6	1679.05	681.6	1680.24	2963.8
1677.15	560.2	1679.15	746.0	1680.24	2736.4
1677.25	566.5	1679.25	731.7	1680.34	2925.3
1677.35	549.0	1679.25	690.3	1680.34	2472.6
1677.45	563.0	1679.35	714.3	1680.34	2937.3
1677.55	588.4	1679.45	709.5	1680.44	2210.7
1677.65	601.7	1679.54	834.8	1680.44	2311.1
1677.75	559.8	1679.54	757.1	1680.44	2318.0
1677.85	621.1	1679.64	740.5	1680.74	1741.8
1677.95	595.6	1679.64	744.5	1680.84	724.4
1678.05	620.5	1679.74	745.9	1681.04	2760.4
1678.15	577.9	1679.74	747.6	1681.54	2423.0
1678.25	591.3	1679.74	741.7	1681.64	2892.5
1678.35	637.5	1679.84	761.5	1681.74	2820.5
1678.45	640.6	1679.94	733.9	1681.84	2861.3
1678.45	610.8	1679.94	836.0	1681.94	2936.7
1678.55	674.5	1679.94	694.4	1682.83	1914.6
1678.55	653.1	1680.04	726.6	1682.93	1735.5

(p) s/R = 1.00; ϕ = 242.00°; x = 0.2000 in.

1676.75	568.3	1678.95	638.2	1680.24	2845.8
1676.85	537.9	1679.05	678.0	1680.24	2851.8
1676.95	523.3	1679.15	720.4	1680.24	2820.1
1677.05	553.4	1679.25	728.0	1680.34	2760.8
1677.15	545.5	1679.25	652.7	1680.34	2920.0
1677.25	584.0	1679.35	699.1	1680.54	2882.0
1677.35	549.0	1679.45	748.2	1680.64	2980.7
1677.45	555.8	1679.54	834.8	1680.74	2855.6
1677.55	581.3	1679.54	781.4	1680.84	2914.9
1677.65	619.2	1679.64	645.6	1681.04	2789.4
1677.75	556.2	1679.64	736.9	1681.24	2948.3
1677.85	614.0	1679.64	728.7	1681.34	3084.8
1677.95	588.5	1679.74	665.2	1681.44	2943.9
1678.05	609.8	1679.74	698.5	1681.84	2827.3
1678.15	595.8	1679.74	702.3	1682.04	3029.1
1678.25	622.8	1679.84	761.5	1682.23	3003.2
1678.35	641.0	1679.94	726.2	1682.24	2843.9
1678.45	626.5	1679.94	680.4	1682.33	2768.7
1678.45	659.5	1679.94	652.9	1682.34	2678.3
1678.55	653.0	1680.04	755.0	1682.43	2749.5
1678.55	645.6	1680.04	776.5	1682.53	2288.7
1678.65	681.4	1680.14	2844.8	1682.63	2810.4
1678.65	645.8	1680.14	2884.6	1682.73	3077.5
1678.75	638.8	1680.14	2698.8	1682.83	2925.5

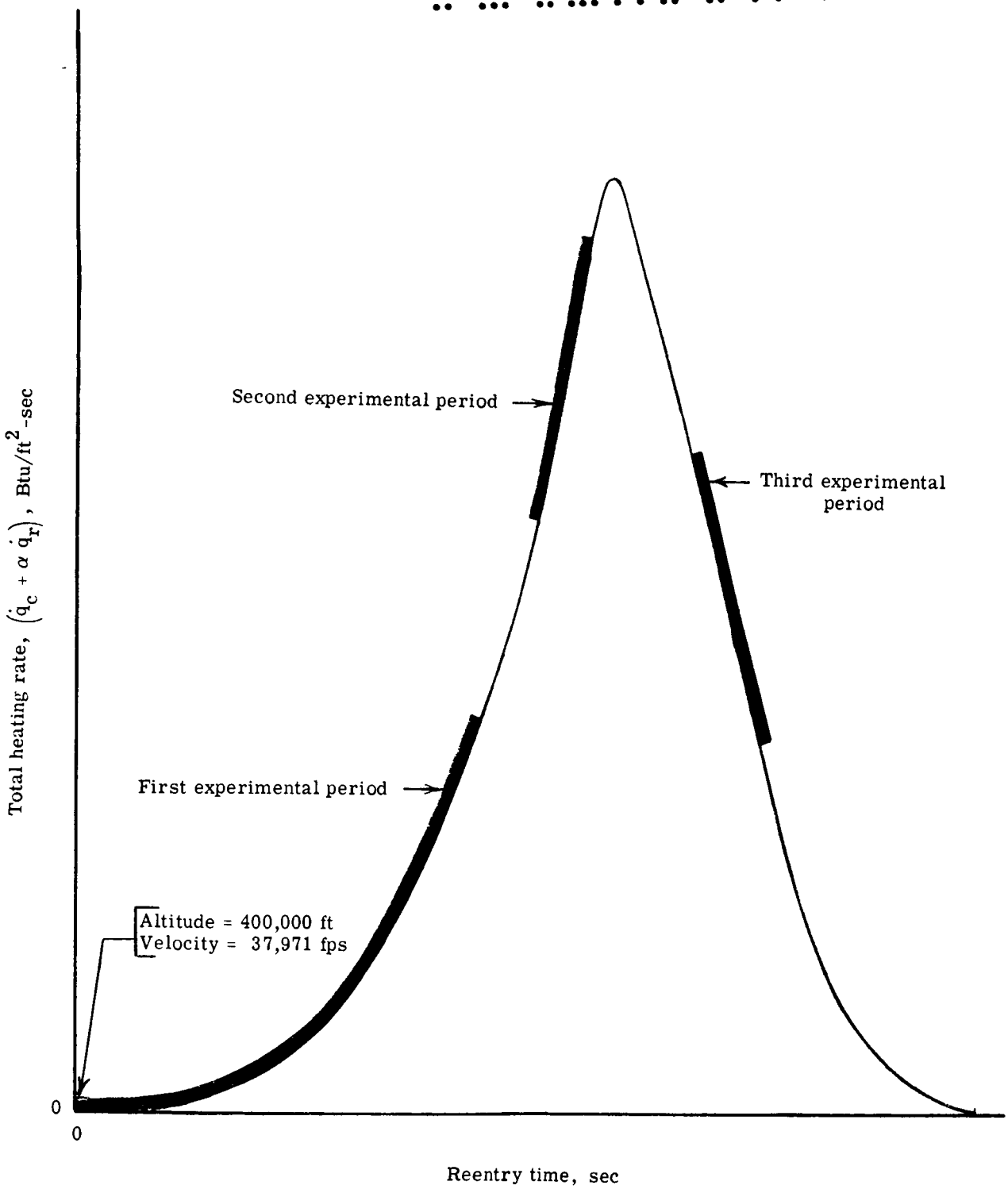


Figure 1.- Typical forebody heating rate and primary data periods.

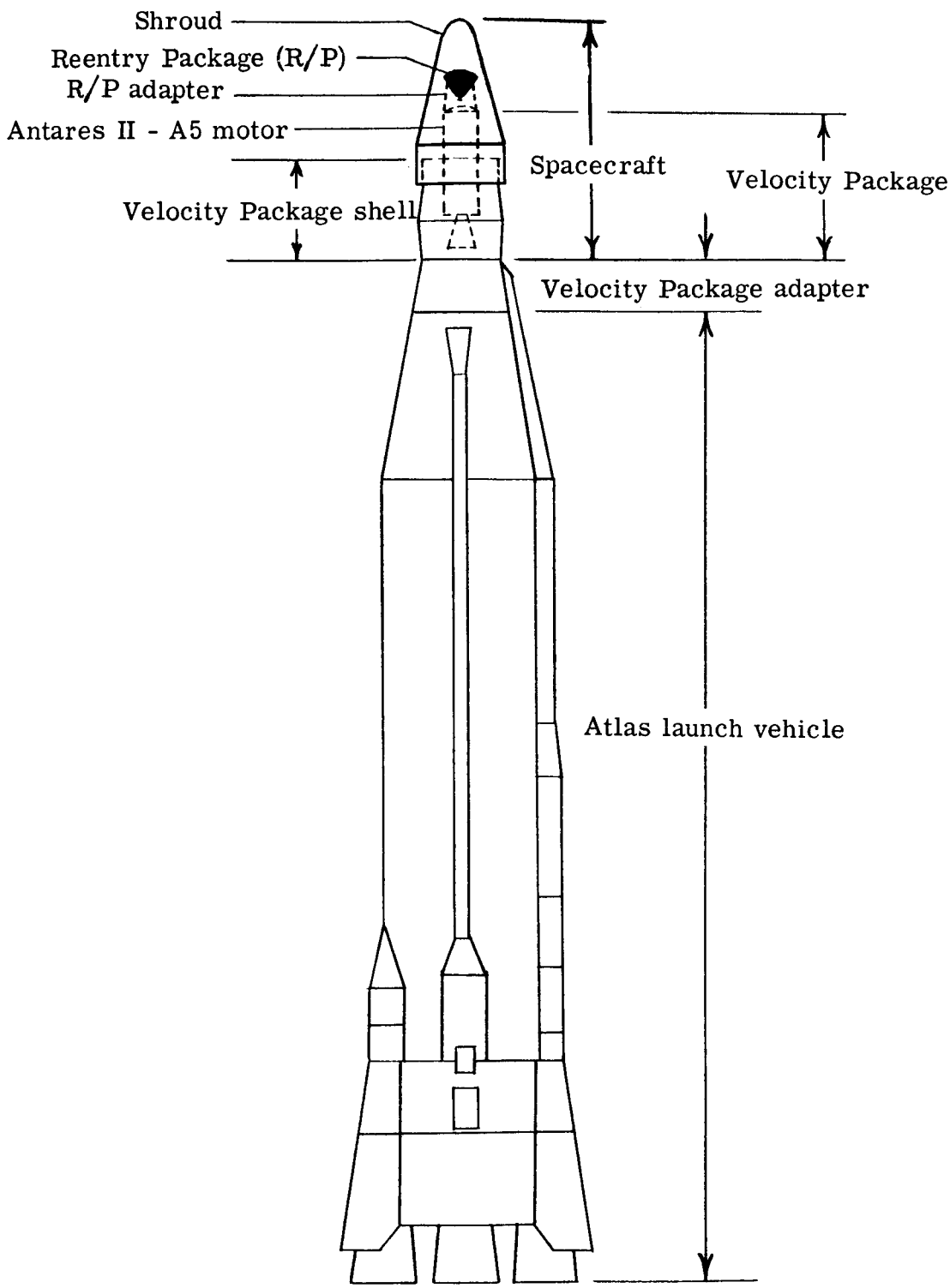


Figure 2.- Sketch of Project Fire space vehicle.

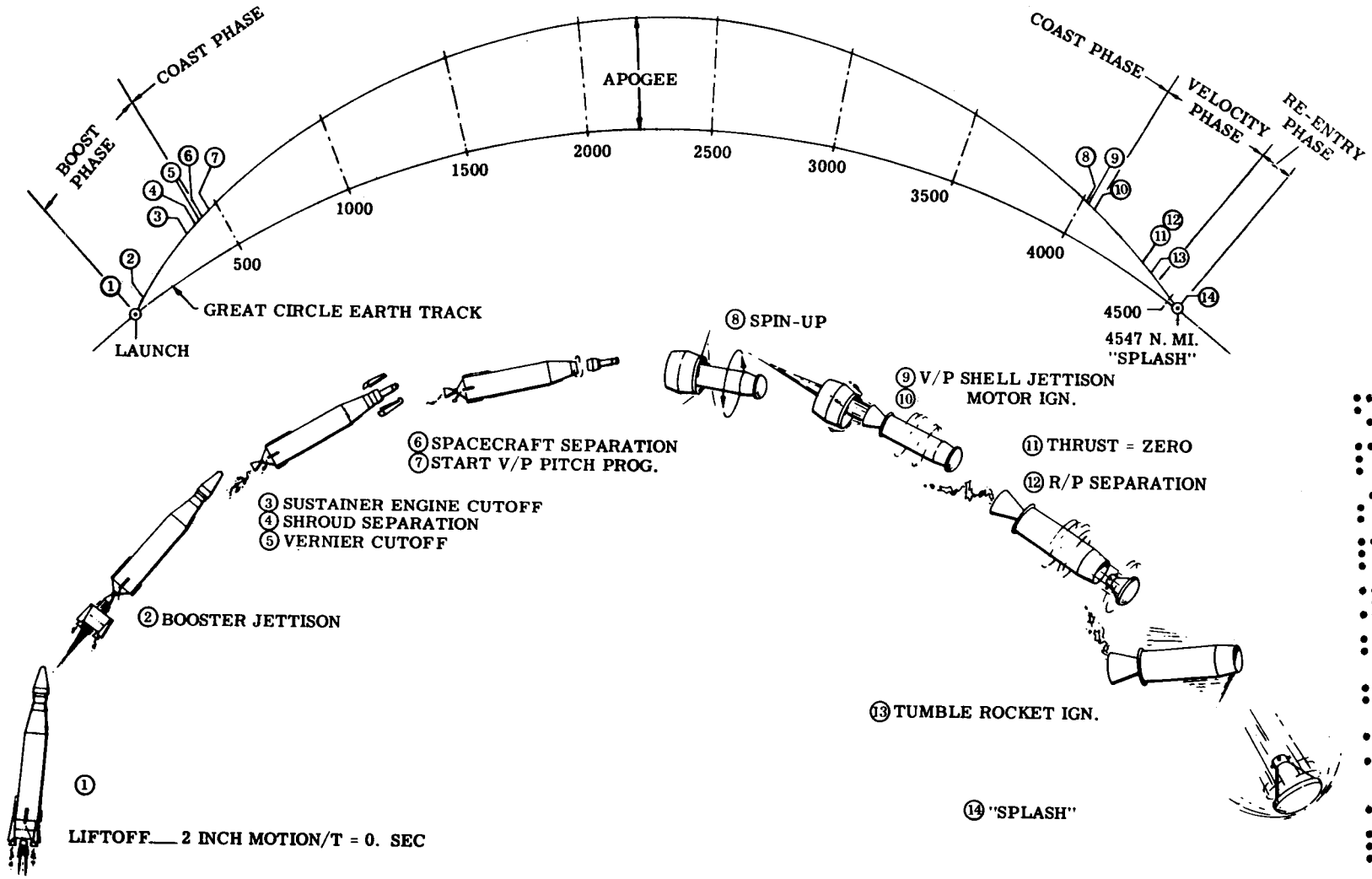


Figure 3.- Project Fire vehicle trajectory and flight sequence of events.

[redacted]

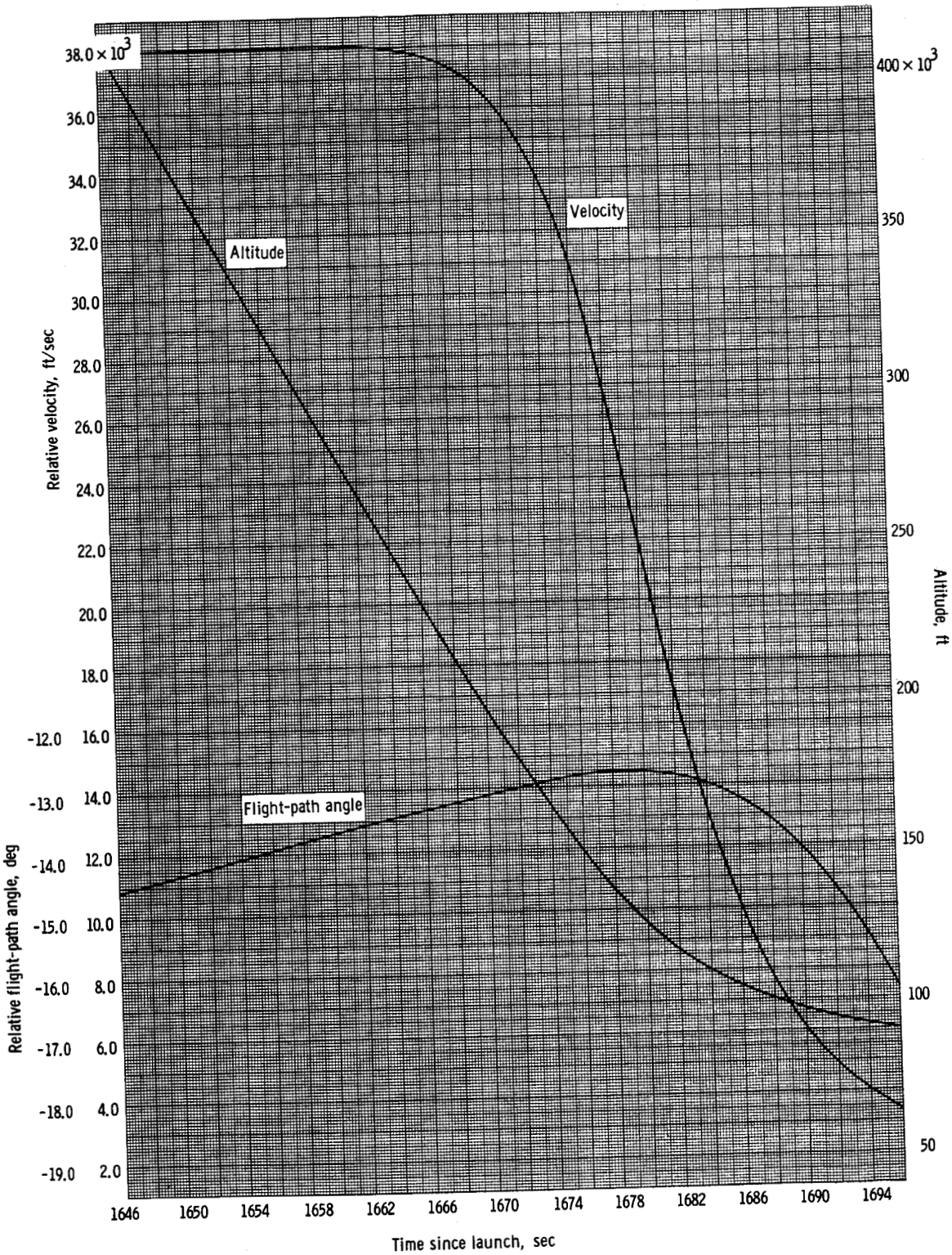
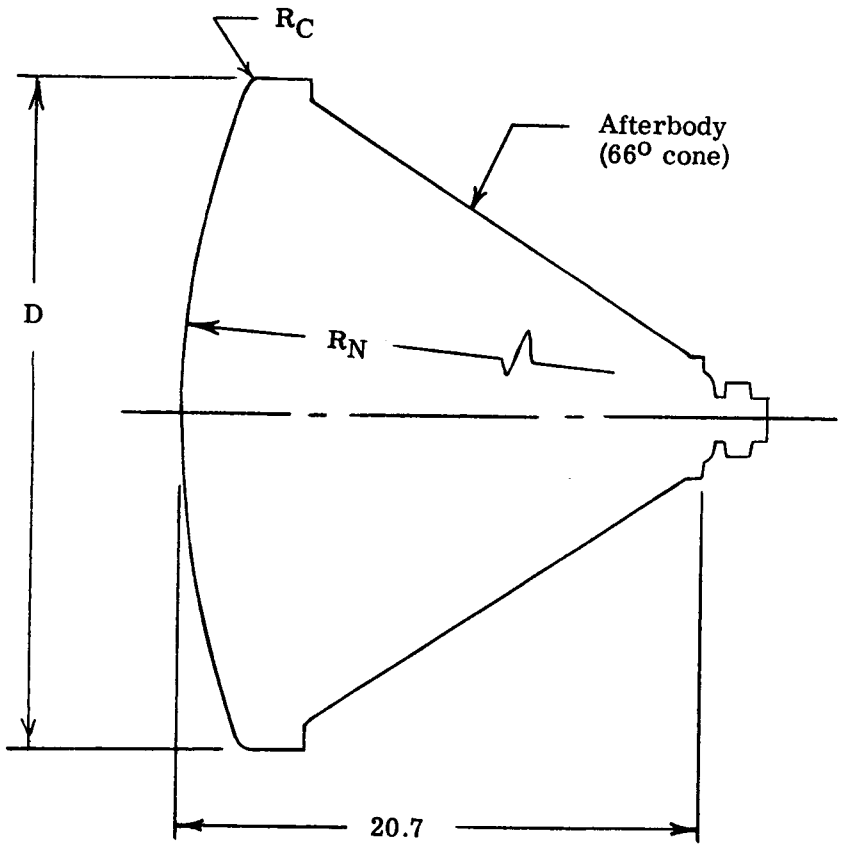


Figure 4.- Variation of altitude, velocity, and flight-path angle with time.

[redacted]



Experiment period	Reentry package dimensions		
	D	R_N	R_C
1	26.44	36.80	0.40
2	24.80	31.70	1.40
3	23.11	27.64	0.24

Figure 5.- Reentry package dimensions. (All dimensions are in inches except as noted.)

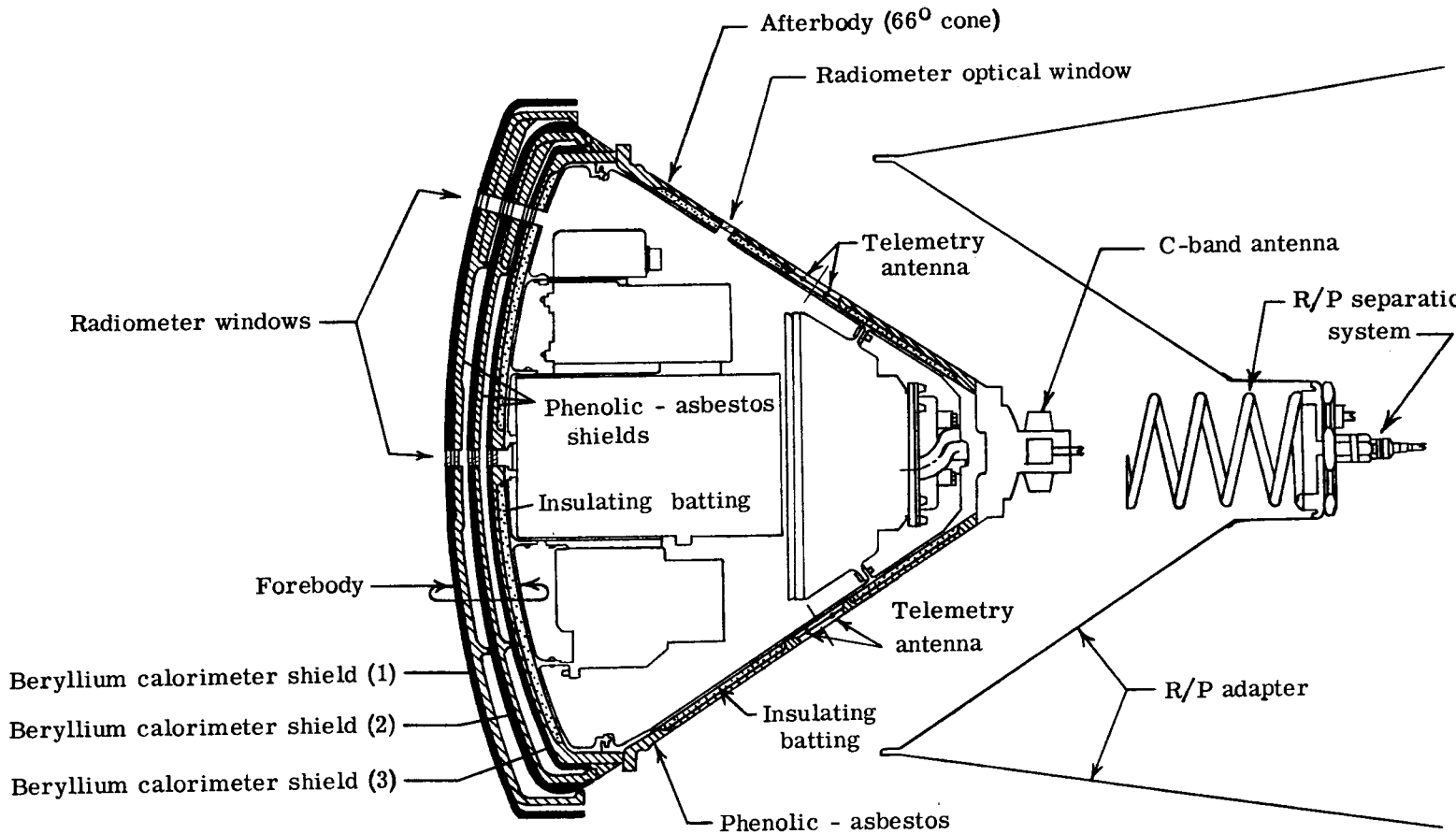


Figure 6.- Sketch of Project Fire reentry package and adapter illustrating the layered arrangement of the forebody heat shielding.

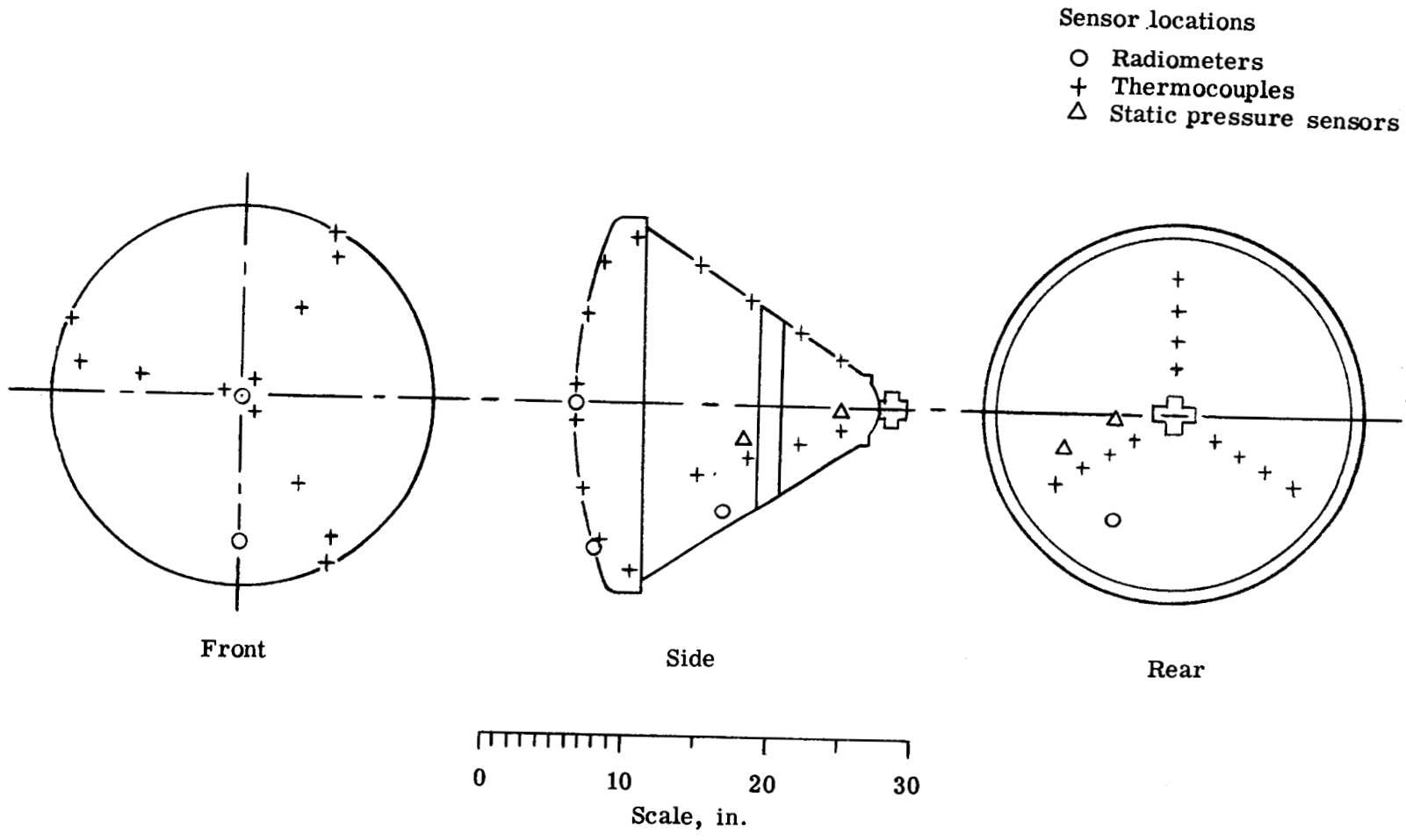


Figure 7.- Location of main data sensors on the Project Fire reentry package.

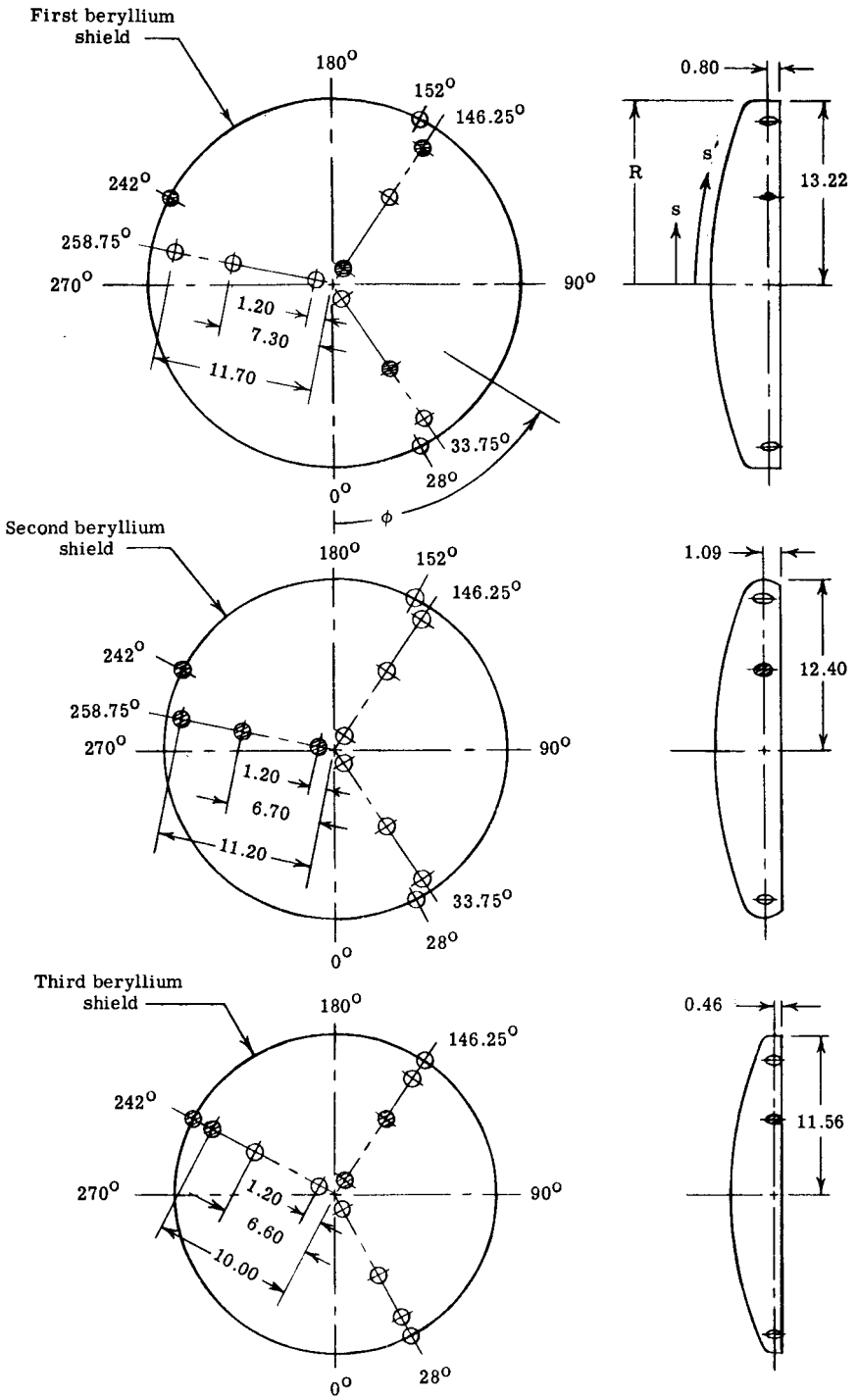
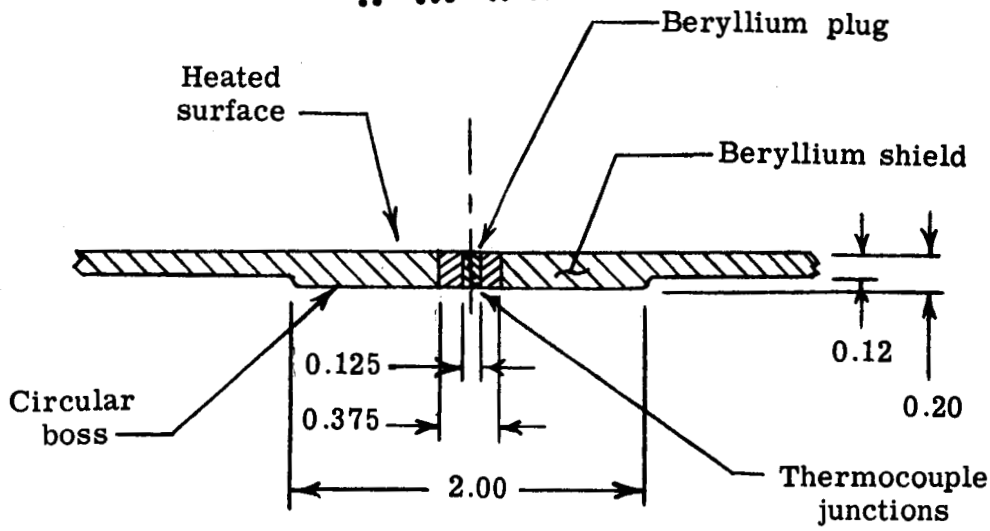
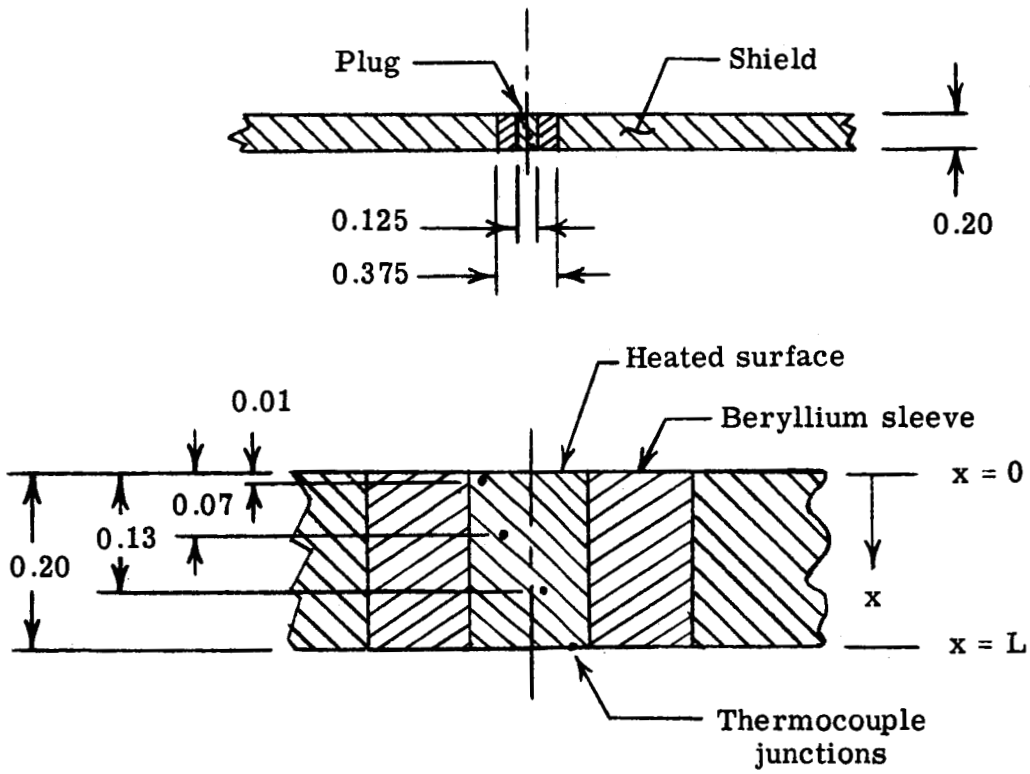


Figure 8.- Location of plugs in the three beryllium calorimeter shields on the forebody of the Fire reentry package. Linear dimensions are shown in inches. The plugs shown crosshatched are those for which data are presented. The radial dimensions shown are typical of those for the plugs in the other rays on the same shield.



(a) Typical plug installation illustrating bosses used on the first and third beryllium shields.



(b) Typical plug installation for the second beryllium shield and nominal thermocouple depths.

Figure 9.- Sketch of beryllium plug installations. All dimensions are in inches.

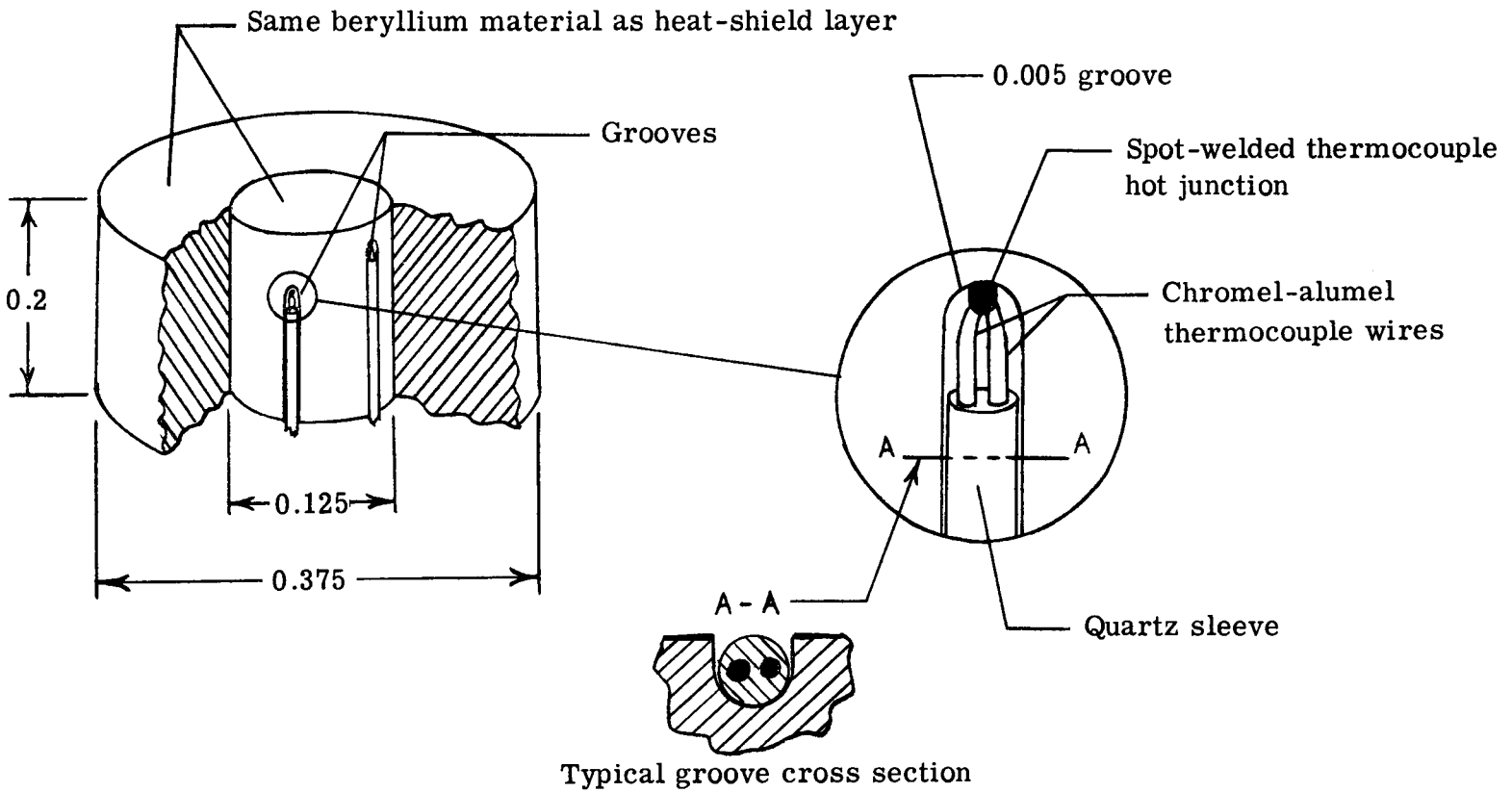


Figure 10.- Typical thermocuple installation and forebody calorimeter plug. All dimensions are in inches.

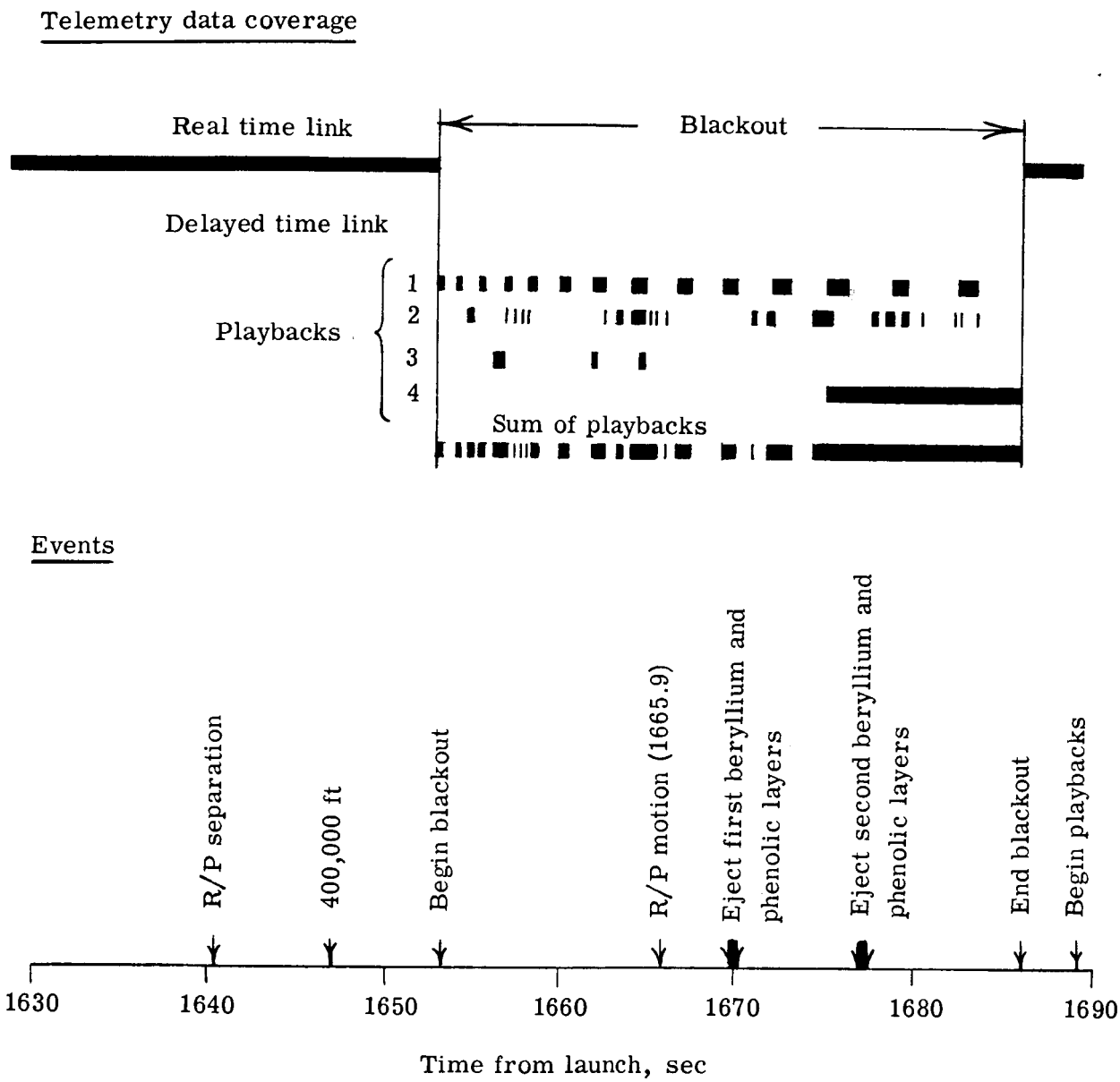


Figure 11.- Telemetry data coverage and timing of events during the Fire 1 reentry.

[redacted]

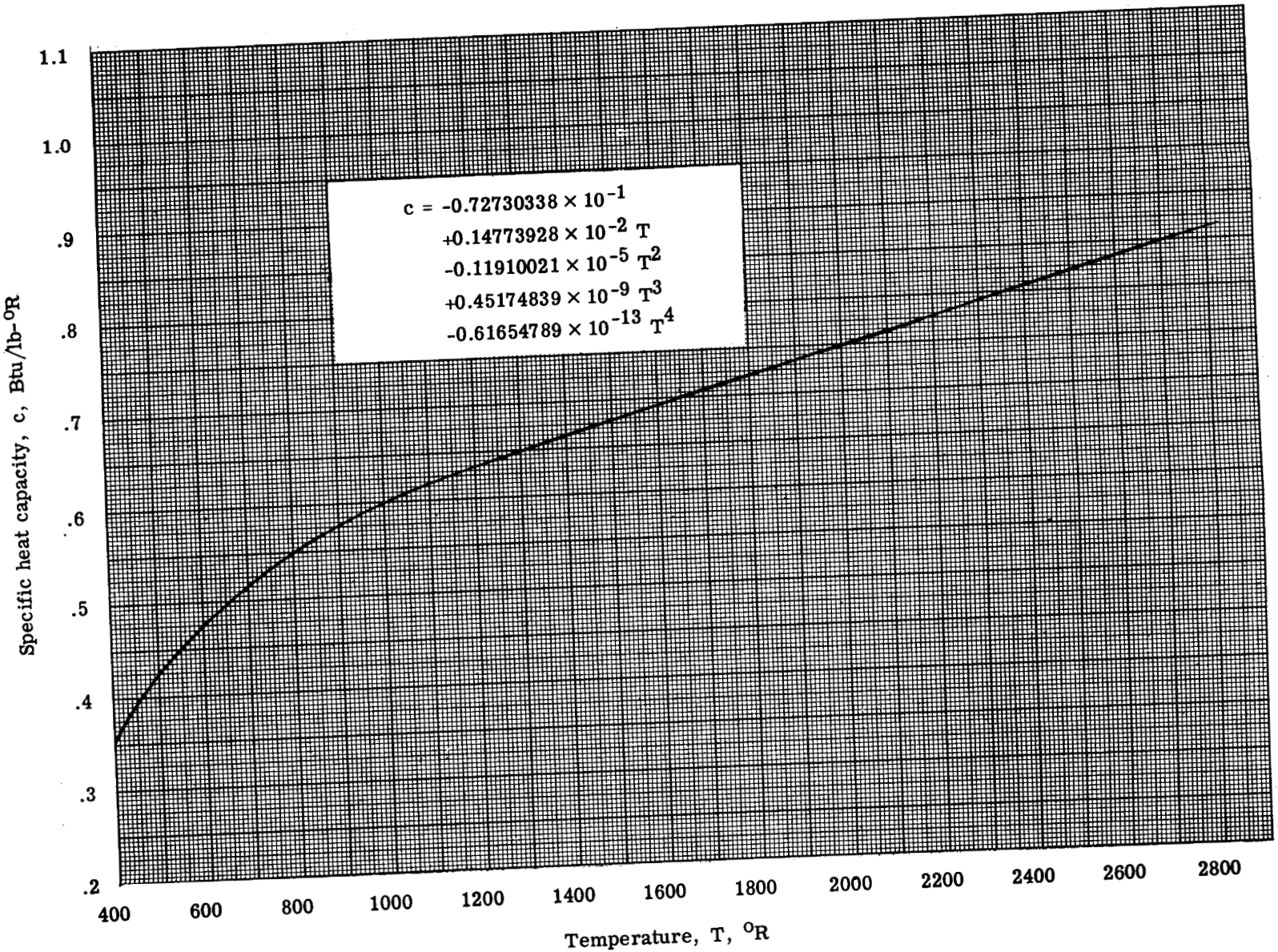


Figure 12.- Variation of the specific-heat capacity of beryllium with temperature.

[redacted]

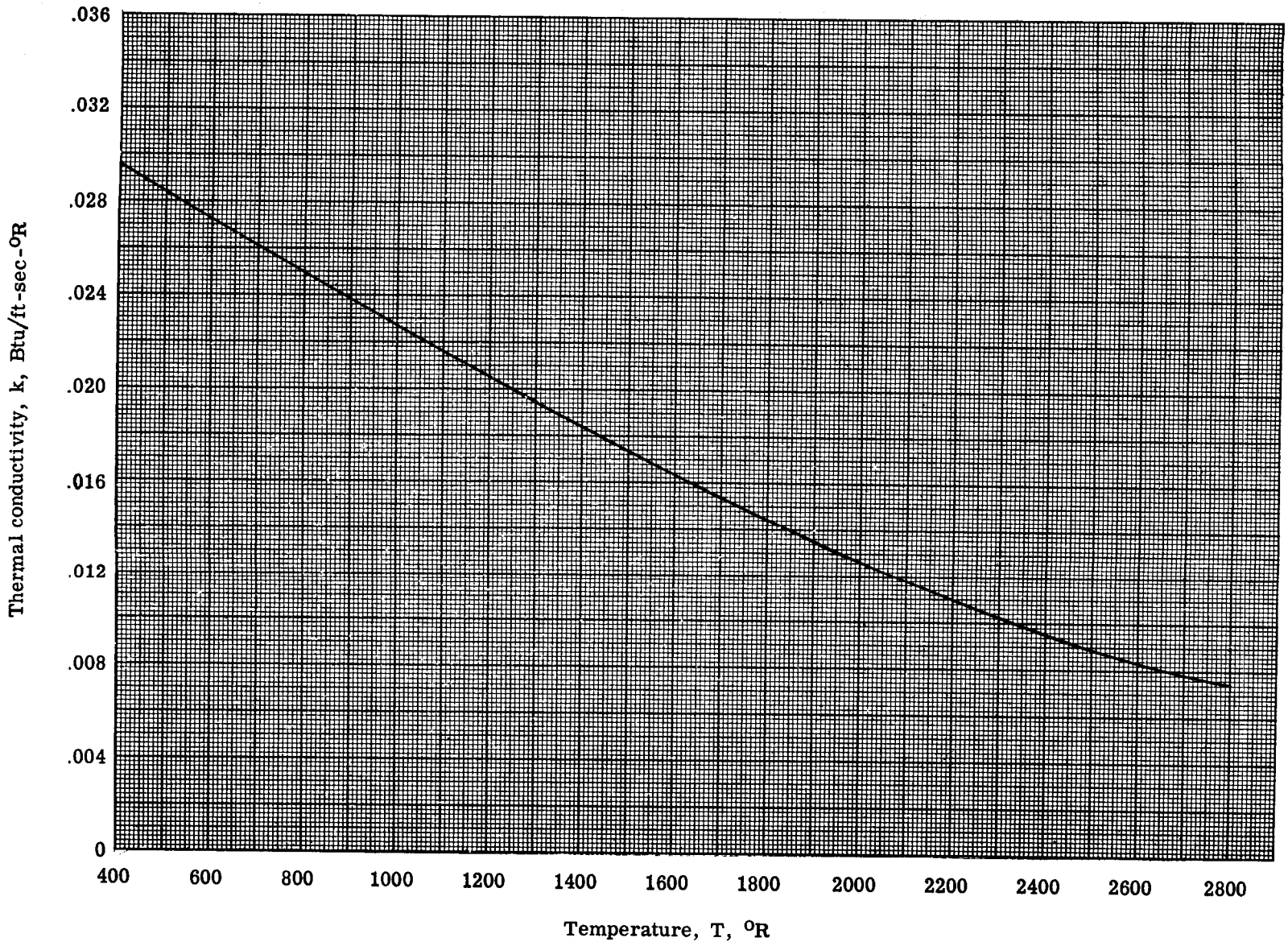
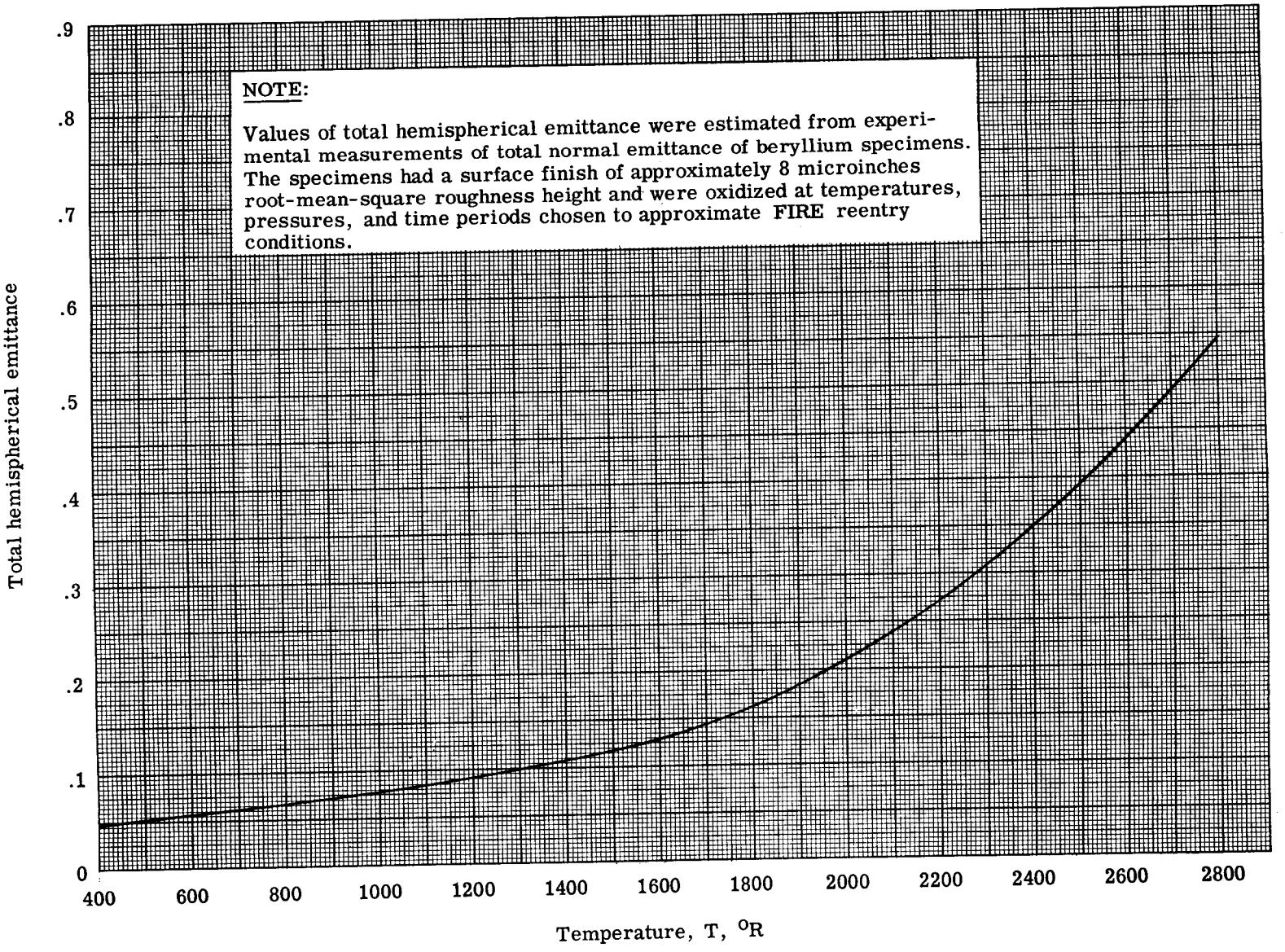


Figure 13.- Variation of the thermal conductivity of beryllium with temperature.

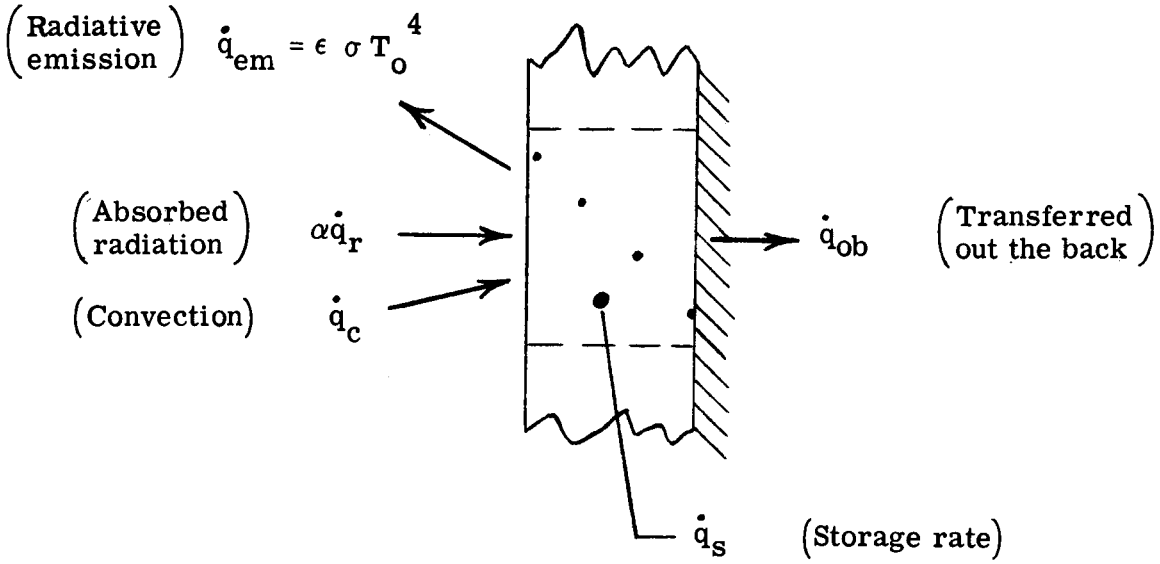
[redacted]



[redacted]

Figure 14.- Variation of the total hemispherical emittance of beryllium with temperature.

Theoretical model of beryllium calorimeter plug



HEAT IN = HEAT STORED + HEAT OUT

$$\dot{q}_c + \alpha \dot{q}_r = \dot{q}_s + \epsilon \sigma T_o^4 + \dot{q}_{ob}$$

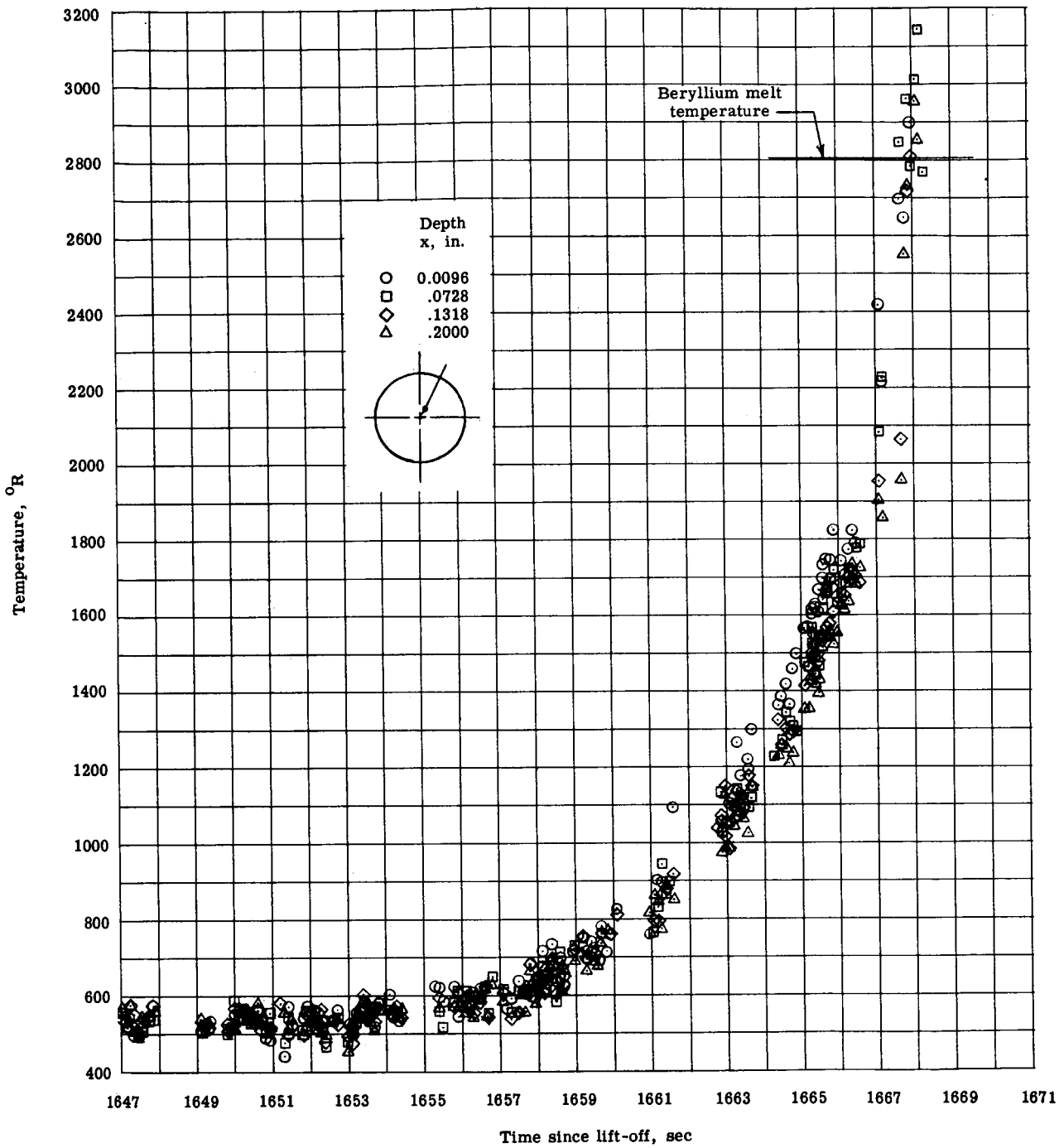
Experimentally measured

Calculated from FIRE data

Known constant

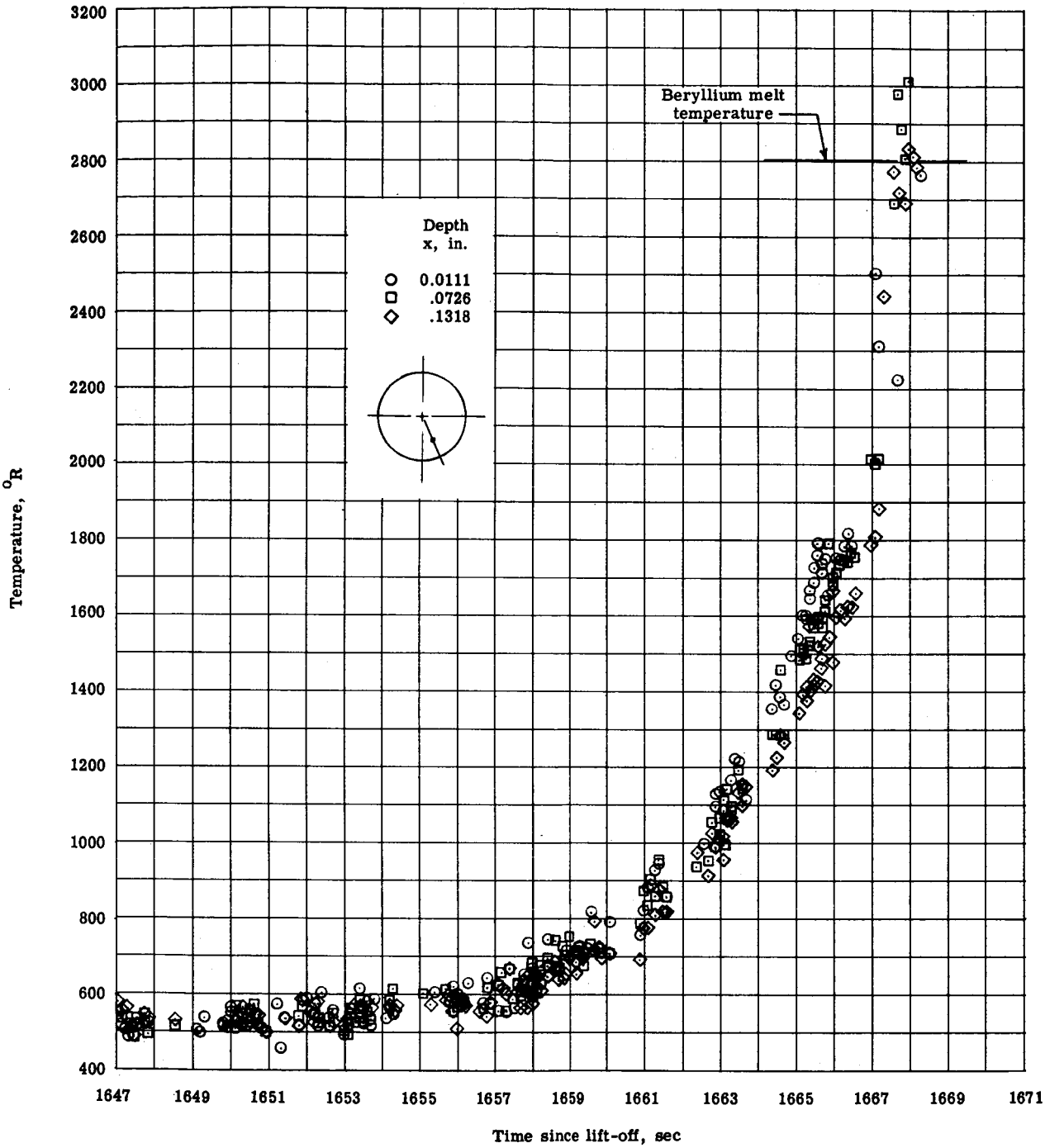
Calculated from FIRE data

Figure 15.- Basic heat balance for a typical forebody calorimeter plug.



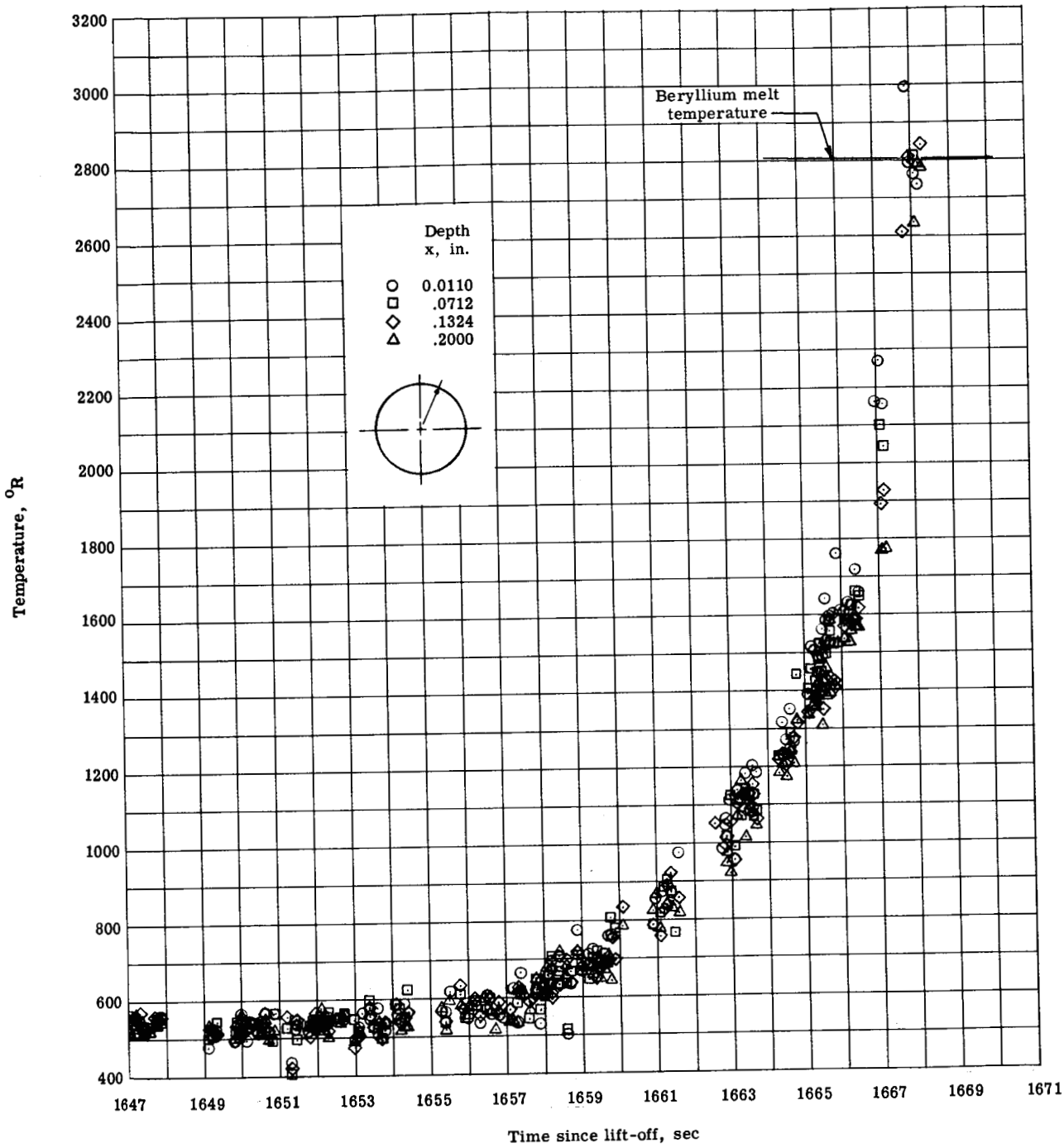
(a) s/R = 0.09; ϕ = 146.25°.

Figure 16.- Temperature-time histories measured in the first forebody beryllium calorimeter shield.



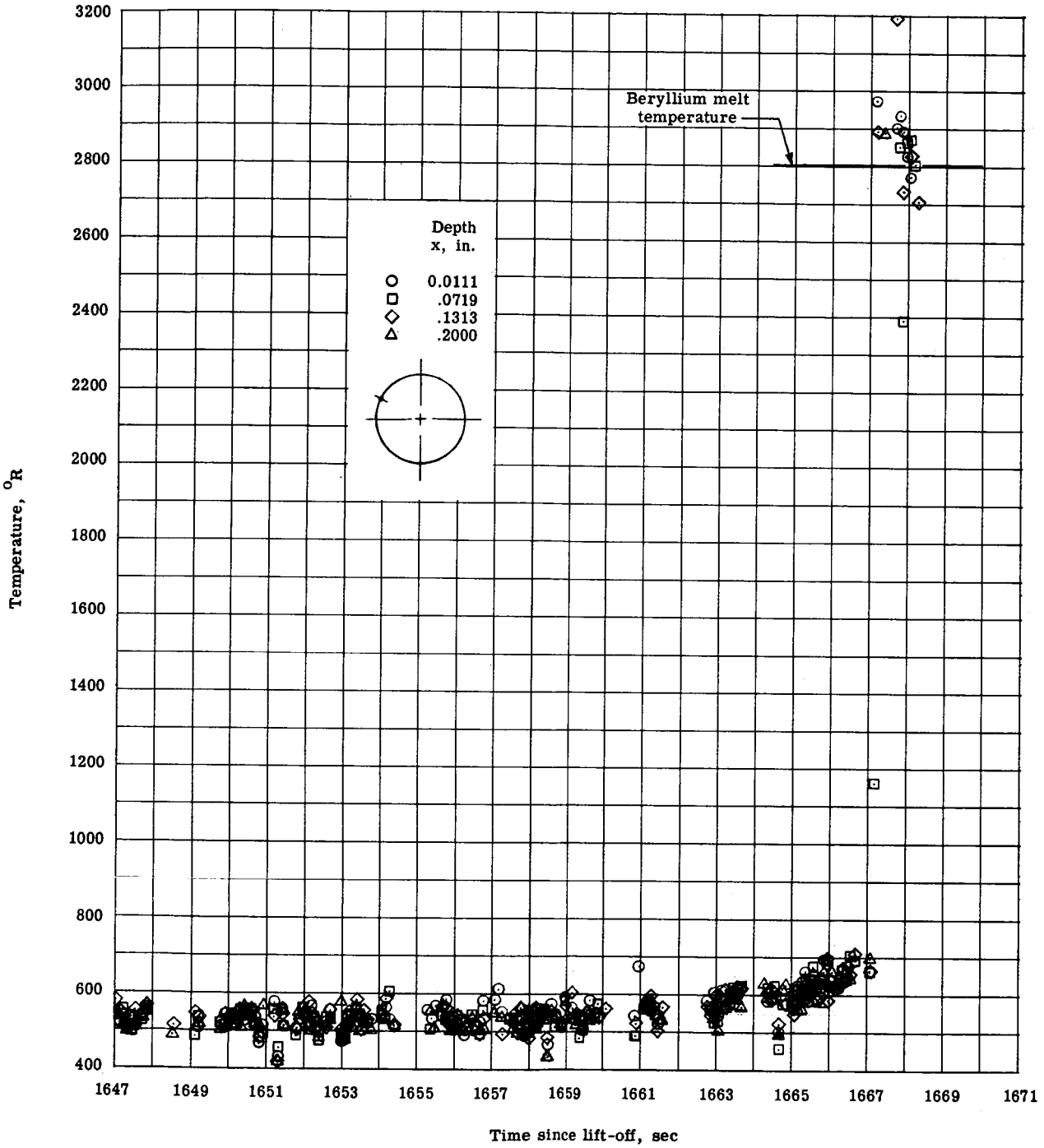
(b) $s/R = 0.55$; $\phi = 33.75^{\circ}$.

Figure 16.- Continued.



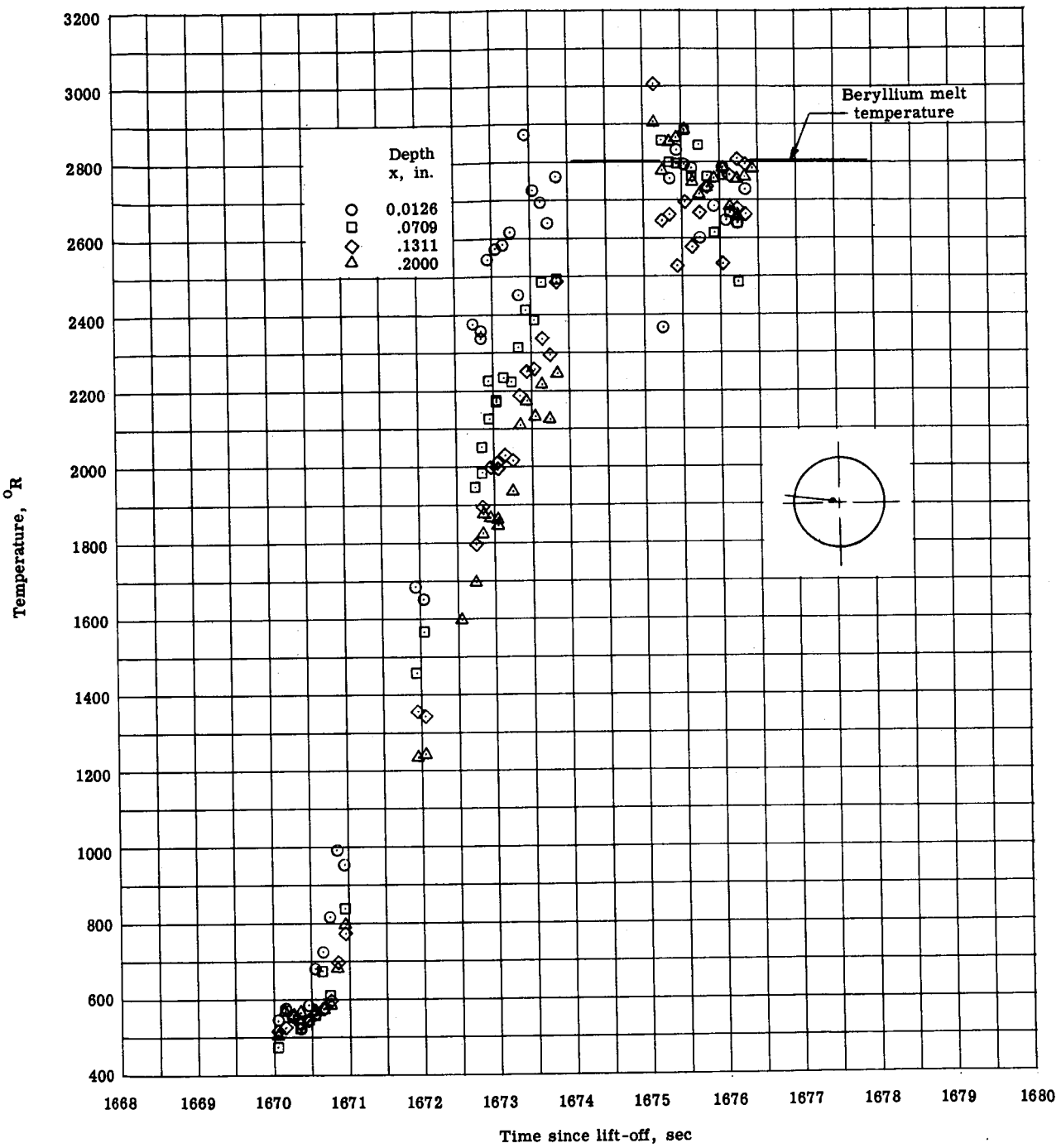
(c) s/R = 0.89; ϕ = 146.25°.

Figure 16.- Continued.



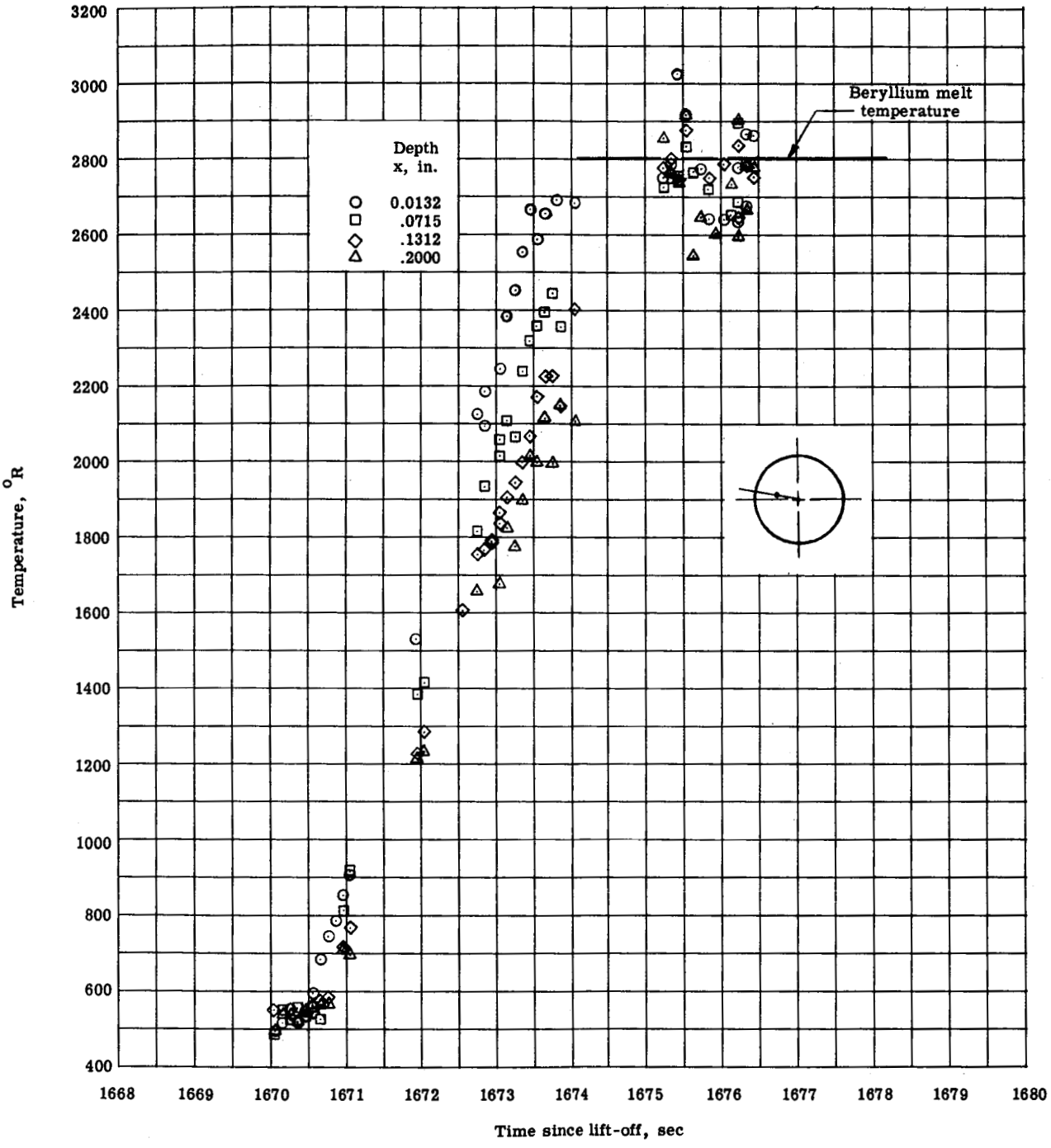
(d) s/R = 1.00; ϕ = 242.00°.

Figure 16.- Concluded.



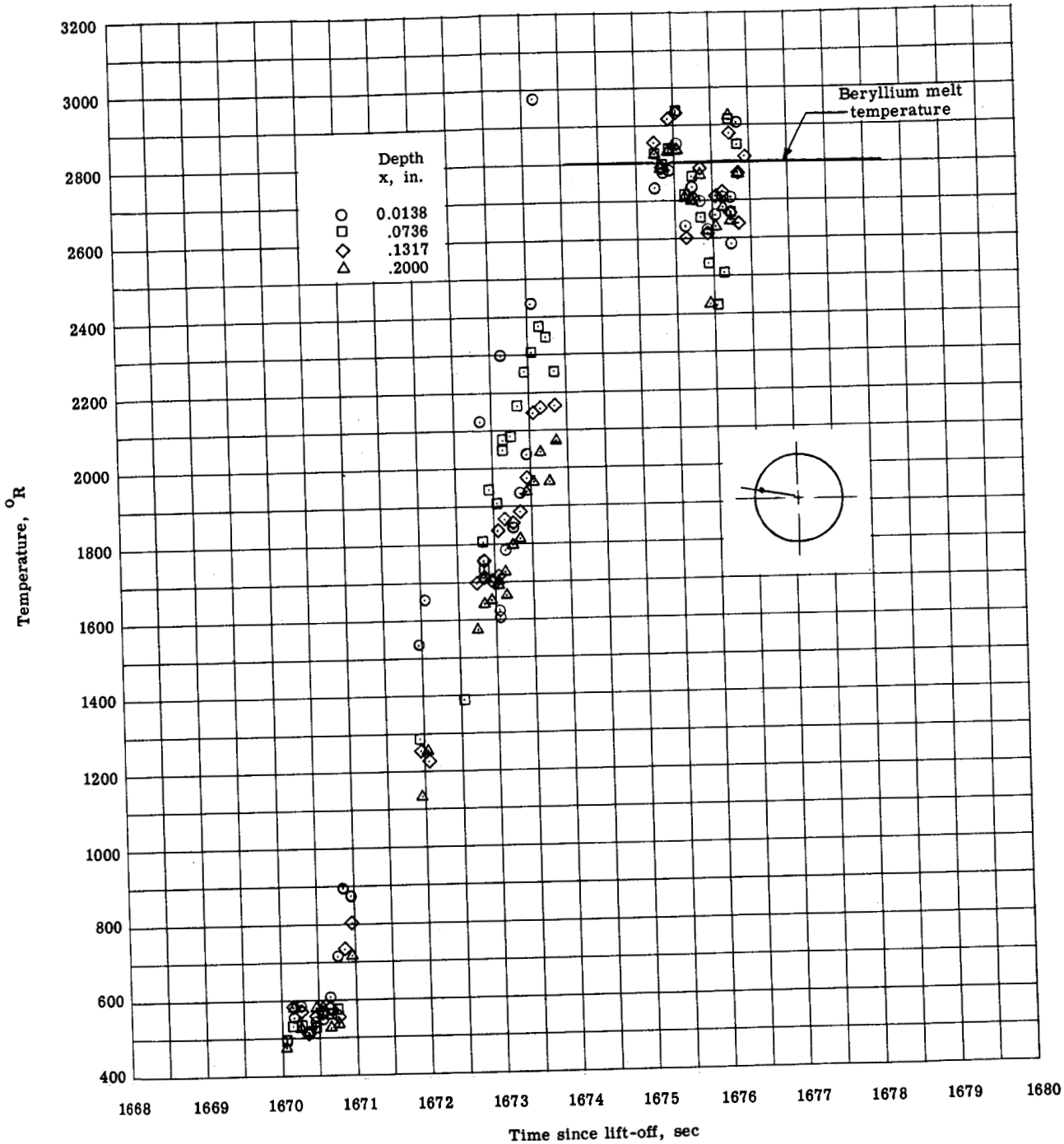
(a) s/R = 0.10; ϕ = 258.75°.

Figure 17.- Temperature-time histories measured in the second forebody beryllium calorimeter shield.



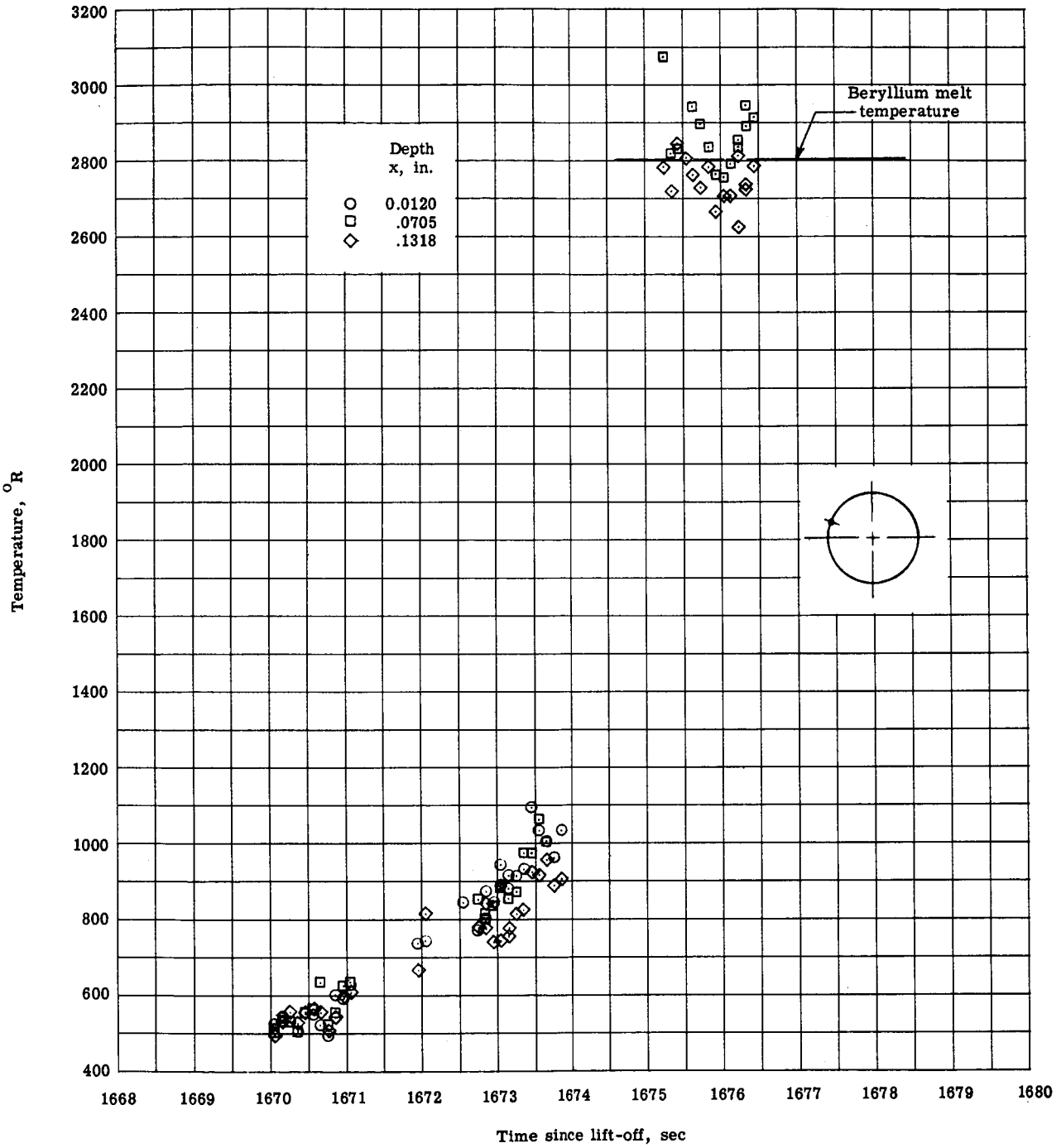
(b) s/R = 0.54; ϕ = 258.75°.

Figure 17.- Continued.



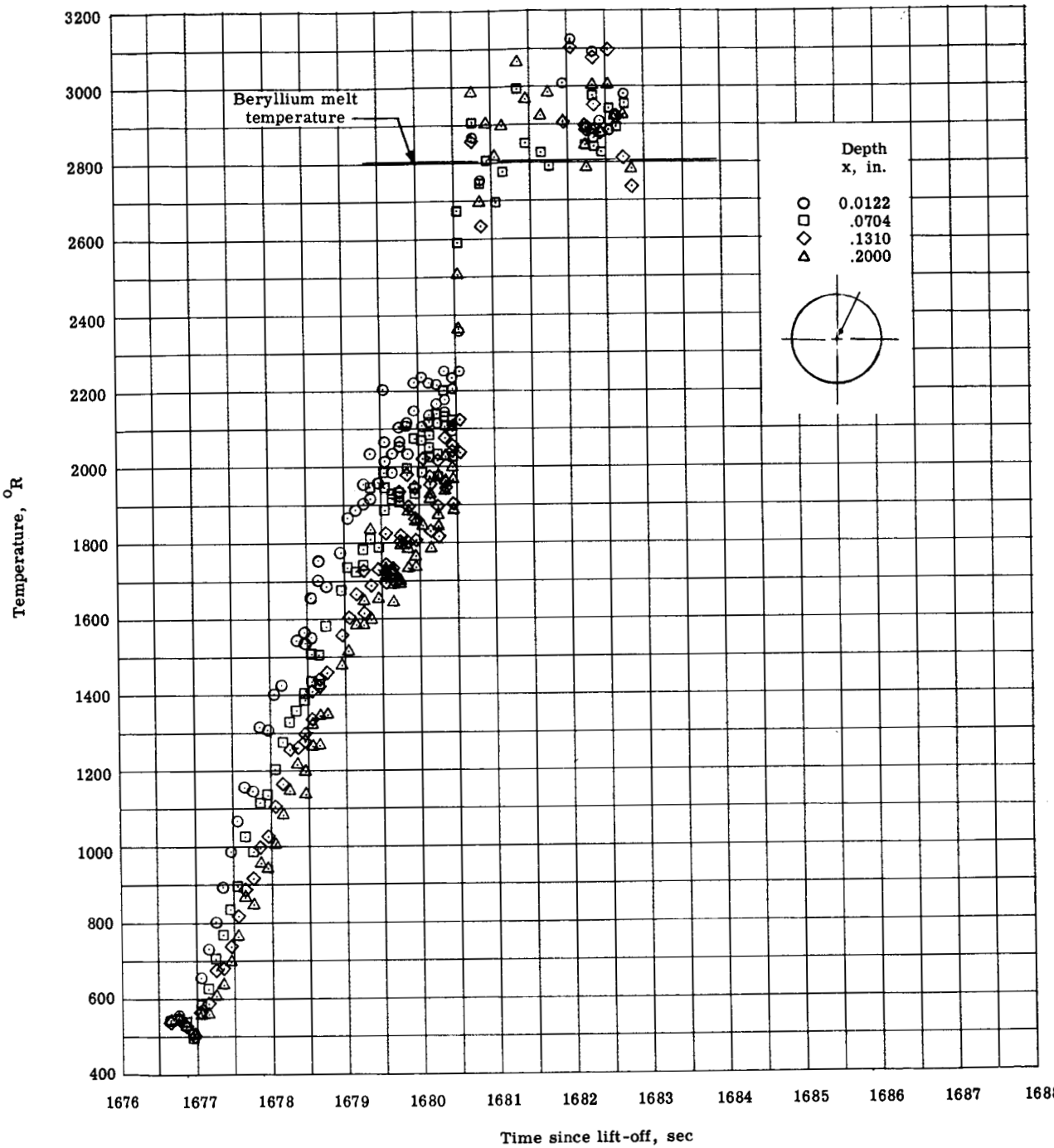
(c) s/R = 0.90; ϕ = 258.75°.

Figure 17.- Continued.



(d) s/R = 1.00; ϕ = 242.00°.

Figure 17.- Concluded.



(a) s/R = 0.10; ϕ = 146.25°.

Figure 18.- Temperature-time histories measured in the third forebody beryllium calorimeter shield.

[redacted]

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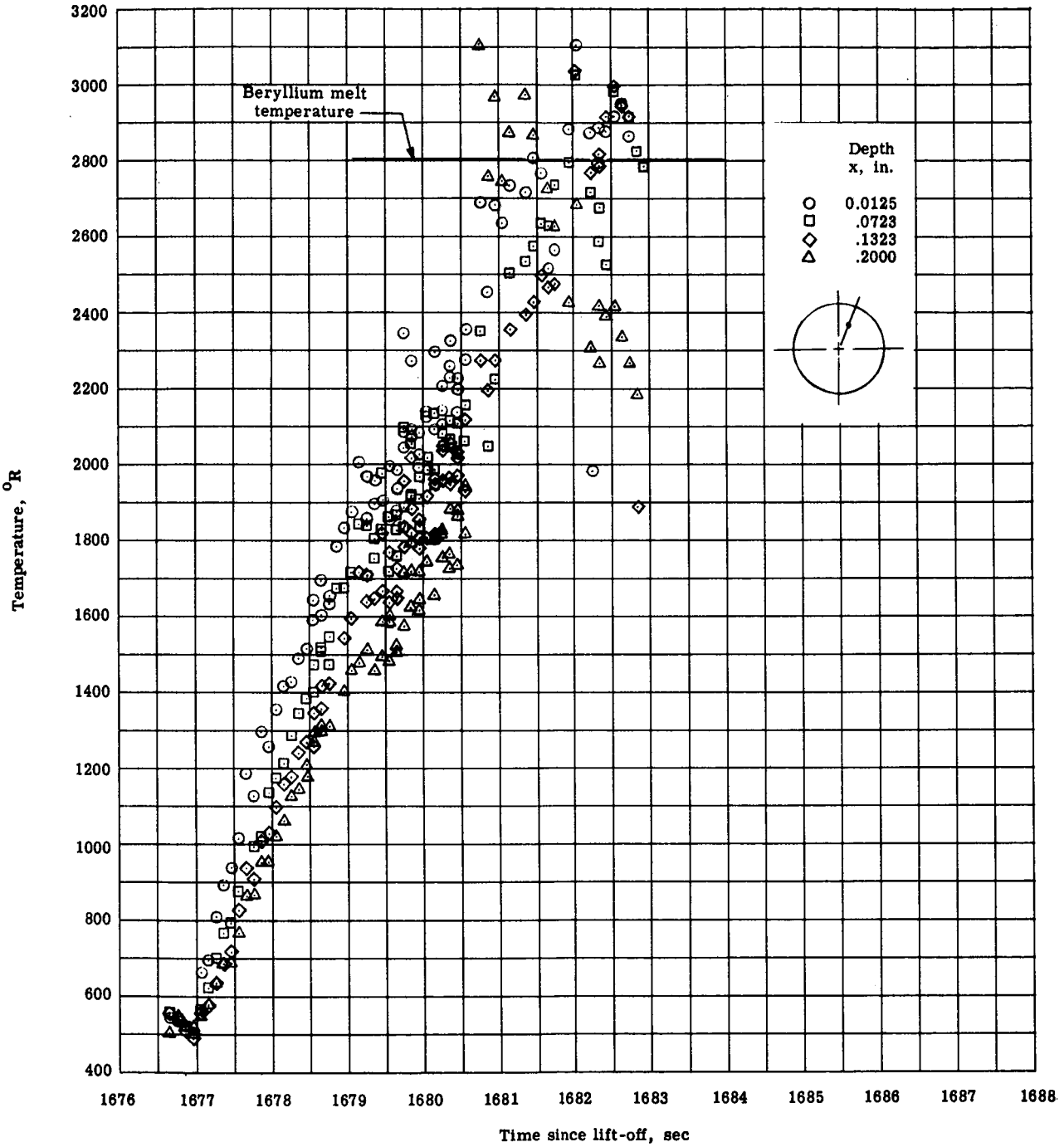
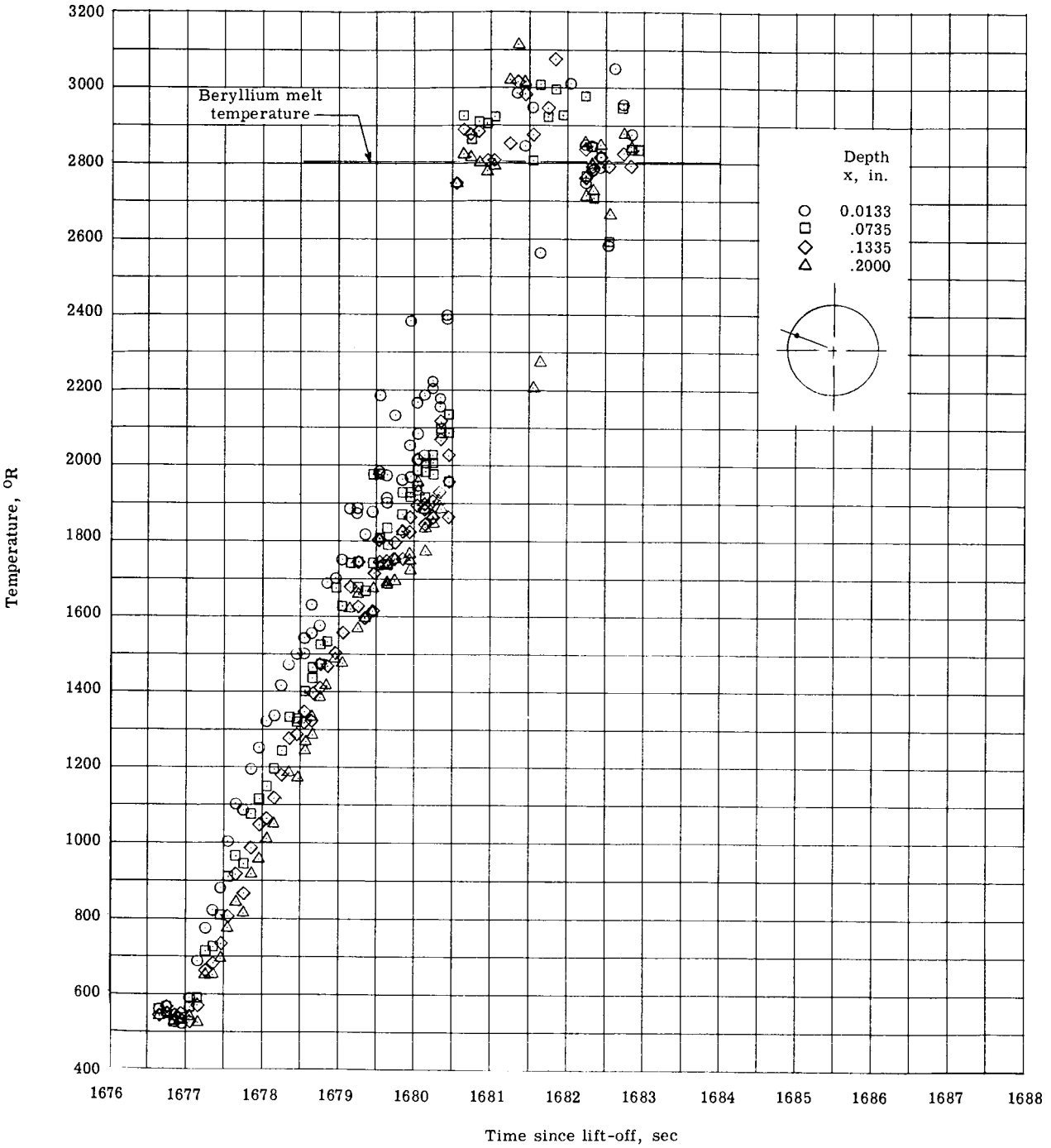


(b) $s/R = 0.57$; $\phi = 146.25^{\circ}$.

Figure 18.- Continued.

[redacted]

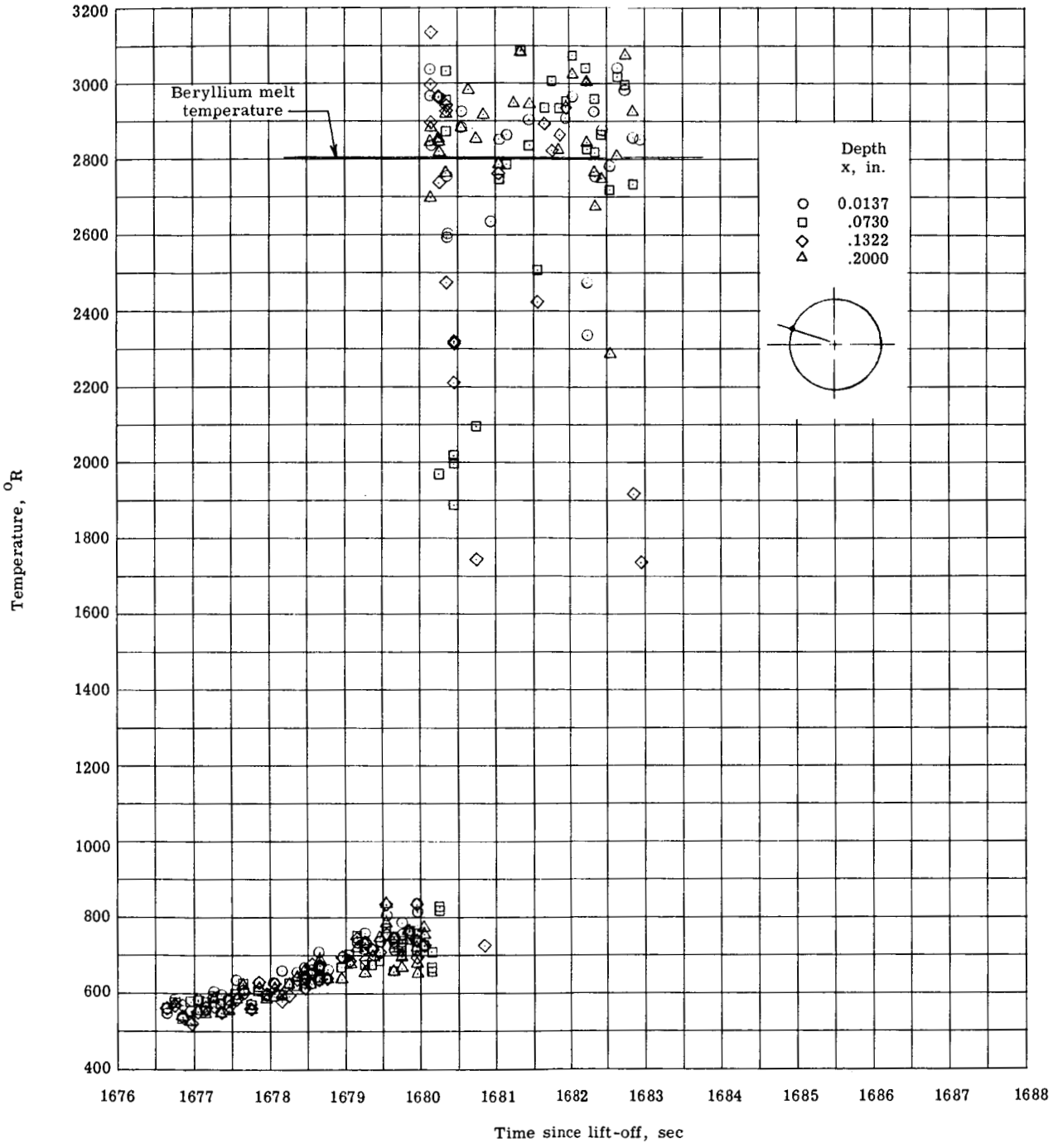
[redacted]



(c) s/R = 0.87; ϕ = 242.00°.

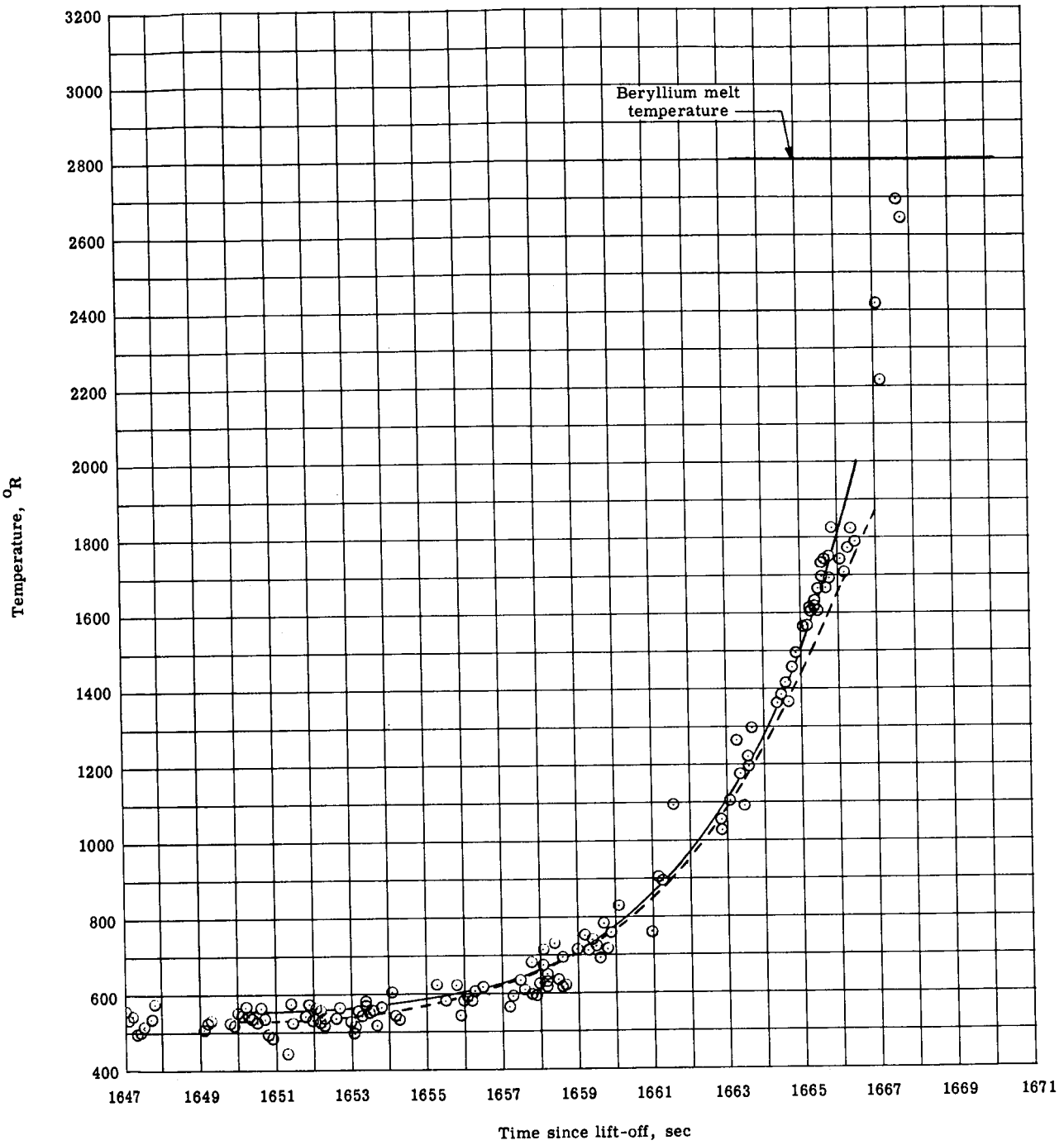
Figure 18.- Continued.

[redacted]



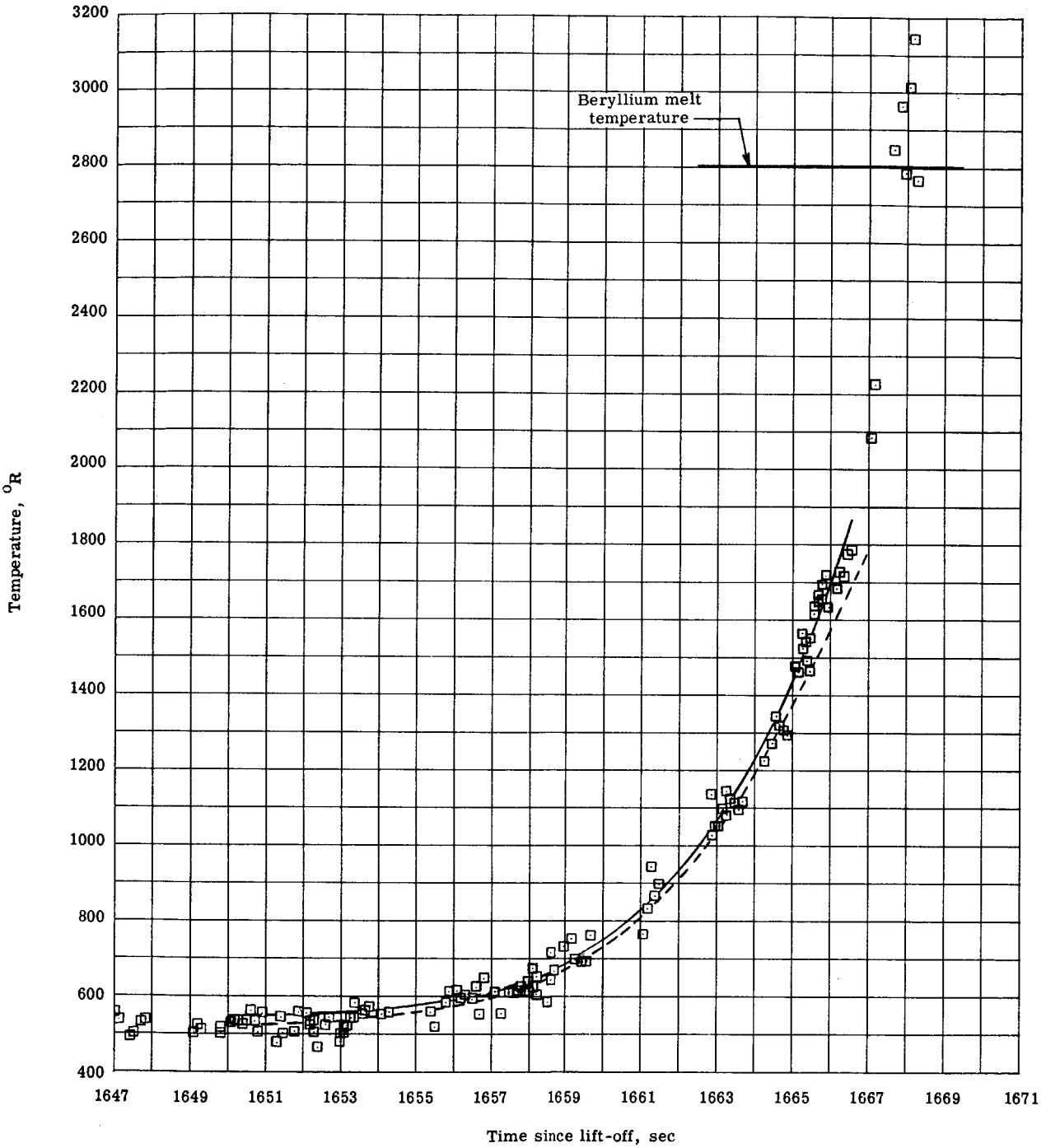
(d) s/R = 1.00; ϕ = 242.00°.

Figure 18.- Concluded.



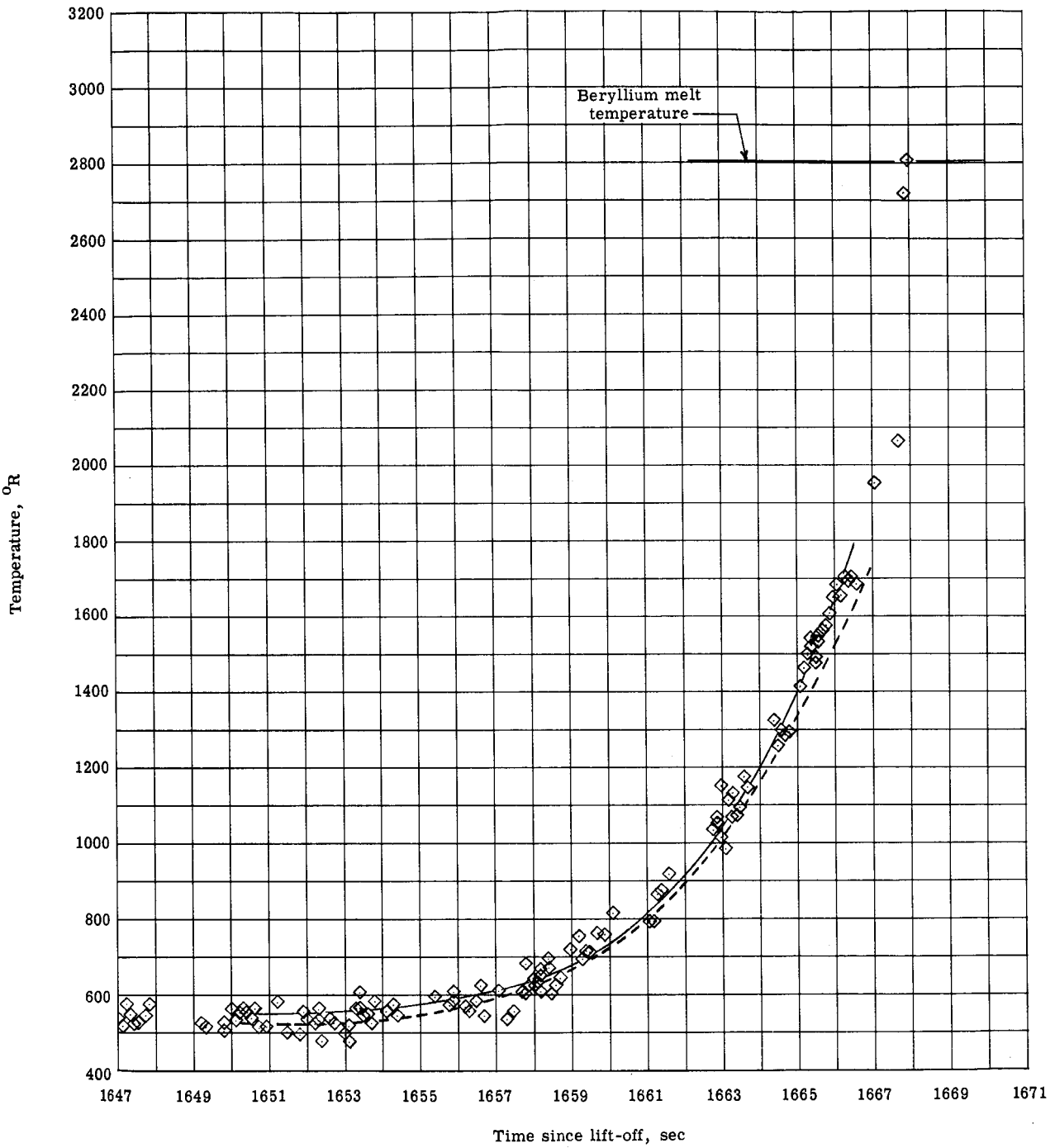
(a) s/R = 0.09; ϕ = 146.25°; x = 0.0096 in.

Figure 19.- Temperature-time data and curve fit representation for individual thermocouples in the first forebody beryllium calorimeter shield.



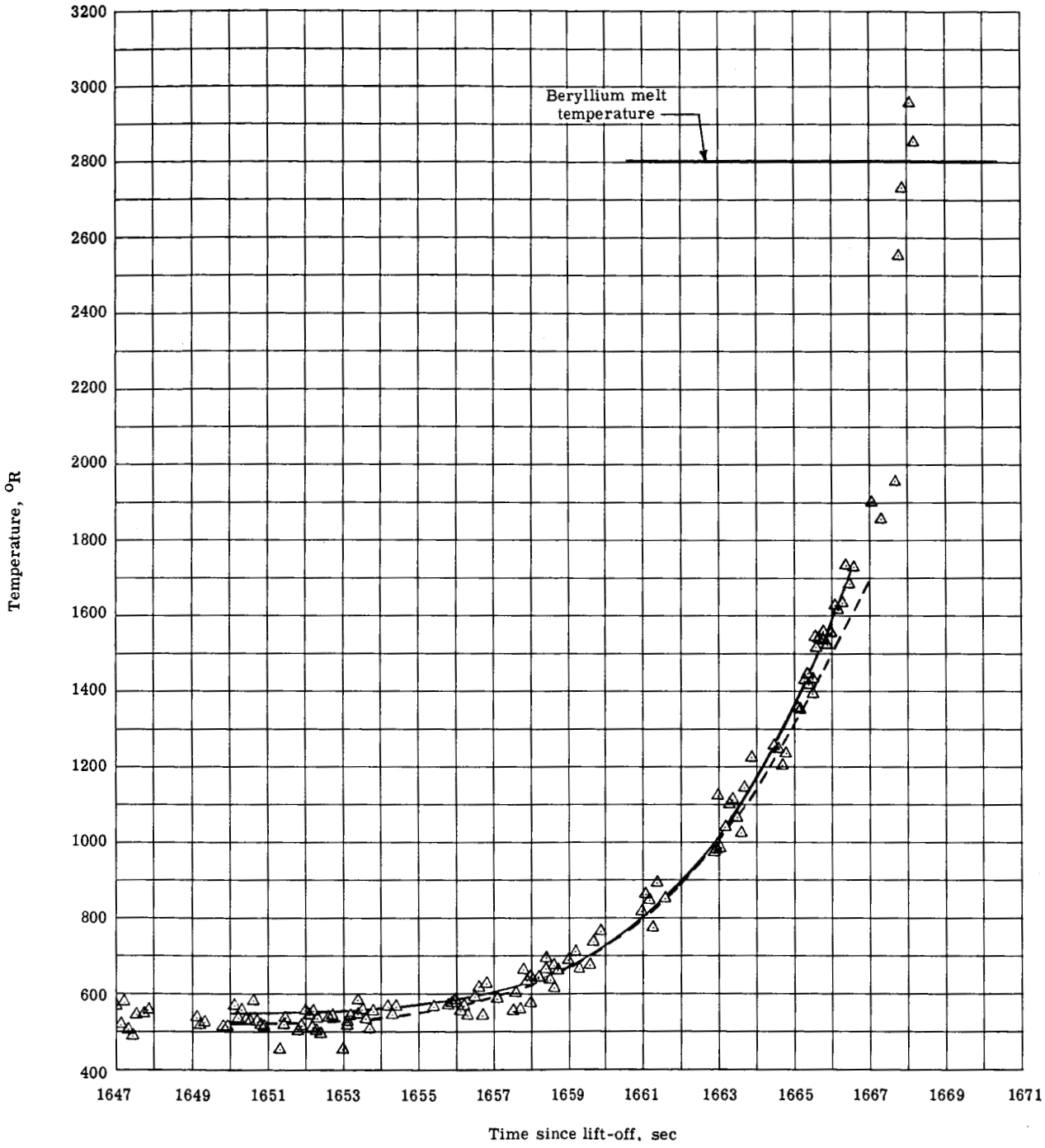
(b) s/R = 0.09; ∅ = 146.25°; x = 0.0728 in.

Figure 19.- Continued.



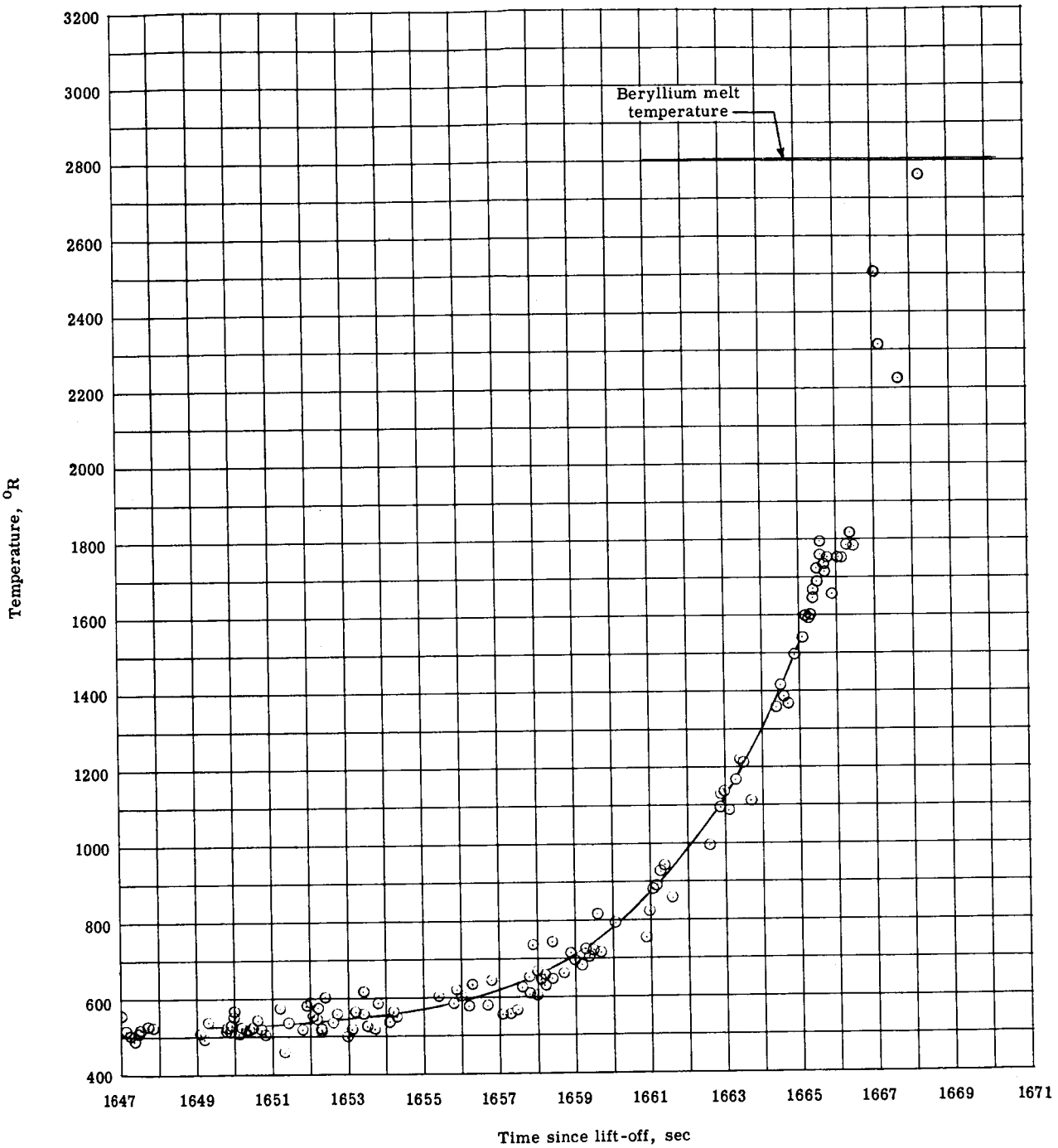
(c) s/R = 0.09; ϕ = 146.25°; x = 0.1318 in.

Figure 19.- Continued.



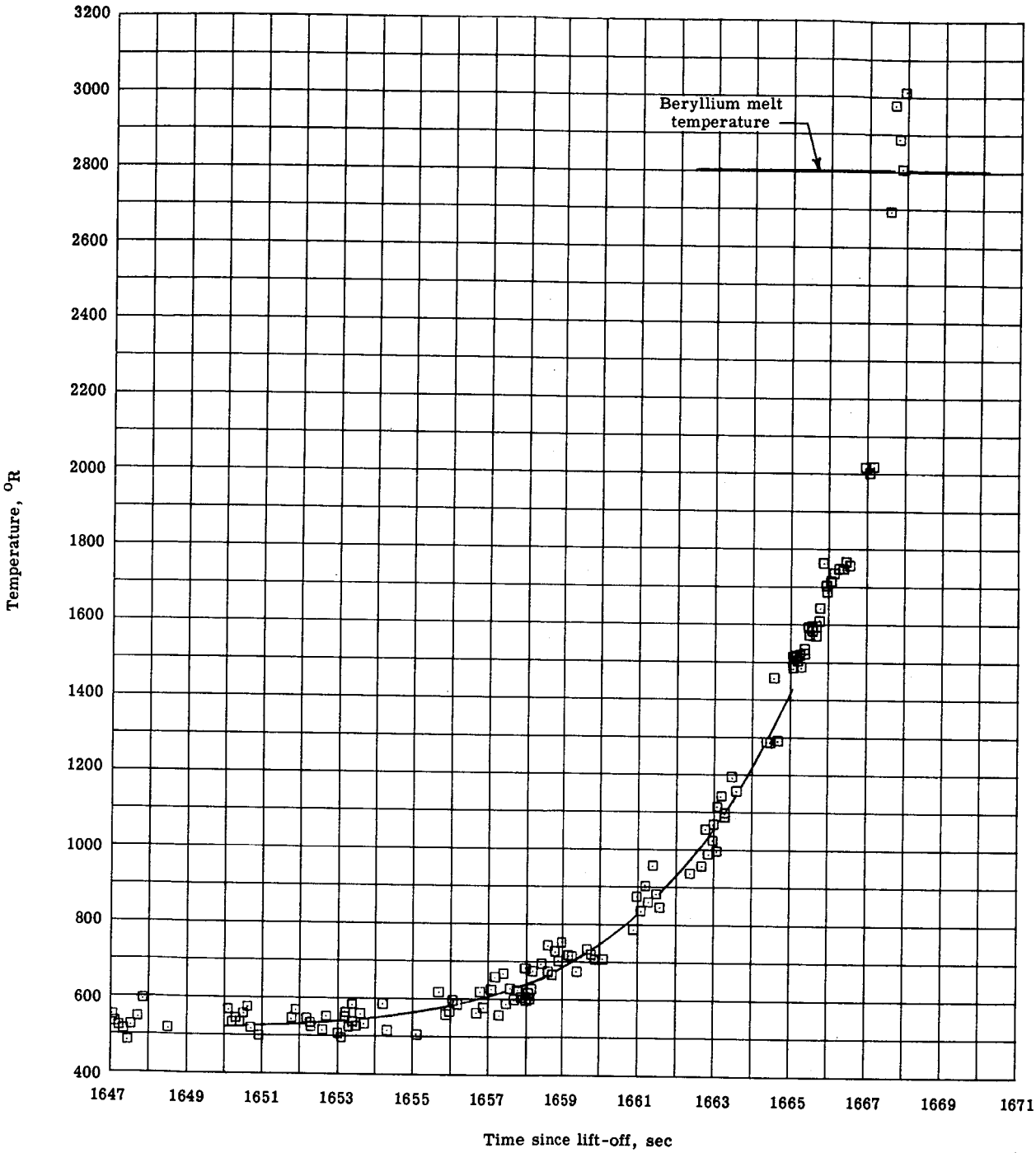
(d) s/R = 0.09; ϕ = 146.25°; x = 0.2000 in.

Figure 19.- Continued.



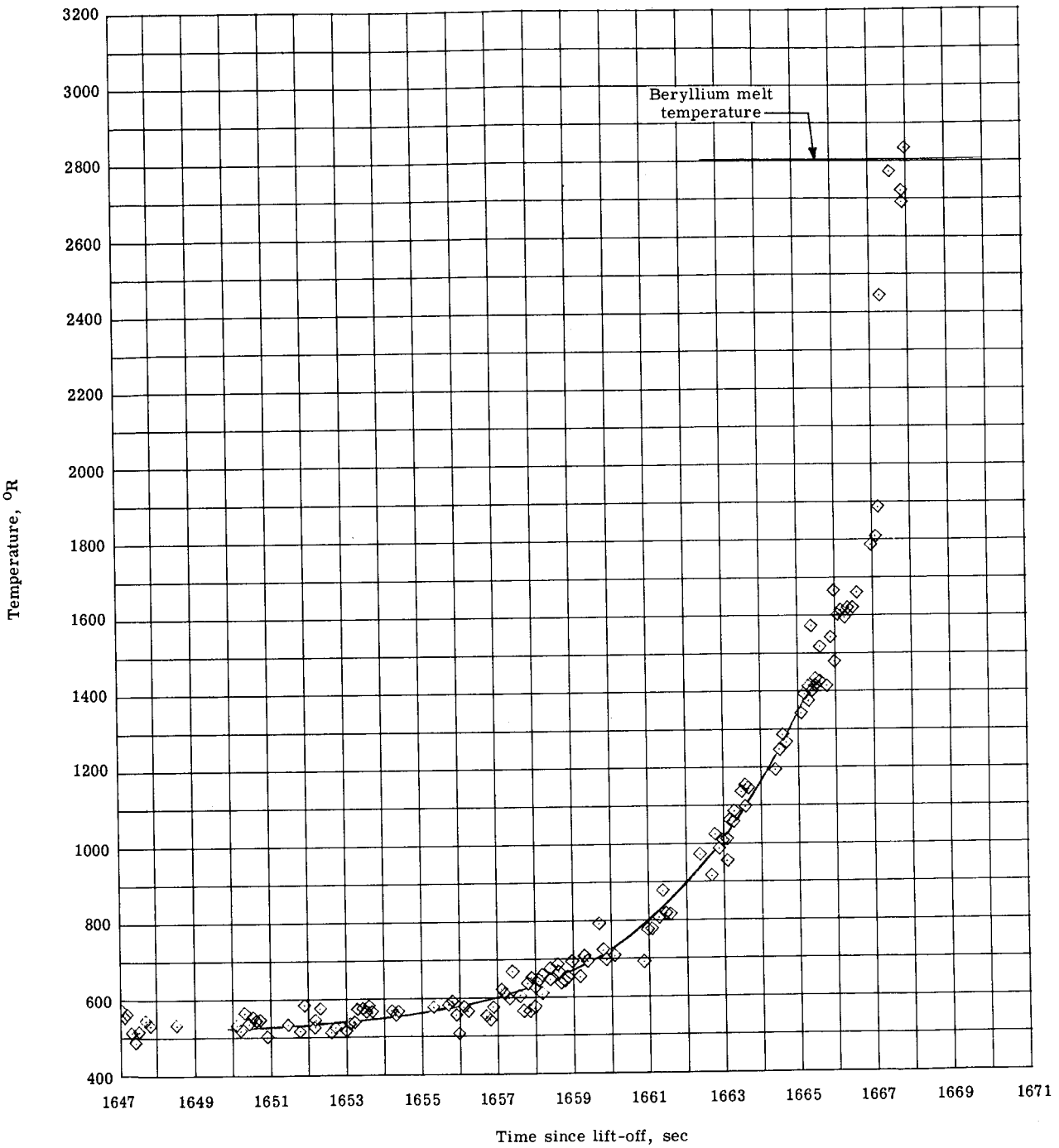
(e) s/R = 0.55; ϕ = 33.75°; x = 0.0111 in.

Figure 19.- Continued.



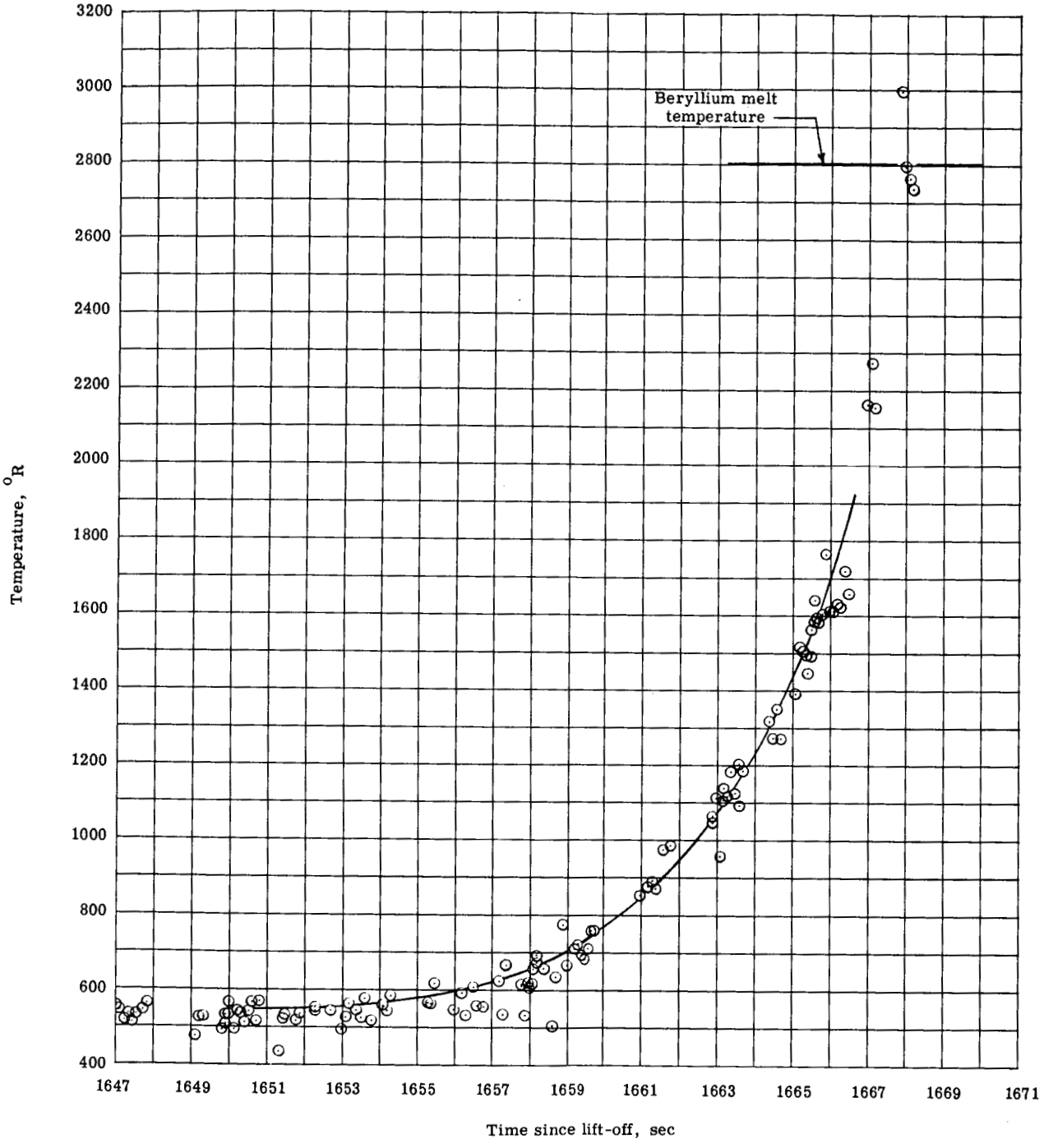
(f) s/R = 0.55; ϕ = 33.75°; x = 0.0726 in.

Figure 19.- Continued.



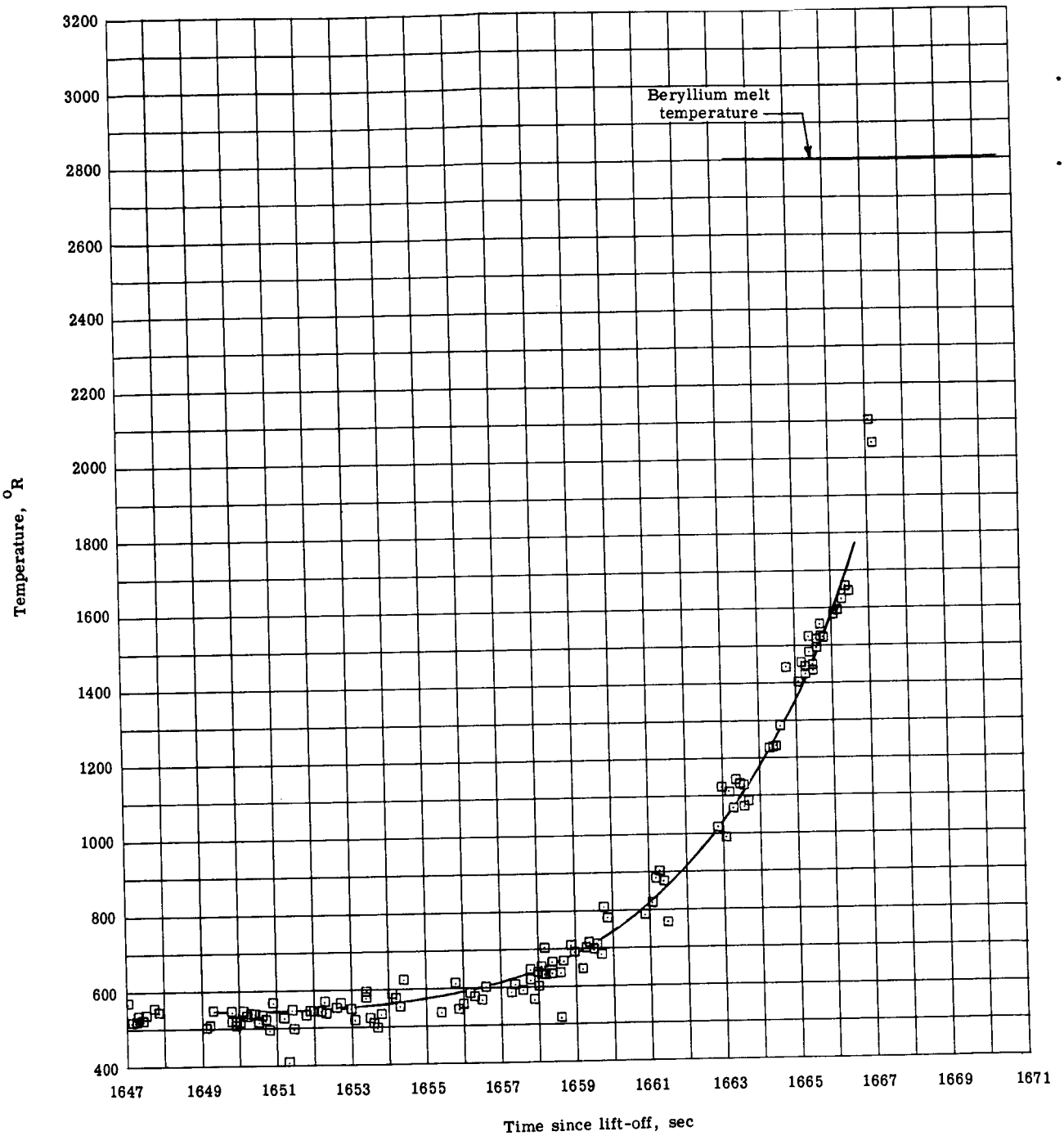
(g) s/R = 0.55; ϕ = 33.75°; x = 0.1318 in.

Figure 19.- Continued.



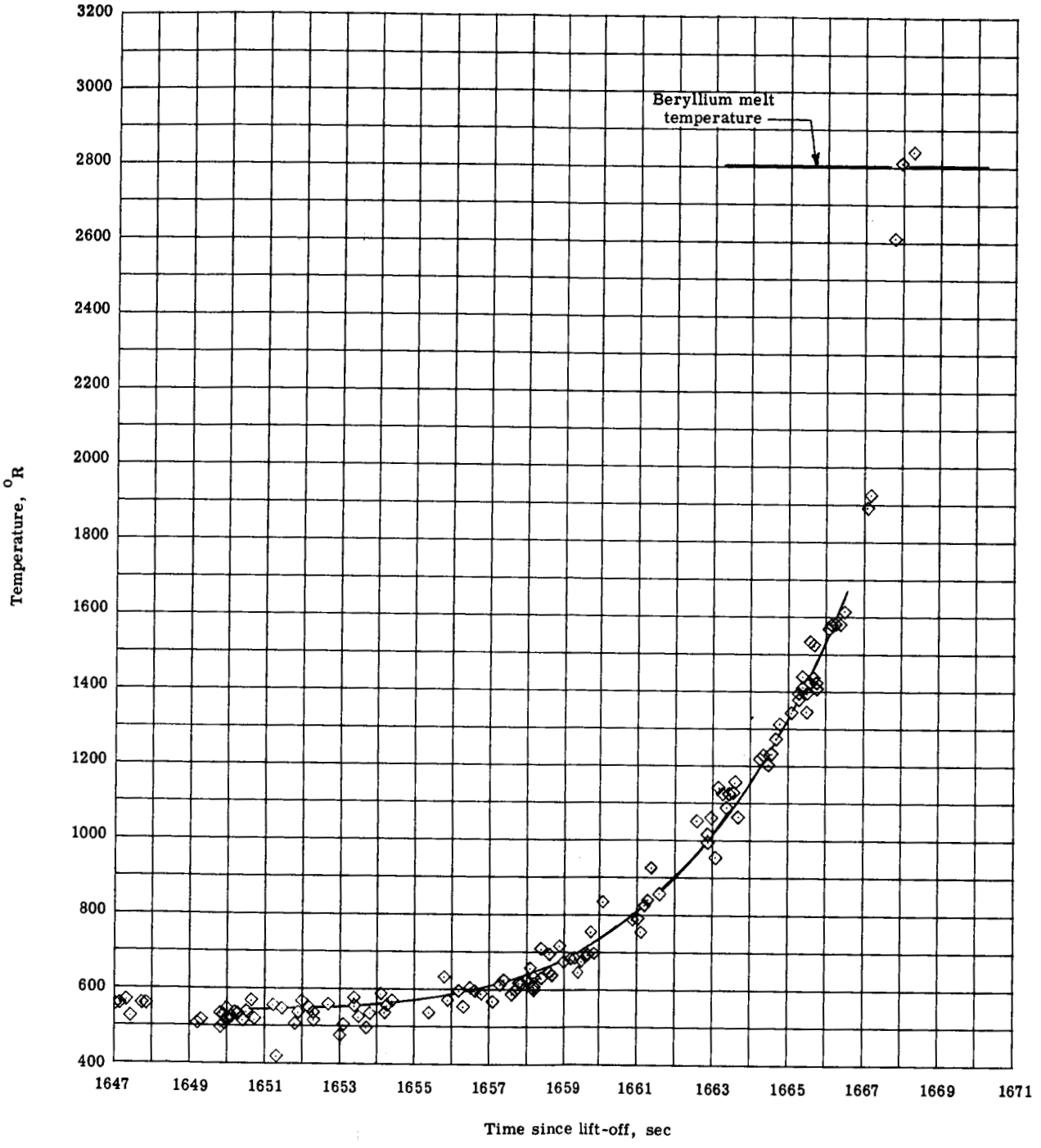
(h) s/R = 0.89; ϕ = 146.25°; x = 0.0110 in.

Figure 19.- Continued.



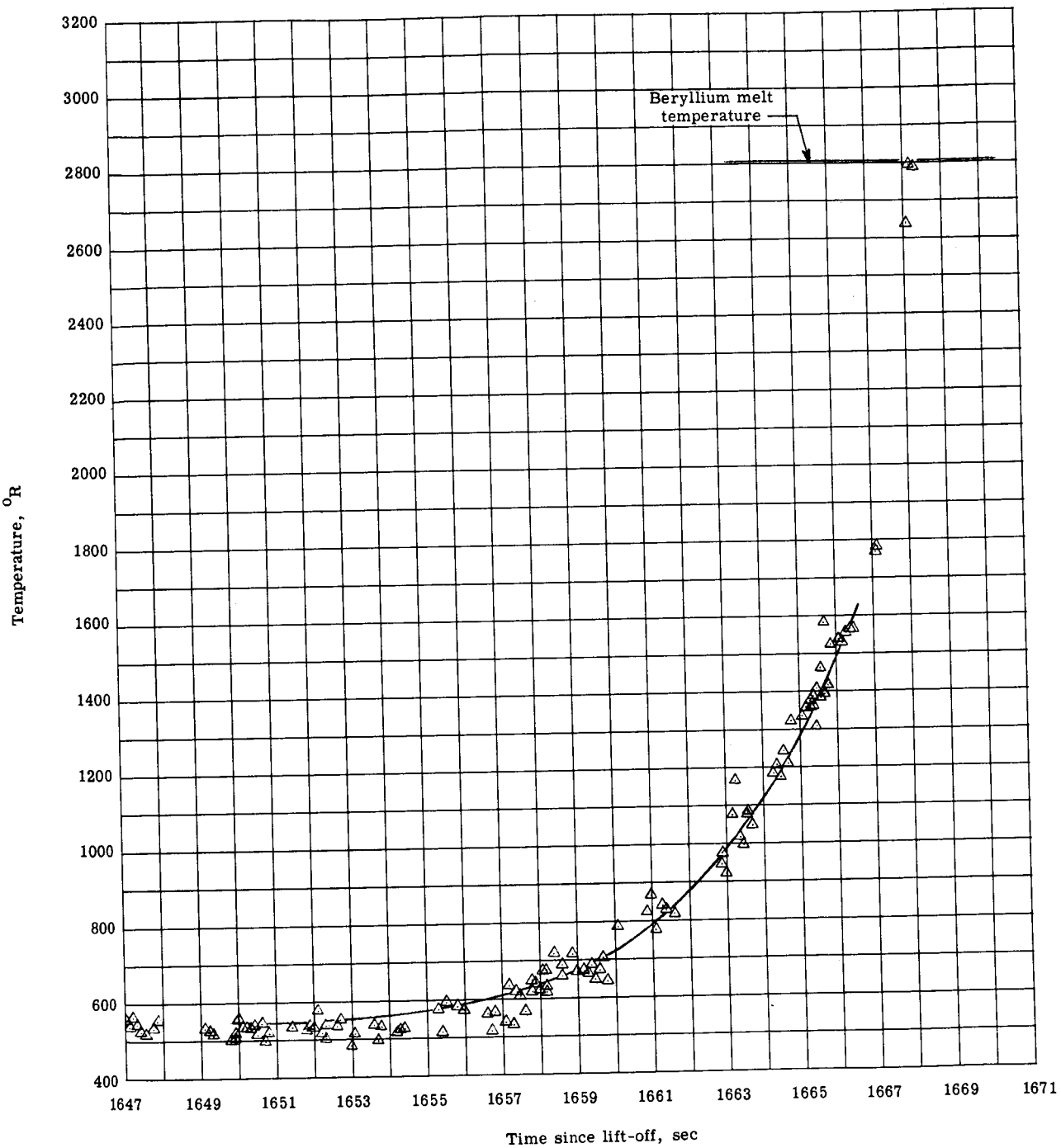
(i) s/R = 0.89; ϕ = 146.25°; x = 0.0712 in.

Figure 19.- Continued.



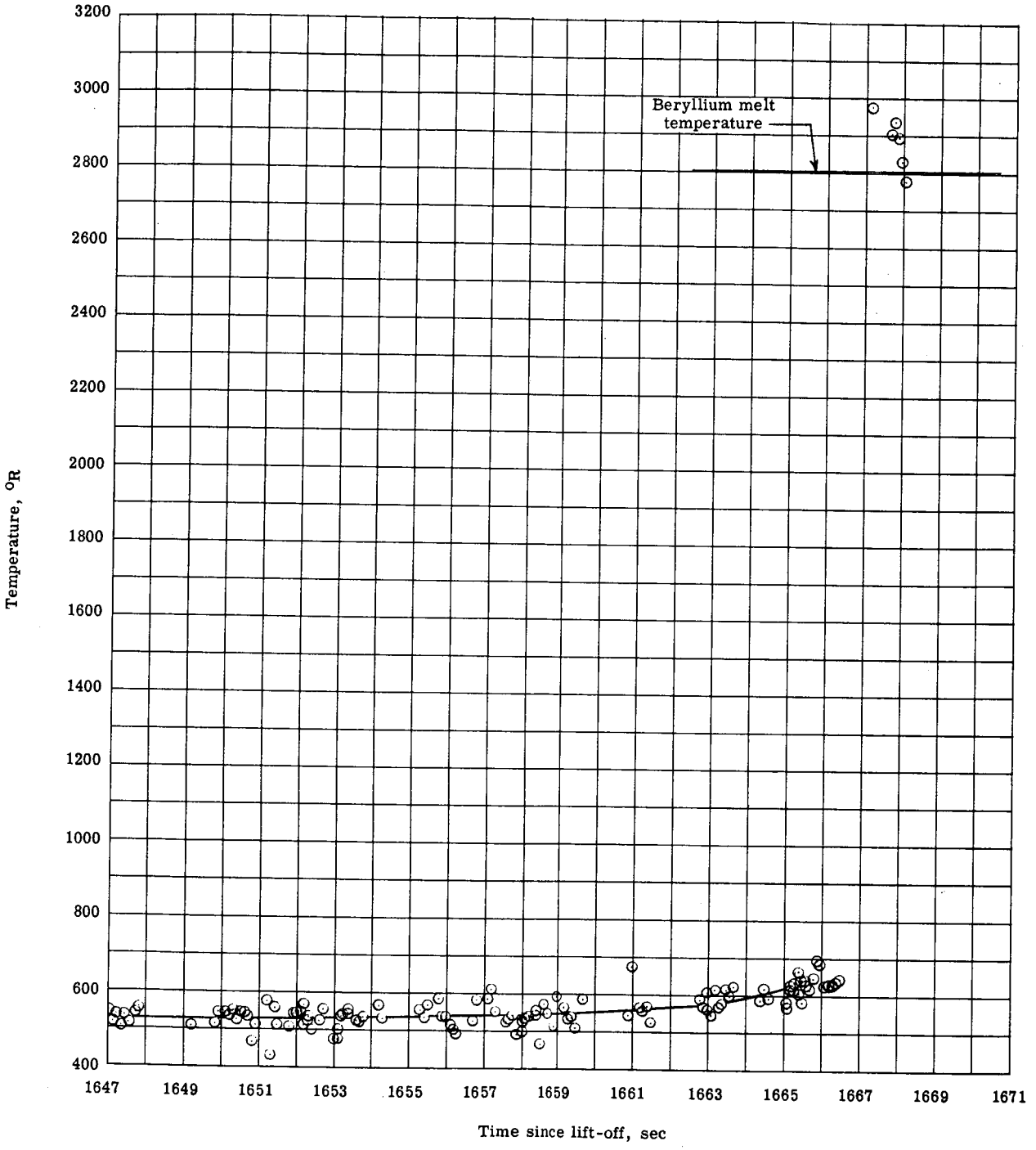
(j) s/R = 0.89; ϕ = 146.25°; x = 0.1324 in.

Figure 19.- Continued.



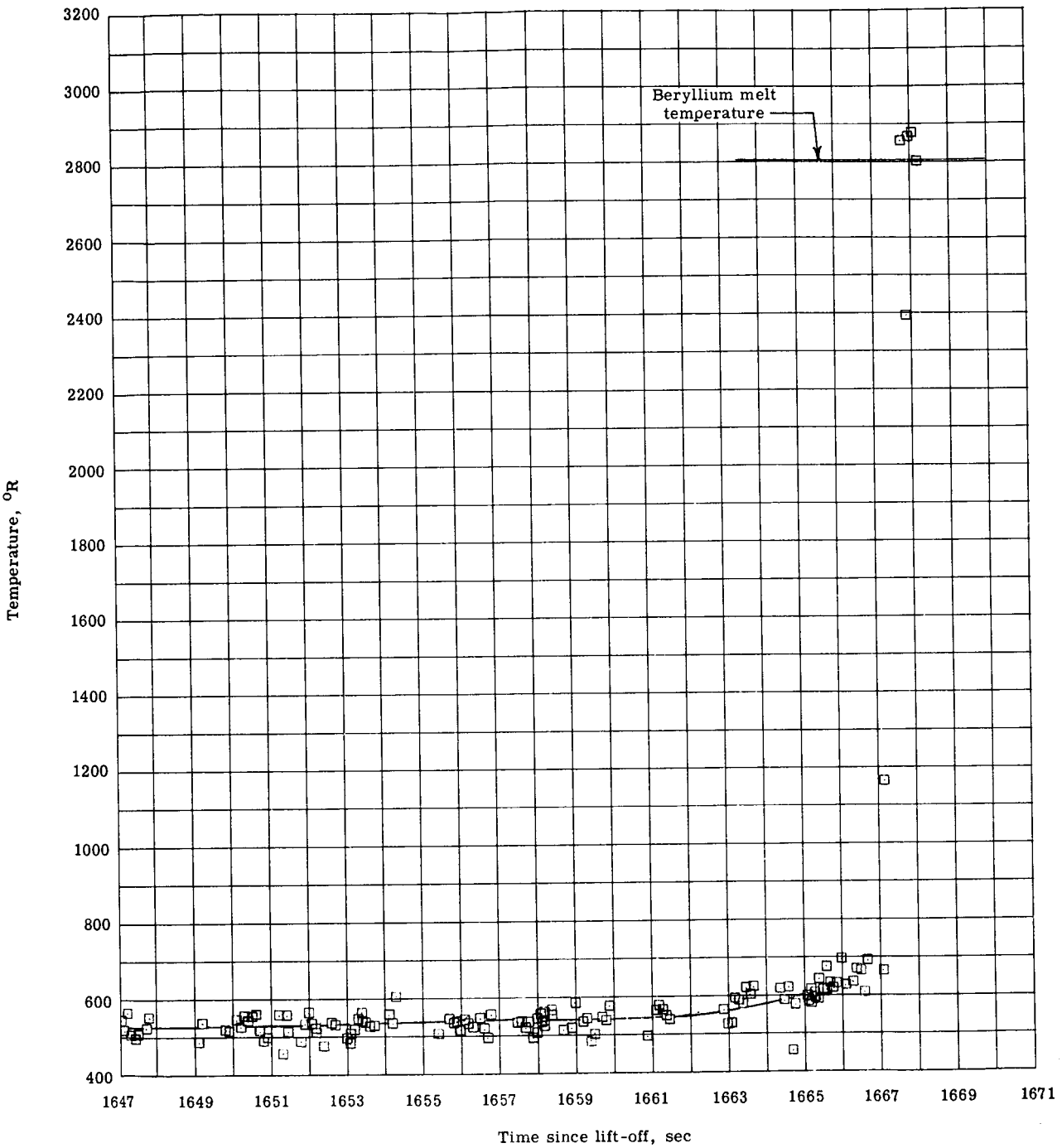
(k) s/R = 0.89; ϕ = 146.25°; x = 0.2000 in.

Figure 19.- Continued.



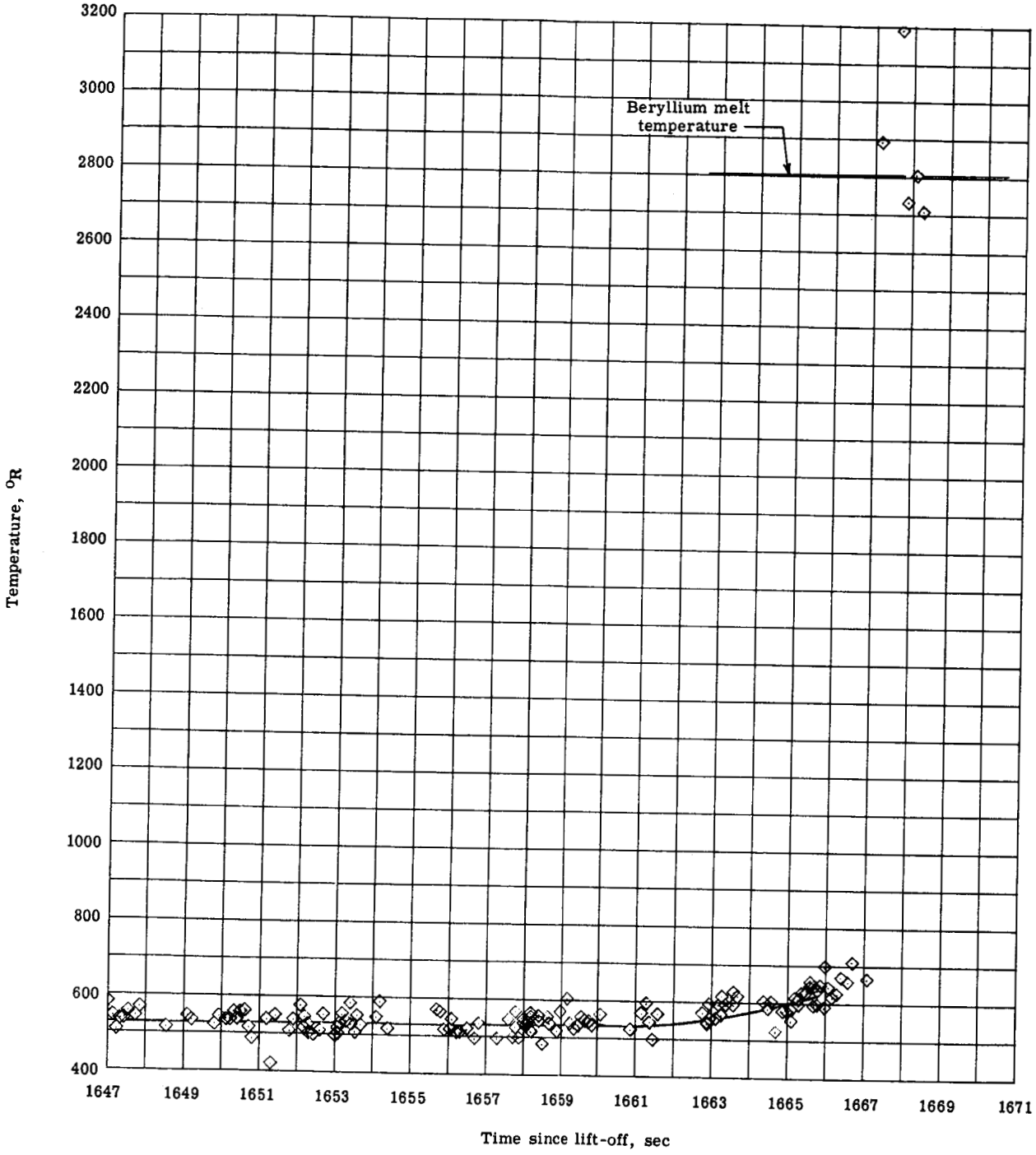
(l) s/R = 1.00; ϕ = 242.00°; x = 0.0111 in.

Figure 19.- Continued.



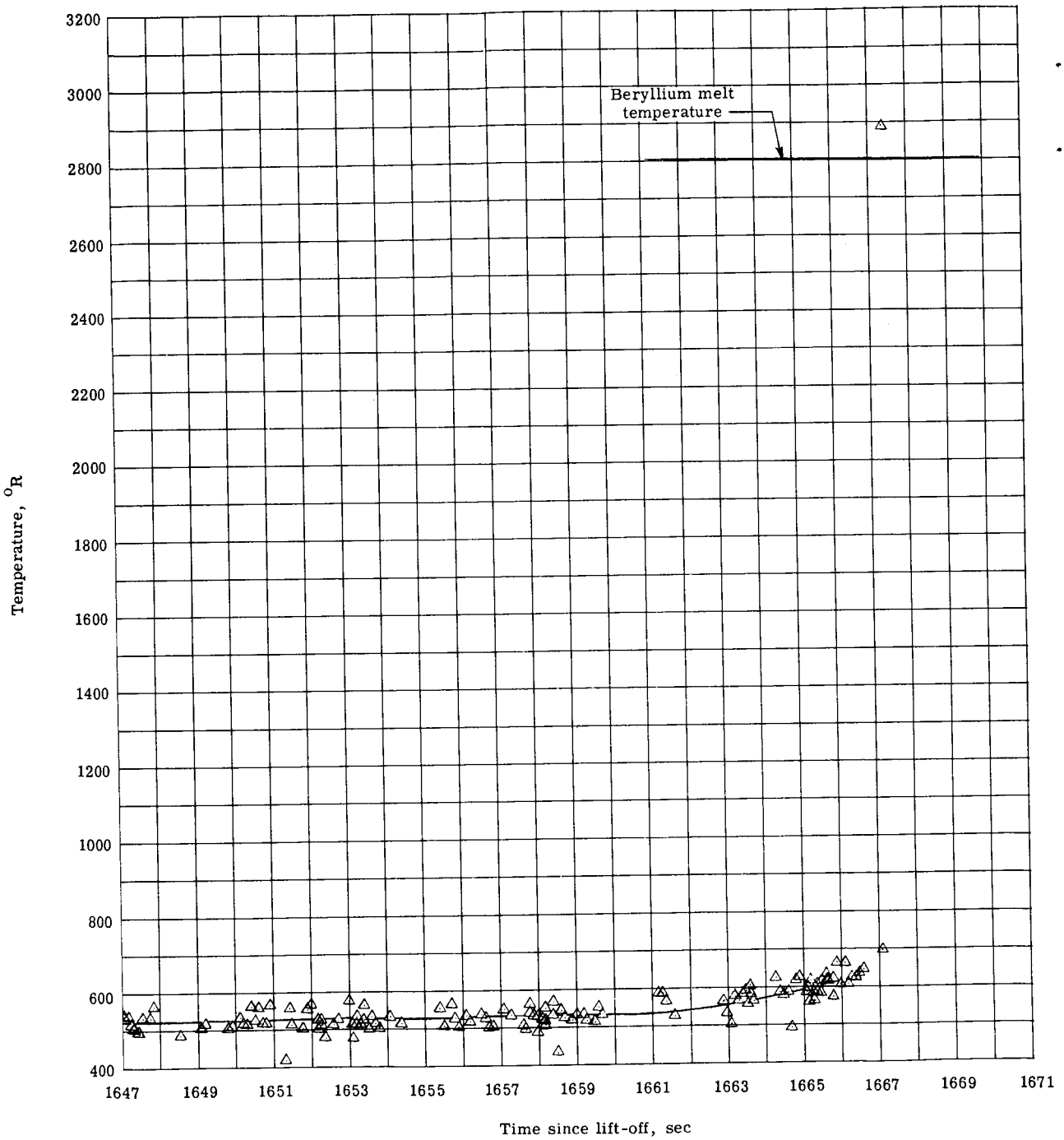
(m) s/R = 1.00; ϕ = 242.00°; x = 0.0719 in.

Figure 19.- Continued.



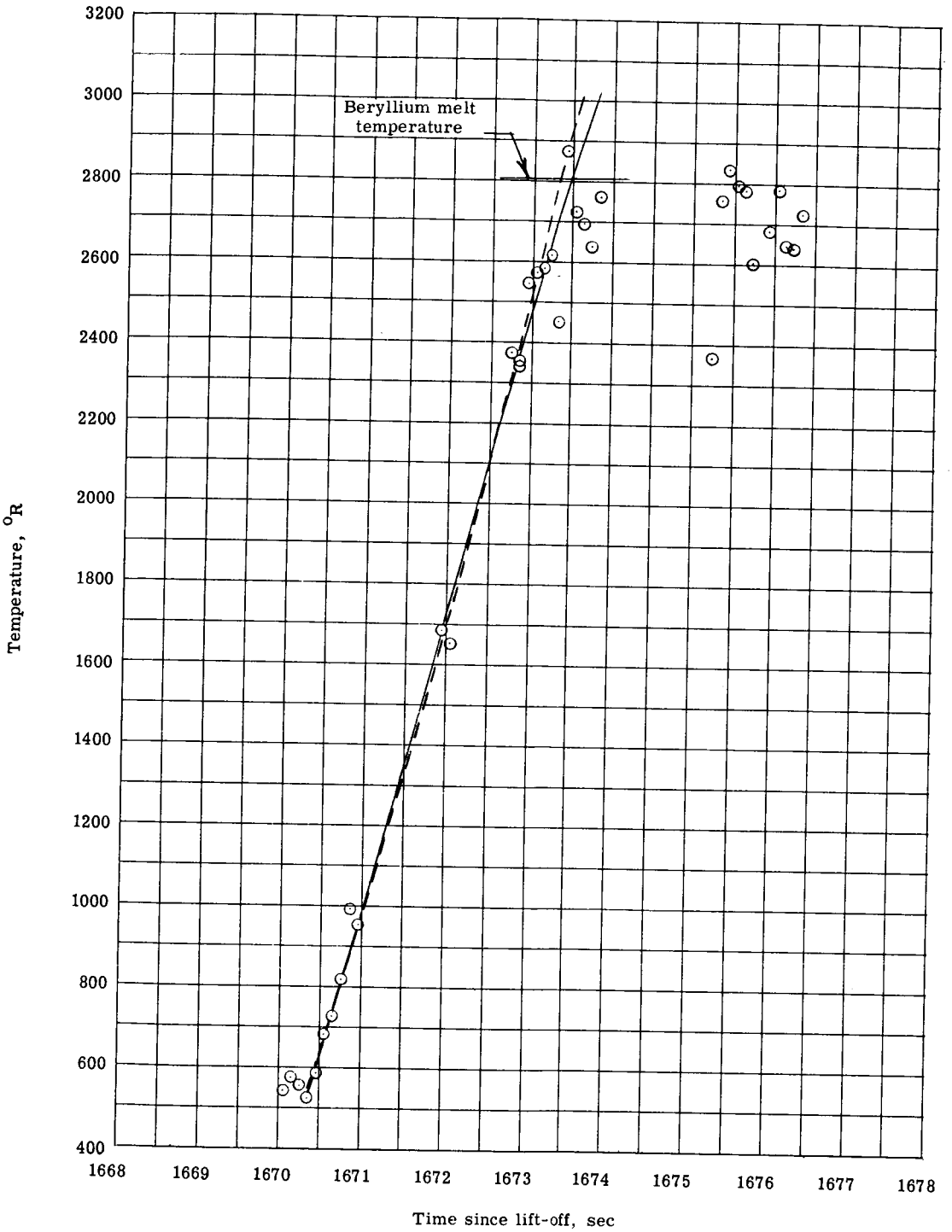
(n) s/R = 1.00; ϕ = 242.00°; x = 0.1313 in.

Figure 19.- Continued.



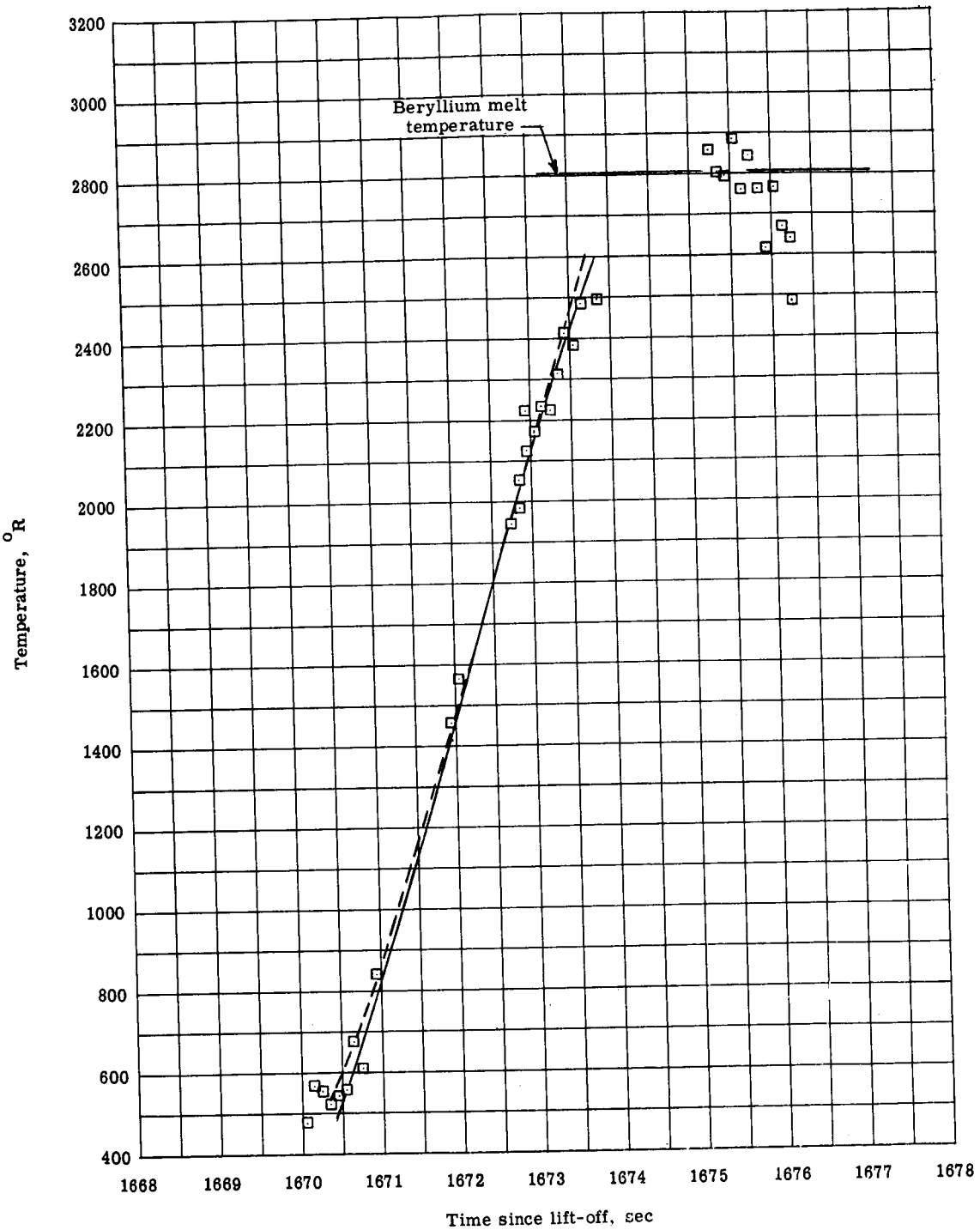
(o) s/R = 1.00; ϕ = 242.00°; x = 0.2000 in.

Figure 19.- Concluded.



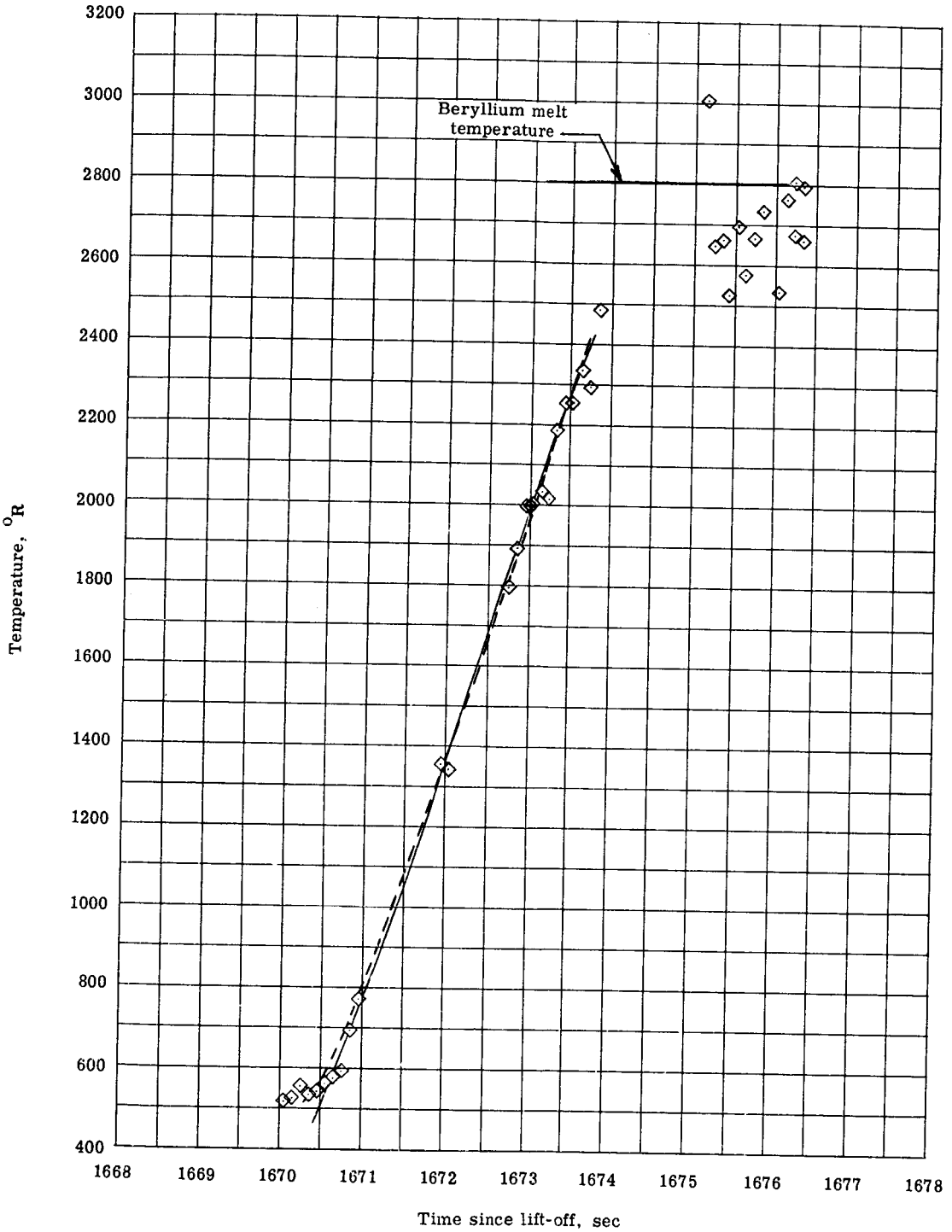
(a) s/R = 0.10; ϕ = 258.75°; x = 0.0126 in.

Figure 20.- Temperature-time data and curve fit representation for individual thermocouples in the second forebody beryllium calorimeter shield.



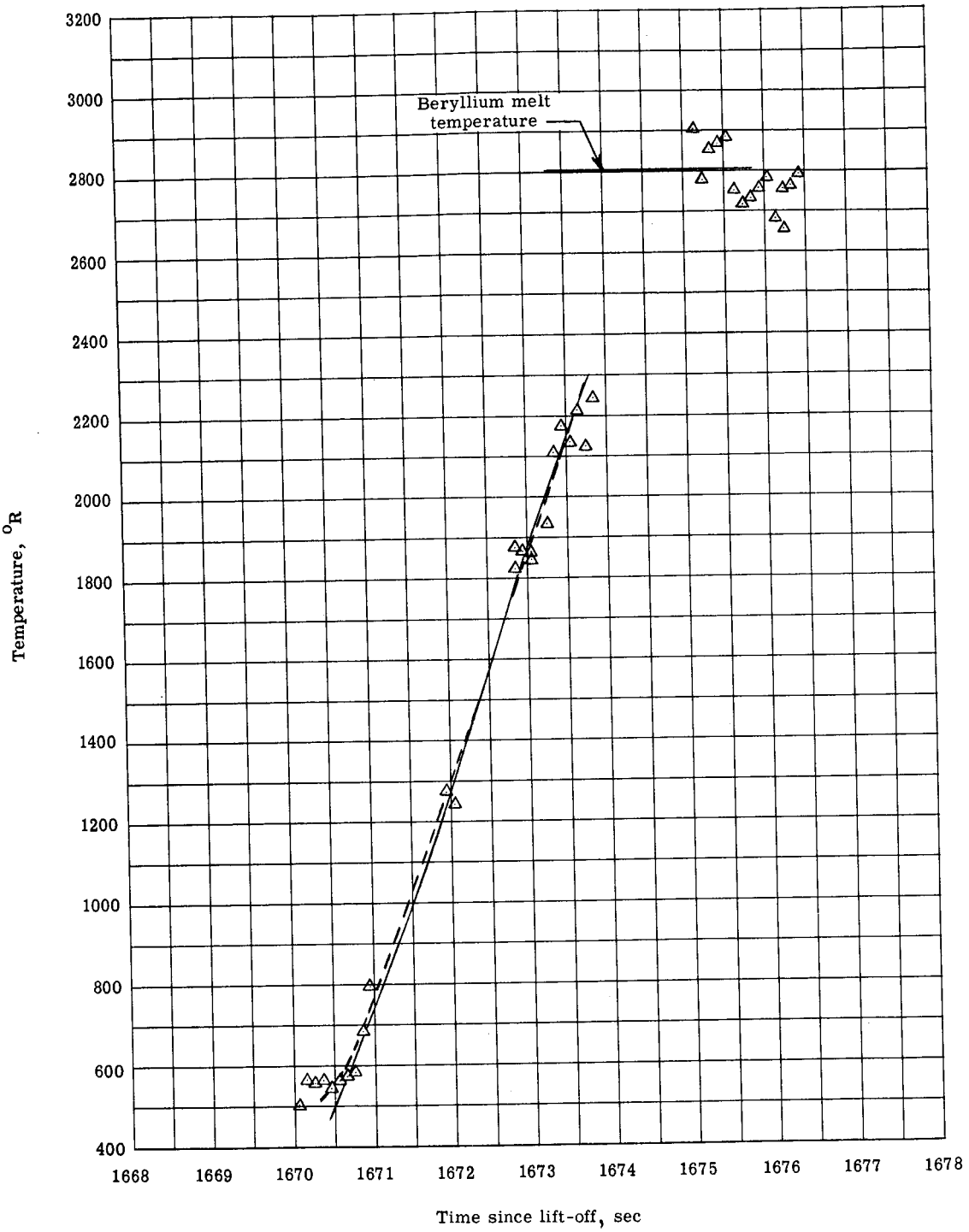
(b) s/R = 0.10; ϕ = 258.75°; x = 0.0709 in.

Figure 20.- Continued.



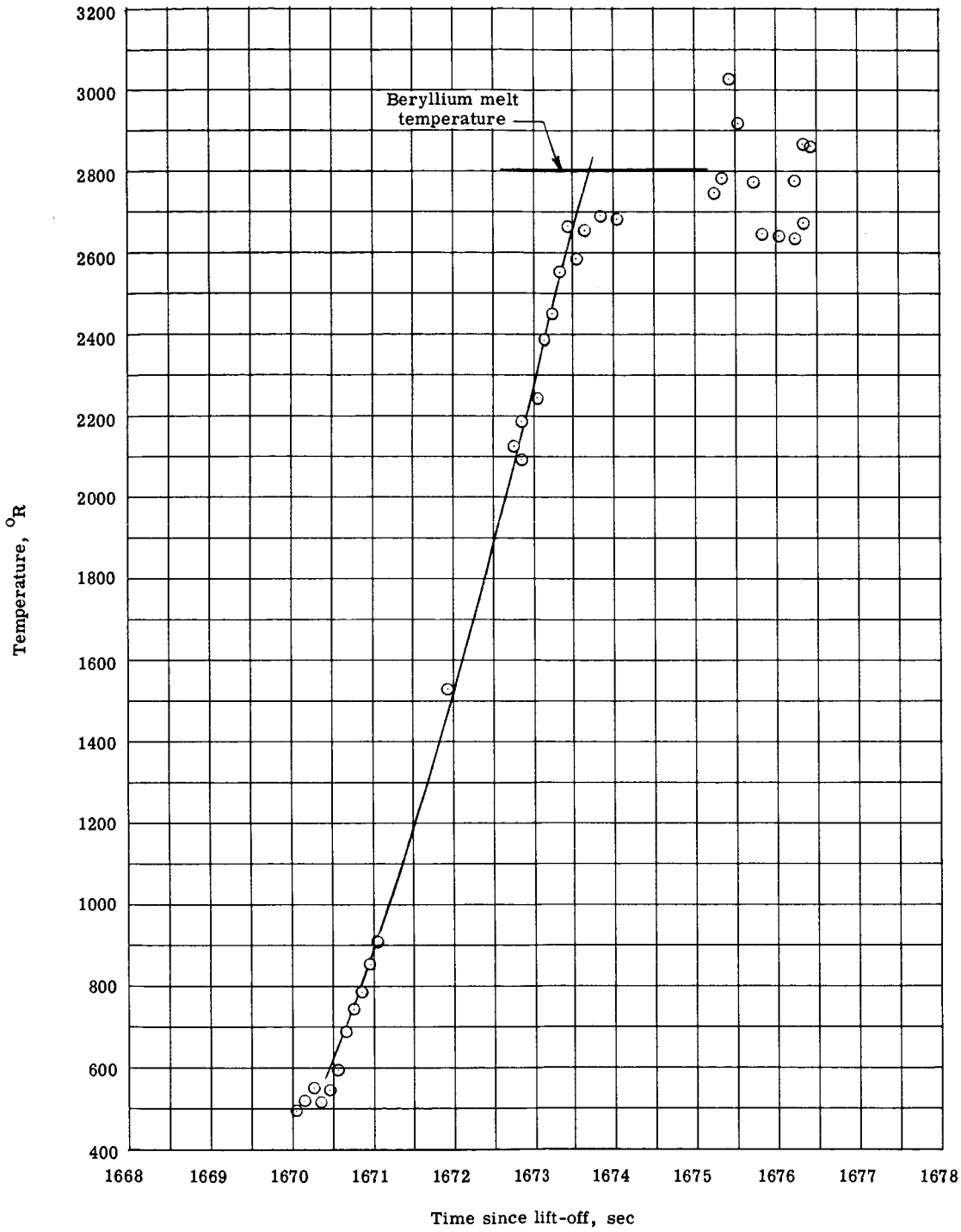
(c) s/R = 0.10; ϕ = 258.75°; x = 0.1311 in.

Figure 20.- Continued.



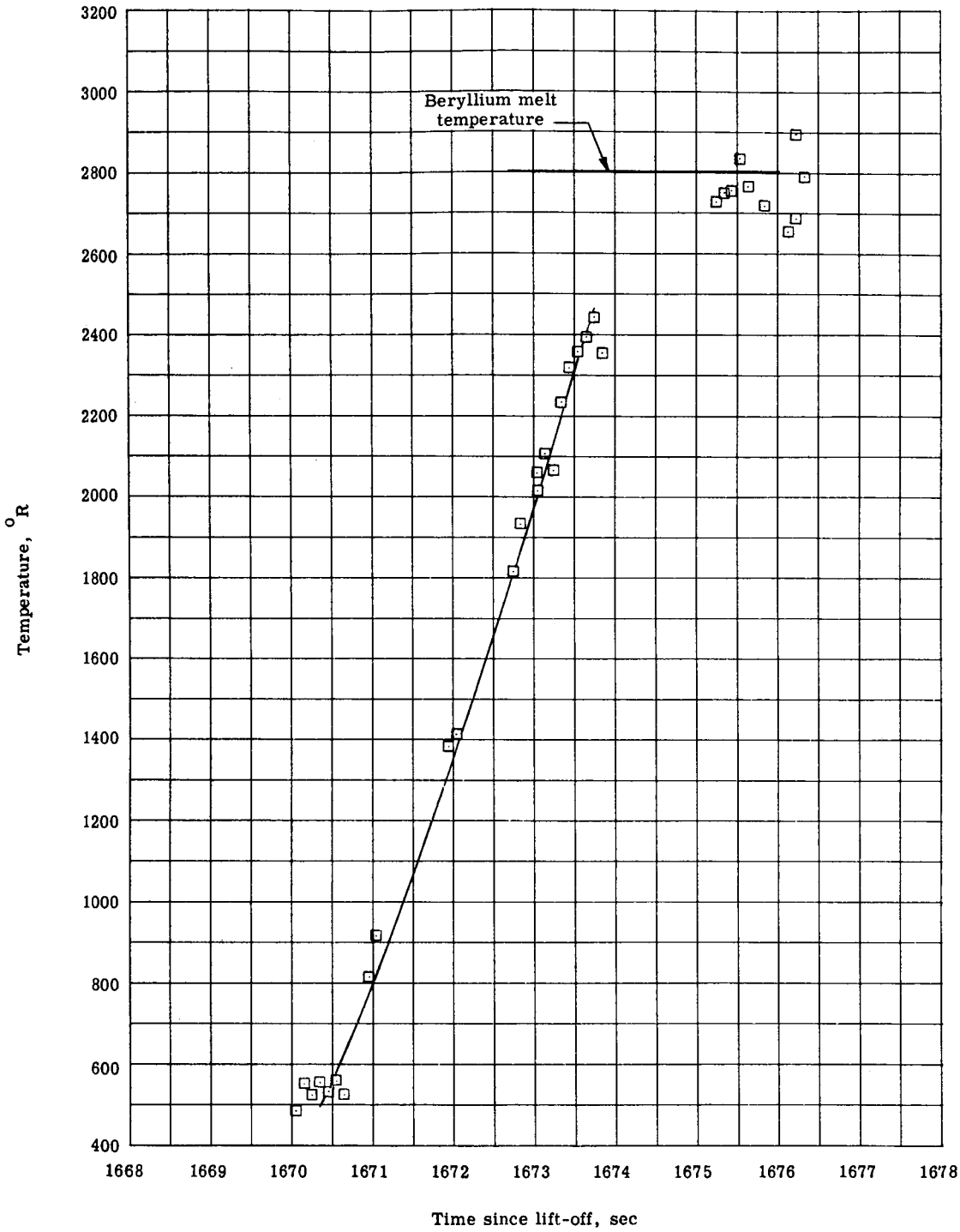
(d) s/R = 0.10; ϕ = 258.75°; x = 0.2000 in.

Figure 20.- Continued.



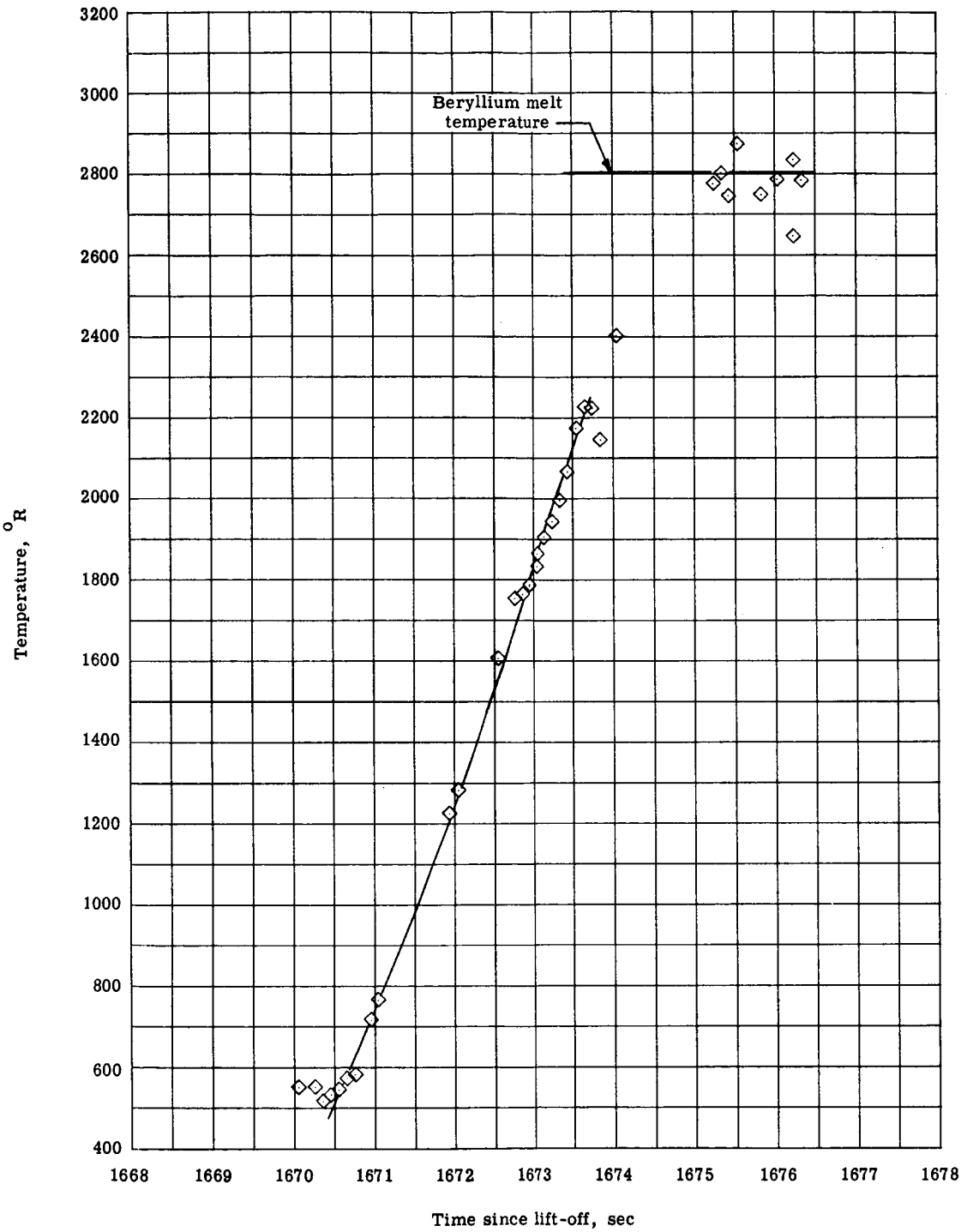
(e) s/R = 0.54; ϕ = 258.75°; x = 0.0132 in.

Figure 20.- Continued.



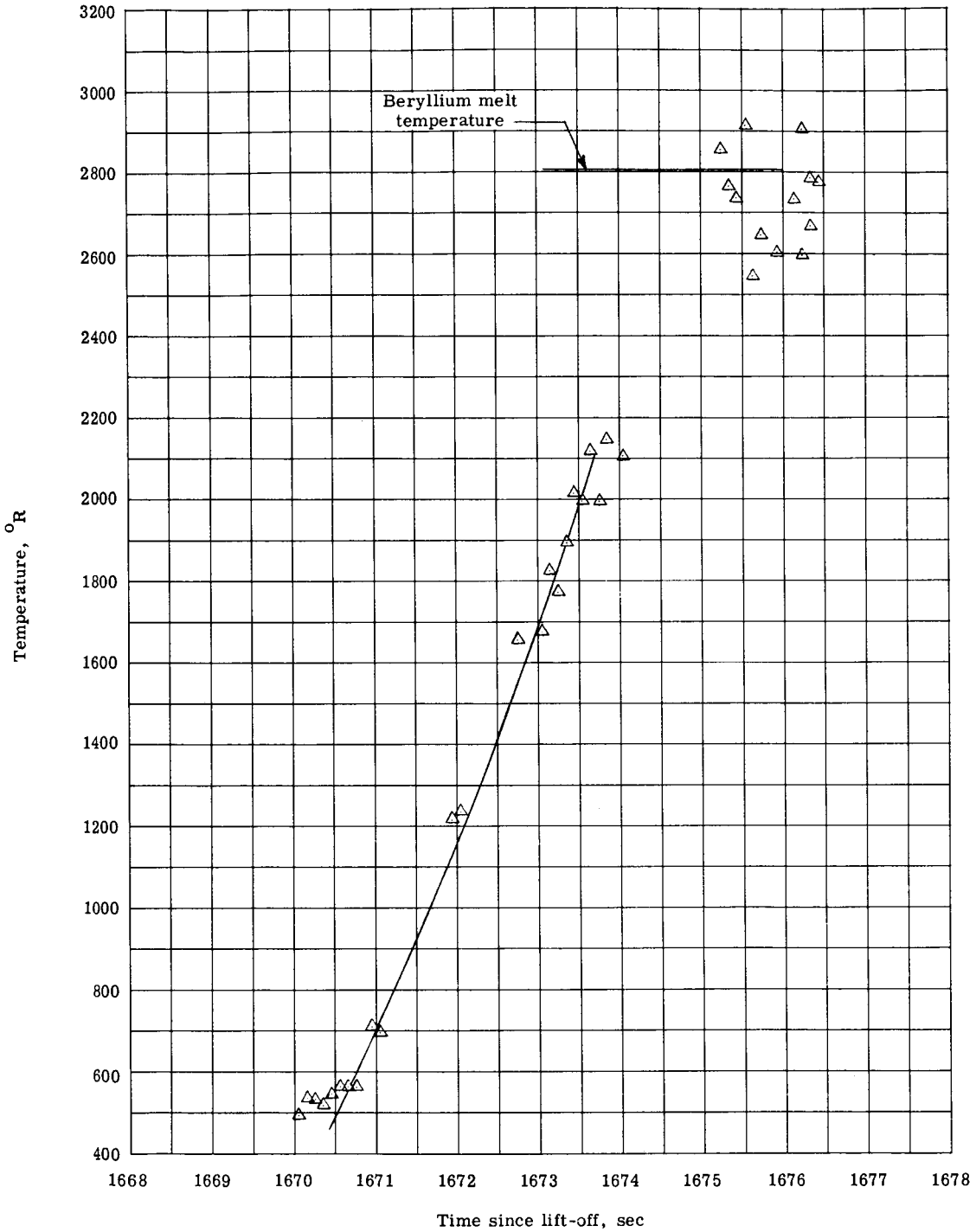
(f) s/R = 0.54; ϕ = 258.75°; x = 0.0715 in.

Figure 20.- Continued.



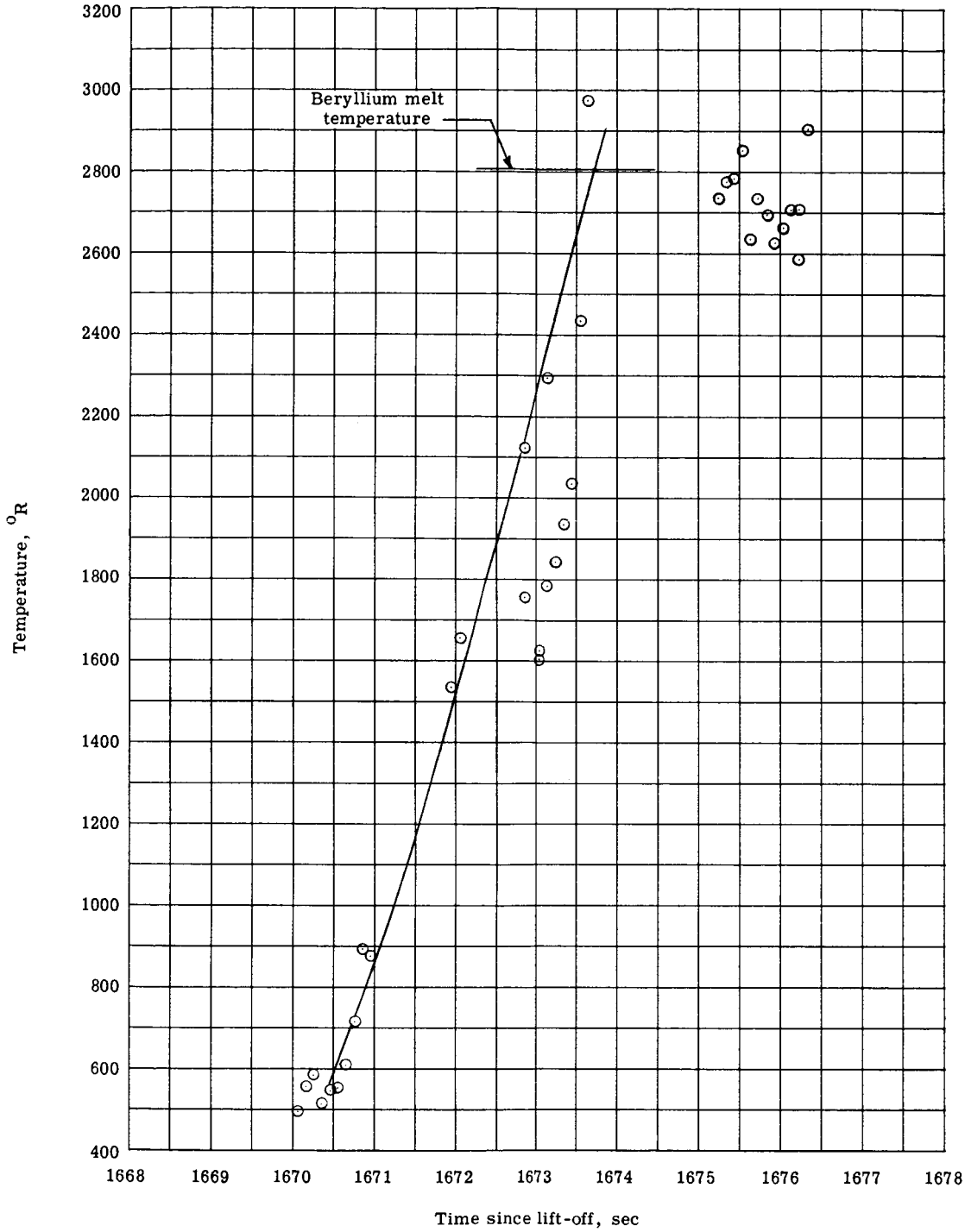
(g) s/R = 0.54; ϕ = 258.75°; x = 0.1312 in.

Figure 20.- Continued.



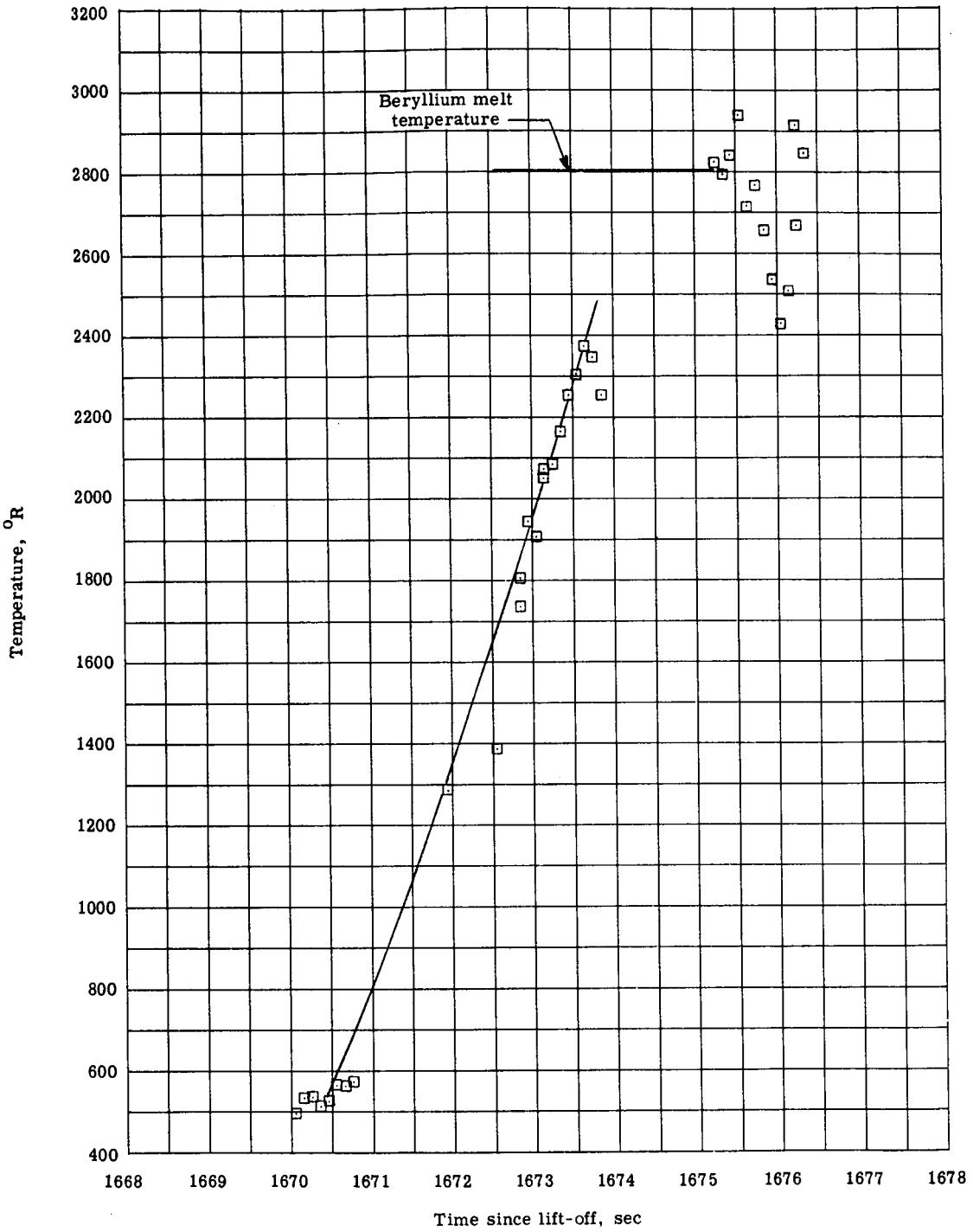
(h) s/R = 0.54; ϕ = 258.75°; x = 0.2000 in.

Figure 20.- Continued.



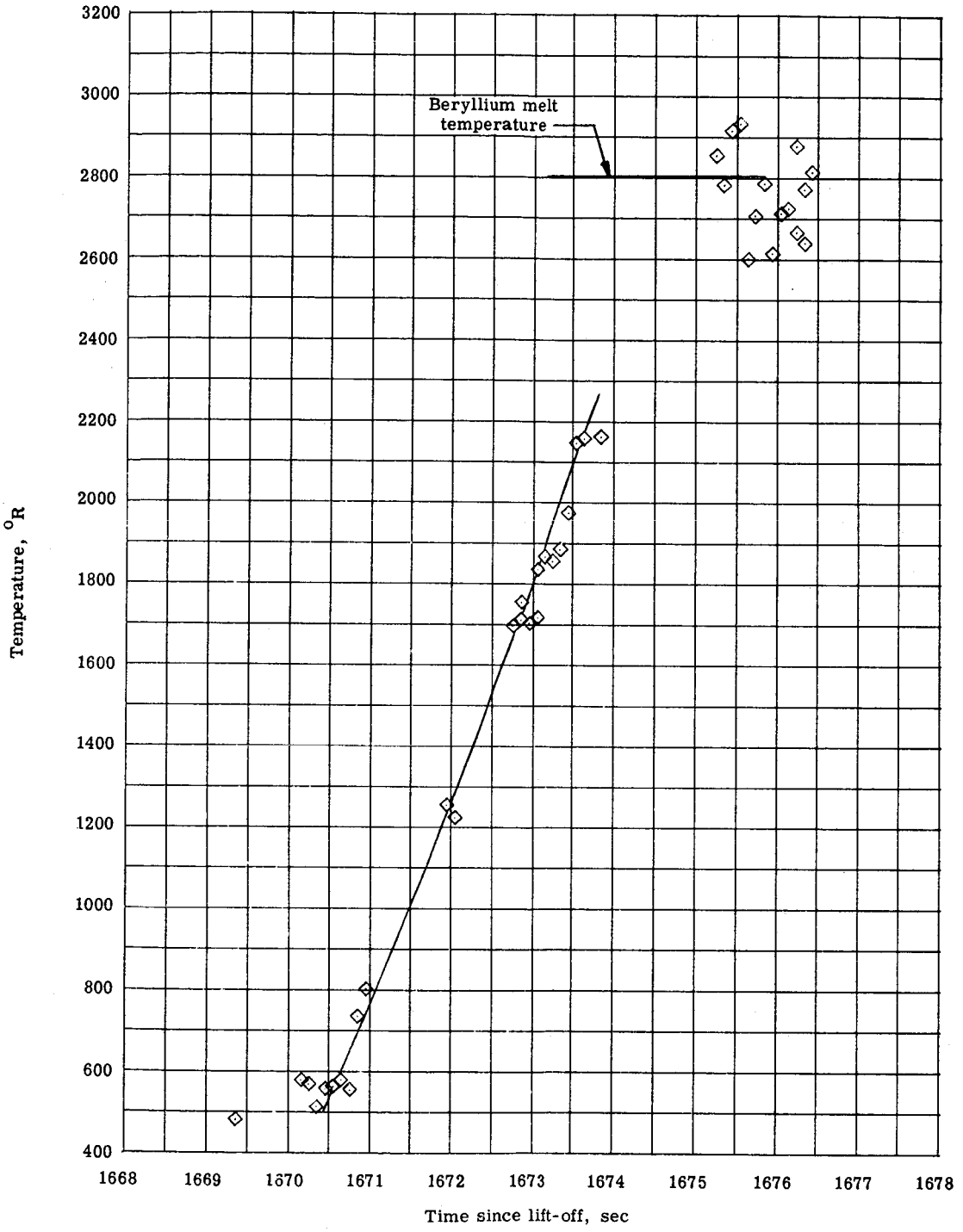
(i) s/R = 0.90; ϕ = 258.75°; x = 0.0138 in.

Figure 20.- Continued.



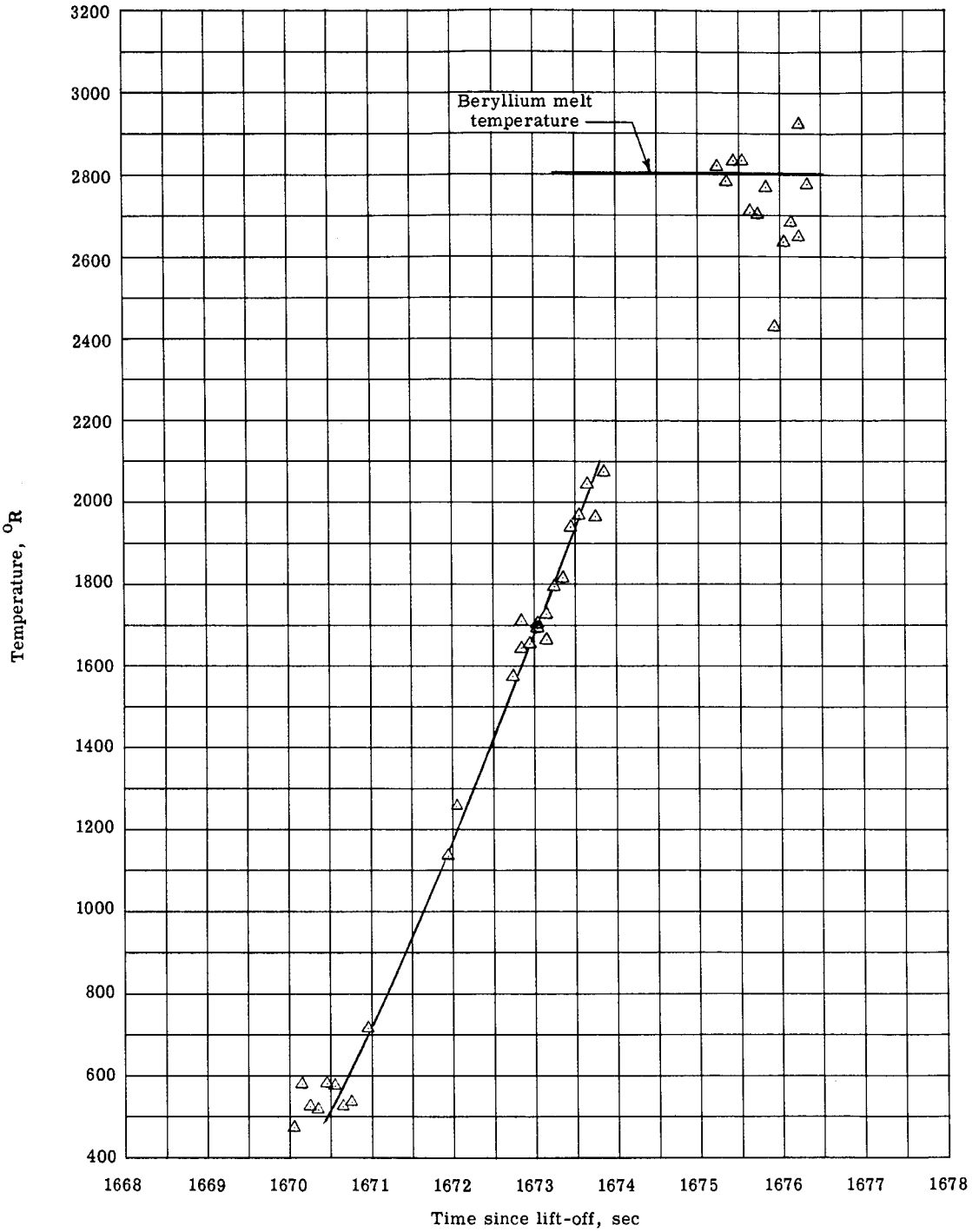
(j) s/R = 0.90; ϕ = 258.75°; x = 0.0736 in.

Figure 20.- Continued.



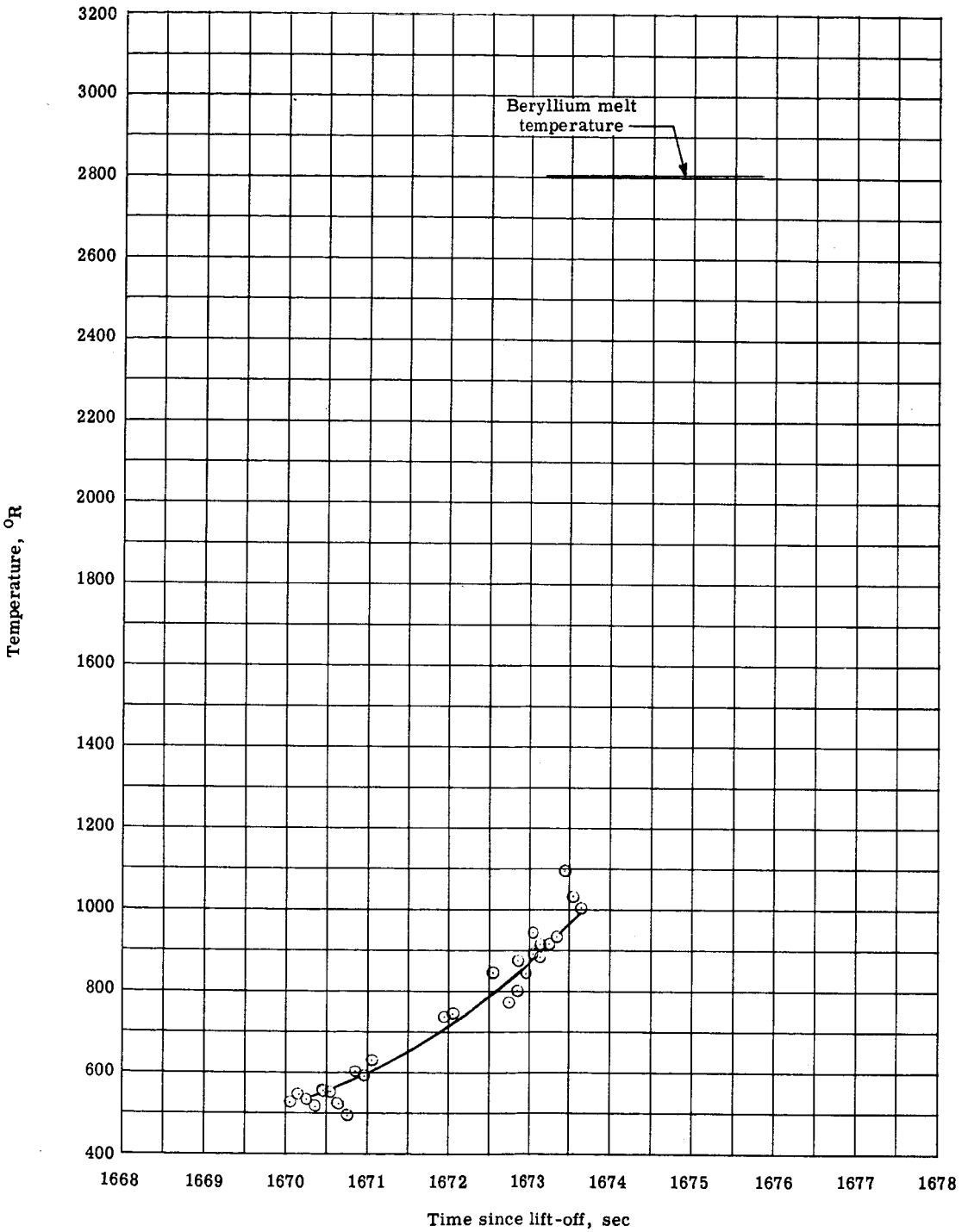
(k) s/R = 0.90; ϕ = 258.75°; x = 0.1317 in.

Figure 20.- Continued.



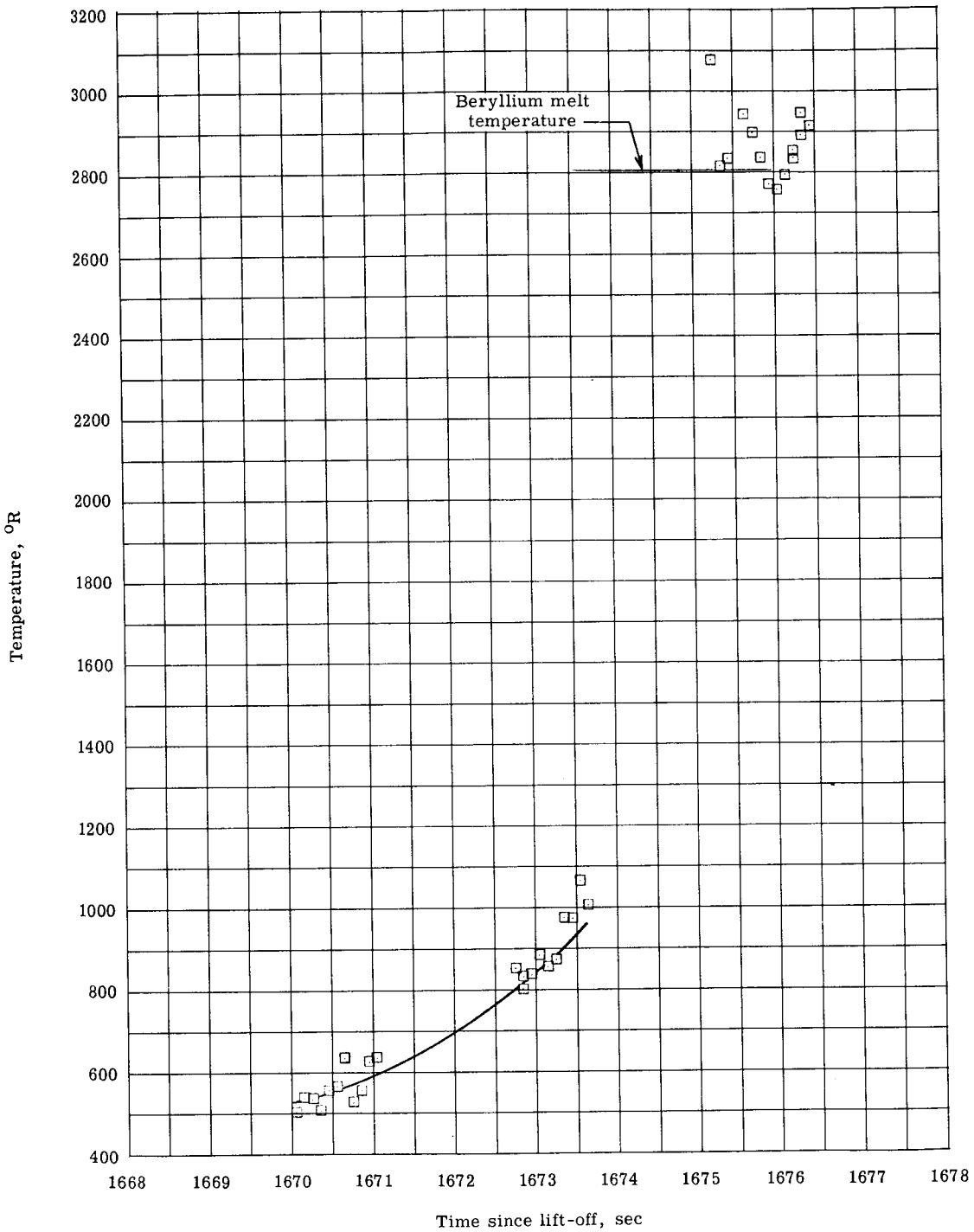
(l) s/R = 0.90; ϕ = 258.75°; x = 0.2000 in.

Figure 20.- Continued.



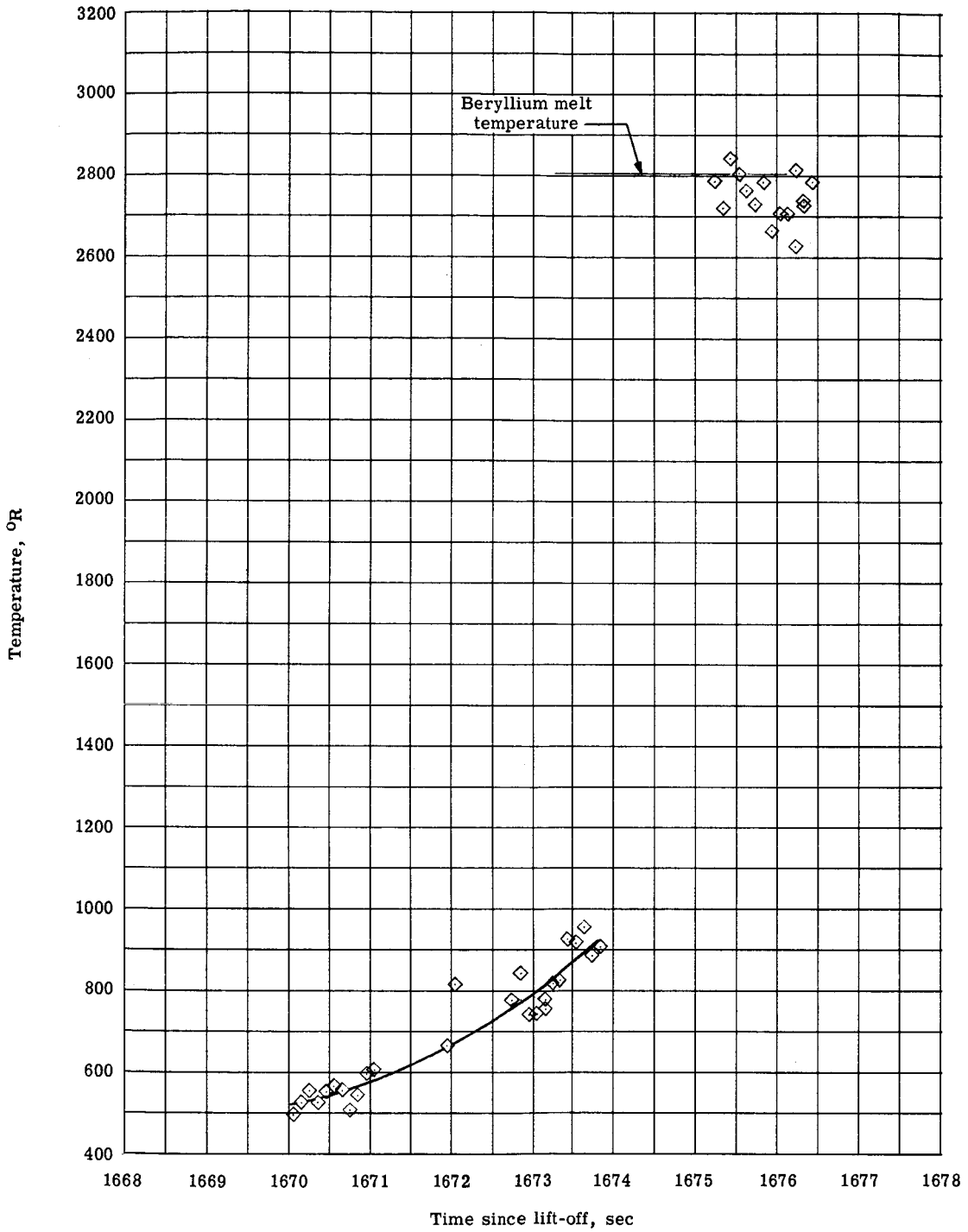
(m) s/R = 1.00; ϕ = 242.00°; x = 0.0120 in.

Figure 20.- Continued.



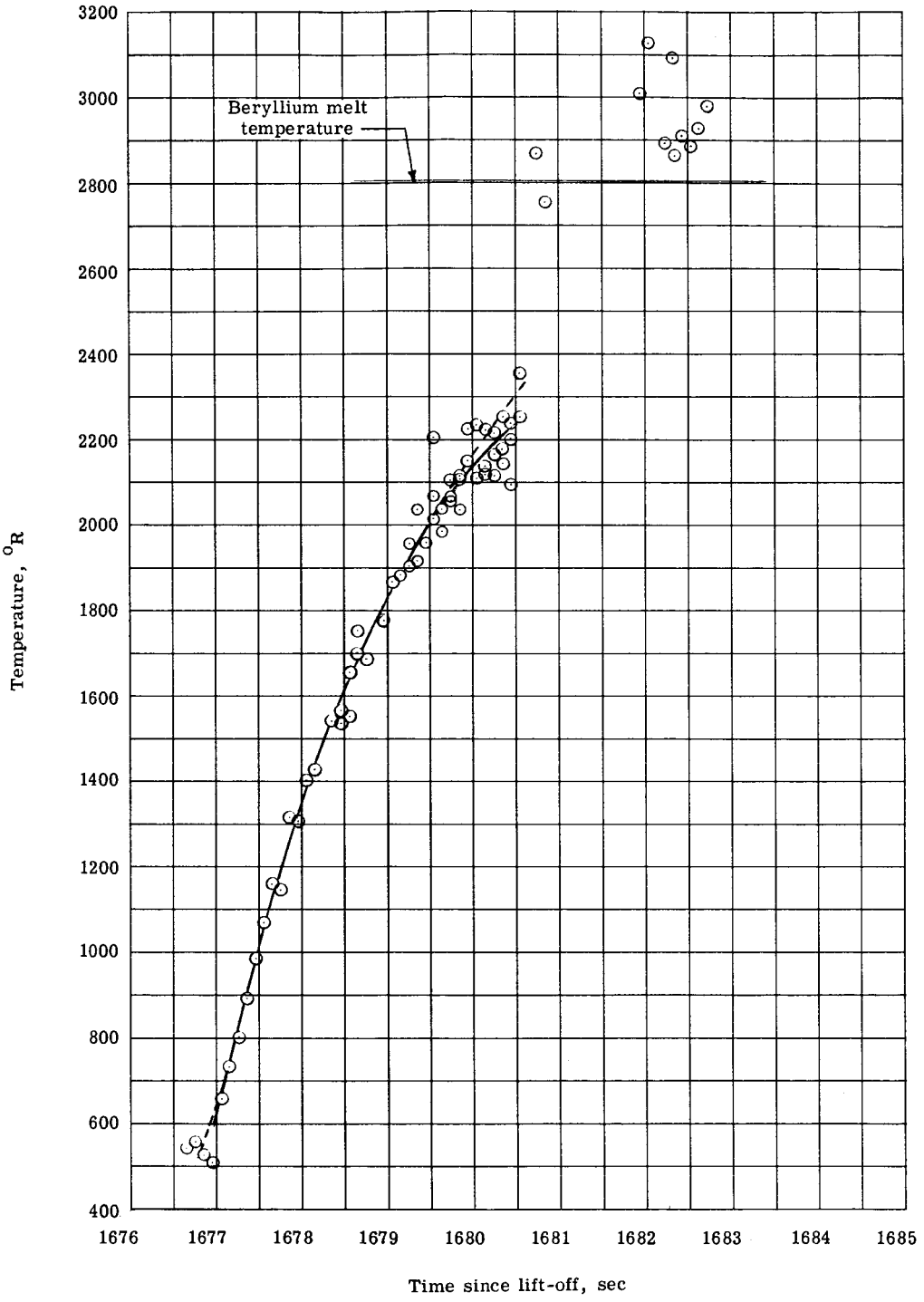
(n) s/R = 1.00; ϕ = 242.00°; x = 0.0705 in.

Figure 20.- Continued.



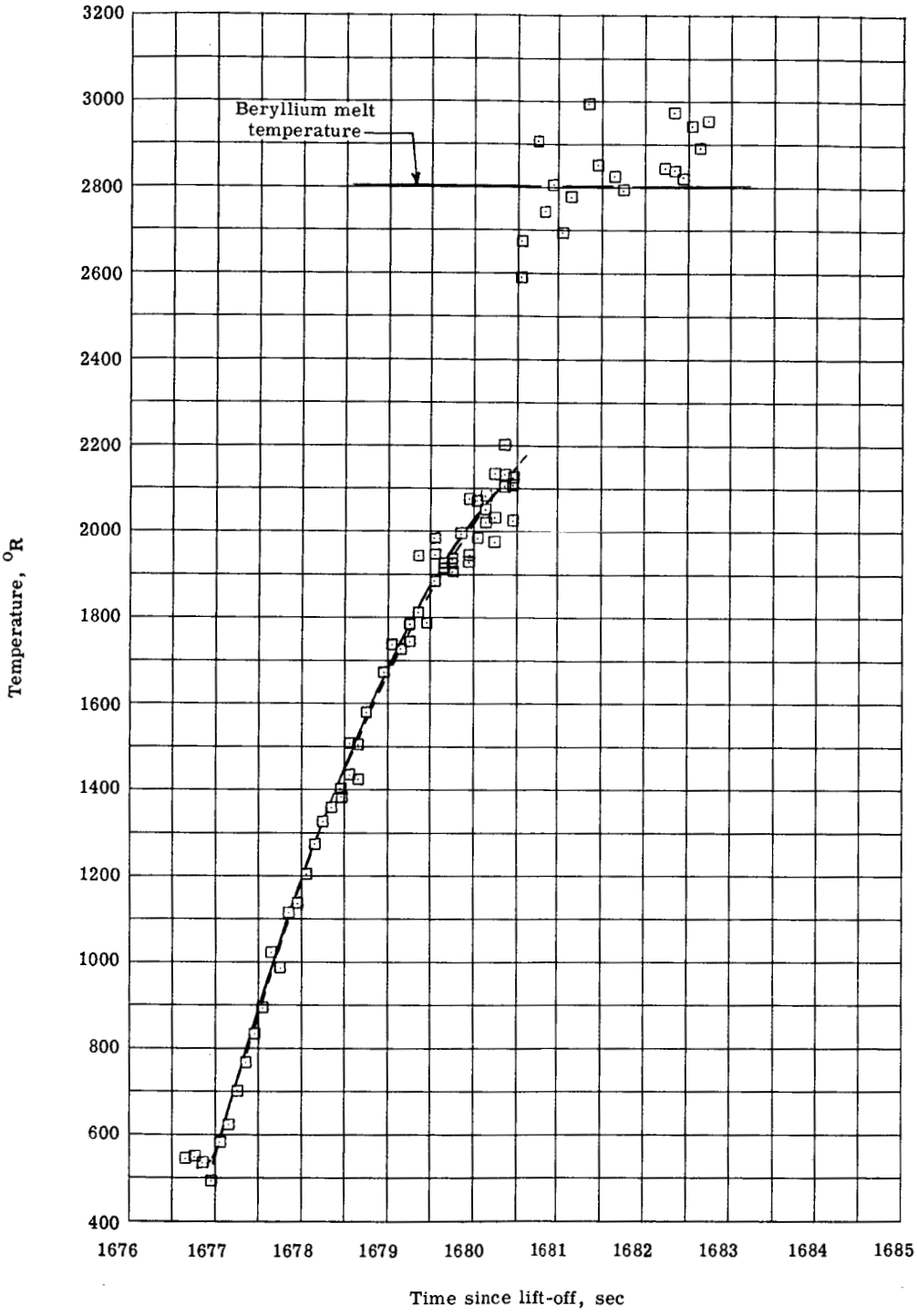
(o) s/R = 1.00; ϕ = 242.00°; x = 0.1318 in.

Figure 20.- Concluded.



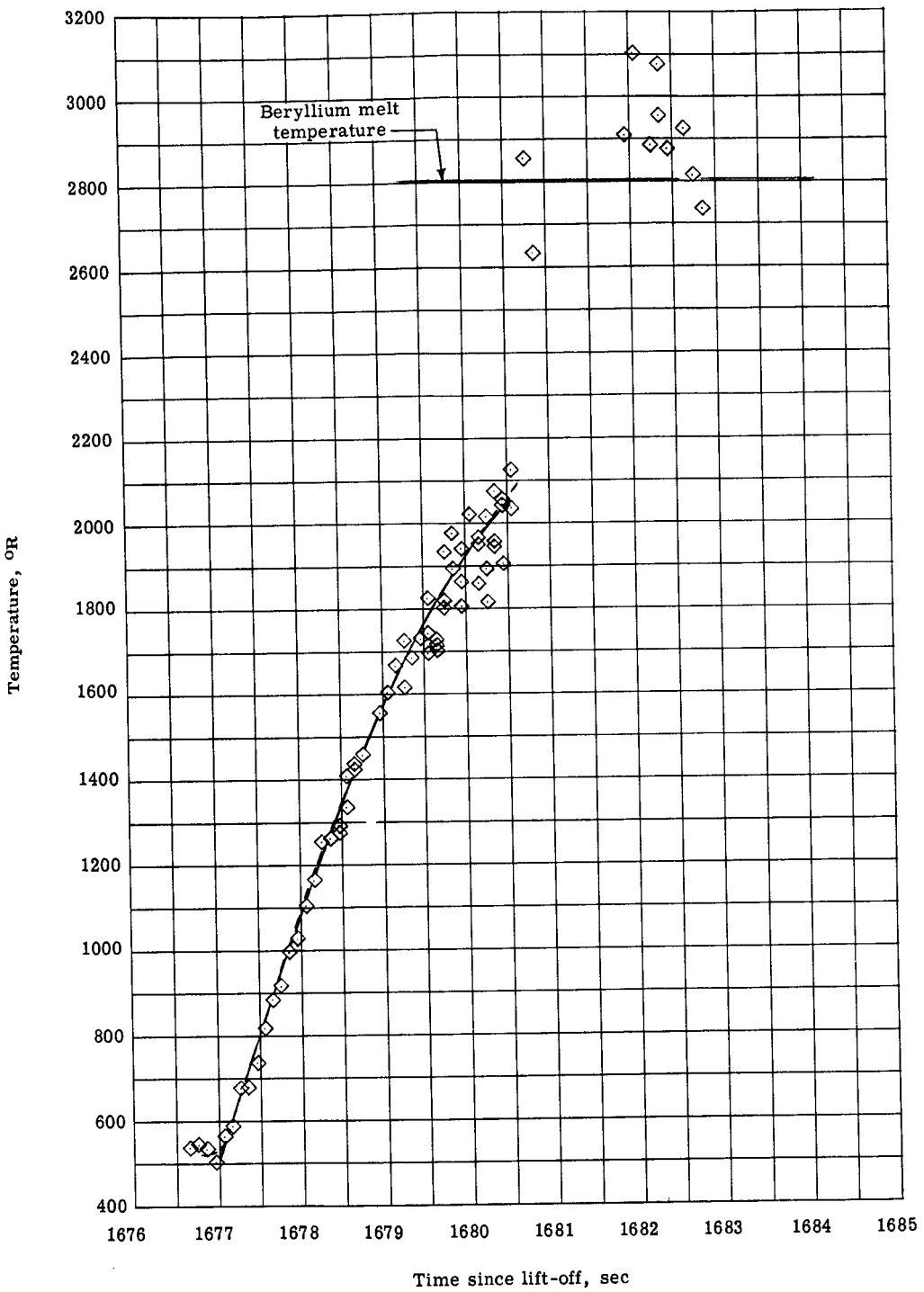
(a) s/R = 0.10; ϕ = 146.25°; x = 0.0122 in.

Figure 21.- Temperature-time data and curve fit representation for individual thermocouples in the third forebody beryllium calorimeter shield.



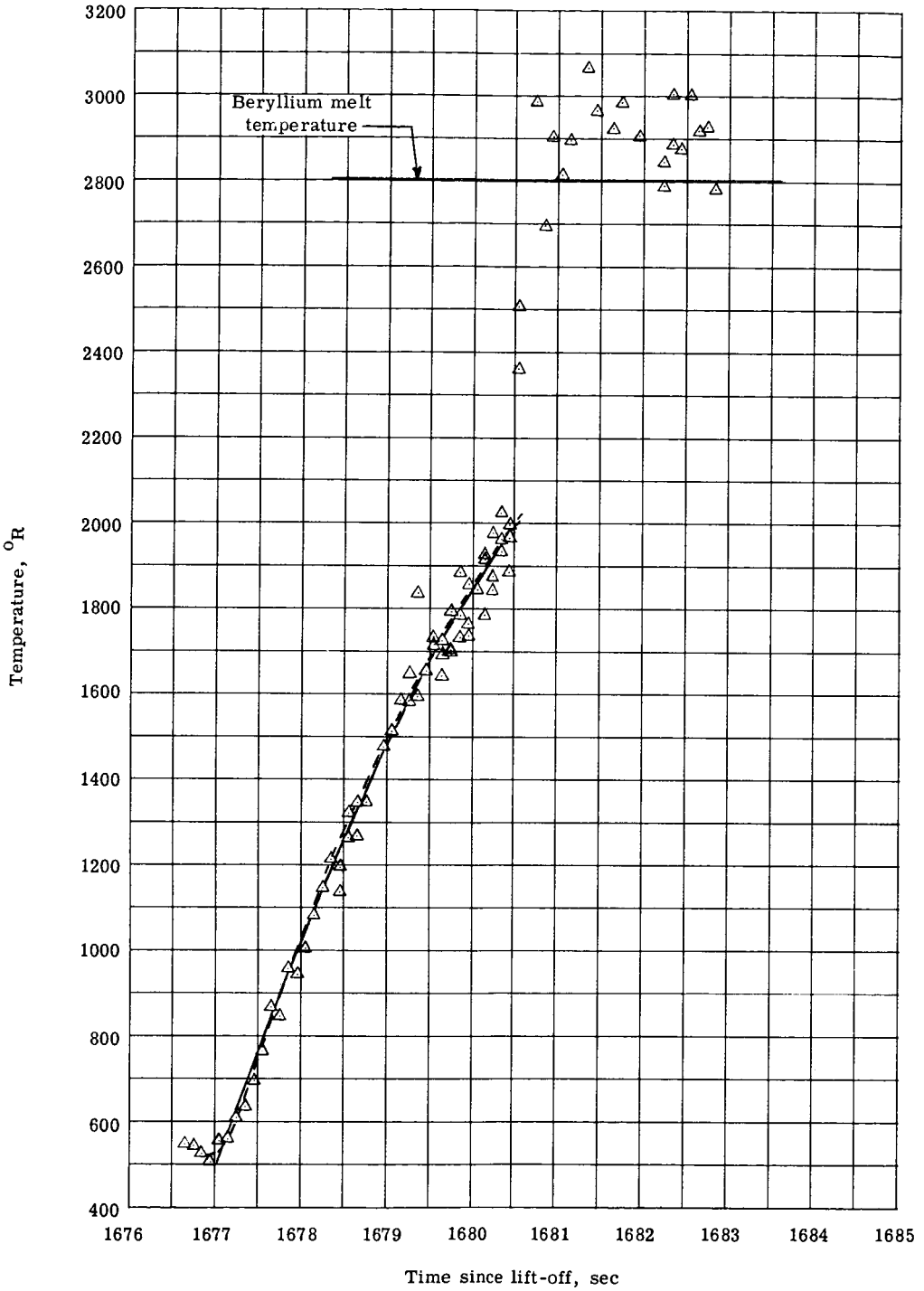
(b) s/R = 0.10; ϕ = 146.25°; x = 0.0704 in.

Figure 21.- Continued.



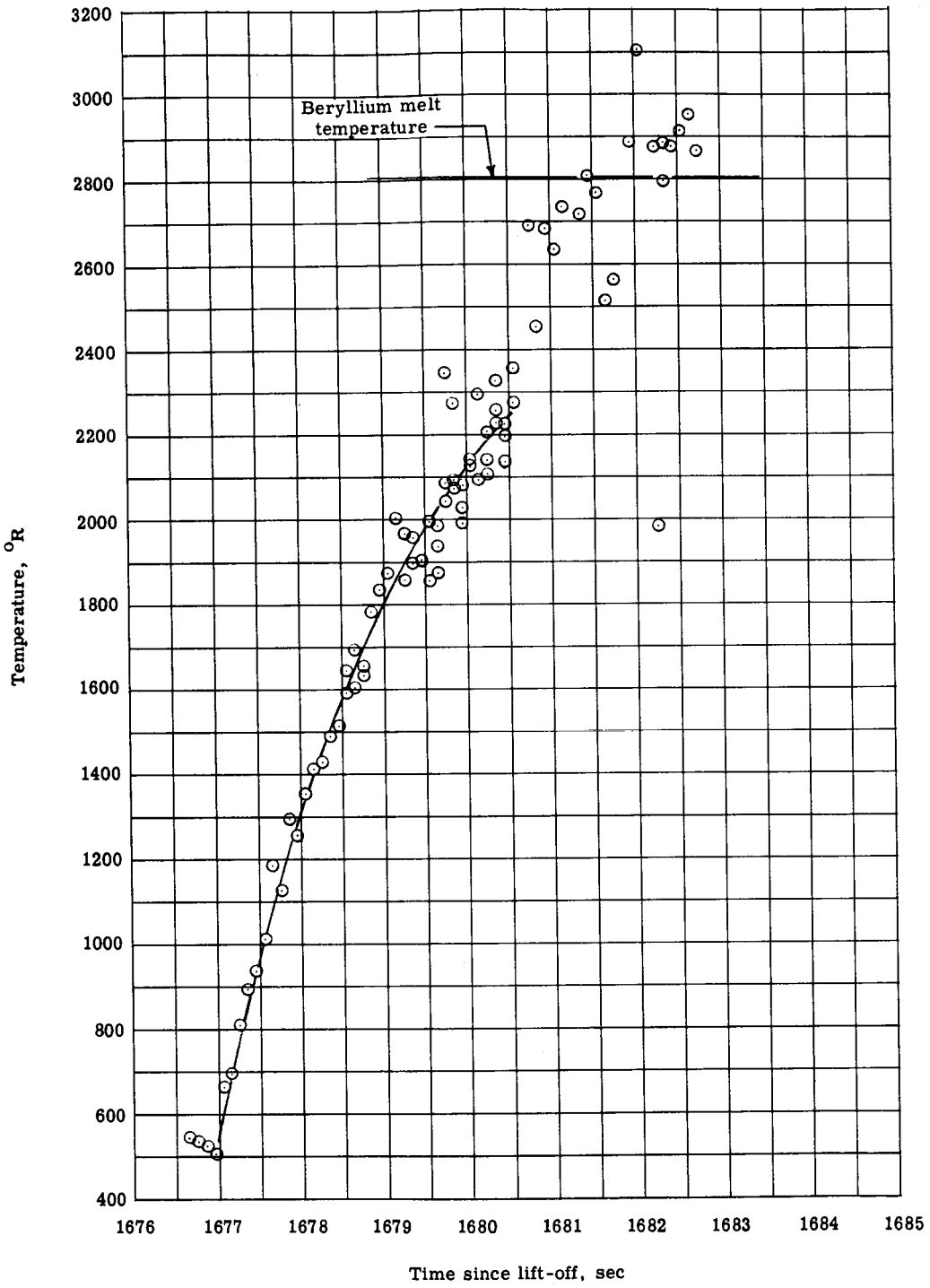
(c) s/R = 0.10; ϕ = 146.25°; x = 0.1310 in.

Figure 21.- Continued.



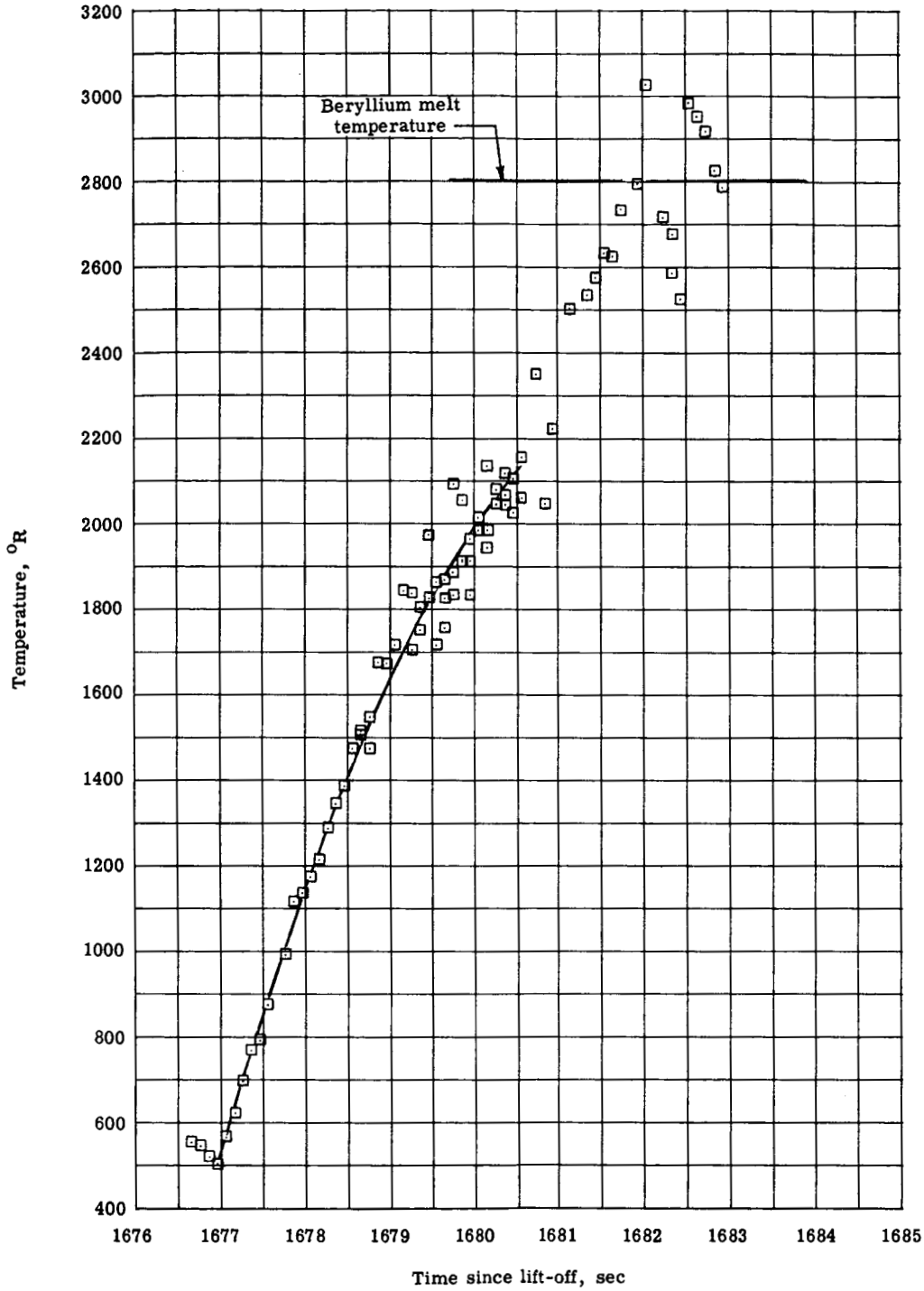
(d) s/R = 0.10; ϕ = 146.25°; x = 0.2000 in.

Figure 21.- Continued.



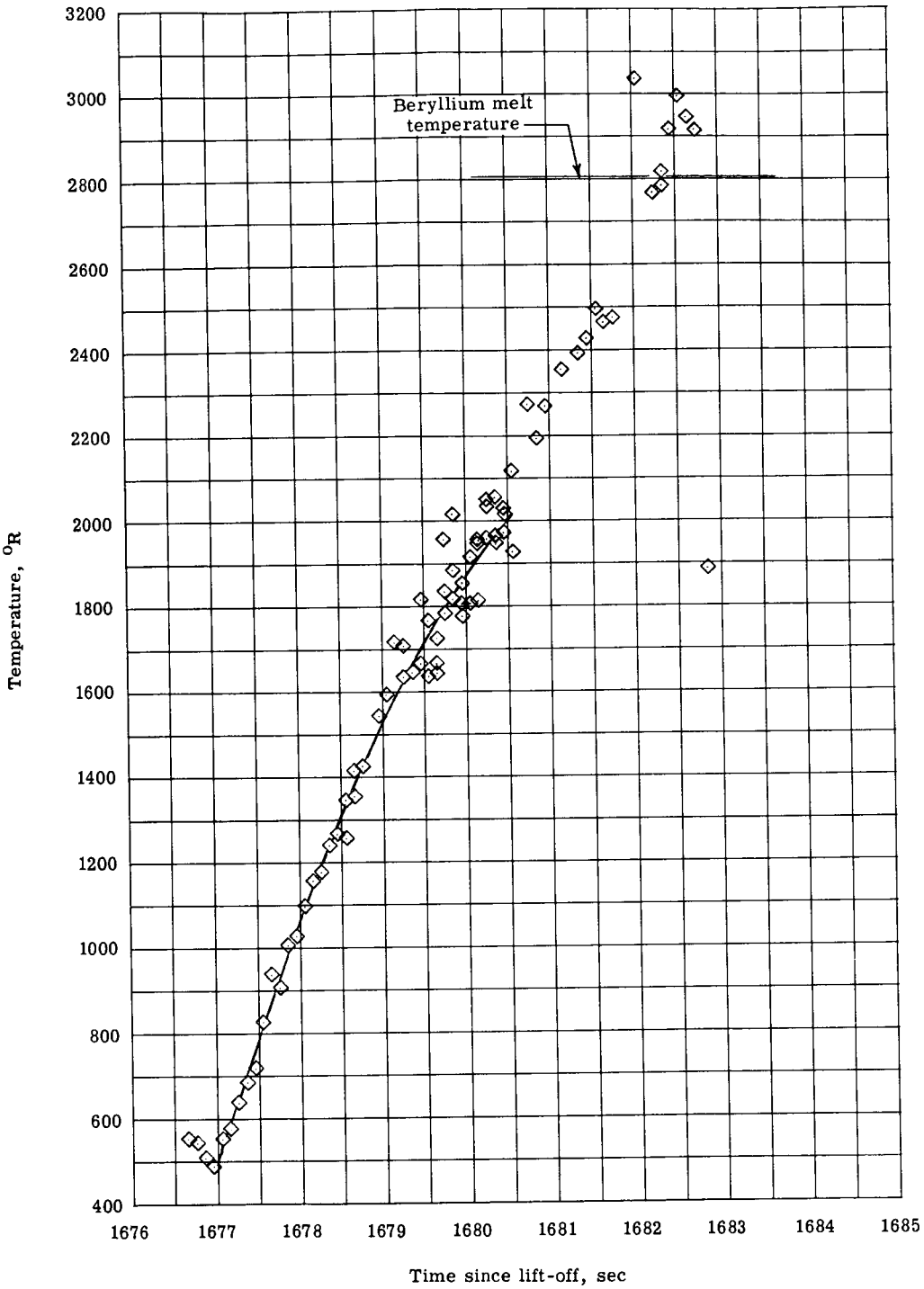
(e) s/R = 0.57; ∅ = 146.25°; x = 0.0125 in.

Figure 21.- Continued.



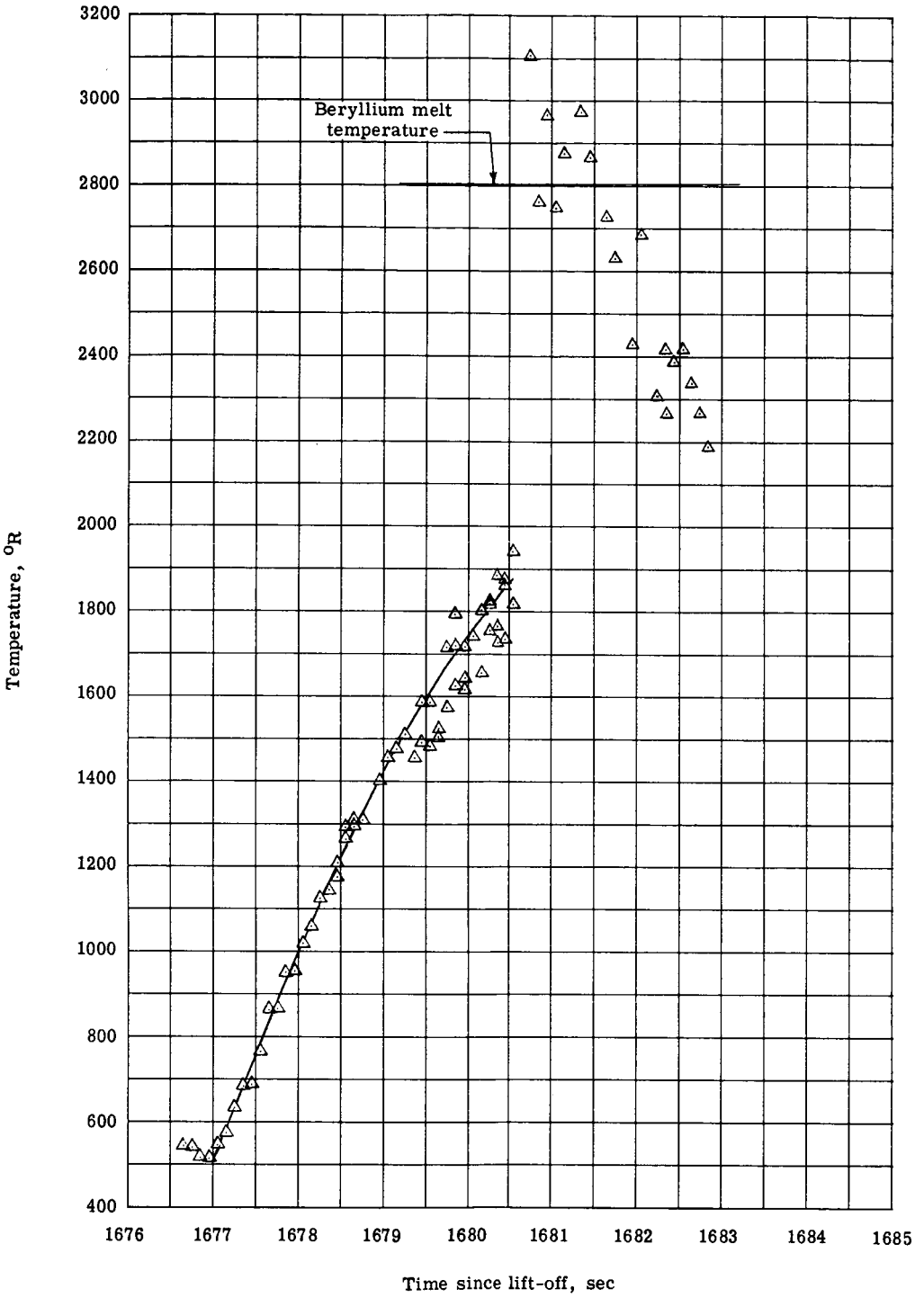
(f) s/R = 0.57; ϕ = 146.25°; x = 0.0723 in.

Figure 21.- Continued.



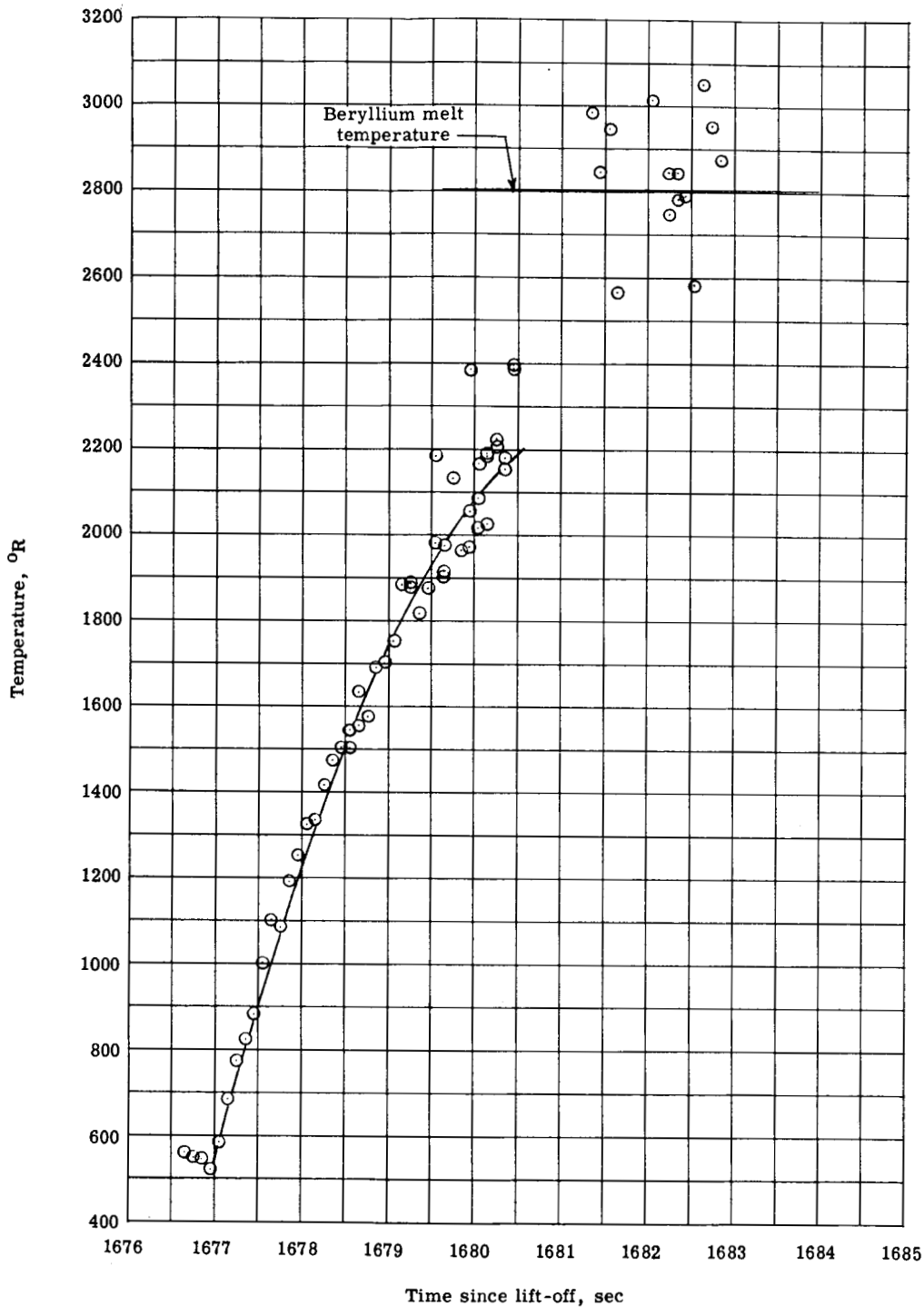
(g) s/R = 0.57; ϕ = 146.25°; x = 0.1323 in.

Figure 21.- Continued.



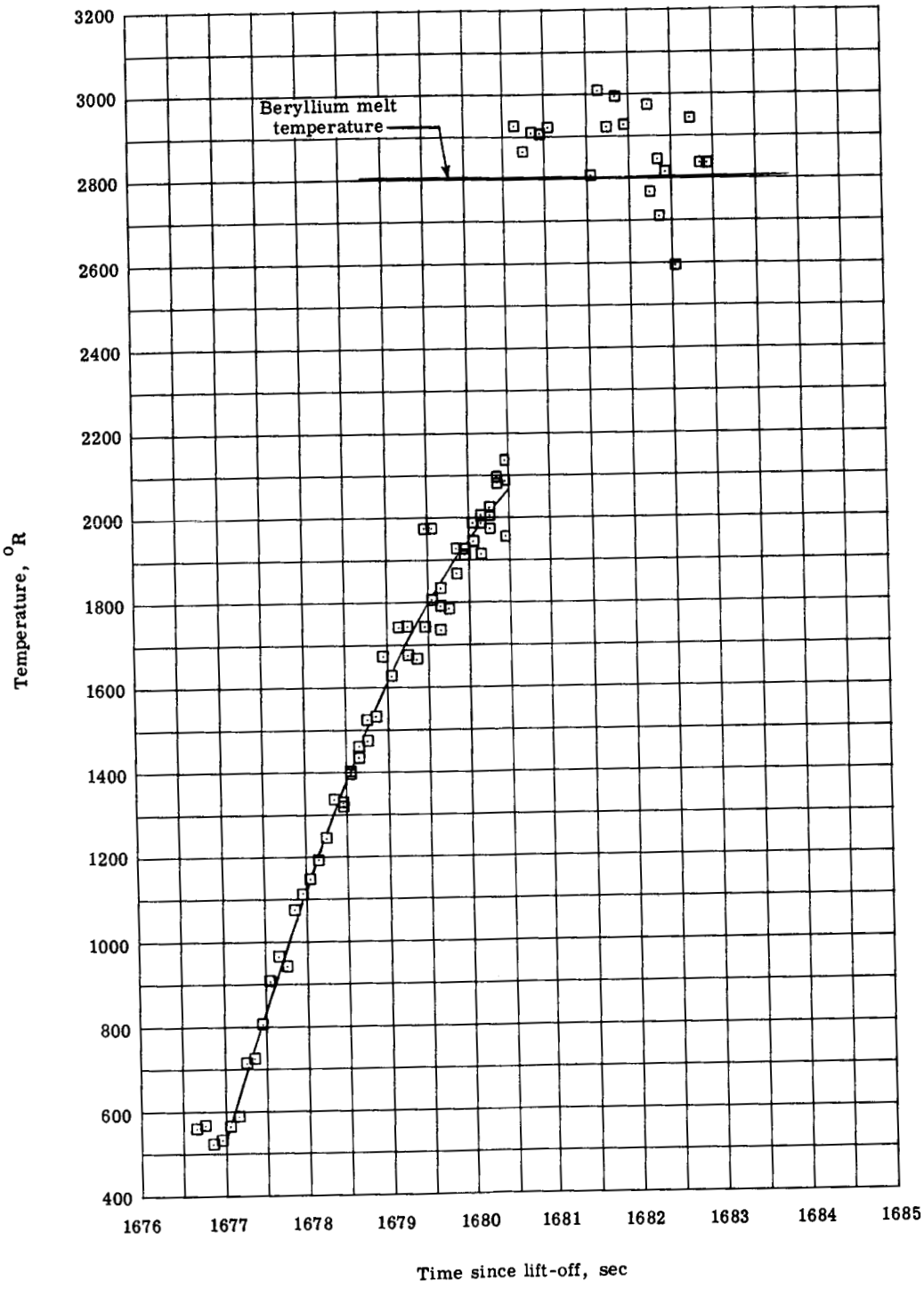
(h) s/R = 0.57; ϕ = 146.25°; x = 0.2000 in.

Figure 21.- Continued.



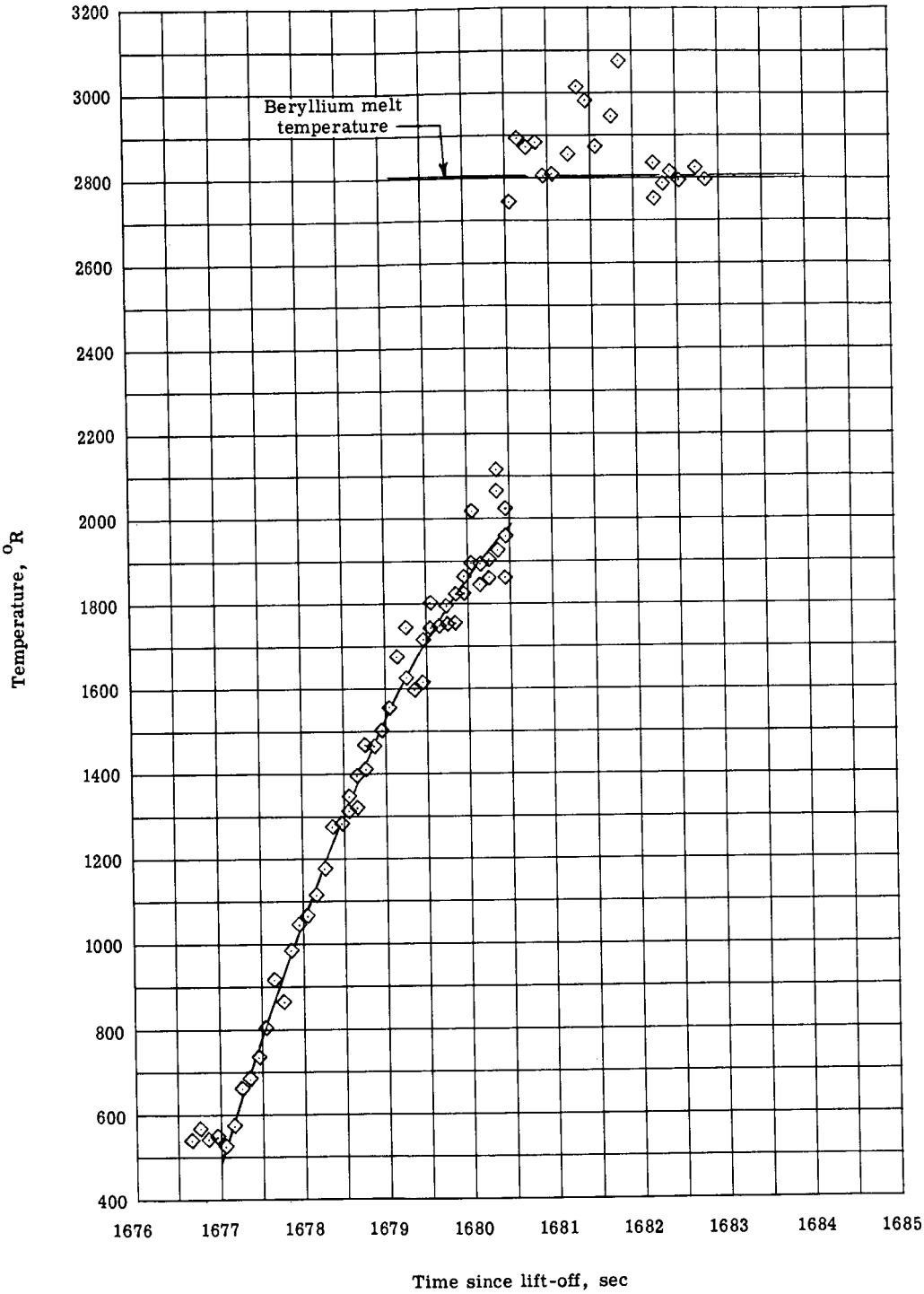
(i) s/R = 0.87; ϕ = 242.00°; x = 0.0133 in.

Figure 21.- Continued.



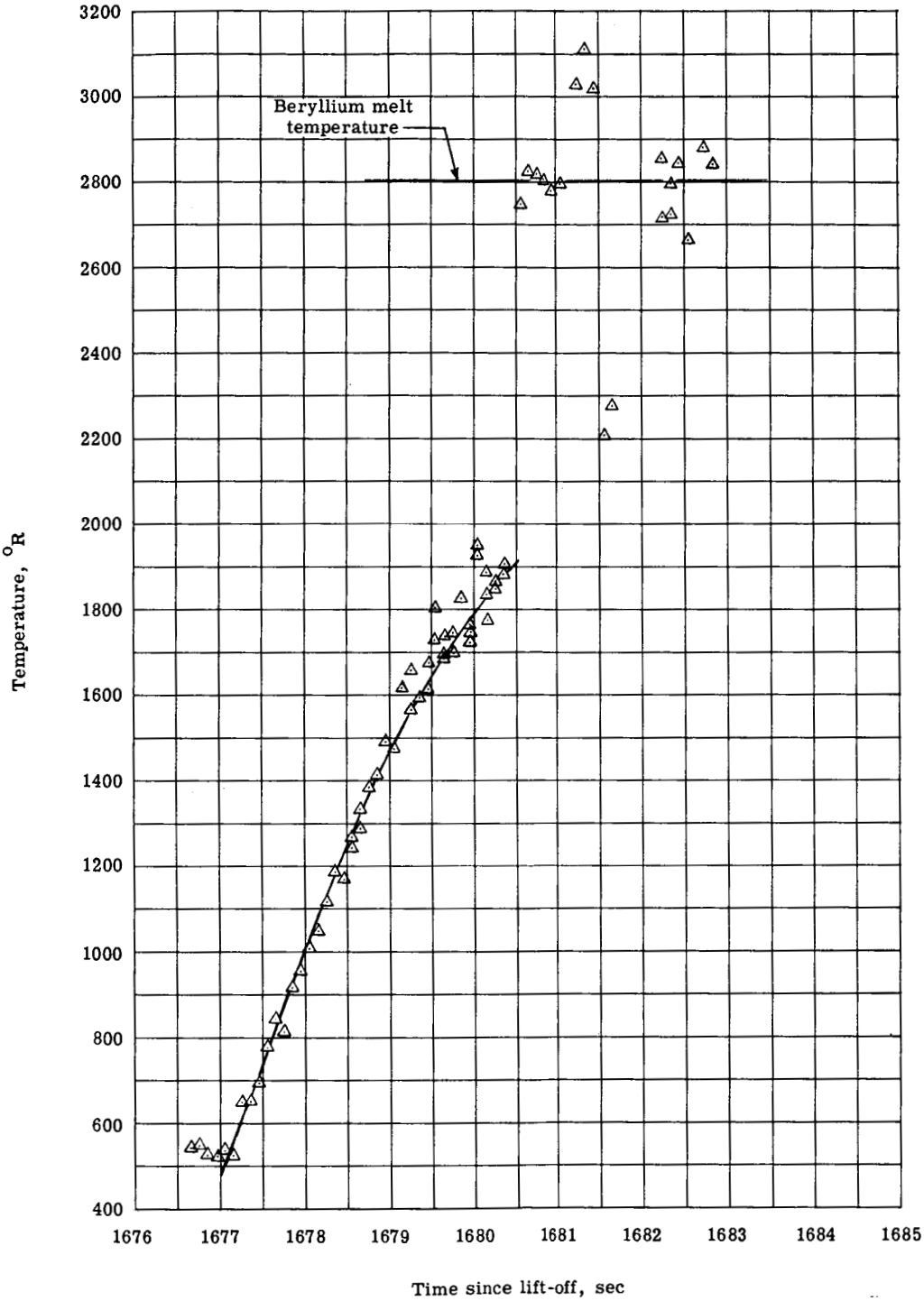
(j) s/R = 0.87; ϕ = 242.00°; x = 0.0735 in.

Figure 21.- Continued.



(k) s/R = 0.87; ϕ = 242.00°; x = 0.1335 in.

Figure 21.- Continued.



(l) s/R = 0.87; ϕ = 242.00°; x = 0.2000 in.

Figure 21.- Continued.

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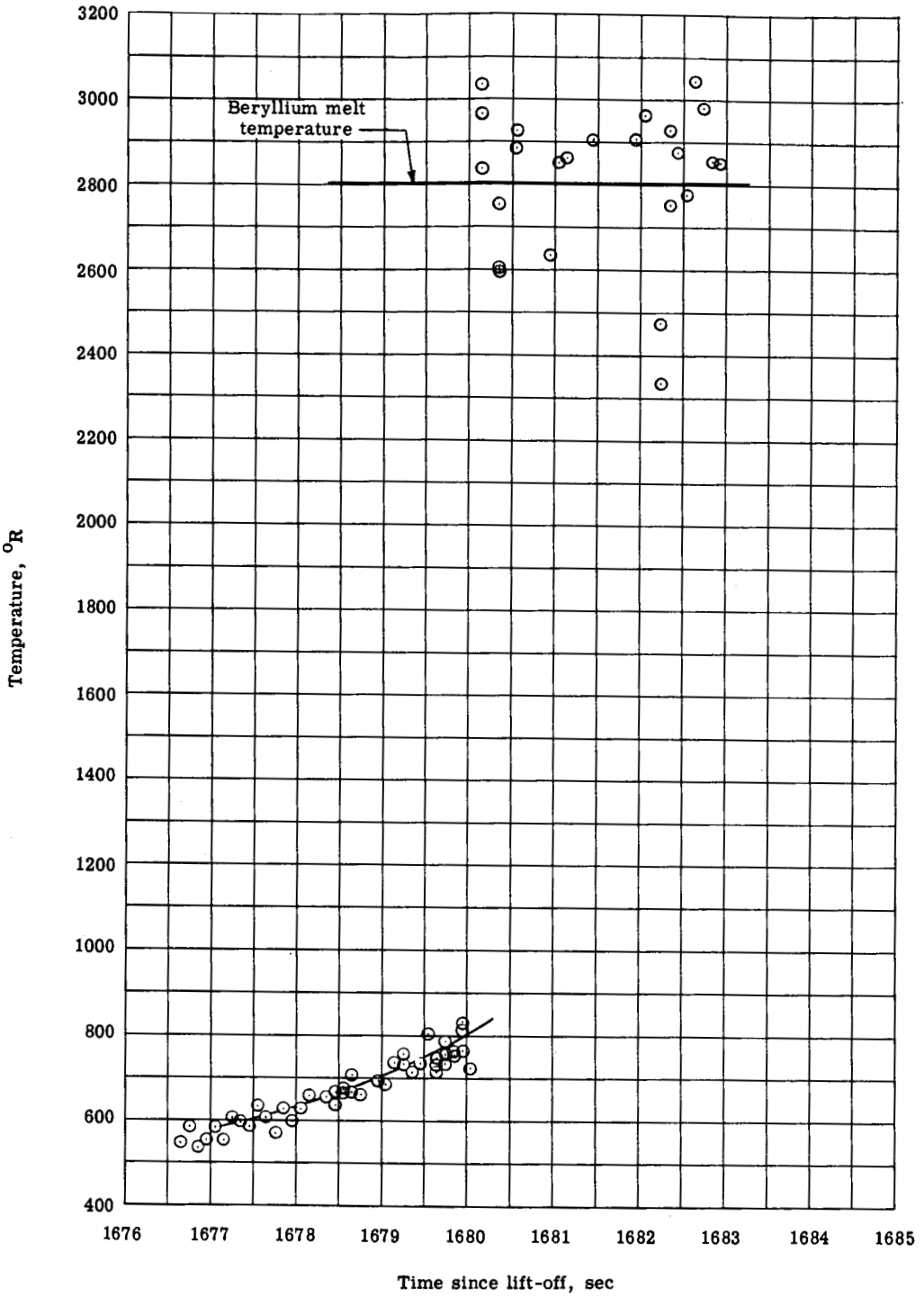
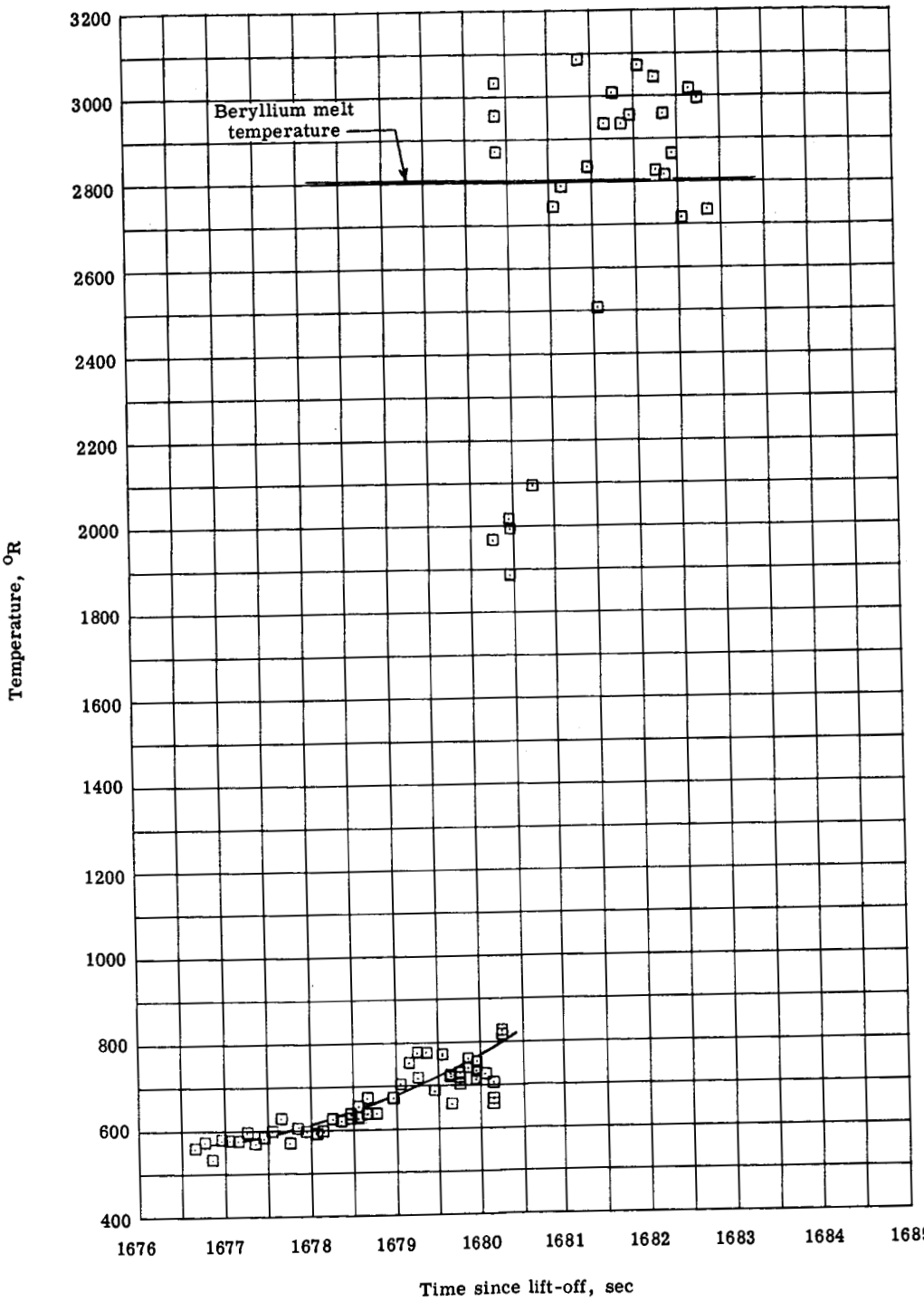


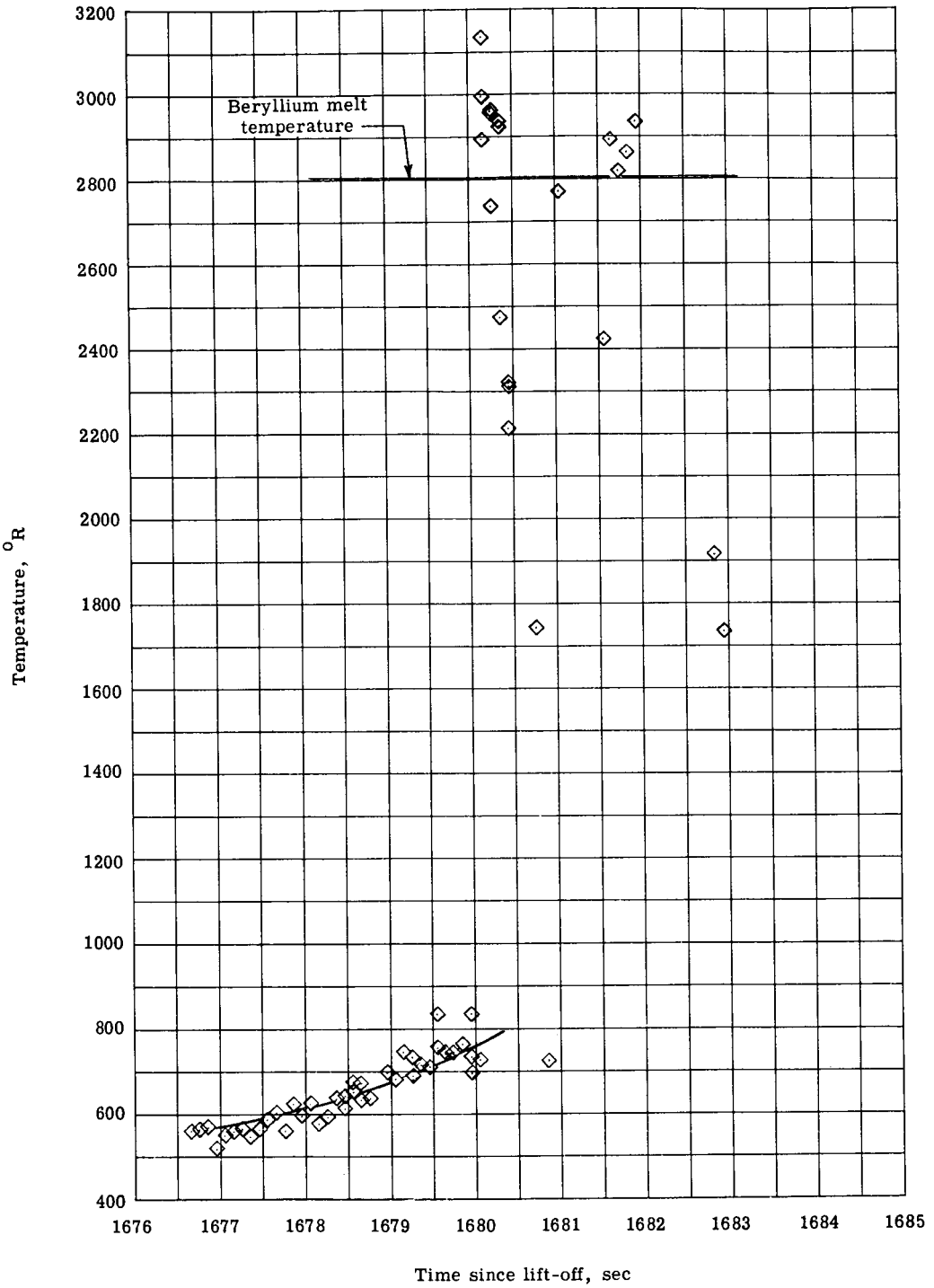
(m) s/R = 1.00; ϕ = 242.00°; x = 0.0137 in.

Figure 21.- Continued.



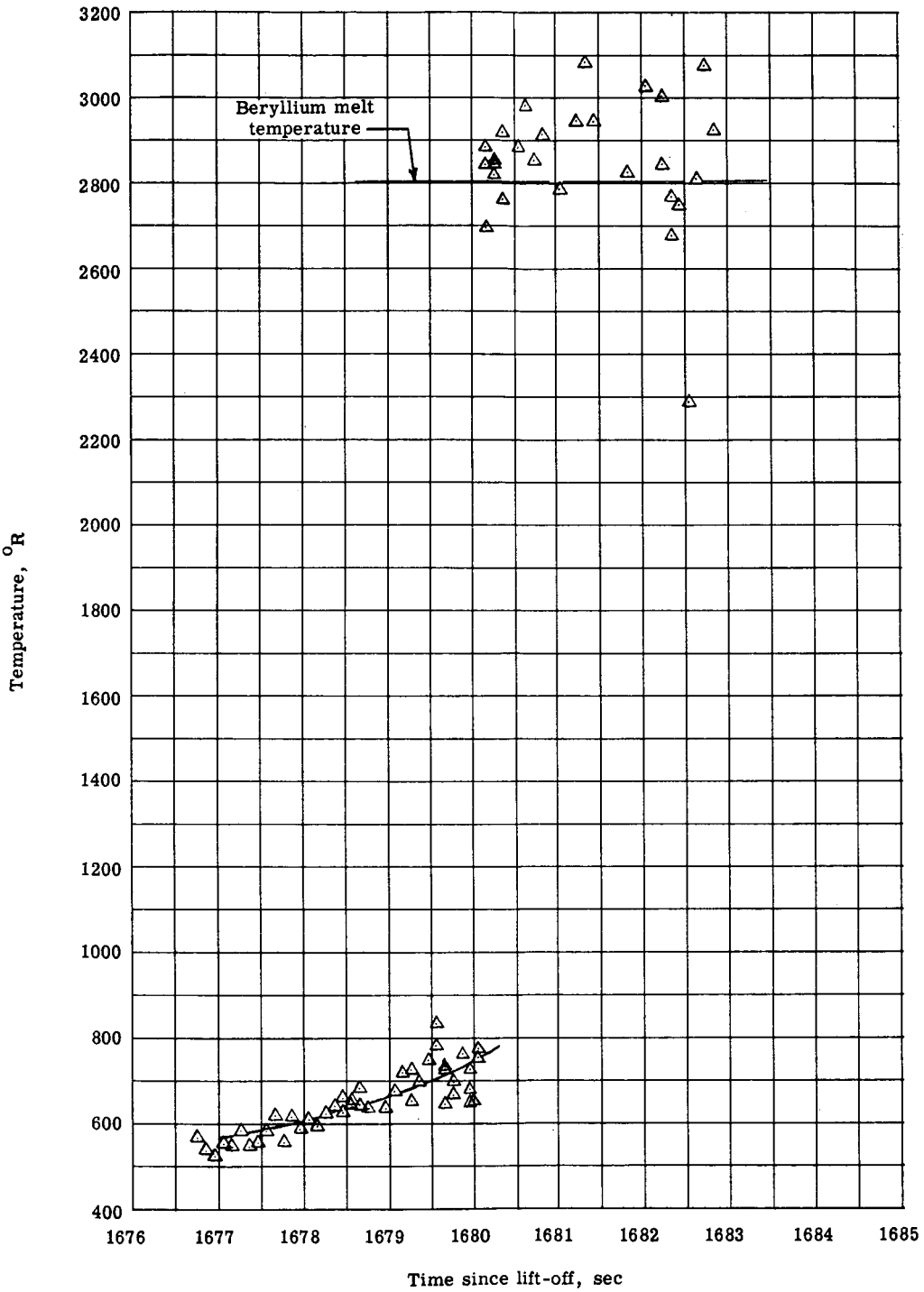
(n) s/R = 1.00; ϕ = 242.00°; x = 0.0730 in.

Figure 21.- Continued.



(o) s/R = 1.00; ϕ = 242.00°; x = 0.1322 in.

Figure 21.- Continued.



(p) s/R = 1.00; ϕ = 242.00°; x = 0.2000 in.

Figure 21.- Concluded.

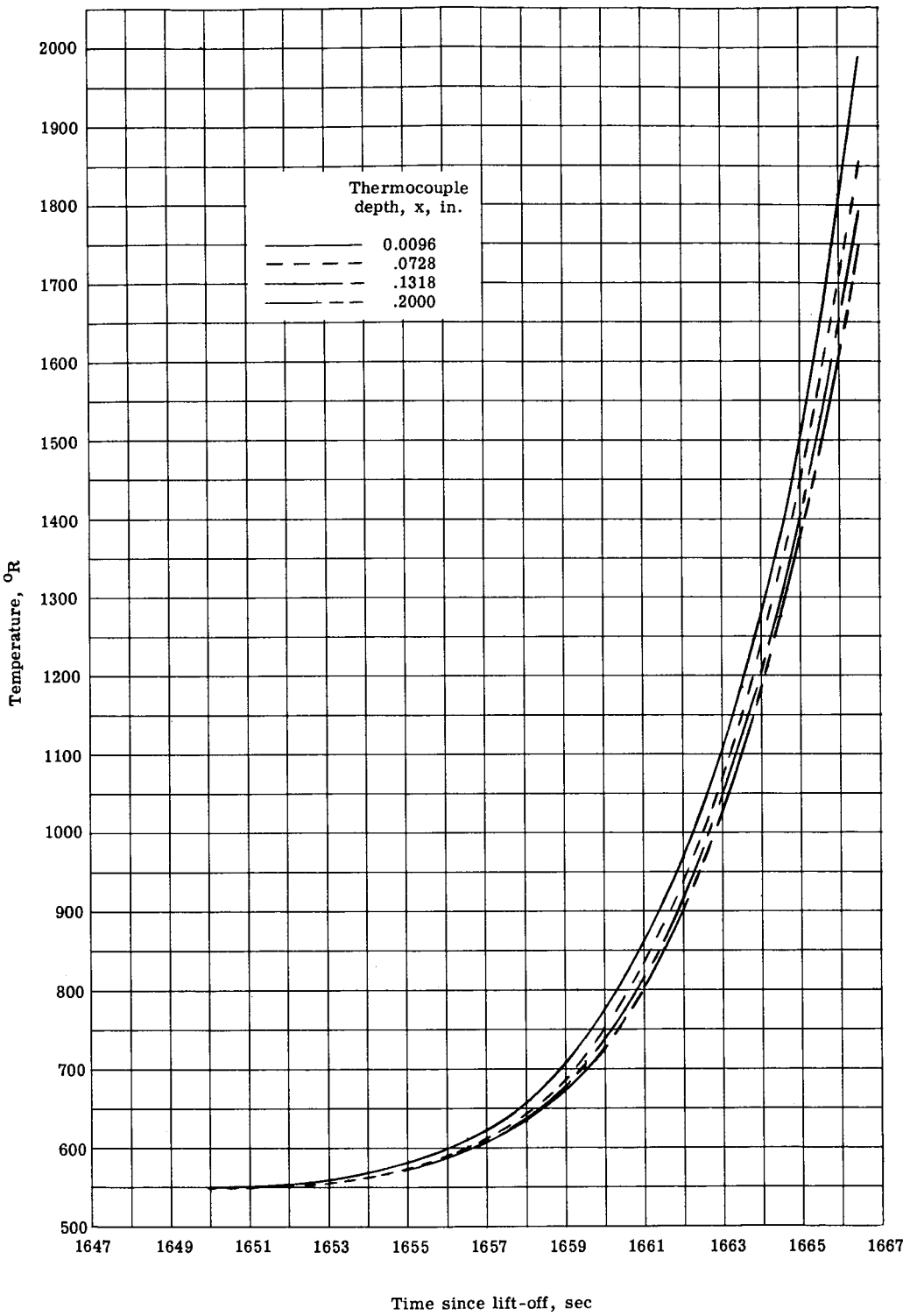


Figure 22.- Comparison of fairings of temperature data for the four thermocouples in the plug at $s/R = 0.09$, $\phi = 146.25^{\circ}$, and beryllium layer 1.

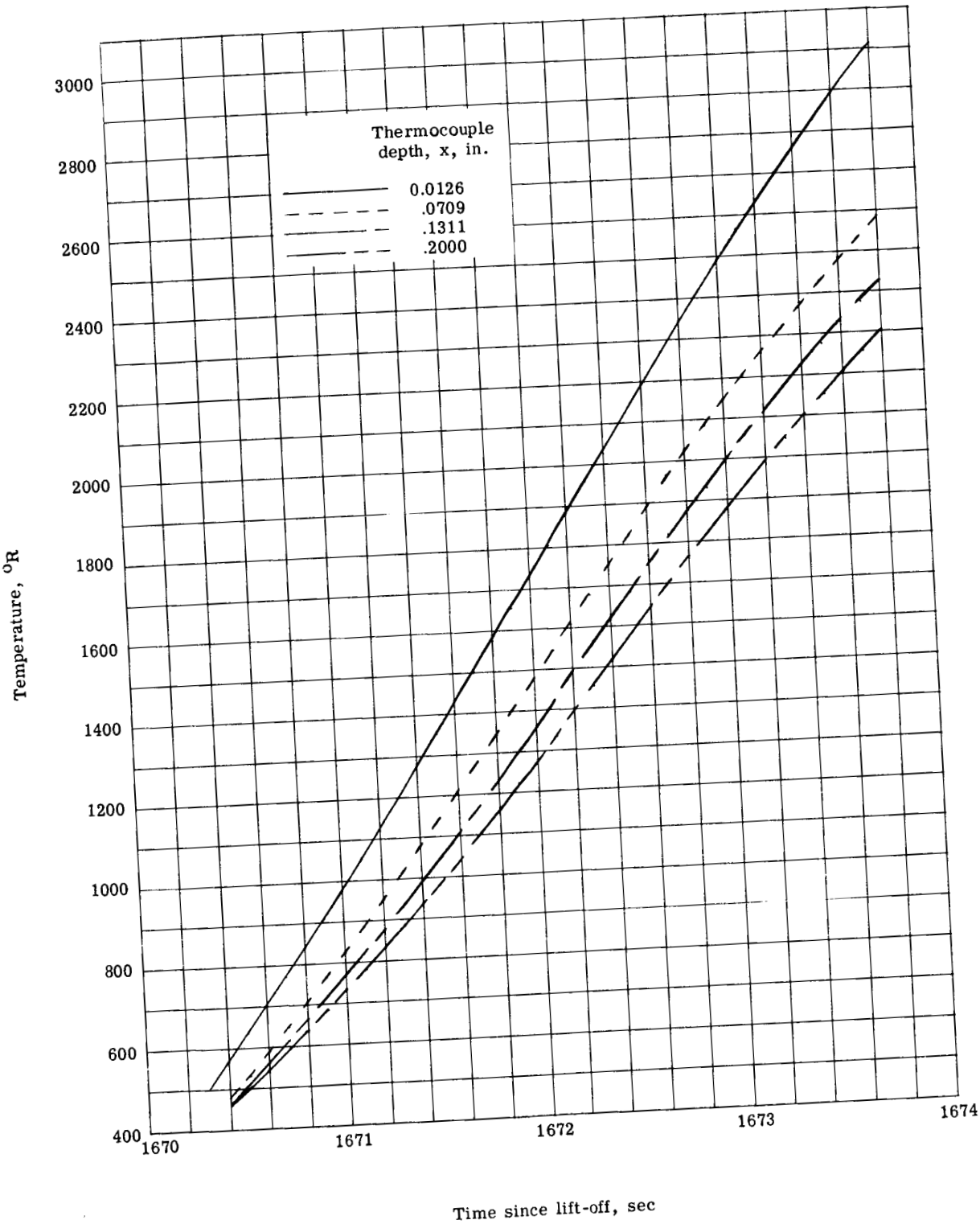


Figure 23.- Comparison of fairings of temperature data for the four thermocouples in the plug at $s/R = 0.10$, $\phi = 258.75^{\circ}$, and beryllium layer 2.

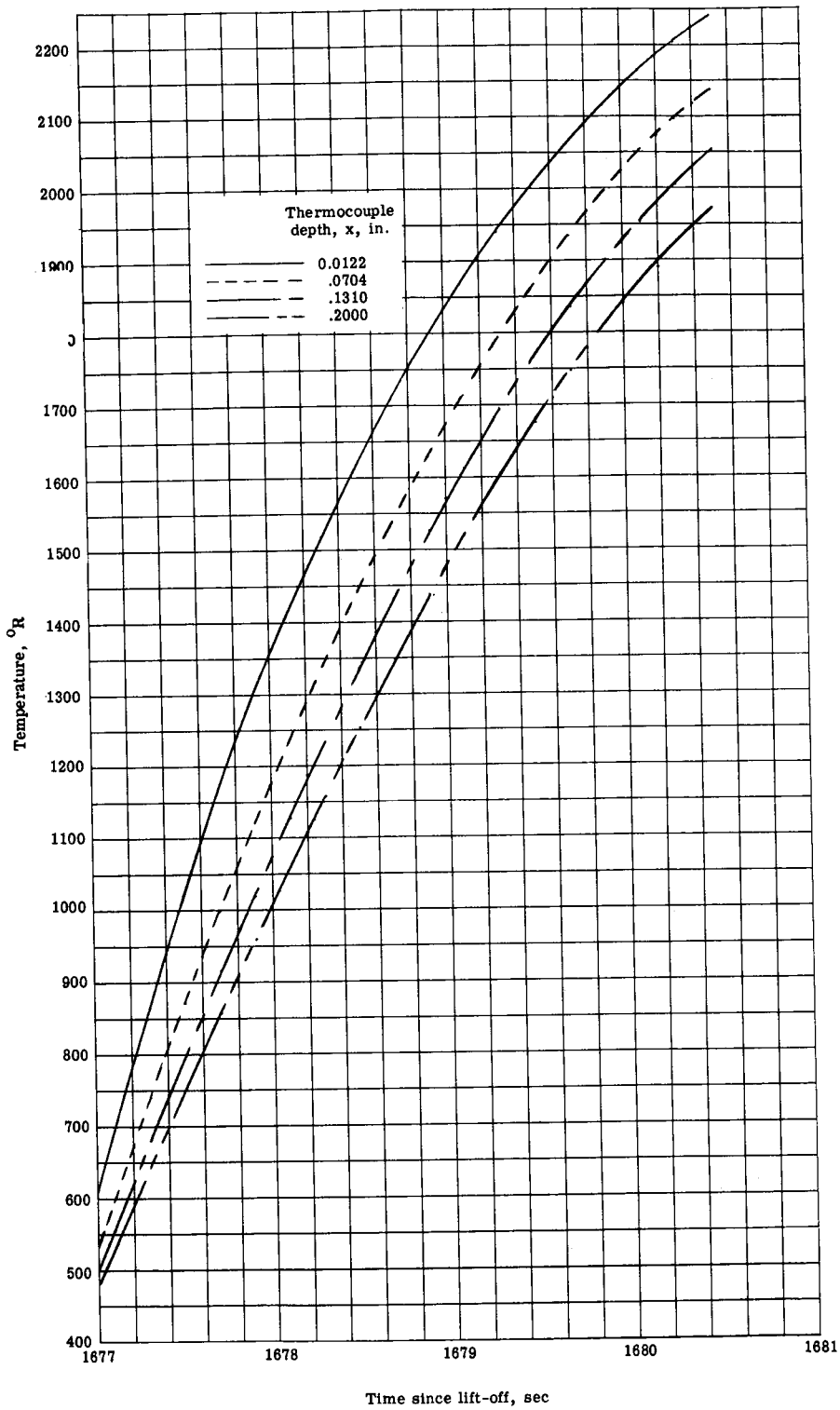


Figure 24.- Comparison of fairings of temperature data for the four thermocouples in the plug at $s/R = 0.10$, $\phi = 146.25^{\circ}$, and beryllium layer 3.

[redacted]

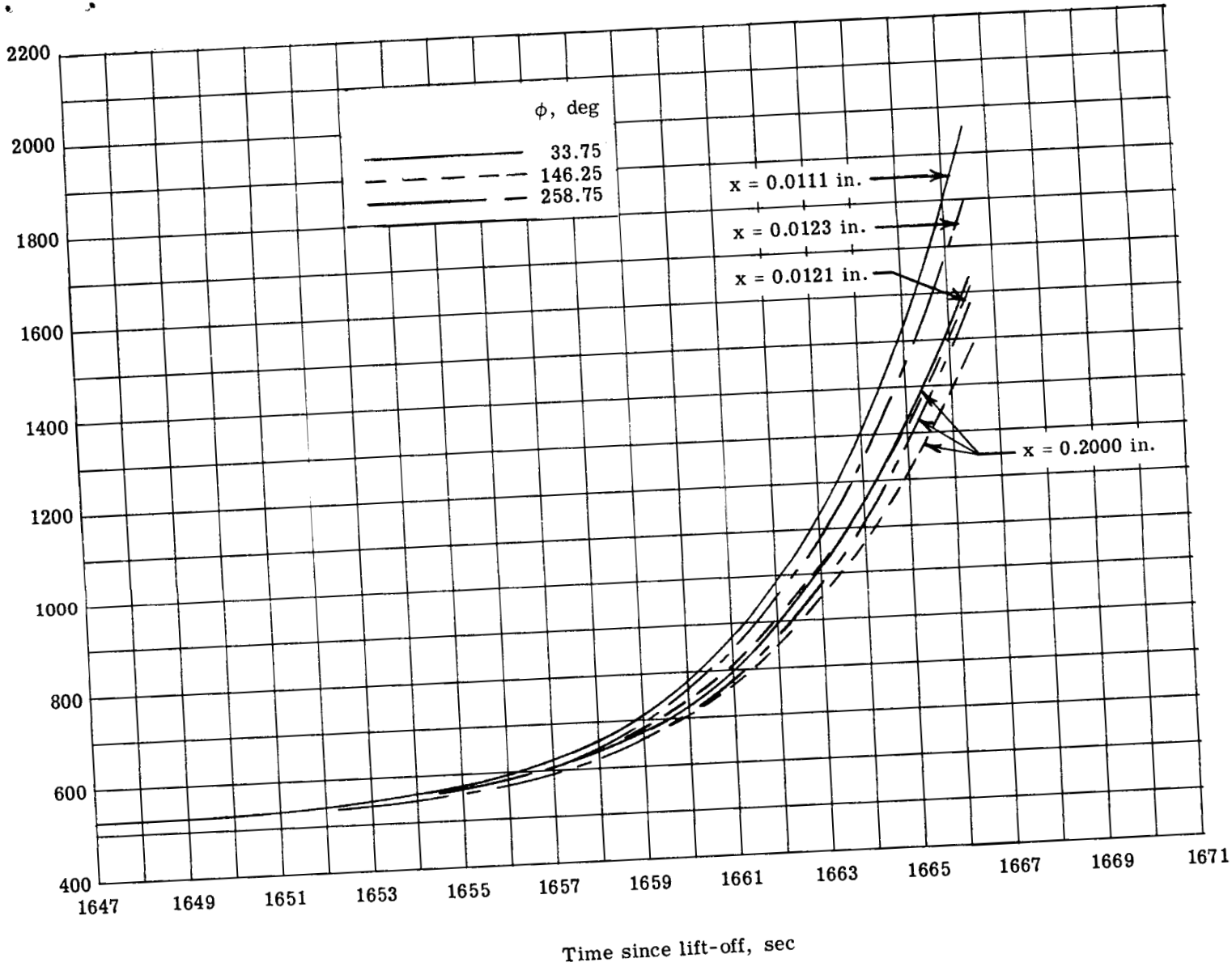


Figure 25.- Comparison of thermal response of beryllium plugs at various azimuth angles. First experimental period; s/R = 0.55.

[redacted]

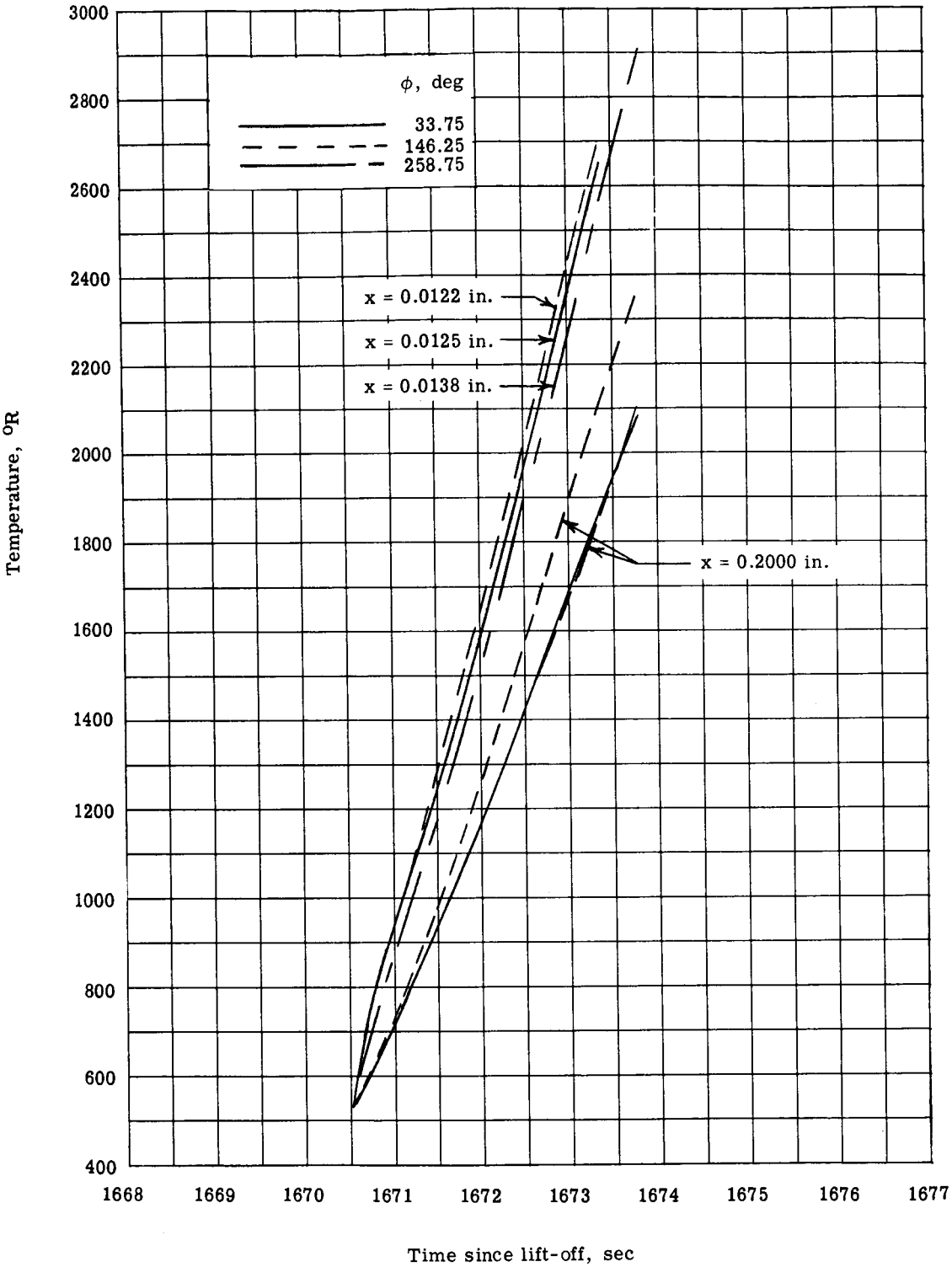
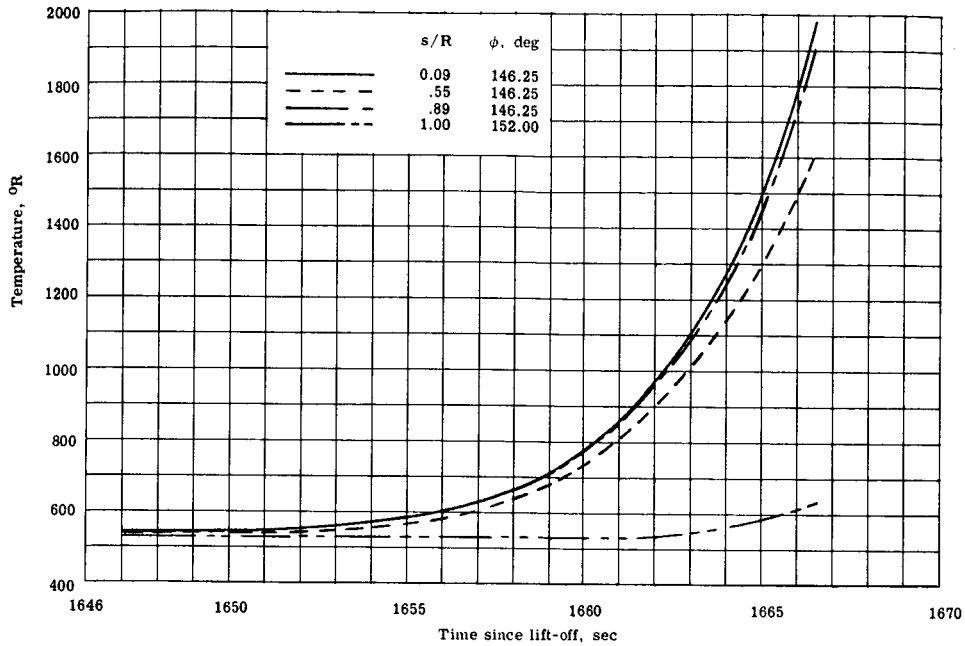
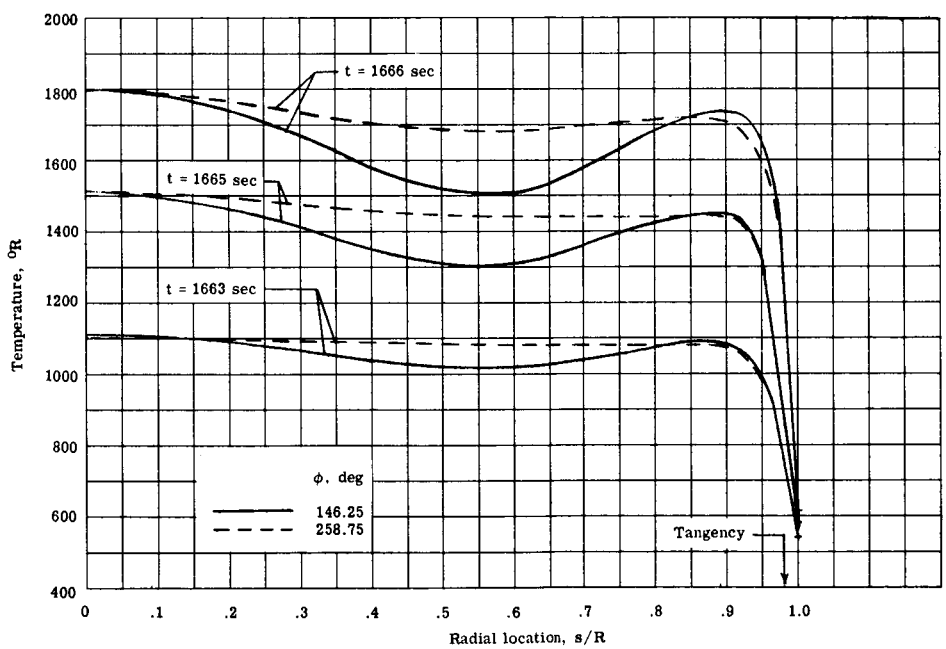


Figure 26.- Comparison of thermal response of beryllium plugs at various azimuth angles. Second experimental period; s/R = 0.90.



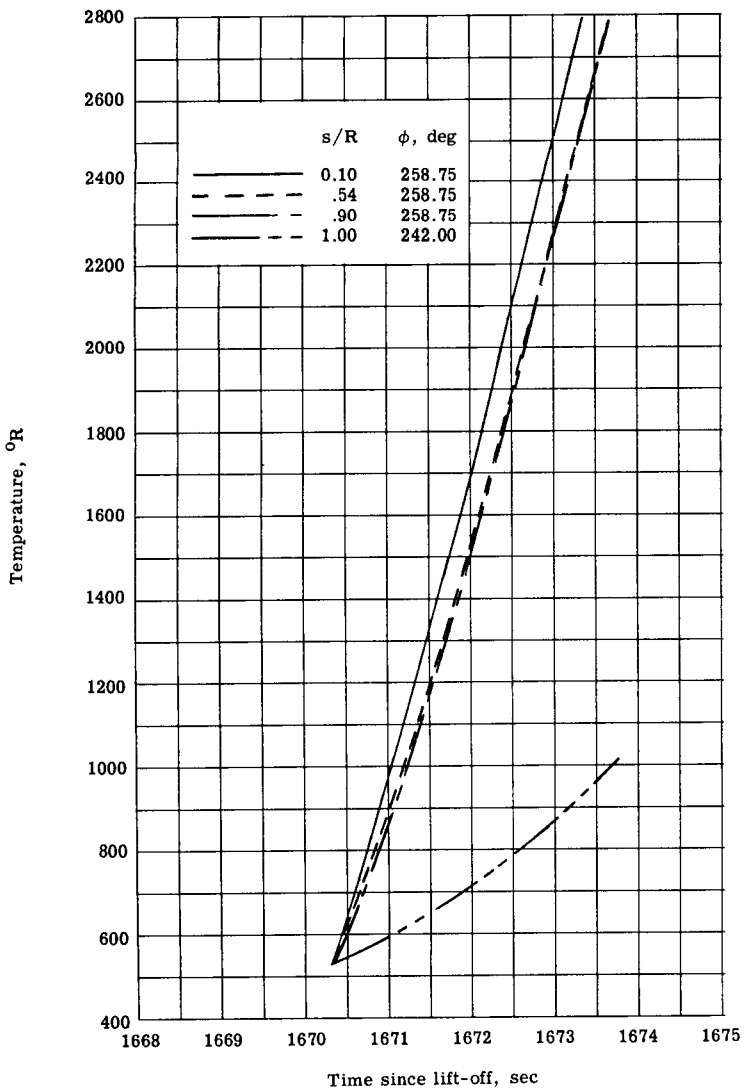
(a) Comparison of temperature-time histories at various radial locations. x = 0.010 in. (approx.).



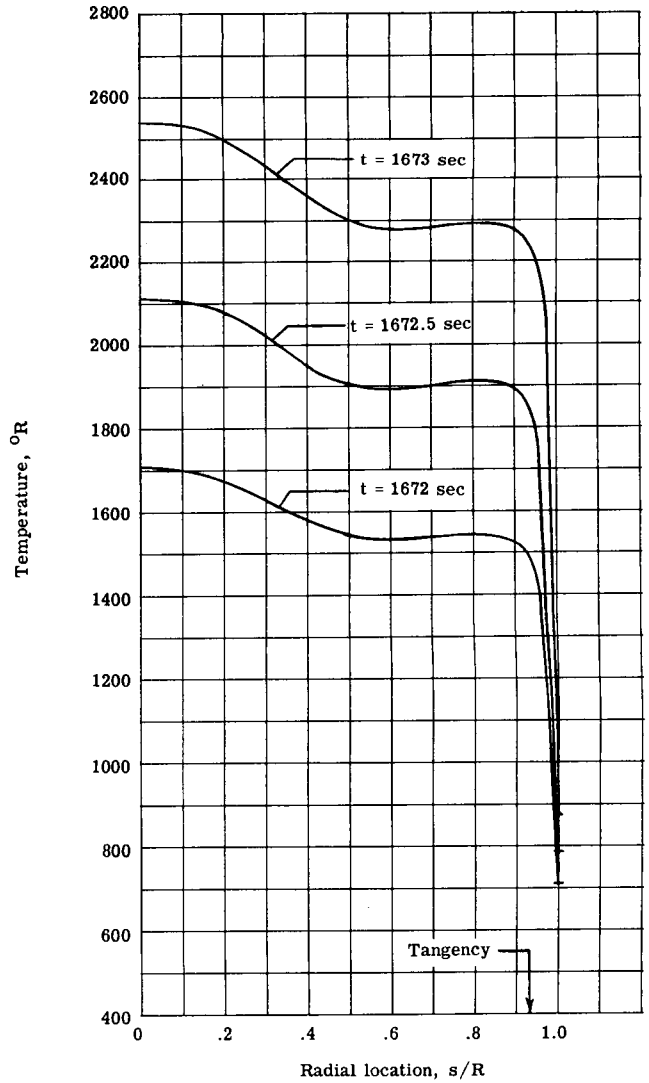
(b) Radial temperature distributions. x = 0.010 in. (approx.).

Figure 27.- Temperature-time histories and radial temperature distributions measured during the first experimental period.

[redacted]



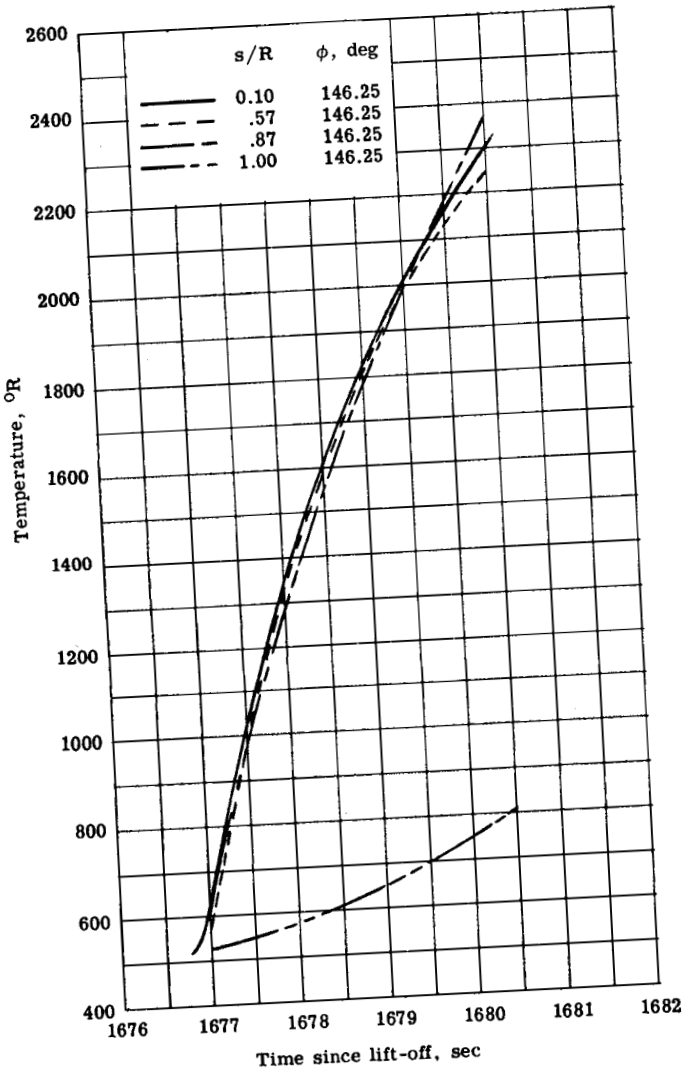
(a) Comparison of temperature-time histories at various radial locations. x = 0.010 in. (approx.).



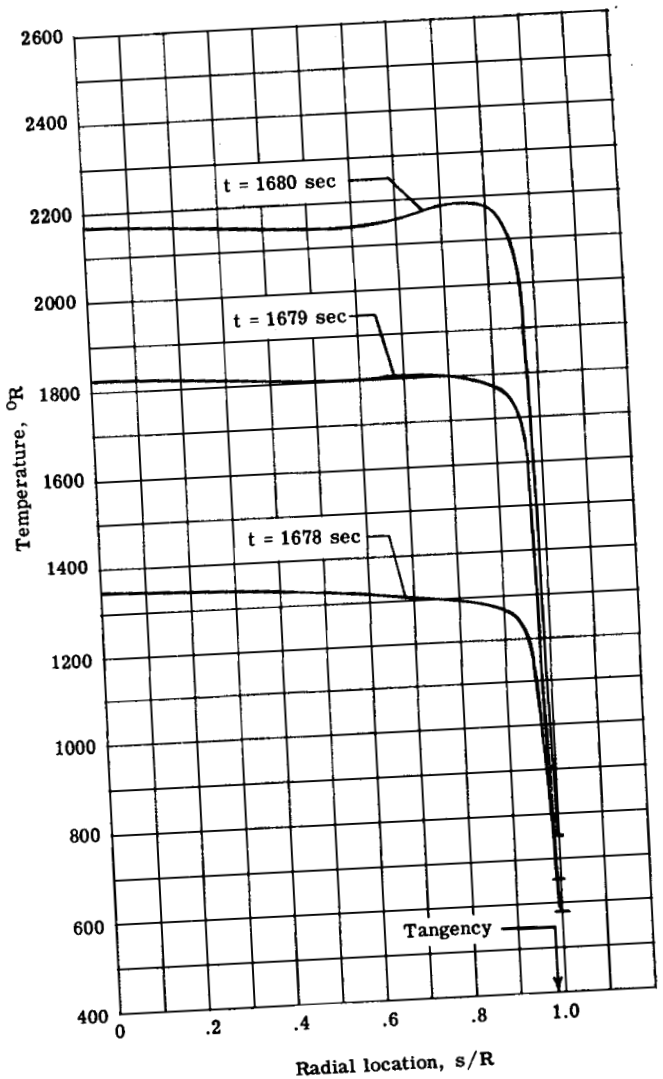
(b) Radial temperature distributions. x = 0.010 in. (approx.).

Figure 28.- Temperature-time histories and radial temperature distributions measured during the second experimental period.

[redacted]



(a) Comparison of temperature-time histories at various radial locations. x = 0.010 in. (approx.).



(b) Radial temperature distributions. x = 0.010 in. (approx.).

Figure 29.- Temperature-time histories and radial temperature distributions measured during the third experimental period.

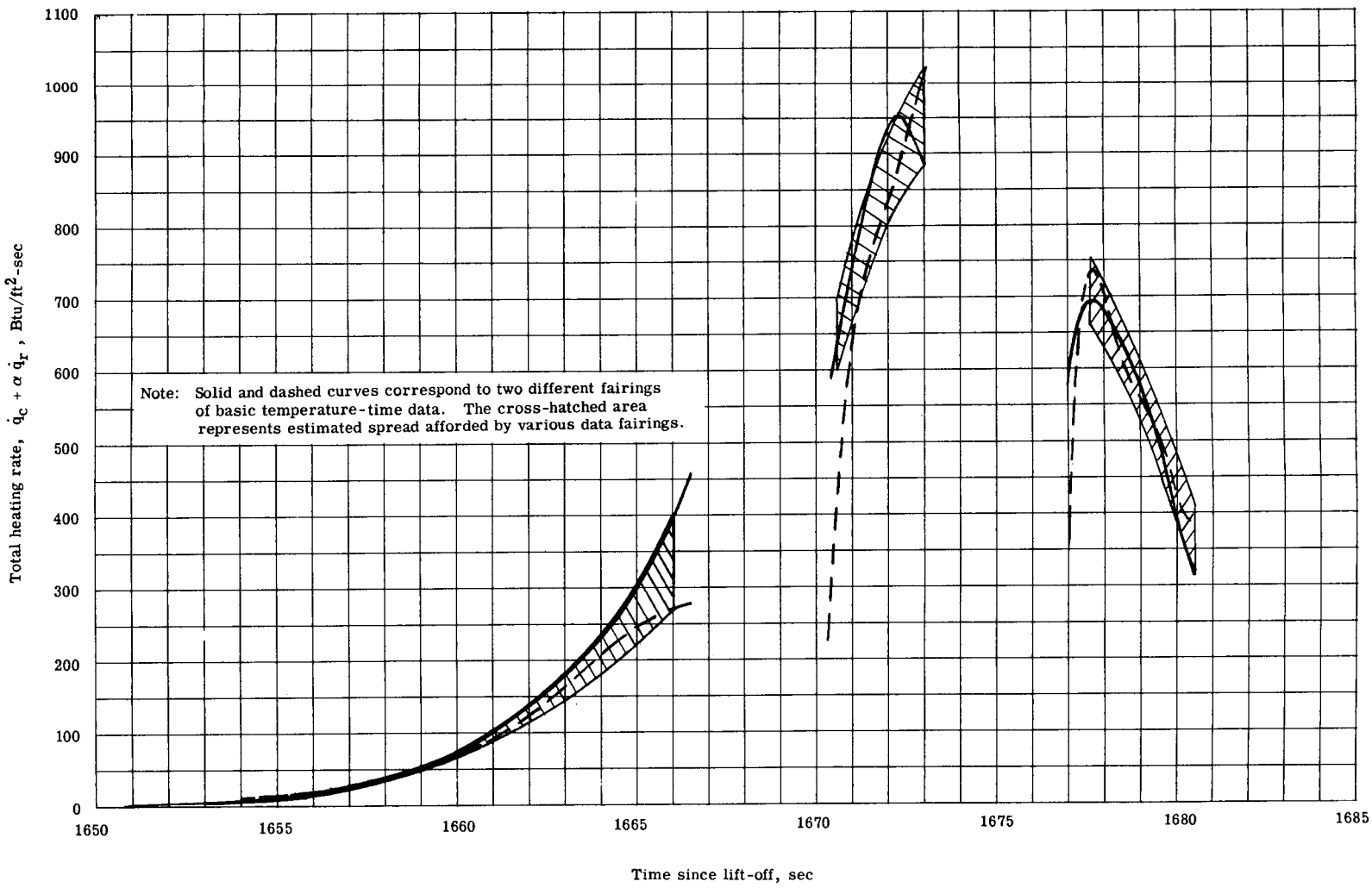


Figure 30.- Variation of total heating rate with time as determined by two different fairings of the temperature-time data. $s/R \approx 0.1$.

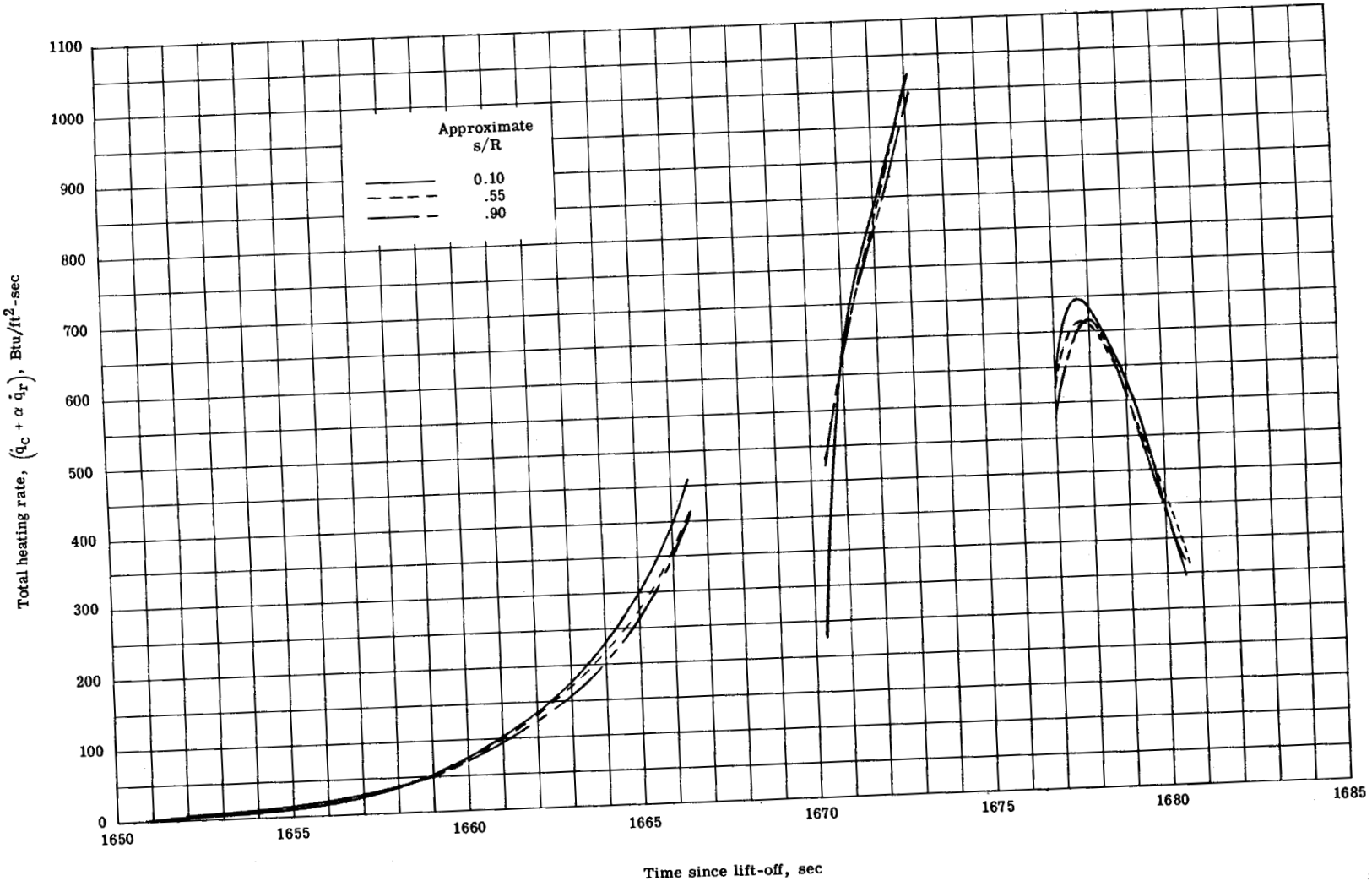


Figure 31.- Comparison of the total heating rates at three radial locations on the forebody of the reentry package.

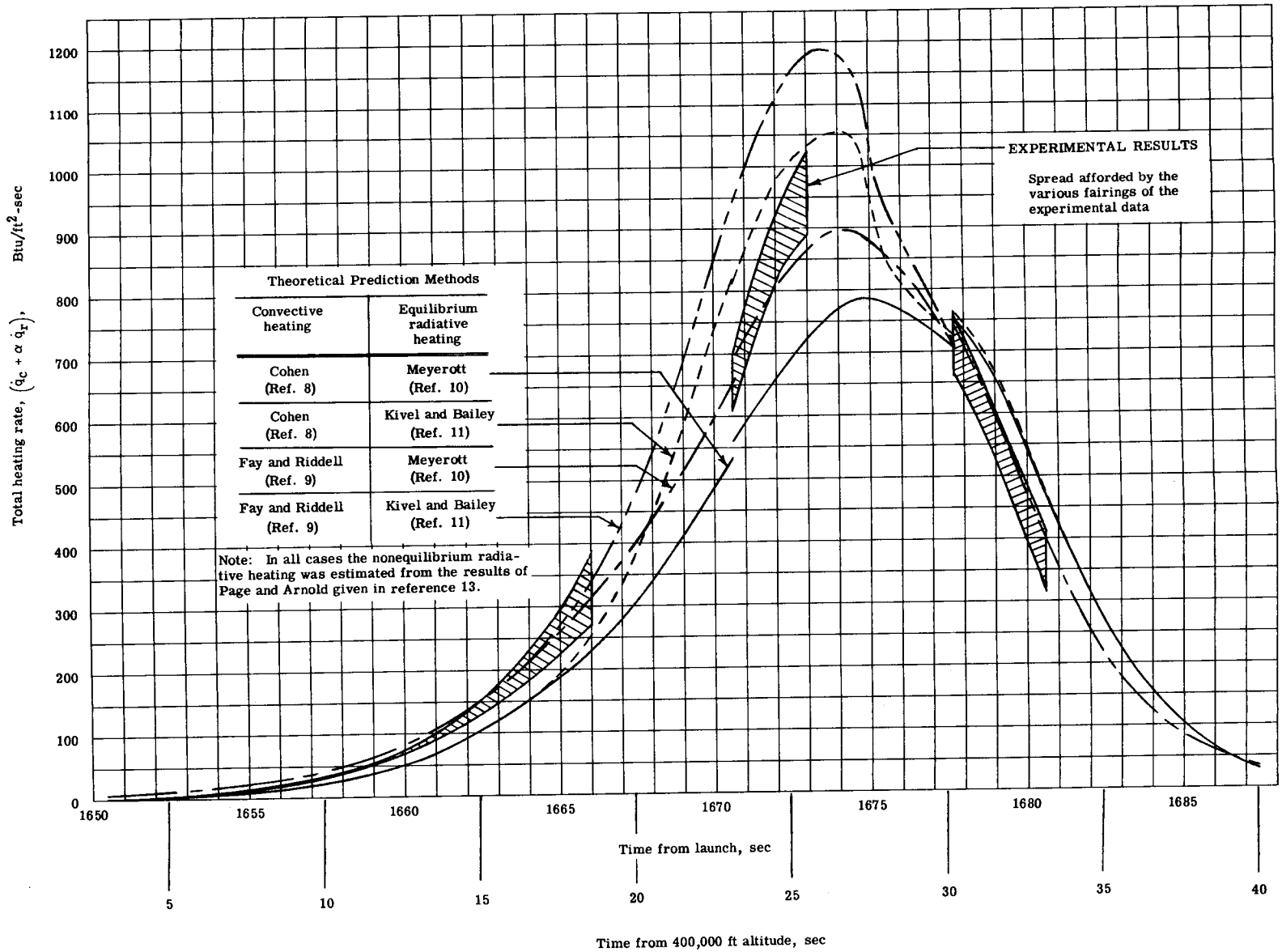
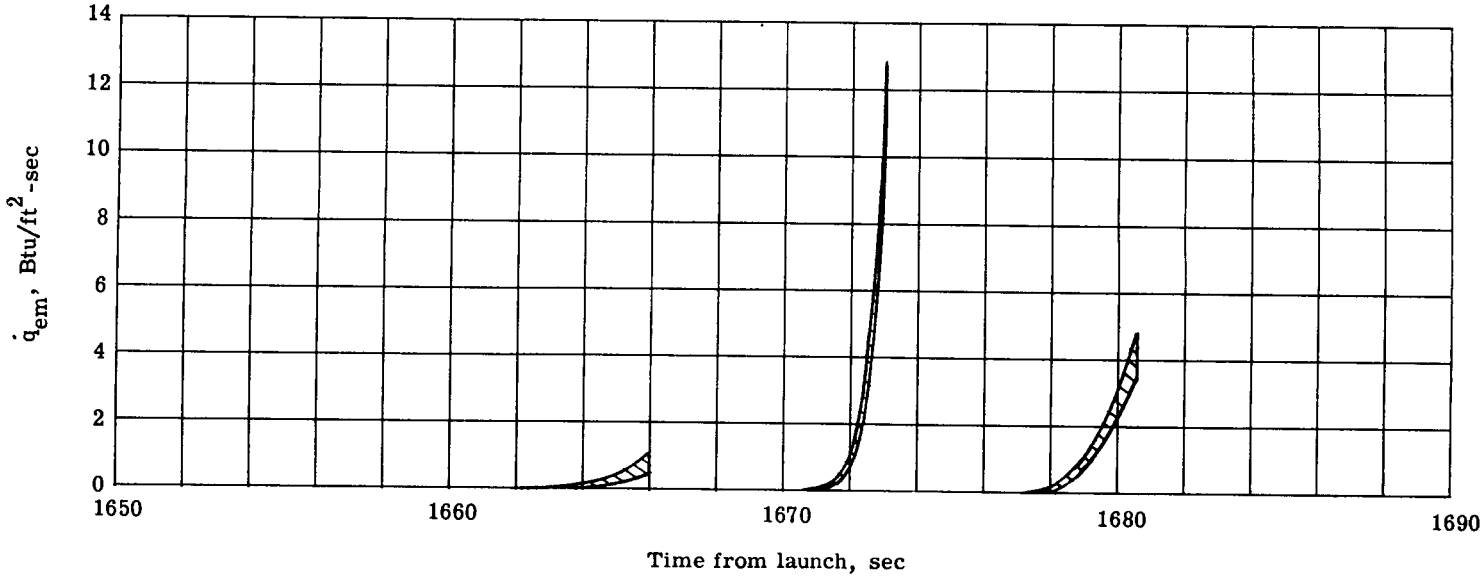
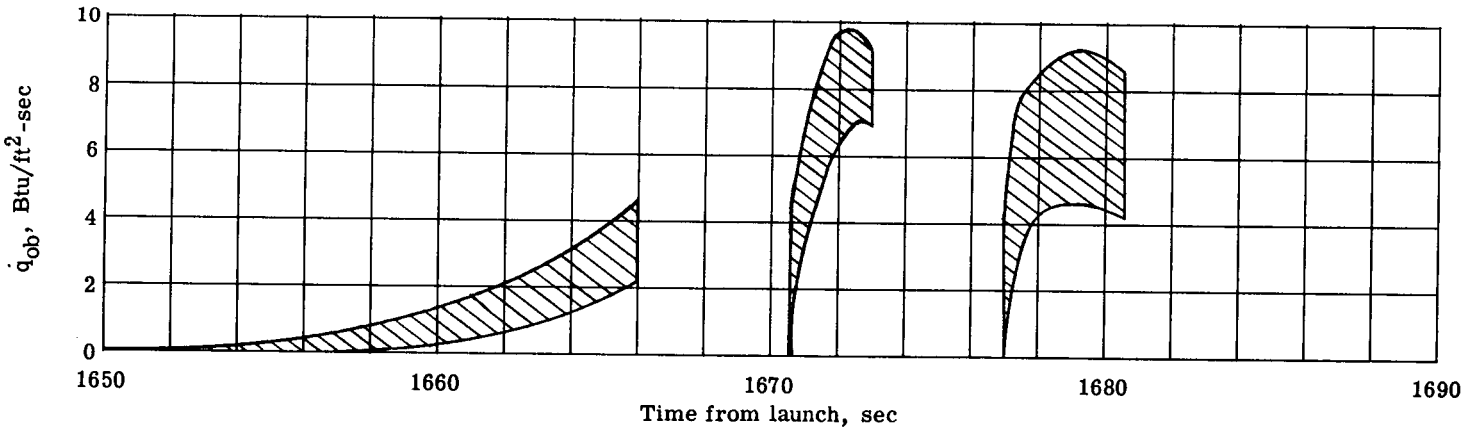


Figure 32.- Comparison of measured and predicted stagnation-point total heating rates for the Project Fire 1 reentry.



(a) Rate of heat emission from the forward exposed calorimeter surface.



(b) Rate of heat transfer out of the calorimeter rear surface.

Figure 33.- Rate of heat loss through the forward and rearward surfaces of the forebody calorimeter plugs during the Fire 1 reentry. Band includes results from all plugs analyzed.

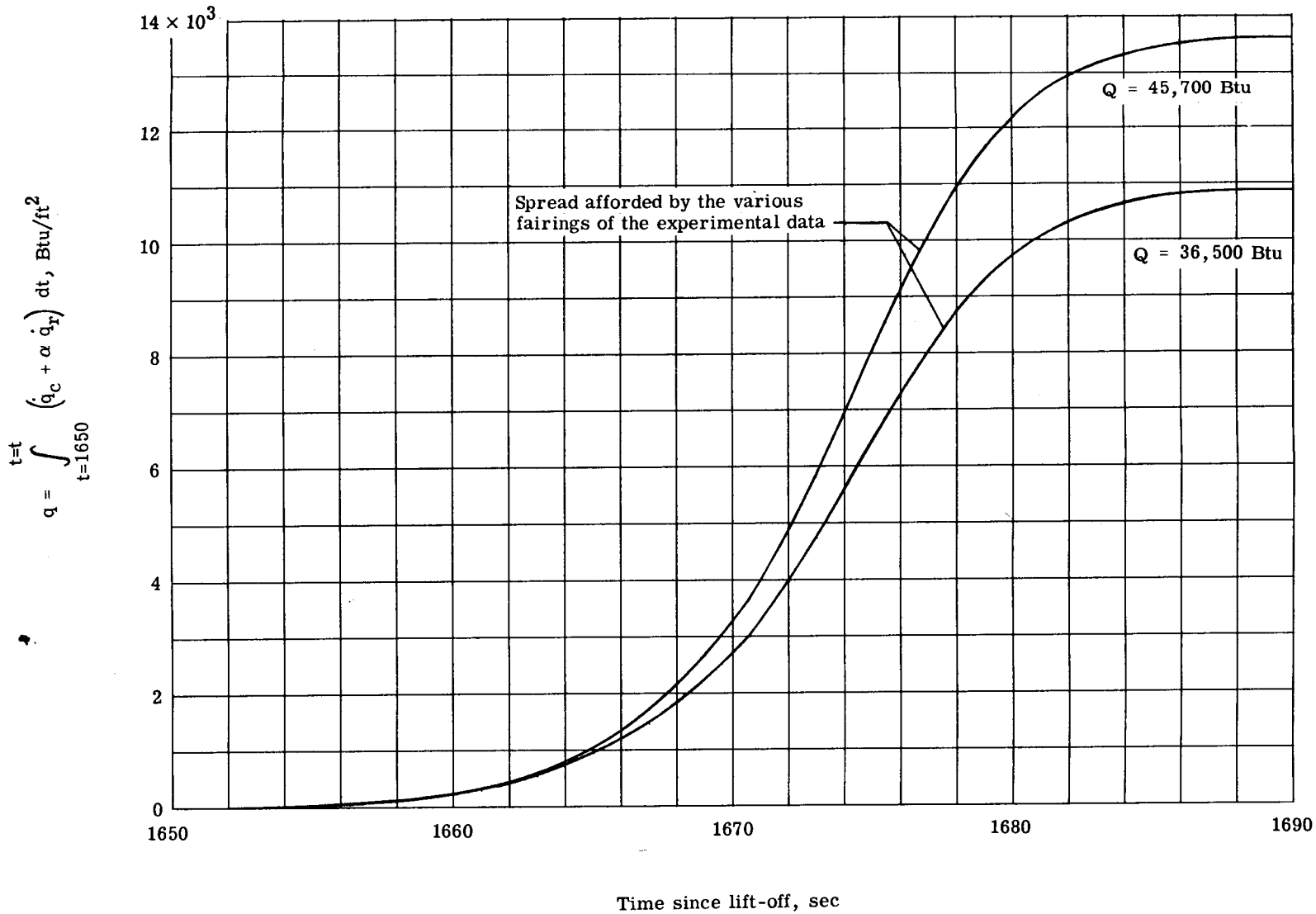


Figure 34.- Accumulative heat load experienced by the forebody of the Fire 1 reentry package.