ABSTRACT

The mathematical formulation of radiant heat transfer problems with variable radiosity, which is defined as the total radiant energy leaving a surface, leads to a set of integral equations. An extension of a relatively simple method, described in[1][I], is introduced to solve these integral equations which are of the Fredholm type. These integral equations are transformed, by using the stokes theorem, into a new set of integral equations which consists of two parts. The first part is a contour integral and the second, an area integral. The zero-order solution can be obtained by replacing J (radiosity), in the first part of the new set of integral equations, on the surface boundary by the average value of J over the boundary. In many practical problems an approximate closed form solution (zero-order solution) will give results of excellent accuracy in comparison with the exact solution obtained by numerical methods and is obtained without an elaborate calculation procedure. For the most severe cases, i.e. very small spacing ratio and surfaces with high reflectivities, this so-called zero-order solution is not acceptable. However it may be used as the starting solution for iteration of the exact equations.

The problem of a system with finite parallel surfaces having different temperature profiles is solved. The values of radiosity for the constant temperature case, obtained by the present method, have been compared with those of [2], obtained by a variational method. Systems with different combinations of W/L (width to length ratio) and H/L (spacing ratio) where the zero-order solutions are acceptable, are examined. The average dimensionless radiosities along the boundaries of surfaces 1 and 2 (i.e. $\bar{B}_1^o$ and $\bar{B}_2^o$)

I Numbers in brackets refer to references on pages 48-49.

have been computed for both surfaces having identical and constant temperatures i.e. $T_1 = T_2 =$ constant. Various combinations of W_2/L_1, H/L_1, W_1/L_1, and L_2/L_1 have been employed.

It is to be noted that this method is not only applicable to two-surface systems but also to multi-surface systems having different temperature distributions and variable radiative properties.

Acknowledgement

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Table of Contents

List of Tables

List of Figures

Nomenclature

A_i	- Area of surface i
$\vec{a}_{ij}$	- $\vec{r}_j \times \vec{n}_i / r_{ij}$, vector
$b_1, \cdots, b_{30}$	- Constants defined in Appendix 2
B_i	- Dimensionless radiosity of surface i
$\bar{B}_i$	- Mean dimensionless radiosity of surface i
$\bar{B}_i^o$	- Mean dimensionless radiosity of the zero-order solution
C_i	- Boundary of surface i
C_{jk}	- The length forming the k^{th} part of the boundary of surface j
$d_1, \cdots, d_4$	- Constants defined on page 22
dA_i, dA_j	- Infinitesimal area elements of surfaces i and j
$dF_{dA_i - dA_j}$	- Configuration factor
E_i	- Emittance of surface i
E_{Ri}	- $\epsilon_i \sigma T^4_{const.}$,emittance evaluated at a convenient temperature and emissivity
F_i	- E_i/E_{Ri}
$g_1, \cdots, g_8$	- Constants defined in Appendix 3
H	- Perpendicular distance between two parallel plates
H_i	- Total energy impinging at surface i, Irradiation
$\vec{i}$, $\vec{j}$, $\vec{k}$	- Unit vectors in x, y, z directions
J_i	- Radiosity of surface i
$\bar{J}_i$	- Mean radiosity
$\bar{J}_i^o$	- Zero-order mean radiosity
L	- Length of the plate
L_i	- Length of the plate i

M	- Number of parts of the contour of each surface
N	- Number of surfaces
$\vec{n}_i$	- Unit vector normal to the area element dA_i
q_i	- Local net heat flux of surface i
q_i^*	- Dimensionless local net heat flux of surface i
Q_i	- Total heat flux of surface i
$\vec{r}_{ij}$	- The vector from dA_i to dA_j
r_{ij}	- Distance between dA_i to dA_j
$\vec{r}_i$	- $\vec{r}_{ij}/r_{ij} = -\vec{r}_j$, unit vector along $\vec{r}_{ij}$
S_i	- The position of the surface element dA_i
T_i	- Absolute temperature of surface i
T_o	- Absolute temperature at X=0, Z=1
T_1	- Absolute temperature at X=1, Z=-1
W	- Width of the plates
W_i	- Width of the plate i
x, y, z	- Rectangular coordinates
X	- x/L, dimensionless coordinate
Z	- z/W, dimensionless coordinate

Greek Letter

α	- Gray body absorptivity
γ_H	- H/L, spacing ratio
γ_{L2}	- L_2/L_1
γ_{W1}	- W_1/L_1
γ_{W2}	- W_2/L_1
γ_W	- W/L

ϵ - Emissivity

θ_i - Angle subtended by $\vec{n_i}$ and $\vec{r_i}$

ρ - Gray body reflectivity $= (1-\epsilon)$

σ - Stefan-Boltzmann constant

Subscripts

1 - Surface 1

2 - Surface 2

i - Surface i

j - Surface j

Superscripts

o - Zero-order value of a solution

n - n-order value of a solution

Chapter 1

INTRODUCTION

1.1. Back Ground

The study of radiant heat transfer problems involving the exchange of diffuse radiant energy among gray surfaces separated by a vacuum, or non-absorbing and non-emitting medium, has been stimulated by modern engineering technology. Applications include the transfer of waste heat from space vehicles, solar energy conversion devices, etc. Eckert and Drake[3] have proposed a simple method to evaluate the heat transfer by assuming that the radiant energy incident on the surface and the local heat flux are uniformly distributed over the entire surface. Based on this assumption, the governing equations for radiant heat transfer become a set of linear algebraic equations. The angle factors commonly tabulated in the literature can be used to solve these linear algebraic equations. But it was found that large nonuniformities of incident radiation and local heat flux could occur as the spacing between the surfaces diminished even for constant temperatures of the surfaces[2,4-6]. In order to obtain more accurate estimates of the over-all heat flux, the variation of incident energy over the surface considered should be taken into account. Then the mathematical formulation of the problem for variable radiosity, which is defined as the total radiant energy leaving a surface, leads to a set of integral equations.

1.2. Exact Solution

Except for a few special cases, such as a spherical cavity or cylindrical arc[7,8] , closed form solutions of the integral equations are almost unobtainable. Solutions have depended upon numerical computation by iteration or finite difference [4,6], approximate solution by variational method [2,5], or kernal approximation [9]. Even for semi-infinite systems, the computing work for all these methods is formidable. To reduce the computing work, the governing integral equations are transformed into a new set of integral equations which are suitable for rapid iteration. It will be shown that the explicit approximate solution (zero-order solution) for radiosity and local heat flux will give results of excellent accuracy in comparison with the exact solutions. These explicit solutions can be obtained without any iterativa procedure for some cases of finite surface system involved with different temperature distributions. The effect of different radiative properties of the plates and the effect of variable temperatures of the plates can be examined rapidly by using the approximate solution.

Chapter 2

METHODS FOR SOLVING INTEGRAL EQUATIONS OF RADIATION HEAT TRANSFER

The energy equation governing the thermal radiation process is found to be a set of integral equations [4] . Closed form solutions of these integral equations are possible only for a few special geometrical configurations [7,8]. For the more general problems, either approximate analytical or numerical methods are used to obtain solutions.

A finite difference method was used to solve a problem of semi-infinite adjoint plates [4]. This is a problem of only one dimension, i.e. radiative quantities a function of X only. First, the linear integral equations were reduced to a corresponding set of linear algebraic equations with 50 mesh points used. A solution was obtained by solving a set of 50 simultaneous algebraic equations. The solution in the range $0.5 \leq X \leq 1$ was established as correct. Then the 50 unknown mesh points were concentrated in the range $0 \leq X \leq 0.5$ from which a correct solution in the range $0.25 \leq X \leq 0.5$ was established. The procedure was repeated in the range closer and closer to the vertex of the plates. The values of radiosity near the vertex were obtained by extrapolation, because the common edge is a singular point for any numerical calculation using finite difference methods. Another numerical approach used in solving the systems of two semi-infinite parallel plates and two circular disks [4,6] is that of successive iterations. The general governing equation for two semi-infinite parallel plates having the same temperature is [4]

$$B(X) = 1 + \rho \frac{H^2}{2L^2} \int_a^b B(Z) \frac{dZ}{\left[(Z-X)^2 + (H/L)^2 \right]^{3/2}}$$

The distribution of the unknown radiosity, B, was first guessed. Then, for a fixed position, say X_1, numerical integration wae carried out on the right-hand side of the above governing equation. A new value of radiosity was obtained at X_1. The procedure was repeated at 50 to 100 different points. The new set of radiosity, $B^1(X)$, which was generated then served as the next input to the right-hand side of the governing equation. The process was repeated until an acceptable solution was obtained. For each iteration, numerical integration was carried out 50 to 100 times. Both methods require a digital computer and a first 'guess' is necessary for the latter method.

The variational method is one of the approximate analytical methods used to solve these heat tranfer problems. In Sparrow's early study [5], consideration was given to problems in which there was a single unknown function, a single independent variable and a symmetric kernal in the governing equation. A function which makes the variational expression an extremum is a solution of the original equation. Suppose the radiant heat transfer problem is governed by the following integral equation

$$B(X) = G(X) + \lambda \int_a^b B(Y)K(Y,X)dY$$

where G is a given function of X, λ a constant parameter, and K(Y,X) a kernal. From the calculus of variation [10], we know that when functions are found which make the variational expression, I, an extremum (actually a maximum for our radiation problem), those same functions are solutions of the original integral equation. The variational expression, I, is [5]

$$I = \lambda \int_a^b \int_a^b K(Y,X)B(X)B(Y)dXdY - \int_a^b (B(X))^2 dX + 2\int_a^b B(X)G(X)dX$$

It is extremely difficult to find the functions that provide an absolute extremum. The approximate solution of problems expressed in variational form can be obtained by using Rayleigh-Ritz method. According to this method, a set of function $f_1(X)$, $f_2(X),\cdots$ is selected and with these, B is written as follow

$$B(X) = \sum_{n=1}^{r} C_n f_n(X)$$

$$B(Y) = \sum_{n=1}^{r} C_n f_n(Y)$$

where C_1, $C_2,\ldots,$ C_r are constants to be determined. With this choice for B's, the integrations indicated in variational expression, I, can be carried out. Now, the expression for variational equation is a function of C_1, $C_2,\cdots,C_r$. To find the extremum for I, the expression of I is differentiated with respect to each coefficient and each resulting equation is set equal to zero. Than the unknown coefficients are evaluated by solving r simultaneous algebraic equations. Frequently, a polynomial of successively increasing degree, satisfying the specific boundary conditions is chosen. It is shown in [4] that for a system of two semi-infinite parallel plates with the same temperature and $H/L > 0.5$, a quadratic solution was satisfactory. As the spacing ratio decreased, a quartic expression was necessary to obtain good results. Recently, Sparrow and Haji-Sheikh [2] presented a generalized variational method for radiant exchange between N surfaces, each of which might have a different temperature distribution and different radiative properties. The procedure for obtaining the solution remains the same. In two dimensional cases (finite surfaces), certain quadruple integrals must be evaluated in order to find the coefficients of the function assumed.

According to [2], it was convenient to carry out the first two integrations analytically and the others numerically. The work was formidable.

Another approach, known as kernal approximation, is also used in thermal radiation problems. The aim of this method is to reduce the integral equation to a differential equation. The actual angle factor (kernal) is replaced by an approximate exponential function. Usiskin and Siegel [9] used numerical integration, variational and kernal approximate methods to solve the same problem. Among these three methods, the agreement between numerical integration and variational methods was very good. The results obtained from kernal approximation method did not agree very well with those other two methods.

Chapter 3

GENERAL EQUATIONS

3.1. Equations of Radiosity and Irradiation

The radiant energy exchange is among N surfaces which are assumed to be gray and to emit and reflect radiation diffusely. Those surfaces are separated by radiatively non-participating media. The total radiant energy per unit time and area leaving an infinitesimal area dA_i, as shown in Figure 1, is defined as $J_i(S_i)$. The position of the surface element dA_i is denoted as S_i, where $i = 1, 2, 3, \cdots, N$.

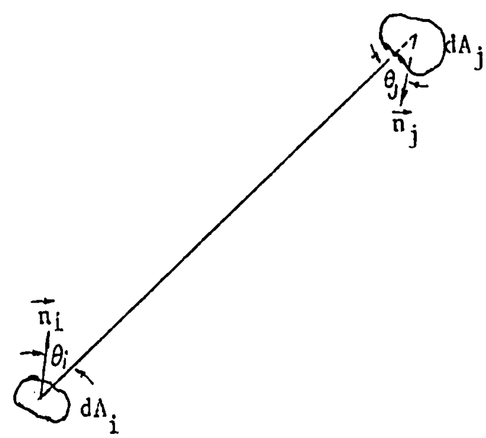


Figure 1 Configuration for interchange between two infinitesimal elements

The out-going flux is composed of two parts: the direct emittance $\epsilon_i \sigma T_i^4(S_i)$ and the reflection, $\rho_i H_i(S_i)$; $H_i(S_i)$ is the total radiant energy impinging at S_i per unit time and unit area. Then $\rho_i H_i(S_i)$ is the amount of energy being reflected. Thus the outgoing radiant energy, called the radiosity, at S_i can be written as

$$J_i(S_i) = E_i(S_i) + \rho_i H_i(S_i) \qquad (1)$$

where $E_i(S_i) = \epsilon_i \sigma T_i^4(S_i)$ is the emittance.

Since the surfaces are assumed to be gray and it is assumed that Kirchhoff's Law $\epsilon_i = \alpha_i$ is valid, the relationship $\epsilon_i = 1 - \rho_i$ applies, and Equation (1) becomes

$$J_i(S_i) = E_i(S_i) + (1 - \epsilon_i)H_i(S_i) \tag{2}$$

Equation (2) contains two unknowns, $J_i(S_i)$ and $H_i(S_i)$, which are functions of position S_i. In order to solve Equation (2), an additional relationship between $J_i(S_i)$ and $H_i(S_i)$ is required.

Consideration is given to an infinitesimal area dA_j. The energy leaving dA_j is $J_j(S_j)dA_j$. The amount of radiant energy leaving dA_j that is incident on dA_i is $J_j(S_j)dA_j dF_{dA_j-dA_i}$, where $dF_{dA_j-dA_i}$ is the configuration factor of dA_j for dA_i. This factor is defined as the fraction of energy directly incident on a surface from another surface assumed to be emitting energy diffusely. In mathematical terms,

$$dF_{dA_j-dA_i} = \frac{\cos\theta_i \cos\theta_j}{\pi r_{ij}^2} \quad dA_i \tag{3}$$

where r_{ij} is the distance between S_i and S_j on dA_i and dA_j. θ_i and θ_j are the angles subtended by r_{ij} and the normal of dA_i, $\vec{n}_i$, and that of dA_j, $\vec{n}_j$ respectively as shown in Figure 1. By applying the rule of reciprocity, $dA_i dF_{dA_i-dA_j} = dA_j dF_{dA_j-dA_i}$, one has $J_j(S_j)dA_i dF_{dA_i-dA_j}$. The total amount of radiant energy impinging at S_i on dA_i due to N gray surfaces can be expressed as

$$H_i(S_i)dA_i = \sum_{j=1}^{N} \int_{A_j} J_j(S_j)dA_i dF_{dA_i-dA_j} \tag{4}$$

The result of substituting Equations (3) and (4) into (1) is

$$J_i(S_i) = E_i(S_i) + \rho_i \sum_{j=1}^{N} \int_{A_j} J_j(S_j) \frac{\cos\theta_i \cos\theta_j}{\pi r_{ij}^2} dA_j \tag{5}$$

One can introduce the vector relations, $\cos\theta_i = \vec{n}_i \cdot \vec{r}_i$, $\cos\theta_j = \vec{n}_j \cdot \vec{r}_j$, where $\vec{n}_i$ and $\vec{n}_j$ are the inward drawn normals of dA_i and dA_j respectively. The vector $\vec{r}_{ij}$ is drawn from S_i to S_j and $\vec{r}_i = -\vec{r}_j = \dfrac{\vec{r}_{ij}}{r_{ij}}$. Equation (5) can be written as

$$J_i(S_i) = E_i(S_i) - \rho_i \sum_{j=1}^{N} \int_{A_j} J_j(S_j) \frac{\vec{n}_j \cdot \vec{r}_j (\vec{n}_i \cdot \vec{r}_j)}{\pi r_{ij}^2} dA_j \tag{6}$$

We can make use of the following identities with the details shown in Appendix 1.

$$\mathrm{curl}\left(\frac{\vec{r}_j}{r_{ij}} \times \vec{n}_i\right) = 2\,\frac{\vec{r}_j\,(\vec{n}_i \cdot \vec{r}_j)}{r_{ij}^2}$$

$$\vec{a}_{ij} \equiv \frac{\vec{r}_j}{r_{ij}} \times \vec{n}_i$$

Stokes Theorem is

$$\int_A J\,\nabla\times\vec{a}\cdot d\vec{A} = \oint J\,\vec{a}\cdot d\vec{c} - \int_A \nabla J \times \vec{a}\cdot d\vec{A}$$

After substitution, Equation (6) becomes,

$$J_i(S_i) = G_i(S_i) + \frac{\rho_i}{2\pi}\sum_{j=1}^{N}\int_{A_j}\nabla J_j(S_j)\times\vec{a}_{ij}\cdot d\vec{A}_j \tag{7}$$

where $$G_i(S_i) = \epsilon_i\sigma T_i^4(S_i) - \frac{\rho_i}{2\pi}\sum_{j=1}^{N}\oint_{c_j} J_j(S_{cj})\,\vec{a}_{ij}\cdot d\vec{c}_j \tag{8}$$

A location on the boundary of the surface is S_{cj}. In the present study, J_j is not constant along the surface boundary. Equation (8), however, can still be used to generate a simple zero-order solution of $J_i(S_i)$. This can be done by replacing $J_j(S_{cj})$ by its average value $\bar{J}_j(S_{cj})$, where

$$\bar{J}_j(S_{cj}) = \frac{\int_{c_j} J_j(S_{cj})\,dc_j}{C_j} \tag{9}$$

The length of the boundary of the surface j is C_j. Thus,

$$J_i^o(S_i) = \epsilon_i\sigma T_i^4(S_i) - \frac{\rho_i}{2\pi}\sum_{j=1}^{N}\bar{J}_j^o(S_{cj})\oint_{c_j}\vec{a}_{ij}\cdot d\vec{c}_j \tag{10}$$

The superscript o denotes the zero-order solution of a function. If the contour of surface j is composed of M parts, then the zero-order solution of $J_i(S_i)$ becomes,

$$J_i^o(S_i) = \epsilon_i\sigma T_i^4(S_i) - \frac{\rho_i}{2\pi}\sum_{j=1}^{N}\sum_{K=1}^{M}\bar{J}_j^o(S_{cjK})\int_{C_{jK}}\vec{a}_{ijK}\cdot d\vec{c}_{jK} \tag{11}$$

The average radiosity along each part of the contour, $\bar{J}_j^o(S_{cjk})$, is defined as before,

$$\bar{J}_j^o(S_{cjK}) = \int_{c_{jK}} J^o(S_{cjK})\,dc_{jK}/C_{jK} \tag{12}$$

where C_{jk} denotes the length of the line forming the part of the boundary k of the surface j.

For a system of N surfaces, if the contour of each surface is composed of M lines, there are MxN equations comprising M x N mean radiosities which can be evaluated by solving this set of linear algebraic equations simultaneously. Then $J_j^o(S_j)$, which can be easily obtained, is used as the initial approximation and substituted in the right hand side of Equation (7) to obtain the exact solution. It will be seen later that for many cases, the difference between $J_j^o(S_j)$ and $J_j(S_j)$ is so small that $J_j^o(S_j)$ can be accepted as an excellent approximate solution of $J_j(S_j)$. For other more severe cases, $J_j^o(S_j)$ can be utilized as the starting solution for iteration as described above.

3.2. Heat Transfer Equations

The local net radiant heat transfer flux is the difference between the outgoing flux and the incident flux. It can be written in the following different forms

$$q_i(S_i) = J_i(S_i) - H_i(S_i) \tag{13}$$

$$q_i(S_i) = \epsilon_i \sigma T_i^4(S_i) - \alpha_i H_i(S_i) \tag{14}$$

The portion of incoming radiant energy absorbed at position S_i is $\alpha_i H_i(S_i)$. By substituting Equations (14) into (13) and eliminating the irradiation $H_i(S_i)$ the expression for $q_i(S_i)$ becomes

$$q_i(S_i) = \frac{\epsilon_i}{1-\epsilon_i}\left[\sigma T_i^4(S_i) - J_i(S_i)\right] \tag{15}$$

Obviously, if $T_i(S_i)$ is known, once the variation of J_i over the entire surface i is known, $q_i(S_i)$ can be easily computed and the overall heat flux can be evaluated by integration from

$$Q_i = \frac{\epsilon_i}{1-\epsilon_i} \int_{A_i} \left[\sigma T_i^4(S_i) - J_i(S_i) \right] dA_i \tag{16}$$

Chapter 4

GENERAL GOVERNING EQUATIONS FOR TWO FINITE PARALLEL SURFACES

4.1. Radiosity Equations

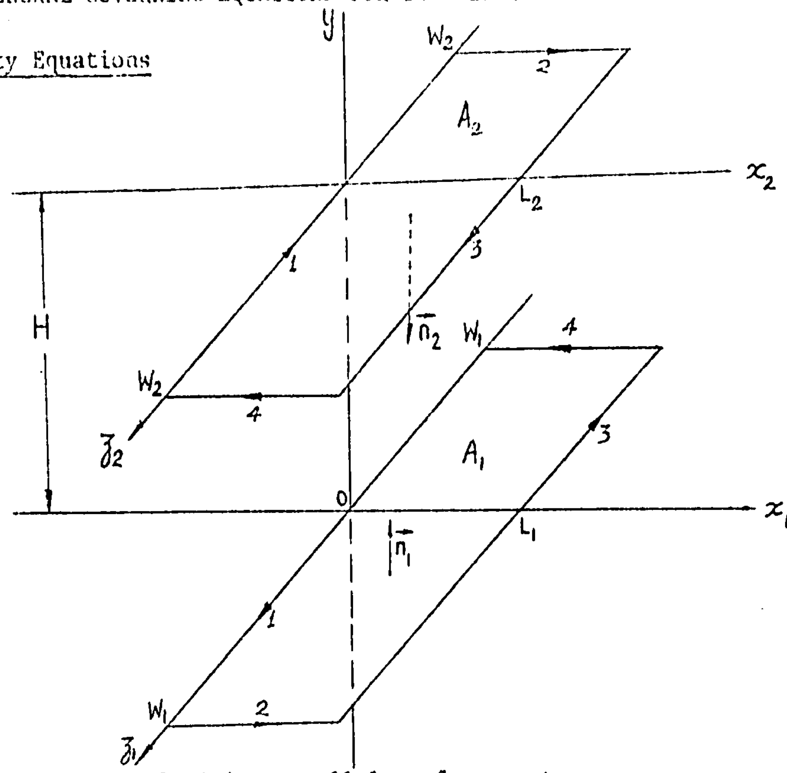


Figure 2 Finite parallel surface system

Two parallel finite surfaces with spacing H are shown in Figure 2. Subscripts 1 and 2 denote the lower and upper surfaces respectively. Surfaces 1 and 2 are kept at prescribed temperature distributions $T_1(x_1, z_1)$ and $T_2(x_2, z_2)$. For simplicity, ϵ_i is assumed to be constant and the environmental temperature to be at absolute zero. The governing Equations (7) when applied to this specific case become

$$J_1(x_1 z_1) = \epsilon_1 \sigma T_1^4(x_1, z_1) - \frac{\rho_1}{2\pi}\Big[\sum_{K=1}^{4}\int_{C_{2K}} J_2(x_{2K}, z_{2K})\vec{a}_{12K} \cdot d\vec{C}_{2K} + \int_{A_2} \nabla J_2 \times \vec{a}_{12} \cdot d\vec{A}_2\Big] \quad (17a)$$

$$J_2(x_2, z_2) = \epsilon_2 \sigma T_2^4(x_2, z_2) - \frac{\rho_2}{2\pi}\Big[\sum_{K=1}^{4}\int_{C_{1K}} J_1(x_{1K}, z_{1K})\vec{a}_{21K} \cdot d\vec{C}_{1K} + \int_{A_1} \nabla J_1 \times \vec{a}_{21} \cdot d\vec{A}_1\Big] \quad (17b)$$

The boundary or contour C_2 of surface 2 is composed of four parts: 1,2,3 and 4. The values of x, z on each part of this boundary are: 1, $x_2 = 0$, 2, $z_2 = -W_2$, 3, $x_2 = L_2$ and 4, $z_2 = W_2$. Thus Equation (17a) becomes

$$J_1(x_1,z_1) = \epsilon_1 \sigma T_1^4(x_1,z_1) - \frac{\rho_1}{2\pi}\Big[\int_{C_{21}} J_2(0,z_2)\,\overline{a}_{121}\cdot d\overline{C}_{21} + \int_{C_{22}} J_2(x_2,-W_2)\,\vec{a}_{122}\cdot d\vec{C}_{22} + \int_{C_{23}} J_2(L_2,z_2)\,\vec{a}_{123}\cdot d\vec{C}_{23} + \int_{C_{24}} J_2(x_2,W_2)\,\vec{a}_{124}\cdot d\vec{C}_{24}\Big] + \frac{\rho_1}{2\pi}\int_{A_2} \nabla J_2 \times \vec{a}_{12}\cdot d\vec{A}_2 \tag{18}$$

By definition $$\vec{a}_{12} = \frac{\vec{r}_2}{r_{12}} \times \vec{n}_1$$

where
$$\vec{r}_2 = \frac{(x_1-x_2)\vec{i} + (y_1-y_2)\vec{j} + (z_1-z_2)\vec{k}}{[(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]^{1/2}}$$

$$r_{12} = [(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]^{1/2}$$

$$\vec{n}_1 = \vec{j}$$

and
$$d\vec{C}_2 = dx_2\vec{i} + dz_2\vec{k}$$

Therefore
$$\vec{a}_{12} = \frac{(x_1-x_2)\vec{k} - (z_1-z_2)\vec{i}}{(x_1-x_2)^2 + H^2 + (z_1-z_2)^2}$$

The first integral of the right-hand side of Equation (18) is evaluated along the line $x_2 = 0$ from W_2 to $-W_2$

$$\int_{W_2}^{-W_2} J_2(0,z_2)\left[\frac{(x_1-x_2)\vec{k} - (z_1-z_2)\vec{i}}{(x_1-x_2)^2 + H^2 + (z_1-z_2)^2}\right]\cdot\left[dx_2\vec{i} + dz_2\vec{k}\right]$$

Substituting $x_2 = 0$ and $dx_2 = 0$ in this expression results in

$$\int_{W_2}^{-W_2} J_2(0,z_2)\ \frac{x_1}{x_1^2 + H^2 + (z_1-z_2)^2}\,dz_2$$

Similarly, the second, third and fourth integrals can be written as

$$-\int_0^{L_2} J_2(x_2,-W_2)\ \frac{(W_2+z_1)}{(x_1-x_2)^2 + H^2 + (z_1+W_2)^2}\,dx_2$$

$$\int_{-W_2}^{W_2} J_2(L_2,z_2)\ \frac{x_1 - L_2}{(x_1-L_2)^2 + H^2 + (z_1-z_2)^2}\,dz_2$$

$$-\int_{L_2}^{0} J_2(x_2,W_2)\ \frac{(z_1-W_2)}{(z_1-W_2)^2 + H^2 + (x_1-x_2)^2}\,dx_2$$

For the area integral,

$$
\begin{aligned}
&\int_{A_2} \nabla J_2(x_2, z_2) \times \vec{a}_{12} \cdot d\vec{A}_2 \\
&= \int_{A_2} \left[\frac{\partial J_2}{\partial x_2}\vec{i} + \frac{\partial J_2}{\partial z_2}\vec{k} \right] \times \left[\frac{(x_1 - x_2)\vec{k} - (z_1 - z_2)\vec{i}}{(x_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} \right] \cdot (-\vec{j}\, dA_2) \\
&= \int_{z_2}\int_{x_2} \left[\frac{(x_1 - x_2)}{(x_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} \frac{\partial J_2}{\partial x_2} + \frac{(z_1 - z_2)}{(x_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} \frac{\partial J_2}{\partial z_2} \right] dx_2\, dz_2
\end{aligned}
$$

Substituting these into Equation (18) yields,

$$
\begin{aligned}
J_1(x_1, z_1) = {} & \epsilon_1 \sigma T_1^4(x_1, z_1) + \frac{\rho_1}{2\pi} \Bigg\{ \int_{-W_2}^{W} J_2(0, z_2) \frac{x_1}{x_1^2 + H^2 + (z_1 - z_2)^2} dz_2 \\
& + \int_{-W_2}^{W_2} J_2(L_2, z_2) \frac{(L_2 - x_1)}{(L_2 - x_1)^2 + H^2 + (z_1 - z_2)^2} dz_2 + \int_0^{L_2} J_2(x_2, -W_2) \frac{(W_2 - z_1)\, dx_2}{(x_1 - x_2)^2 + H^2 + (W_2 - z_1)^2} \\
& + \int_0^{L_2} J_2(x_2, W_2) \frac{(W_2 - z_1)\, dx_2}{(x_1 - x_2)^2 + H^2 + (W_2 - z_1)^2} + \int_{-W_2}^{W_2}\int_0^{L_2} \Bigg[\frac{x_1 - x_2}{(x_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} \frac{\partial J_2}{\partial x_2} \\
& + \frac{z_1 - z_2}{(x_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} \frac{\partial J_2}{\partial z_2} \Bigg] dx_2\, dz_2 \Bigg\}
\end{aligned}
\tag{19a}
$$

By the same procedure, Equation (17b) leads to

$$
\begin{aligned}
J_2(x_2, z_2) = {} & \epsilon_2 \sigma T_2^4(x_2, z_2) + \frac{\rho_2}{2\pi} \Bigg\{ \int_{-W_1}^{W_1} J_1(0, z_1) \frac{x_2}{x_2^2 + H^2 + (z_1 - z_2)^2} dz_1 \\
& + \int_{-W_1}^{W_1} J_1(L_1, z_1) \frac{(L_1 - x_2)}{(L_1 - x_2)^2 + H^2 + (z_1 - z_2)^2} dz_1 + \int_0^{L_1} J_1(x_1, -W_1) \frac{(W_1 + z_2)\, dx_1}{(x_2 - x_1)^2 + H^2 + (W_1 + z_2)^2} \\
& + \int_0^{L_1} J_1(x_1, W_1) \frac{(W_1 - z_2)\, dx_1}{(x_2 - x_1)^2 + H^2 + (W_1 - z_2)^2} + \int_{-W_1}^{W_1}\int_0^{L_1} \Bigg[\frac{(z_2 - z_1)}{(x_2 - x_1)^2 + H^2 + (z_2 - z_1)^2} \frac{\partial J_1}{\partial z_1} \\
& + \frac{x_2 - x_1}{(x_2 - x_1)^2 + H^2 + (z_2 - z_1)^2} \frac{\partial J_1}{\partial x_1} \Bigg] dx_1\, dz_1
\end{aligned}
\tag{19b}
$$

The zero-order solution of J_1, directly obtained from Equation (11) or Equation (19a), can be expressed as

$$
\begin{aligned}
J_1^o(x_1,z_1) = E_1(x_1,z_1) + \frac{\rho_1}{2\pi}\Bigg[& \bar{J}_2^o(x_2=0)\int_{-W_2}^{W_2}\frac{x_1\,dz_2}{x_1^2+H^2+(z_1-z_2)^2} \\
& + \bar{J}_2^o(x_2=L_2)\int_{-W_2}^{W_2}\frac{(L_2-x_1)\,dz_2}{(L_2-x_1)^2+H^2+(z_1-z_2)^2} + \bar{J}_2^o(z_2=-W_2)\int_0^{L_2}\frac{(z_1+W_2)\,dx_2}{(x_1-x_2)^2+H^2+(W_2+z_1)^2} \\
& + \bar{J}_2^o(z_2=W_2)\int_0^{L_2}\frac{(W_2-z_1)\,dx_2}{(x_1-x_2)^2+H^2+(W_2-z_1)^2}\Bigg]
\end{aligned}
$$

After carrying out the integrations,

$$
\begin{aligned}
J_1^o(x_1,z_1) = \epsilon_1\sigma T_1^4(x_1,z_1) + \frac{\rho_1}{2\pi}\Bigg\{ & \bar{J}_2^o\frac{x_1}{\sqrt{x_1^2+H^2}}\left(\tan^{-1}\frac{W_2-z_1}{\sqrt{x_1^2+H^2}} - \tan^{-1}\frac{-W_2-z_1}{\sqrt{x_1^2+H^2}}\right) \\
& + \bar{J}_2^o(x_2=L_2)\frac{L_2-x_1}{\sqrt{(L_2-x_1)^2+H^2}}\left(\tan^{-1}\frac{W_2-z_1}{\sqrt{(L_2-x_1)^2+H^2}} - \tan^{-1}\frac{-W_2-z_1}{\sqrt{(L_2-x_1)^2+H^2}}\right) \\
& + \bar{J}_2^o(z_2=-W_2)\frac{z_1+W_2}{\sqrt{(z_1+W_2)^2+H^2}}\left(\tan^{-1}\frac{L_2-x_1}{\sqrt{(z_1+W_2)^2+H^2}} - \tan^{-1}\frac{-x_1}{\sqrt{(z_1+W_2)^2+H^2}}\right) \\
& + \bar{J}_2^o(z_2=W_2)\frac{W_2-z_1}{\sqrt{(W_2-z_1)^2+H^2}}\left(\tan^{-1}\frac{L_2-x_1}{\sqrt{(W_2-z_1)^2+H^2}} - \tan^{-1}\frac{-x_1}{\sqrt{(W_2-z_1)^2+H^2}}\right)\Bigg\} \quad (20a)
\end{aligned}
$$

(20a)

Similarly, the expression for the zero-order solution of J_2 is

$$
\begin{aligned}
J_2^o(x_2,z_2) = \epsilon_2\sigma T_2^4(x_2,z_2) + \frac{\rho_2}{2\pi}\Bigg\{ & \bar{J}_1^o(x_1=0)\frac{x_2}{\sqrt{x_2^2+H^2}}\left(\tan^{-1}\frac{W_1-z_2}{\sqrt{x_2^2+H^2}} - \tan^{-1}\frac{-W_1-z_2}{\sqrt{x_2^2+H^2}}\right) \\
& + \bar{J}_1^o(x_1=L_1)\frac{(L_1-x_2)}{\sqrt{(L_1-x_2)^2+H^2}}\left(\tan^{-1}\frac{W_1-z_2}{\sqrt{(L_1-x_2)^2+H^2}} - \tan^{-1}\frac{-W_1-z_2}{\sqrt{(L_1-x_2)^2+H^2}}\right) \\
& + \bar{J}_1^o(z_1=-W_1)\frac{z_2+W_1}{\sqrt{(z_2+W_1)^2+H^2}}\left(\tan^{-1}\frac{L_1-x_2}{\sqrt{(z_2+W_1)^2+H^2}} - \tan^{-1}\frac{-x_2}{\sqrt{(z_2+W_1)^2+H^2}}\right) \\
& + \bar{J}_1^o(z_1=W_1)\frac{W_1-z_2}{\sqrt{(W_1-z_2)^2+H^2}}\left(\tan^{-1}\frac{L_1-x_2}{\sqrt{(W_1-z_2)^2+H^2}} - \tan^{-1}\frac{-x_2}{\sqrt{(W_1-z_2)^2+H^2}}\right)\Bigg\}
\end{aligned}
$$

(20b)

We now non-dimensionalize the resulting governing equations by introducing the following: $X_1=x_1/L_1$, $X_2=x_2/L_2$, $Z_1=z_1/W_1$, $Z_2=z_2/W_2$, $\gamma_H=H/L$, $\gamma_{L1}=1$, $\gamma_{L2}=L_2/L_1$, $\gamma_{W1}=W_1/L_1$, $\gamma_{W2}=W_2/L_1$, $\bar{B}_i^o=\bar{J}_i^o/E_{Ri}$ and $\bar{B}_i^B=\bar{J}_i^B/E_{Ri}$

$E_{R1} = \epsilon_1 \sigma T^4_{const.}$ is the emittance evaluated at a convenient temperature and emissivity. Equations (19) and (20) in non-dimensional form are,

$$
\begin{aligned}
B_1(X_1,Z_1) = {} & \frac{E_1(X_1,Z_1)}{E_{R1}} + \frac{\rho_1}{2\pi}\frac{\epsilon_2}{\epsilon_1}\Bigg\{ \int_{-1}^{1} B_2(0,Z_2)\frac{\gamma_{W2} X_1 \, dZ_2}{X_1^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2} \\
& + \int_{-1}^{1} B_2(1,Z_2)\frac{\gamma_{W2}(\gamma_{L2}-X_1)\,dZ_2}{(\gamma_{L2}-X_1)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2} + \int_0^1 B_2(X_2,-1)\frac{\gamma_{L2}(\gamma_{W2}+\gamma_{W1}Z_1)\,dX_2}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1}Z_1)^2} \\
& + \int_0^1 B_2(X_2,1)\frac{(\gamma_{W2}-\gamma_{W1}Z_1)\gamma_{L2}\,dX_2}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1}Z_1)^2} + \int_{-1}^{1}\int_0^1 \Bigg[\frac{\gamma_{W1}Z_1-\gamma_{W2}Z_2}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}\frac{\partial B_2}{\partial Z_2} \\
& + \frac{\gamma_{W2}(X_1-\gamma_{L2}X_2)}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}\frac{\partial B_2}{\partial X_2}\Bigg] dX_2\, dZ_2 \Bigg\}
\end{aligned}
\tag{21a}
$$

$$
\begin{aligned}
B_2(X_2,Z_2) = {} & \frac{E_2(X_2,Z_2)}{E_{R2}} + \frac{\rho_2}{2\pi}\frac{\epsilon_1}{\epsilon_2}\Bigg\{ \int_{-1}^{1} B_1(0,Z_1)\frac{\gamma_{L2}\gamma_{W1} X_2 \, dZ_1}{(\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2} \\
& + \int_{-1}^{1} B_1(1,Z_1)\frac{(1-\gamma_{L2}X_2)\gamma_{W1}\,dZ_1}{(1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2} + \int_0^1 B_1(X_1,-1)\frac{(\gamma_{W1}+\gamma_{W2}Z_2)\,dX_1}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2}Z_2)^2} \\
& + \int_0^1 B_1(X_1,1)\frac{(\gamma_{W1}-\gamma_{W2}Z_2)\,dX_1}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2}Z_2)^2} + \int_{-1}^{1}\int_0^1 \Bigg[\frac{(\gamma_{W2}Z_2-\gamma_{W1}Z_1)}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W2}Z_2-\gamma_{W1}Z_1)^2}\frac{\partial B_1}{\partial Z_1} \\
& + \frac{(\gamma_{L2}X_2-X_1)\gamma_{W1}}{(X_2\gamma_{L2}-X_1)^2+\gamma_H^2+(\gamma_{W2}Z_2-\gamma_{W1}Z_1)^2}\frac{\partial B_1}{\partial X_1}\Bigg] dX_1\, dZ_1 \Bigg\}
\end{aligned}
\tag{21b}
$$

$$
\begin{aligned}
B_1^{\circ}(X_1,Z_1) = {} & \frac{E_1(X_1,Z_1)}{E_{R1}} + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\Bigg[\bar{B}_2^{\circ}(X_2{=}0)\frac{X_1}{\sqrt{X_1^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}}\right) \\
& + \bar{B}_2^{\circ}(X_2{=}1)\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}}\right) \\
& + \bar{B}_2^{\circ}(Z_2{=}-1)\frac{\gamma_{W2}+\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}} - \tan^{-1}\frac{-X_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\right) \\
& + \bar{B}_2^{\circ}(Z_2{=}1)\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}} - \tan^{-1}\frac{-X_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\right)\Bigg]
\end{aligned}
\tag{22a}
$$

and

$$B_2^o(X_2,Z_2) = \frac{E_2(X_2,Z_2)}{E_{R2}} + \frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\left[\bar{B}_1^o(X_1=0)\frac{\gamma_{L2}X_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}}\right)\right.$$

$$+\bar{B}_1^o(X_1=1)\frac{(1-\gamma_{L2}X_2)}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}}\right)$$

$$+\bar{B}_1^o(Z_1=-1)\frac{\gamma_{W2}Z_2+\gamma_{W1}}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}}\left(\tan^{-1}\frac{1-\gamma_{L2}X_2}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{L2}X_2}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}}\right)$$

$$\left.+\bar{B}_1^o(Z_1=1)\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}}\left(\tan^{-1}\frac{1-\gamma_{L2}X_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{L2}X_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}}\right)\right] \quad (22b)$$

The zero-order solutions, B_1^o and B_2^o, can be computed if the average radiosities appearing in Equations (22) are known. To find $\bar{B}^o$, say along $X_1 = 0$, we can substitute Equation (22a) into Equation (12). So,

$$\bar{B}_1^o(X_1=0) = \frac{1}{2}\int_{-1}^{1}\frac{E_1(0,Z_1)dZ_1}{E_{R1}} + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{\bar{B}_2^o(X_2=1)\frac{\gamma_{L2}}{2\sqrt{\gamma_{L2}^2+\gamma_H^2}}\int_{-1}^{1}\left(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right)dZ_1\right.$$

$$+\frac{\bar{B}_2^o(Z_2=1)}{2}\int_{-1}^{1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}dZ_1$$

$$\left.+\frac{\bar{B}_2^o(Z_2=-1)}{2}\int_{-1}^{1}\frac{\gamma_{W2}+\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}dZ_1\right\} \quad (23)$$

For the second integral on the right-hand side of Equation (23)

$$\int_{-1}^{1}\left(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right)dZ_1$$

$$=\left\{-(\gamma_{W2}-\gamma_{W1}Z_1)\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} + \frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{2}\ln\left[\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1}Z_1)^2\right] - (\gamma_{W2}+\gamma_{W1}Z_1)\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right.$$

$$\left.+\frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{2}\ln\left[\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1}Z_1)^2\right]\right\}_{-1}^{1}$$

$$=(\gamma_{W2}+\gamma_{W1})\left[\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right] + (\gamma_{W2}-\gamma_{W1})\left[\tan^{-1}\frac{-\gamma_{W2}+\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right]$$

$$+\sqrt{\gamma_{L2}^2+\gamma_H^2}\,\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

For the third integral, $\int_{-1}^{1} \frac{\gamma_{W2}+\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\, dZ_1$, of Equation (23), let $p = \frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}$

After differentiating the expression of p, one can obtain

$$dp = \frac{-\gamma_{L2}(\gamma_{W2}+\gamma_{W1}Z_1)\gamma_{W1}\,dZ_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}\left[(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2\right]}$$

Substitute p and dp into the third integral and rearrange it, thus

$$\int_{-1}^{1} \frac{\gamma_{W2}+\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\, dZ_1$$

$$= \int_{p_1}^{p_2} -\frac{\gamma_{L2}}{\gamma_{W2}}\,\frac{\tan^{-1}p}{p^2}\, dp$$

$$= \frac{\gamma_{L2}}{\gamma_{W1}}\left[\frac{1}{p}\tan^{-1}p + \frac{1}{2}\ln\frac{1+p^2}{p^2}\right]_{p_1}^{p_2}$$

$$= \frac{\gamma_{L2}}{\gamma_{W1}}\left[\frac{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}} + \frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1}Z_1)^2}{\gamma_{L2}^2}\right]_{-1}^{1}$$

$$= \frac{\gamma_{L2}}{\gamma_{W1}}\Bigg[\frac{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}$$

$$+ \frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}\Bigg]$$

Similarly, the fourth integral becomes,

$$\int_{-1}^{1} \frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\, dZ_1$$

$$= -\frac{\gamma_{L2}}{\gamma_{W1}}\left[\frac{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}} + \frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1}Z_1)^2}{\gamma_{L2}^2}\right]_{-1}^{1}$$

$$= \frac{\gamma_{L2}}{\gamma_{W1}}\Bigg[\frac{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}$$

$$+ \frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}\Bigg]$$

Substituting these into Equation (23) gives

$$\bar{B}_1^o(X_1=0) = \frac{1}{2}\int_{-1}^{1}\frac{E_1(0,Z_1)}{E_{R1}}\,dZ_1 + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{b_1\bar{B}_2^o(X_2=1) + b_2\bar{B}_2^o(Z_2=-1) + b_3\bar{B}_2^o(Z_2=-1)\right\}$$

The other seven mean dimensionless radiosities of the zero-order solution, $\bar{B}^o$'s can be found by utilizing the same procedure.

$$\bar{B}_1^o(X_1=0) = \frac{1}{2}\int_{-1}^{1}\frac{E_1(0,Z_1)}{E_{R1}}\,dZ_1 + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{b_1\bar{B}_2^o(X_2=1) + b_2\bar{B}_2^o(Z_2=-1) + b_3\bar{B}_2^o(Z_2=-1)\right\} \quad (24a)$$

$$\bar{B}_1^o(X_1=1) = \frac{1}{2}\int_{-1}^{1}\frac{E_1(1,Z_1)}{E_{R1}}\,dZ_1 + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{b_4\bar{B}_2^o(X_2=0) + b_5\bar{B}_2^o(X_2=1) + b_6\bar{B}_2^o(Z_2=-1) + b_7\bar{B}_2^o(Z_2=1)\right\} \quad (24b)$$

$$\bar{B}_1^o(Z_1=-1) = \int_{0}^{1}\frac{E_1(X_1,-1)}{E_{R1}}\,dX_1 + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{b_8\bar{B}_2^o(X_2=0) + b_9\bar{B}_2^o(X_2=1) + b_{10}\bar{B}_2^o(Z_2=-1) + b_{11}\bar{B}_2^o(Z_2=1)\right\} \quad (24c)$$

$$\bar{B}_1^o(Z_1=1) = \int_{0}^{1}\frac{E_1(X_1,1)}{E_{R1}}\,dX_1 + \frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\left\{b_{12}\bar{B}_2^o(X_2=0) + b_{13}\bar{B}_2^o(X_2=1) + b_{14}\bar{B}_2^o(Z_2=-1) + b_{15}\bar{B}_2^o(Z_2=1)\right\} \quad (24d)$$

$$\bar{B}_2^o(X_2=0) = \frac{1}{2}\int_{-1}^{1}\frac{E_2(0,Z_2)}{E_{R2}}\,dZ_2 + \frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\left\{b_{16}\bar{B}_1^o(X_1=1) + b_{17}\bar{B}_1^o(Z_1=-1) + b_{18}\bar{B}_1^o(Z_1=1)\right\} \quad (24e)$$

$$\bar{B}_2^o(X_2=1) = \frac{1}{2}\int_{-1}^{1}\frac{E_2(1,Z_2)}{E_{R2}}\,dZ_2 + \frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\left\{b_{19}\bar{B}_1^o(X_1=0) + b_{20}\bar{B}_1^o(X_1=1) + b_{21}\bar{B}_1^o(Z_1=-1) + b_{22}\bar{B}_1^o(Z_1=1)\right\} \quad (24f)$$

$$\bar{B}_2^o(Z_2=-1) = \int_{0}^{1}\frac{E_2(X_2,-1)}{E_{R2}}\,dX_2 + \frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\left\{b_{23}\bar{B}_1^o(X_1=0) + b_{24}\bar{B}_1^o(X_1=1) + b_{25}\bar{B}_1^o(Z_1=-1) + b_{26}\bar{B}_1^o(Z_1=1)\right\} \quad (24g)$$

$$\bar{B}_2^o(Z_2=1) = \int_{0}^{1}\frac{E_2(X_2,1)}{E_{R2}}\,dX_2 + \frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\left\{b_{27}\bar{B}_1^o(X_1=0) + b_{28}\bar{B}_1^o(X_1=1) + b_{29}\bar{B}_1^o(Z_1=-1) + b_{30}\bar{B}_1^o(Z_1=1)\right\} \quad (24h)$$

where $b_1, b_2, \cdots, b_{30}$ depend on γ_{W1}, γ_{W2}, γ_H, γ_{L2} and are given in Appendix (2)

The zero-order solutions of B_1 and B_2 are obtained by solving Equations (24), a set of linear algebraic equations, for the mean radiosities and introducing the results into Equations (22). Now, if the values of B_1 and B_2 on the right hand side of Equations (21a) and (21b) are taken as the zero-order values then a simultaneous iterative solutions of Equations (21a) and (21b) can be carried out. The $(n+1)^{th}$ approximation is evaluated using the following forms.

$$\overset{n+1}{B_1}(X_1,Z_1)=\frac{E_1(X_1,Z_1)}{E_{R1}}+\frac{\epsilon_2}{\epsilon_1}\frac{\rho_1}{2\pi}\Bigg\{\int_{-1}^{1}\overset{n}{B_2}(0,Z_2)\frac{\gamma_{W2}\,X_1\,dZ_2}{X_1^2+\gamma_H^2+(\gamma_{W2}Z_2-\gamma_{W1}Z_1)^2}$$
$$+\int_{-1}^{1}\overset{n}{B_2}(1,Z_2)\frac{\gamma_{W2}(\gamma_{L2}-X_1)\,dZ_2}{(\gamma_{L2}-X_1)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}+\int_{0}^{1}\overset{n}{B_2}(X_2,-1)\frac{(\gamma_{W2}+\gamma_{W1}Z_1)\gamma_{L2}\,dX_2}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1}Z_1)^2}$$
$$+\int_{0}^{1}\overset{n}{B_2}(X_2,1)\frac{(\gamma_{W2}-\gamma_{W1}Z_1)\gamma_{L2}\,dX_2}{(X_1-X_2\gamma_{L2})^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1}Z_1)^2}+\int_{-1}^{1}\!\!\int_{0}^{1}\Bigg[\frac{\gamma_{W1}Z_1-\gamma_{W2}Z_2}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}\frac{\partial \overset{n}{B_2}}{\partial Z_2}$$
$$+\frac{\gamma_{W2}(X_1-X_2\gamma_{L2})}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}\frac{\partial \overset{n}{B_2}}{\partial X_2}\Bigg]dX_2\,dZ_2\Bigg\} \tag{25a}$$

$$\overset{n+1}{B_2}(X_2,Z_2)=\frac{E_2(X_2,Z_2)}{E_{R2}}+\frac{\epsilon_1}{\epsilon_2}\frac{\rho_2}{2\pi}\Bigg\{\int_{-1}^{1}\overset{n}{B_1}(0,Z_1)\frac{\gamma_{L2}\,\gamma_{W1}\,X_2\,dZ_1}{(\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}$$
$$+\int_{-1}^{1}\overset{n}{B_1}(1,Z_1)\frac{(1-\gamma_{L2}X_2)\gamma_{W1}\,dZ_1}{(1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}Z_1-\gamma_{W2}Z_2)^2}+\int_{0}^{1}\overset{n}{B_1}(X_1,-1)\frac{(\gamma_{W1}+\gamma_{W2}Z_2)\,dX_1}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2}Z_2)^2}$$
$$+\int_{0}^{1}\overset{n}{B_1}(X_1,1)\frac{(\gamma_{W1}-\gamma_{W2}Z_2)\,dX_1}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2}Z_2)^2}+\int_{-1}^{1}\!\!\int_{0}^{1}\Bigg[\frac{(\gamma_{W2}Z_2-\gamma_{W1}Z_1)}{(X_1-\gamma_{L2}X_2)^2+\gamma_H^2+(\gamma_{W2}Z_2-\gamma_{W1}Z_1)^2}\frac{\partial \overset{n}{B_1}}{\partial Z_1}$$
$$+\frac{\gamma_{W1}(\gamma_{L2}X_2-X_1)}{(\gamma_{L2}X_2-X_1)^2+\gamma_H^2+(\gamma_{W2}Z_2-\gamma_{W1}Z_1)^2}\frac{\partial \overset{n}{B_1}}{\partial X_1}\Bigg]dX_1\,dZ_1\Bigg\} \tag{25b}$$

[illegible].2. Heat Transfer Equations

Introducing dimensionless variables, $q_i^* = q_i/E_{Ri}$ and $Q_i^* = Q_i/E_{Ri}$, the expressions for q_i and Q_i become

$$q_i^*(X_i,Z_i)=\frac{\epsilon_i}{1-\epsilon_i}\left[\sigma T_i^4(X_i,Z_i)/E_{Ri}-B_i(X_i,Z_i)\right] \tag{26}$$

$$\frac{Q_i^*}{A_i}=\frac{\epsilon_i}{2(1-\epsilon_i)}\int_{Z_i}\!\int_{X_i}\left[\frac{\sigma T_i^4(X_i,Z_i)}{E_{Ri}}-B_i(X_i,Z_i)\right]dX_i\,dZ_i \tag{27}$$

Substituting Equations (22) into (27) and carrying out the double integration, the expressions for the approximate solutions of total heat flux become

$$\frac{Q_1^o}{A_1E_{R1}}=\frac{1}{2}\int_{-1}^{1}\!\int_{0}^{1}\frac{\epsilon_1\sigma T_1^4(X_1,Z_1)}{E_{R1}}dX_1\,dZ_1-\frac{\epsilon_2}{4\pi}\left[g_1\bar{B}_2^o(X_2=0)+g_2\bar{B}_2^o(X_2=1)+g_3\bar{B}_2^o(Z_2=-1)+g_4\bar{B}_2^o(Z_2=1)\right] \tag{28a}$$

$$\frac{Q_2^o}{A_2E_{R2}}=\frac{1}{2}\int_{-1}^{1}\!\int_{0}^{1}\frac{\epsilon_2\sigma T_2^4(X_2,Z_2)}{E_{R2}}dX_2\,dZ_2-\frac{\epsilon_1}{4\pi}\left[g_5\bar{B}_1^o(X_1=0)+g_6\bar{B}_1^o(X_1=1)+g_7\bar{B}_1^o(Z_1=-1)+g_8\bar{B}_1^o(Z_1=1)\right] \tag{28b}$$

The expressions of $g_1, g_2, \cdots,$ and g_8 are shown in Appendix (3).

Chapter 5

TWO FINITE PARALLEL PLATES WITH THE IDENTICAL SURFACE PROPERTIES AND TEMPERATURE DISTRIBUTION.

5.1. Radiosity Equations for Two Dimensional, One Surface Problem.

In order to illustrate the usefulness of this method and compare the values obtained to those available in the literature, a relatively simple system is considered which is the only known case for comparison with published results [5]. This system consists of two parallel plates having the same lengths and widths, and identical radiative properties and temperature distribution. Thus, $\gamma_{W1} = \gamma_{W2} = \gamma_W$, $\gamma_{L2} = \gamma_{L1} = 1$, $\epsilon_1 = \epsilon_2 = \epsilon$ and $T_1(X_1, Z_1) = T_2(X_2, Z_2)$. This is a two dimensional, one surface problem. A one surface system is one in which both surfaces have identical radiative properties and dimensions, and are at the same temperature distribution. Then Equations (22) reduce to one equation which can be written as

$$
\begin{aligned}
B^{o}(X,Z) = F(X,Z) + \frac{\rho}{2\pi}\Bigg\{ & B^{o}(X{=}0)\frac{X}{\sqrt{X^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_W-\gamma_W Z}{\sqrt{X^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_W-\gamma_W Z}{\sqrt{X^2+\gamma_H^2}}\right) \\
& + \bar{B}^{o}(X{=}1)\frac{1-X}{\sqrt{(1-X)^2+\gamma_H^2}}\left(\tan^{-1}\frac{\gamma_W-\gamma_W Z}{\sqrt{(1-X)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_W-\gamma_W Z}{\sqrt{(1-X)^2+\gamma_H^2}}\right) \\
& + \bar{B}^{o}(Z{=}-1)\frac{\gamma_W+\gamma_W Z}{\sqrt{(\gamma_W+\gamma_W Z)^2+\gamma_H^2}}\left(\tan^{-1}\frac{1-X}{\sqrt{(\gamma_W+\gamma_W Z)^2+\gamma_H^2}} - \tan^{-1}\frac{-X}{\sqrt{(\gamma_W+\gamma_W Z)^2+\gamma_H^2}}\right) \\
& + \bar{B}^{o}(Z{=}1)\frac{\gamma_W-\gamma_W Z}{\sqrt{(\gamma_W-\gamma_W Z)^2+\gamma_H^2}}\left(\tan^{-1}\frac{1-X}{\sqrt{(\gamma_W-\gamma_W Z)^2+\gamma_H^2}} - \tan^{-1}\frac{-X}{\sqrt{(\gamma_W-\gamma_W Z)^2+\gamma_H^2}}\right)\Bigg\} \qquad (29)
\end{aligned}
$$

Where $F(X,Z) = E(X,Z)/E_R$.

Equations (24) utilized to determine B^{o} reduce to four equations, namely,

$$\bar{B}^{o}(X{=}0) = \frac{1}{2}\int_{-1}^{1} F(0,Z)\,dZ + \frac{\rho}{2\pi}\left\{ d_1 \bar{B}^{o}(X{=}1) + d_2 \bar{B}^{o}(Z{=}-1) + d_2 \bar{B}^{o}(Z{=}1)\right\} \qquad (30a)$$

$$\bar{B}^{o}(X=1)=\frac{1}{2}\int_{-1}^{1}F(1,Z)\,dZ+\frac{\rho}{2\pi}\left\{d_1\bar{B}^{o}(X=0)+d_2\bar{B}^{o}(Z=-1)+d_2\bar{B}^{o}(Z=1)\right\} \tag{30b}$$

$$\bar{B}^{o}(Z=-1)=\frac{1}{2}\int_{0}^{1}F(X,-1)\,dX+\frac{\rho}{2\pi}\left\{d_3\bar{B}^{o}(X=0)+d_3\bar{B}^{o}(X=1)+d_4\bar{B}^{o}(Z=1)\right\} \tag{30c}$$

$$\bar{B}^{o}(Z=1)=\int_{0}^{1}F(X,1)\,dX+\frac{\rho}{2\pi}\left\{d_3\bar{B}^{o}(X=0)+d_3\bar{B}^{o}(X=1)+d_4\bar{B}^{o}(Z=-1)\right\} \tag{30d}$$

where

$$d_1=\frac{1}{\sqrt{1+\gamma_H^2}}\tan^{-1}\frac{2\gamma_W}{\sqrt{1+\gamma_H^2}}-\frac{1}{\sqrt{1+\gamma_H^2}}\tan^{-1}\frac{-2\gamma_W}{\sqrt{1+\gamma_H^2}}+\frac{1}{2\gamma_H}\ln\frac{1+\gamma_H^2}{1+\gamma_H^2+4\gamma_W^2}$$

$$d_2=\frac{\sqrt{4\gamma_W^2+\gamma_H^2}}{2\gamma_W}\tan^{-1}\frac{1}{\sqrt{4\gamma_W^2+\gamma_H^2}}-\frac{\gamma_H}{2\gamma_W}\tan^{-1}\frac{1}{\gamma_H}-\frac{1}{4\gamma_W}\ln\frac{1+\gamma_H^2}{1+\gamma_H^2+4\gamma_W^2}$$

$$d_3=\sqrt{1+\gamma_H^2}\,\tan^{-1}\frac{2\gamma_W}{\sqrt{1+\gamma_H^2}}-\gamma_H\tan^{-1}\frac{2\gamma_W}{\gamma_H}+\gamma_W\ln\frac{1+\gamma_H^2+4\gamma_W^2}{\gamma_H^2+4\gamma_W^2}$$

$$d_4=\frac{2\gamma_W}{\sqrt{4\gamma_W^2+\gamma_H^2}}\tan^{-1}\frac{1}{\sqrt{4\gamma_W^2+\gamma_H^2}}-\frac{2\gamma_W}{\sqrt{4\gamma_W^2+\gamma_H^2}}\tan^{-1}\frac{-1}{\sqrt{4\gamma_W^2+\gamma_H^2}}+2\gamma_W\ln\frac{4\gamma_W^2+\gamma_H^2}{1+\gamma_H^2+4\gamma_W^2}$$

The equation used for calculating the $(n+1)^{th}$ approximation now is

$$\begin{aligned}B^{n+1}(X,Z)=F(X,Z)+\frac{\rho}{2\pi}\Bigg\{&\int_{-1}^{1}B^{n}(0,Z')\frac{\gamma_W X\,dZ'}{X^2+\gamma_H^2+\gamma_W^2(Z-Z')^2}+\int_{-1}^{1}B^{n}(1,Z')\frac{(1-X)\gamma_W\,dZ'}{(1-X)^2+\gamma_H^2+\gamma_W^2(Z-Z')^2}\\&+\int_{0}^{1}B^{n}(X',-1)\frac{\gamma_W(1+Z)\,dX'}{(X-X')^2+\gamma_H^2+(\gamma_W+\gamma_W Z)^2}+\int_{0}^{1}B^{n}(X,1)\frac{\gamma_W(1-Z)\,dX'}{(X-X')^2+\gamma_H^2+(\gamma_W-\gamma_W Z)^2}\\&+\int_{-1}^{1}\int_{0}^{1}\left[\frac{\gamma_W(Z-Z')}{(X-X')^2+\gamma_H^2+\gamma_W^2(Z-Z')^2}\frac{\partial B^n}{\partial Z'}+\frac{\gamma_W(X-X')}{(X-X')^2+\gamma_H^2+\gamma_W^2(Z-Z')^2}\frac{\partial B^n}{\partial X'}\right]dX'dZ'\Bigg\}\end{aligned} \tag{31}$$

5.2. The Temperature Distribution of The System Considered.

If the temperature is prescribed at the surfaces of the system considered, the distributions of B along the various surfaces can be found by using Equations (30) and (31). Now, three different temperature distributions are used to solve for B and the local heat flux. The temperature functions are as follow.

(1) Temperature is constant for the entire surface.

(2) $T = T_o(1 + (T_1/T_o - 1) \cdot X)$ and,

(3) $T = T_o(1 + X(1-Z)(T_1/T_o - 1)/2)$.

T_o and T_1 are the temperatures at (0,1) and (1,-1) respectively. For convenience, we let $E_{Ri} = \epsilon_i \sigma T_o^4$. Then the function F(X,Z) and the first integral of Equations (30) are tabulated in Table 1. Numerical, iterative solutions of these three cases can be easily evaluated using Equations (29), (30) and (31).

Table 1. Values for function F and the first integral of Eqs. (30)

	Case 1	Case 2	Case 3
$F(X,Z) = E(X,Z)/E_{Ri}$	1	$(1+(T_1/T_o-1)X)^4$	$(1+X(1-Z)(T_1/T_o-1)/2)^4$
$\frac{1}{2}\int_{-1}^{1} F(0,Z)dZ$	1	1	1
$\frac{1}{2}\int_{-1}^{1} F(1,Z)dZ$	1	$(T_1/T_o)^4$	$\dfrac{(T_1/T_o)^5-1}{5(T_1/T_o)-5}$
$\int_{0}^{1} F(X,-1)dX$	1	$\dfrac{(T_1/T_o)^5-1}{5(T_1/T_o)-5}$	$\dfrac{(T_1/T_o)^5-1}{5(T_1/T_o)-5}$
$\int_{0}^{1} F(X,1)dX$	1	$\dfrac{(T_1/T_o)^5-1}{5(T_1/T_o)-5}$	1

Chapter 6

RESULTS AND DISCUSSION

6.1. Calculation Procedure

The IBM 360/65 digital computer of the University of Ottawa was utilized for all of the computing work. Numerical evaluations of integrals were carried out using Simpson's Rule. The computer programming for the cases of T=constant and T=f(X) are similar to T=f(X,Z). Therefore only the program for computing the case T=f(X,Z) is shown in Appendix 4 . Since the accuracy of the numerical solutions relies upon the increment sizes, ΔX and ΔZ, various increment sizes, such as $\Delta X=0.1, \Delta Z=0.1$; $\Delta X=0.05$, $\Delta Z=0.1$; and $\Delta X=0.05$, $\Delta Z=0.05$ were employed.

$\bar{\bar{B}}^0$ could be evaluated by solving Equations (30a) to (30d) simultaneously. Once B^0 is known, the local radiosities of the zero-order solution can be computed from Equation (29) without difficulty. These values will serve as the input values to the right- hand side of Equation (31) for the next approximation. Iteration of the equation was carried out numerically until the difference between two sucessive approximations, i.e. $|B^{n+1} - B^n| / B^{n+1}$, was less than 0.01%. For the more severe case, $\gamma_W=0.5$, $\gamma_H=0.1$ and $\rho=0.9$ (Table 10), smaller increment sizes, such as $\Delta X=0.025$ and $\Delta Z=0.05$, were used in order to obtain accurate results. In this severe case, due to the slow convergence of the solution and the limitation of computer time, the solution of the eighth iteration was obtained. The diference between the seventh and the eighth approximations was about 4%.

The square parallel plate systems with surfaces having three different temperature profiles have been solved for a range of spacing ratio, γ_H, extending from 0.1 to 2.0 and for emissivities of 0.1, 0.5, and 0.9. The discussion for each case is as follows.

6.2. Constant Temperature Case

The local dimensionless radiosities and heat flux for the constant case are shown in Tables 2 to 10 and Figures 3 to 5 respectively. Since the values are symmetrical about $X=0.5$ and $Z=0$, only one-fourth of the values of B are presented. The present results are compared with those obtained from [5] using a variational method, in Tables 2 to 10. For $\gamma_H=2$, the agreement is good and the zero-order solution is acceptable. For decreasing values of the spacing ratio, the predictions of the variational quartic are less precise. For example, $\gamma_H=0.5$, $\gamma_W=0.5$ and $\rho=0.9$, the value of radiosity at (0,1) is about 3% higher than the present method. For $\gamma_H=0.1$, shown in Tables 8 to 10, the values of B calculated from quartic do not decrease continously from the centre of the plate to the plate boundaries, as is required by the symmetry of the system. Also for the case, $\gamma_H=0.1$, $\gamma_W=0.5$ and $\rho=0.9$ (Table 10) at (0,1) the value of B is less than unity which is not possible. From Equation (2), we know that B is never less than unity. In order to get more precise results, a sixth degree or even higher degree polynomial is required in the variational method. Attention may now be given to the local flux. For $\gamma_H=2$, the variation of heat flux is not very large over the entire surface and almost equal to the energy emitted. The problem thus can be formulated on the assumption of uniform radiosity over the entire surface considered (Figure 3 to 5). But the decrease in gap spacing, γ_H, will increase the non-uniformity of heat flux and its level decreases. The assumption of uniform B is not applicable. The minimum heat transfer occurs at the centre ($X=0.5$, $Z=0$)

and a surface with higher emissivity has greater non-uniformity and lower local heat flux. In the middle region of the surface, the heat tranfer rate approaches zero for small gap ratio and high emissivity, for example $\gamma_H = 0.1$, $\gamma'_W = 0.5$ and $\epsilon = 0.9$ or $\rho = 0.1$ (Figure 3). It is shown that the solution of a system having high emissivity surfaces converges very rapidly. Only a few iterations are required even for very small spacing ratio (Tables 2, 5 and 8).

6.3. Linear Temperature Variation in X Direction Only.

In this case the temperature profile, $T = T_0(1+(T_1/T_0-1)X)$, is used. If $T_1/T_0=1$, the problem becomes the same as the previous one. The solutions of $T_1/T_0=0.5$ were solved and are shown in Tables 11 to 18 and Figures 6 to 13. The heat fluxes are symmetrical about Z=0. Distributions are entirely different from those of the constsnt temperature case. For this case, the maximum heat flux is at the end points ($X=0$, $Z=\pm 1$) of the edge possessing maximum temperature. Heat flux varies slightly in Z direction but significantly in X direction. It is mainly due to the prescribed temperature. For a given value of Z, as X increases, the local heat flux decreases considerably and an adiabatic point may occur. When $\gamma_W = 0.5$, $\gamma_H = 0.1$ and $\epsilon = 0.9$ (Table 18), near the central region of the surface, heat gained at that region is more than heat lost and a negative heat flux is obtained. Near the edge, i.e. X=1, the heat flux increases and becomes positive. This is because more heat is transfered out than is absorbed in the large low temperature area and due to geometry effect also.

6.4. Temperature Variation in X and Z Directions

In this case, $T=T_0(1+X(1-Z)(T_1/T_0-1)/2)$ is used. The solutions of T_1/T_o=0.5 are shown in Tables 19 to 25 and Figures 6 to 12 and 14. Owing to the symmetry of temperature distribution about line joining (0,1) and (1,-1), the results obtained are also symmetrical about that line. For $\gamma_H \geq 0.5$, minimum heat flux is at the point of mininum temperature. Decreasing the spacing ratio, i.e. γ_H, will cause the mininum heat flux to shift along the line of symmetry towards the higher temperature area. Although the end points of the edge along X=0 have the same temperature, one end has a heat flux higher than the other. This is because the location having lower heat flux is exposed over a large area of higher temperature and much more energy is absorbed than the other one. Since the temperature profiles are strictly arbitrary, data obtained from those cases are not available in the literature, and comparisons cannot be made. Also there are no variable temperature cases done previously.

6.5. Zero-Order Mean Radiosity and Zero-Order Solution

Graphs for B_1^o and B_2^o vs. W_1/L_1 for different combinations of L_2/L_1, H/L_1, W_2/L_1, ρ_1 and ρ_2 are plotted as Figures 15 to 39. Systems of different combinations of W/L and H/L, where the zero-order solution is acceptable, are examined. This information is then shown in Figures 40 to 42. In the region below the curve, the zero- order solution is considered to be acceptable. For example, in Figure 40 H/L=1.15 and if W/L is less or equal to 0.1, the zero-order solution is within 0.01% of the first-order solution. The coefficients, $g_1, g_2, \cdots$, and g_8, of Equation (28) have been evaluated and are tabulated in Tables 27 to 32. Method of calculating B_1^o, B_2^o, q_1^{*o}, q_2^{*o}, Q_1^o, and Q_2^o will be shown by an example in Appendix 5, using the Figures and Tables.

Appendix 1

VECTOR IDENTITIES

$$\mathrm{curl}\left(\frac{\vec{r}_j}{r_{ij}}\times\vec{n}_i\right)=2\,\frac{\vec{r}_j\,(\vec{n}_i\cdot\vec{r}_j)}{r_{ij}^2} \tag{A-1}$$

$$\int_A J\,\nabla\times\vec{a}\cdot d\vec{A}=\oint_C J\vec{a}\cdot d\vec{c}-\int_A \nabla J\times\vec{a}\cdot d\vec{A} \tag{A-2}$$

In the Cartesian coordinate system,

$$r_{ij}=\left[(x_i-x_j)^2+(y_i-y_j)^2+(z_i-z_j)^2\right]^{1/2}$$

The identity for the curl of product of two general vectors is,

$$\mathrm{curl}(\vec{U}\times\vec{V})=(\vec{V}\cdot\nabla)\vec{U}-(\vec{U}\cdot\nabla)\vec{V}+\vec{U}(\nabla\cdot\vec{V})-\vec{V}(\nabla\cdot\vec{U}) \tag{A-3}$$

Substituting $\vec{U} = \vec{r}_j / r_{ij}$ and $\vec{V} = \vec{n}_i$ in (A-3) results in

$$\mathrm{curl}\left(\frac{\vec{r}_j}{r_{ij}}\times\vec{n}_i\right)=(\vec{n}_i\cdot\nabla)\frac{\vec{r}_j}{r_{ij}}-\left(\frac{\vec{r}_j}{r_{ij}}\cdot\nabla\right)\vec{n}_i+\frac{\vec{r}_j}{r_{ij}}(\nabla\cdot\vec{n}_i)-\vec{n}_i\left(\nabla\cdot\frac{\vec{r}_j}{r_{ij}}\right)$$

The del operator, ∇ , involves only coordinates of j surface. Then

$$\mathrm{curl}\left(\frac{\vec{r}_j}{r_{ij}}\times\vec{n}_i\right)=(\vec{n}_i\cdot\nabla)\frac{\vec{r}_j}{r_{ij}}-\vec{n}_i\left(\nabla\cdot\frac{\vec{r}_j}{r_{ij}}\right) \tag{A-4}$$

Since $\vec{r}_j = -\vec{r}_{ij}/r_{ij}$, Equation (A-4) becomes

$$\mathrm{curl}\left(\vec{r}_j/r_{ij}\times\vec{n}_i\right)=-(\vec{n}_i\cdot\nabla)\,\vec{r}_{ij}/r_{ij}^2+\vec{n}_i\left(\nabla\cdot\vec{r}_{ij}/r_{ij}^2\right) \tag{A-5}$$

From the first part of (A-5), we have

$$(\vec{n}_i\cdot\nabla)\frac{\vec{r}_{ij}}{r_{ij}^2}=n_{xi}\frac{\partial}{\partial x_j}\left[\frac{(x_j-x_i)\vec{i}+(y_j-y_i)\vec{j}+(z_j-z_i)\vec{k}}{(x_j-x_i)^2+(y_j-y_i)^2+(z_j-z_i)^2}\right]+n_{yi}\frac{\partial}{\partial y_j}\left[\frac{\vec{r}_{ij}}{r_{ij}^2}\right]+n_{zi}\frac{\partial}{\partial z_j}\left[\frac{\vec{r}_{ij}}{r_{ij}^2}\right] \tag{A-6}$$

where n_{xi}, n_{yi} and n_{zi} are the components of $\vec{n}_i$ in x, y and z directions.

In the first part of (A-6), differentiation is carried out and we have

$$n_{xi}\frac{\partial}{\partial x_j}\left[\frac{(x_j-x_i)\vec{i}+(y_j-y_i)\vec{j}+(z_j-z_i)\vec{k}}{(x_j-x_i)^2+(y_j-y_i)^2+(z_j-z_i)^2}\right]=\frac{n_{xi}\vec{i}}{r_{ij}^2}-n_{xi}\vec{r_{ij}}\frac{2(x_j-x_i)}{r_{ij}^4} \tag{A-7}$$

Similarly, the second and the last parts of (A-4) become

$$n_{yi}\frac{\partial}{\partial y_j}\left[\vec{r_{ij}}/r_{ij}^2\right]=\frac{n_{yi}\vec{j}}{r_{ij}^2}-2\frac{n_{yi}(y_j-y_i)}{r_{ij}^4}\vec{r_{ij}} \tag{A-8}$$

$$n_{zi}\frac{\partial}{\partial z_i}\left[\vec{r_{ij}}/r_{ij}^2\right]=\frac{n_{zi}}{r_{ij}^2}\vec{k}-2\frac{n_{zi}(z_i-z_i)}{r_{ij}^4}\vec{r_{ij}} \tag{A-9}$$

Substituting equations (A-7), (A-8) and (A-9) into (A-6), we have

$$(\vec{n_i}\cdot\nabla)\vec{r_{ij}}/r_{ij}^2=\frac{\vec{n_i}}{r_{ij}^2}-\frac{2}{r_{ij}^4}(\vec{n_i}\cdot\vec{r_{ij}})\vec{r_{ij}} \tag{A-10}$$

From the second part of (A-5)

$$\begin{aligned}\nabla\cdot\frac{\vec{r_{ij}}}{r_{ij}^2}&=-\frac{1}{r_{ij}^2}(\nabla\cdot\vec{r_{ij}})-\left(\nabla\frac{1}{r_{ij}^2}\right)\cdot\vec{r_{ij}}\\&=-\frac{3}{r_{ij}^2}+\frac{2}{r_{ij}^4}(\vec{r_{ij}}\cdot\vec{r_{ij}})\\&=-\frac{1}{r_{ij}^2}\end{aligned} \tag{A-11}$$

Substituting (A-8) and (A-9) into (A-5) results in

$$\begin{aligned}curl\left(\frac{\vec{r_j}}{r_{ij}}\times\vec{n_i}\right)&=-\frac{\vec{n_i}}{r_{ij}^2}+\frac{2}{r_{ij}^4}(\vec{n_i}\cdot\vec{r_{ij}})\vec{r_{ij}}-\vec{n_i}\left(-\frac{1}{r_{ij}^2}\right)\\&=\frac{2}{r_{ij}^2}(\vec{n_i}\cdot\vec{r_j})\vec{r_j}\end{aligned} \tag{A-1}$$

From the Stokes Theorem, $\oint_C\vec{V}\cdot d\vec{c}=\int_A(\nabla\times\vec{V})\cdot d\vec{A}$

Let $\vec{V}=\phi\vec{a}$, where ϕ is a scalar, then

$$\begin{aligned}\oint_C\phi\vec{a}\cdot d\vec{c}&=\int_A(\nabla\times\phi\vec{a})\cdot d\vec{A}\\&=\int_A(\phi\nabla\times\vec{a}+\nabla\phi\times\vec{a})\cdot d\vec{A}\end{aligned}$$

Therefore,

$$\int_A\phi\nabla\times\vec{a}\cdot d\vec{A}=\oint_C\phi\vec{a}\cdot d\vec{c}-\int\nabla\phi\times\vec{a}\cdot d\vec{A} \tag{A-2}$$

Appendix 2

PARAMETERS OF MEAN RADIOSITY, b_i

The expressions for parameters b_1, b_2, $\cdots$, and b_{30} can be found by substituting Equations (22) into Equation (12) and carrying out the integrations. For example, let the coefficients of $\bar{B}_2^{0}(X_2=1)$, $\bar{B}_2^{0}(Z_2=-1)$ $\bar{B}_2^{0}(Z_2=1)$ of Equation (23) be b_1, b_2, and b_3 respectively. The other parameters can be obtained by the same method.

$$b_1=\frac{\gamma_{L2}}{2\sqrt{\gamma_{L2}^2+\gamma_H^2}}\int_{-1}^{1}\left(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}-\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right)dZ_1$$

$$=\frac{(\gamma_{W2}+\gamma_{W1})\gamma_{L2}}{2\gamma_{W1}\sqrt{\gamma_{L2}^2+\gamma_H^2}}\left[\tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}-\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right]+\frac{\gamma_{L2}(\gamma_{W2}-\gamma_{W1})}{2\gamma_{W1}\sqrt{\gamma_{L2}^2+\gamma_H^2}}\left[\tan^{-1}\frac{-\gamma_{W2}+\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right.$$

$$\left.-\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right]+\frac{\gamma_{L2}}{2\gamma_{W2}}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

$$b_2=\frac{1}{2}\int_{-1}^{1}\frac{\gamma_{W2}+\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1}Z_1)^2+\gamma_H^2}}dZ_1$$

$$=\frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{2\gamma_{W1}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}-\frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W1}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}$$

$$+\frac{\gamma_{L2}}{4\gamma_{W1}}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}$$

$$b_3=b_2$$

$$b_4=\frac{(\gamma_{W2}+\gamma_{W1})}{2\gamma_{W1}\sqrt{1+\gamma_H^2}}\left[\tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{1+\gamma_H^2}}-\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}}\right]+\frac{(\gamma_{W2}-\gamma_{W1})}{2\gamma_{W1}\sqrt{1+\gamma_H^2}}\left[\tan^{-1}\frac{-\gamma_{W2}+\gamma_{W1}}{\sqrt{1+\gamma_H^2}}-\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}}\right]$$

$$+\frac{1}{2\gamma_{W1}}\ln\frac{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

$$b_5 = \frac{(\gamma_{L2}-1)(\gamma_{W2}+\gamma_{W1})}{\gamma_{W1}\sqrt{(\gamma_{L2}-\gamma_{L1})^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}} + \frac{(\gamma_{L2}-1)(\gamma_{W2}-\gamma_{W1})}{\gamma_{W1}\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}}$$

$$+ \frac{(\gamma_{L2}-1)}{2\gamma_{W1}} \ln \frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

$$b_6 = \frac{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W1}}\left[\tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}} - \tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}\right] + \frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W1}} \times$$

$$\left[\tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}\right] + \frac{(\gamma_{L2}-1)}{4\gamma_{W1}} \ln \frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}$$

$$+ \frac{1}{4\gamma_{W1}} \ln \frac{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}$$

$$b_7 = b_6$$

$$b_8 = \sqrt{1+\gamma_H^2}\left[\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}}\right] + \gamma_H\left[\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\gamma_H} - \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\gamma_H}\right]$$

$$+ \frac{(\gamma_{W2}-\gamma_{W1})}{2} \ln \frac{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2} + \frac{(\gamma_{W2}+\gamma_{W1})}{2} \ln \frac{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

$$b_9 = \sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}\left[\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}}\right] + \sqrt{\gamma_{L2}^2+\gamma_H^2}\left[\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right.$$

$$\left. - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right] + \frac{(\gamma_{W2}-\gamma_{W1})}{2} \ln \frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2} - \frac{(\gamma_{W2}+\gamma_{W1})}{2} \ln \frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}$$

$$b_{10} = \frac{\gamma_{L2}(\gamma_{W1}+\gamma_{W2})}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\left[\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\right] + \frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}} \times$$

$$\left[\tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}} - \tan^{-1}\frac{-1}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\right] + \frac{\gamma_{W1}+\gamma_{W2}}{2} \ln \frac{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$+ \frac{(\gamma_{W2}+\gamma_{W1})}{2} \ln \frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$b_{11} = \frac{\gamma_{L2}(\gamma_{W2}-\gamma_{W1})}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}\left[\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}\right] + \frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} \times$$

$$\left[\tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} - \tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}\right] + \frac{\gamma_{W2}-\gamma_{W1}}{2}\ln\frac{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}$$

$$+\frac{(\gamma_{W2}-\gamma_{W1})}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}$$

$$b_{12} = b_8$$

$$b_{13} = b_9$$

$$b_{14} = b_{11}$$

$$b_{15} = b_{10}$$

$$b_{16} = \frac{\gamma_{W1}-\gamma_{W2}}{\gamma_{W2}\sqrt{1+\gamma_H^2}}\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}} + \frac{\gamma_{W1}+\gamma_{W2}}{\gamma_{W2}\sqrt{1+\gamma_H^2}}\tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{1+\gamma_H^2}} + \frac{1}{2\gamma_{W2}}\ln\frac{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$b_{17} = \frac{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W2}}\tan\frac{1}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W2}}\tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}$$

$$+\frac{1}{4\gamma_{W2}}\ln\frac{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}$$

$$b_{18} = b_{17}$$

$$b_{19} = \frac{\gamma_{L2}(\gamma_{W1}-\gamma_{W2})}{\gamma_{W2}\sqrt{\gamma_{L2}^2+\gamma_H^2}}\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} + \frac{\gamma_{L2}(\gamma_{W1}+\gamma_{W2})}{\gamma_{W2}\sqrt{\gamma_{L2}^2+\gamma_H^2}}\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}$$

$$+\frac{\gamma_{L2}}{2\gamma_{W2}}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$b_{20} = \frac{(1-\gamma_{L2})(\gamma_{W1}-\gamma_{W2})}{\gamma_{W2}\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}} + \frac{(1-\gamma_{L2})(\gamma_{W1}+\gamma_{W2})}{\gamma_{W2}\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}} \tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}$$
$$+ \frac{(1-\gamma_{L2})}{2\gamma_{W2}} \ln \frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$b_{21} = \frac{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}{2\gamma_{W2}} \tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}{2\gamma_{W2}} \tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}$$
$$+ \frac{1-\gamma_{L2}}{4\gamma_{W2}} \ln \frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2} + \frac{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}{2\gamma_{W2}^2} \tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}$$
$$- \frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{2\gamma_{W2}} \tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}} + \frac{\gamma_{L2}}{4\gamma_{W2}} \ln \frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}$$

$$b_{22} = b_{21}$$

$$b_{23} = \frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{\gamma_{L2}} \left[\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right] + \frac{\gamma_H}{\gamma_{L2}} \left[\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\gamma_H} - \tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\gamma_H}\right]$$
$$+ \frac{(\gamma_{W2}+\gamma_{W1})}{2\gamma_{L2}} \ln \frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2} - \frac{(\gamma_{W1}-\gamma_{W2})}{2\gamma_{L2}} \ln \frac{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}$$

$$b_{24} = \frac{\sqrt{1+\gamma_H^2}}{\gamma_{L2}} \left[\tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{1+\gamma_H^2}} - \tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}}\right] + \frac{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}{\gamma_{L2}} \left[\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}\right.$$
$$\left. - \tan^{-1}\frac{\gamma_{W2}+\gamma_{W1}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}\right] + \frac{\gamma_{W2}+\gamma_{W1}}{2\gamma_{L2}} \ln \frac{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{(1-\gamma_{L2})^2+\gamma_H+(\gamma_{W2}+\gamma_{W1})^2}$$
$$+ \frac{\gamma_{W2}-\gamma_{W1}}{2\gamma_{L2}} \ln \frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}$$

$$b_{25} = \frac{(\gamma_{W1}-\gamma_{W2})}{\gamma_{L2}\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} \left[\tan^{-1}\frac{1}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} - (1-\gamma_{L2})\tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} - \gamma_{L2}\tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}\right]$$
$$+ \frac{(\gamma_{W1}-\gamma_{W2})}{2\gamma_{L2}} \left[\ln \frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2} - \ln \frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}\right]$$

$$b_{26} = \frac{\gamma_{W1}+\gamma_{W2}}{\gamma_{L2}\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\Bigg[\tan^{-1}\frac{1}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}} - (1-\gamma_{L2})\tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}$$

$$-\gamma_{L2}\tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\Bigg] + \frac{(\gamma_{W1}+\gamma_{W2})}{2\gamma_{L2}}\Bigg[\ln\frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}$$

$$-\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}\Bigg]$$

$$b_{27} = b_{23}$$

$$b_{28} = b_{24}$$

$$b_{29} = b_{26}$$

$$b_{30} = b_{25}$$

Appendix 3

PARAMETERS OF HEAT TRANSFER, g_i

By substituting Equations (22) into (27), the expressions for the Q_i^o are

$$\frac{Q_1^o}{A_1 E_{R1}} = \frac{1}{2}\int_{-1}^{1}\int_{0}^{1}\frac{\epsilon_1 \sigma T_1^4(X_1,Z_1)}{E_{R1}}dX_1 dZ_1 - \frac{\epsilon_2}{4\pi}\Bigg[\Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{X_1}{\sqrt{X_1^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}}\Bigg)dX_1 dZ_1\Bigg\}\cdot$$

$$\bar{B}_2^o(X_2=0) + \Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{L2}-X_1)^2+\gamma_H^2}}\Bigg)dX_1 dZ_1\Bigg\}\bar{B}_2^o(X_2=1)$$

$$+\Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{\gamma_{W1}Z_1+\gamma_{W2}}{\sqrt{(\gamma_{W1}Z_1+\gamma_{W2})^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{W1}Z_1+\gamma_{W2})^2+\gamma_H^2}} - \tan^{-1}\frac{-X_1}{\sqrt{(\gamma_{W1}Z_1+\gamma_{W2})^2+\gamma_H^2}}\Bigg)dX_1 dZ_1\Bigg\}\bar{B}_2^o(Z_2=-1)$$

$$+\Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{L2}-X_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}} - \tan^{-1}\frac{-X_1}{\sqrt{(\gamma_{W2}-\gamma_{W1}Z_1)^2+\gamma_H^2}}\Bigg)dX_1 dZ_1\Bigg\}\bar{B}_2^o(Z_2=1)\Bigg] \quad \text{(C-1)}$$

$$\frac{Q_2^o}{A_2 E_{R2}} = \frac{1}{2}\int_{-1}^{1}\int_{0}^{1}\frac{\epsilon_2 \sigma T_2^4(X_2,Z_2)}{E_{R2}}dX_2 dZ_2 - \frac{\epsilon_1}{4\pi}\Bigg[\Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{1-\gamma_{L2}X_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}}$$

$$-\tan^{-1}\frac{-\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{L2}X_2)^2+\gamma_H^2}}\Bigg)dX_2 dZ_2\Bigg\}\bar{B}_1^o(X_1=0) + \Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{1-\gamma_{L2}X_2}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}}$$

$$-\tan^{-1}\frac{-\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(1-\gamma_{L2}X_2)^2+\gamma_H^2}}\Bigg)dX_2 dZ_2\Bigg\}\bar{B}_1^o(X_1=1) + \Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{\gamma_{W2}Z_2+\gamma_{W1}}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{1-\gamma_{L2}X_2}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}}$$

$$-\tan^{-1}\frac{-\gamma_{L2}X_2}{\sqrt{(\gamma_{W2}Z_2+\gamma_{W1})^2+\gamma_H^2}}\Bigg)dX_2 dZ_2\Bigg\}\bar{B}_1^o(Z_1=-1) + \Bigg\{\int_{-1}^{1}\int_{0}^{1}\frac{\gamma_{W1}-\gamma_{W2}Z_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{1-\gamma_{L2}X_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}}$$

$$-\tan^{-1}\frac{-\gamma_{L2}X_2}{\sqrt{(\gamma_{W1}-\gamma_{W2}Z_2)^2+\gamma_H^2}}\Bigg)dX_2 dZ_2\Bigg\}\bar{B}_1^o(Z_1=1)\Bigg] \quad \text{(C-2)}$$

Let the coefficients of $B_2(X_2=0)$, $B_2(X_2=1)$, $\cdots$, and $B_1(Z_1=1)$ of Equations (C-1) and (C-2) be g_1, g_2, $\cdots$, and g_8. Then,

$$g_1 = \int_{-1}^{1}\int_{0}^{1}\frac{X_1}{\sqrt{X_1^2+\gamma_H^2}}\Bigg(\tan^{-1}\frac{\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}} - \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}Z_1}{\sqrt{X_1^2+\gamma_H^2}}\Bigg)dX_1 dZ_1$$

After carrying out the double integration, one can obtain the following expression for g_1

$$g_1 = -2\Bigg[\!\!\Bigg[\frac{(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{W1}}\left(\frac{\sqrt{1+\gamma_H^2}}{\gamma_{W2}+\gamma_{W1}} \tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{1+\gamma_H^2}} - \frac{\gamma_H}{\gamma_{W2}+\gamma_{W1}}\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\gamma_H} - \frac{1}{2}\ln\frac{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}\right)$$

$$+ \frac{(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{W1}}\left(\frac{\sqrt{1+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}} \tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{1+\gamma_H^2}} - \frac{\gamma_H}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\gamma_H} + \frac{1}{2}\ln\frac{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}\right)$$

$$+ \frac{1}{4\gamma_{W1}}\Big[\left\{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}\ln\left\{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\} - \left\{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}\ln\left\{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}$$

$$+\left\{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\ln\left\{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\} - \left\{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\ln\left\{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\Big]\Bigg]\!\!\Bigg]$$

Similarly,

$$g_2 = -2\Bigg[\!\!\Bigg[\frac{(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{W1}}\left(\frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{\gamma_{W2}+\gamma_{W1}}\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}}{\gamma_{W2}+\gamma_{W1}}\tan^{-1}\frac{-\gamma_{W2}-\gamma_{W1}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}}\right.$$

$$\left.+\frac{1}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}\right) + \frac{(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{W1}}\left(\frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}\right.$$

$$\left.-\frac{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{(\gamma_{L2}-1)^2+\gamma_H^2}} - \frac{1}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}\right)$$

$$-\frac{1}{4\gamma_{W1}}\Big[\left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}\ln\left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\} - \left\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})\right\}\times$$

$$\ln\left\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\} - \left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\ln\left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})\right\}$$

$$+\left\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\ln\left\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\right\}\Big]\Bigg]\!\!\Bigg]$$

$$g_3 = \frac{(\gamma_{L2}-1)^2}{\gamma_{W1}}\left[\frac{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}{\gamma_{L2}-1}\tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{\gamma_{L2}-1}\tan^{-1}\frac{\gamma_{L2}-1}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\right.$$

$$\left.-\frac{1}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}\right] + \frac{\gamma_{L2}}{\gamma_{W1}}\left[\frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}\right.$$

$$\left.-\frac{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{\gamma_{L2}}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} + \frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}\right]$$

$$+\frac{1}{\gamma_{W1}}\left[\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}\tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}} - \sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}\tan^{-1}\frac{-1}{\sqrt{(\gamma_{W2}-\gamma_{W1})^2+\gamma_H^2}}\right.$$

$$\left.+\frac{1}{2}\ln\frac{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2}\right] + \frac{1}{4\gamma_{W1}}\Big(\Big[\left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}\ln\left\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\right\}$$

$$-\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\ln\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}+\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}\times$$

$$\ln\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}+\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\ln\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\Big]$$

$$-\frac{1}{4\gamma_{W1}}\Big[\{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}\ln\{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}-\{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\ln\{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}$$

$$-\{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}\ln\{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}+\{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\ln\{\gamma_H^2+(\gamma_{W2}-\gamma_{W1})^2\}\Big]\Big]\Big]$$

$$g_4 = g_3$$

$$g_5 = 2\Big[\Big[\frac{(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{L2}\gamma_{W2}}\Big[\frac{\gamma_H}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\gamma_H}-\frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}$$

$$-\frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}\Big]+\frac{(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}\gamma_{W2}}\Big[\frac{\sqrt{\gamma_{L2}^2+\gamma_H^2}}{\gamma_{W1}+\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{\gamma_{L2}^2+\gamma_H^2}}$$

$$-\frac{\gamma_H}{\gamma_{W1}+\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\gamma_H}+\frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}\Big]+\frac{1}{4\gamma_{L2}\gamma_{W2}}\Big[$$

$$\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}\ln\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}-\{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}\ln\{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}$$

$$-\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}\ln\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}-\{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}\ln\{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}\Big]\Big]\Big]$$

$$g_6 = 2\Big[\Big[\frac{(\gamma_{W1}-\gamma_{W2})^2}{\gamma_{L2}\gamma_{W2}}\Big(\frac{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}-\frac{\sqrt{1+\gamma_H^2}}{\gamma_{W1}-\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}-\gamma_{W2}}{\sqrt{1+\gamma_H^2}}$$

$$+\frac{1}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2}\Big)+\frac{(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}\gamma_{W2}}\Big(\frac{\sqrt{1+\gamma_H^2}}{\gamma_{W1}+\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{1+\gamma_H^2}}$$

$$-\frac{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}{\gamma_{W1}+\gamma_{W2}}\tan^{-1}\frac{\gamma_{W1}+\gamma_{W2}}{\sqrt{(1-\gamma_{L2})^2+\gamma_H^2}}-\frac{1}{2}\ln\frac{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}\Big)$$

$$+\frac{1}{4\gamma_{L2}\gamma_{W2}}\Big[\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}\ln\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\}-\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}\times$$

$$\ln\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\}-\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}\ln\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}$$

$$+\{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}\ln\{1+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\}\Big]\Big]\Big]$$

$$g_7 = \frac{(1-\gamma_{L2})^2}{\gamma_{L2}\gamma_{W2}} \Bigg[\frac{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}{1-\gamma_{L2}} \tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{1-\gamma_H^2} \tan^{-1}\frac{1-\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}$$

$$-\frac{1}{2}\ln\frac{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2}{(1-\gamma_{L2})^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2} \Bigg] + \frac{1}{\gamma_{L2}\gamma_{W2}} \Bigg[\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}\tan^{-1}\frac{1}{\sqrt{(\gamma_{W2}+\gamma_{W1})^2+\gamma_H^2}}$$

$$-\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}\tan^{-1}\frac{1}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} + \frac{1}{2}\ln\frac{1+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})}{1+\gamma_H^2+(\gamma_{W2}-\gamma_{W1})} \Bigg]$$

$$+\frac{\gamma_{L2}}{\gamma_{W2}} \Bigg[\frac{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}-\gamma_{W2})^2+\gamma_H^2}} - \frac{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}{\gamma_{L2}}\tan^{-1}\frac{-\gamma_{L2}}{\sqrt{(\gamma_{W1}+\gamma_{W2})^2+\gamma_H^2}}$$

$$+\frac{1}{2}\ln\frac{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2}{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2} \Bigg] + \frac{1}{4\gamma_{L2}\gamma_{W2}} \Bigg[\Big\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\Big\}\ln\Big\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})\Big\}$$

$$-\Big\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\}\ln\Big\{(\gamma_{L2}-1)^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\} - \Big\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\} \times$$

$$\ln\Big\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\} + \Big\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\}\ln\Big\{1+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\}$$

$$+\Big\{\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\}\ln\Big\{\gamma_H^2+(\gamma_{W2}+\gamma_{W1})^2\Big\} - \Big\{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\}\ln\Big\{\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\}$$

$$-\Big\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\}\ln\Big\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}+\gamma_{W2})^2\Big\} + \Big\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\}\ln\Big\{\gamma_{L2}^2+\gamma_H^2+(\gamma_{W1}-\gamma_{W2})^2\Big\} \Bigg]$$

$$g_8 = g_7$$

Appendix 4

Computer Programming

Computer programming for the cases of T = constant and T = f(X) are similar to T = f(X,Z). Therefore , only the computer programming for T = f(X,Z) is presented.

```
C      TEMP.=F(X,Z)
C   C1-------------ALONG X=0.0
C    C2-----------ALONG X=1.0
C      C3-----------ALONG  Z=1.0
C      C4--------ALONG Z=-1.0
C   TO IS THE TEMP. AT (0,1)
C   TL IS THE TEMP. AT ( 1,1)
C      TR=TL/TO
       IMPLICIT REAL*8(A-H,O-Z)
       DIMENSION T(4,4), C(4),U(4),BA(41,41)   ,     SP(6),EX(6),SUM(6),
      &BP(6),UK(6) ,BI(41,41) ,DILESQ(41,41) ,PERCEN(41,41) ,BI(41,41),
      &DILES(41,41)
       TR=3.0
       IK=0
       READ (1,20)  DELTZ ,NINT  ,DELTX, INT
 20    FORMAT (2(F15.5,I3))
       WRITE(3,100)  DELTZ,NINT,DELTX,INT
 100   FORMAT (1H ,F9.6,10X,I3,10X,F9.6,10X,I3)
 778   IK=IK+1
        READ  (1,77)  R,R1,R0
 77    FORMAT (3F13.6)
C
C   TO SOLVE THE MEAN RADIOSITY ALONG THE PLATE BOUNDARY
C
       C(1)=1.
       C(2)=(TR**5-1.0)/(5.0*(TR-1.0))
       C(3)=1.0
       C(4)=(TR**5-1.0)/(5.0*(TR-1.0))
       P=R0 /(2.*3.14159)
       INT6=(INT-1)/10
       NINT21=1
       A=1./DSQRT(1.+R*P)
       B=2.*R1/DSQRT(1.+R*R)
       D=(1.+R*R+4.*R1*R1)/(1.+R*R)
       E=DSQRT(R*R+4.*R1*R1)/(2.*R1)
       F=1./DSQRT(R*R+4.*R1*R1)
       G=1./R
       H=2.*R1/R
       Q=DSQRT(1.+R*R)
       S=(R*R+4.*R1*R1)/(1.+R*R+4.*R1*R1)
       T(1,1)=1.
       T(1,2)=-P*(A*DATAN(A)-A*DATAN(-A)-(1./(2.*R1))* DLOG(D))
       T(1,3)=-P*(E*DATAN(E)-(1./H)*DATAN(G)+(1./(4.*R1))* DLOG(S))
```

```
      T(1,4)=T(1,3)
      T(2,1)=T(1,2)
      T(2,2)=1.
      T(2,3)=-P*((1./H)*DATAN(-G)-F*DATAN(-F)+(1./(4.*R1))* DLOG(D))
      T(2,4)=T(2,3)
      T(3,1)=-P*(R*DATAN(-H)-Q*DATAN(-3)-R1* DLOG(S))
      T(3,2)=T(3,1)
      T(3,3)=1.
      T(3,4)=-P*((1./F)*DATAN(F)-(1./F)*DATAN(-F)+2.*R1* DLOG(S))
      T(4,1)=-P*(Q*DATAN(P)-R*DATAN(H)-R1* DLOG(S))
      T(4,2)=T(4,1)
      T(4,3)=T(3,4)
      T(4,4)=1.
      DO 11   I=1,4
      WRITE (3,101)   (T(I,J),J=1,4 )
  101 FORMAT (1H1, 4(F14.6,11X))
   11 CONTINUE
      WRITE (3,92)   ( C(I)   ,  I=1,4)
   92 FORMAT  (1H ,4F6.1)
      CALL  MATINV  (T,4)
      CALL  MATMUL  (T,C,U,4,4,1)
C
C   END  END  END
C
      DO 14   I=1,4
      WRITE (3,104)   I, U(I)
  104 FORMAT (//,30X,'AVE. B(',1X,I3,')',3X,'IS',F16.8)
   14 CONTINUE
C
C  ZERO-ORDER SOLUTION OF RADIOSITY OF THE FINITE PLATE
C
       X=0.0
       DO 16   MM=1,INT
       Z=-1.
       DO 17   N=1,NINT
       AAA=(1.0+X*(1.0-Z)*(TR-1.0)/2.0)**4
       W=DSQRT(X*X+R*R)
       W1=R1-Z*R1
       W2=-R1-Z*R1
       W3=DSQRT((1.-X)**2+R**2)
       W4=R1+Z*R1
       W5=DSQRT(R*R+(R1+Z*R1)**2)
       W6=DSQRT(R*R+(R1-Z*R1)**2)
       P1=W1/W
       P2=W2/W
       P3=W1/W3
       P4=W2/W3
       P5=(1.-X)/W5
       P6=-X/W5
       P7=(1.-X)/W6
       P8=-X/W6
       Q1=(X/W)*(DATAN(P1)-DATAN(P2))*R
       Q2=((1.-X)/W3)*(DATAN(P3)-DATAN(P4))*R
       Q3=(W1/W6)*(DATAN(P7)-DATAN(P8))*R
       Q4=(W4/W5)*(DATAN(P5)-DATAN(P6))*R
       BA(MM,N)=           AAA            +Q1*U(1)+Q2*U(2)+Q3*U(3)+Q4*U(4)
       BI(MM,N)=BA(MM,N)/AAA
       BILES(MM,N)=(AAA-(1.0-RO)*BA(MM,N))/RO
       BILES2(MM,N)= (1.0-(1.0-RO)*BI(MM,N))/RO
       Z=Z+DELTZ
   17  CONTINUE
       X=X+DELTX
   16   CONTINUE
```

```
      WRITE (3,967)  TR
967   FORMAT (3X, 'TL/TO=',F5.2)
       WRITE (3,302)  R1,R,RO
302    FORMAT (1H ,'ZERO SOLUTION : R/L=',F9.4,4X,'R/L',F9.4,4X,'RO=',
     &F9.4)
       DO  22  M=1,INT,INT4
       DO  23  N=1,NINT,NINT21
444    WRITE (3,305) M,N,BA(M,N) ,M,N,DILES (M,N)  ,RI(M,N),DILESQ(M,N)
305   FORMAT (1H ,'B(',I2,',',I4,')=',F9.6,9X,'DIMENSIONLESS Q (',I2,
     &',',I4,')=',F12.9,6X,' LOCAL Q =',F12.9,6X,'LOCAL DI-LESS Q=',
     &F12.9)
 23     CONTINUE
 22     CONTINUE
      CALL  TOTALQ (DILES ,TOTQ,INT,NINT,DELTZ,DELTX)
      WRITE(3,829)  TOTQ
829   FORMAT (/,' B IS NOT CONSTANT, TOTAL H. T. /UNIT AREA=',F10.8,/)
C
C
C  TO FIND THE N-ORDER SOLUTIONS OF RADIOSITY AND LOCAL HEAT FLUX OF
C  THE FINITE PLATE
C
C
      L=INT

      NCIN=0
 8    X1=0.0
      NKK=0
      NCIN=NCIN +1
      DO  4  I=1,INT
      IF(I.EQ.INT )  WRITE (3,113)
113   FORMAT (1H ,'DO 4 IS O.K.')
      Z1=-1.
      DO  6  K=1,NINT
      AAA=(1.0+X1*(1.0-Z1)*(TR-1.0)/2.0)**4
      Z2=-1.
      TSUMW1=0.
      TSUMW2=0.
      SUM41=0.
      SUM21=0.
      SUM22=0.
      SUM42=0.
      J=1
      SUM41=SUM41+(R1*BA(1,J))/(X1**2+R*R+R1*R1*(Z2-Z1)**2)
      SUM42=SUM42+(R1*BA(L,J))/((1.-X1)**2+R*R+R1*R1*(Z2-Z1)**2)
      Z2=Z2+DELTZ
 5    SUM41=SUM41+4.*(R1*BA(1,J+1))/(X1**2+R*R+R1*R1*(Z2-Z1)**2)
      SUM21=SUM21+2.*(R1*BA(1,J+2))/(X1**2+R*R+R1*R1*(Z2+DELTZ-Z1)**2)
      SUM42=SUM42+4.*(R1*BA(L,J+1))/((1.-X1)**2+R*R+R1*R1*(Z2-Z1)**2)
      SUM22=SUM22+2.*(R1*BA(L,J+2))/((1.-X1)**2+R*R+R1**2*(Z2+DELTZ
     &-Z1)**2)
      IF(J.EQ.(NINT-4))  GO TO 62
      J=J+2
      Z2=Z2+2.*DELTZ
      GO TO 5
62    Z2=Z2+2.*DELTZ
      SUM41=SUM41+4.0*R1*BA(1,NINT-1)/(X1**2+R*R+R1*R1*(Z2-Z1)**2)+R1*
     &BA(1,NINT)/(X1**2+R*R+R1*R1*(Z2+DELTZ-Z1)**2)
      SUM42=SUM42+4.*R1*BA(L,NINT-1)/((1.-X1)**2+R*R+R1*R1*(Z2-Z1)**2)
     &+R1*BA(L,NINT)/((1.-X1)**2+R*R+R1**2*(Z2+DELTZ-Z1)**2)
      TSUMW1=(SUM41+SUM21)*DELTZ/3.
      TSUMW2=( SUM42+SUM22)*DELTZ/3.0
      X2=0.0
      TSUMX1=0.0
      TSUMX2=0.0
      SUM43=0.
      SUM23=0.
      SUM44=0.
```

```
      SUM24=0.
      M=NINT
      J=1
      TSUMX1=TSUMX1+R1*BA(J,1)/((X2-X1)**2+R*R+R1*R1*(Z1+1.)**2)
      TSUMX2=TSUMX2+R1*BA(J,M)/((X2-X1)**2+R*R+R1*R1*(Z1-1.)**2)
      X2=X2+DELTX
    7 SUM43=SUM43+4.*R1*BA(J+1,1)/((X2-X1)**2+R*R+R1*R1*(Z1+1.)**2)
      SUM23=SUM23+2.*R1*BA(J+2,1)/((X2+DELTX-X1)**2+R*R+R1*R1*(Z1+1.)
     &**2)
      SUM44=SUM44+4.*R1*BA(J+1,M)/((X2-X1)**2+R*R+R1*R1*(Z1-1.)**2)
      SUM24=SUM24+2.*R1*BA(J+2,M)/((X2+DELTX-X1)**2+R*R+R1*R1*(Z1-1.)
     &**2)
      IF(J.EQ.(INT-4))     GO TO 88
      J=J+2
      X2=X2+DELTX*2.0
      GO TO 7
   88 X2=X2+DELTX*2.0
      SUM43=SUM43+4.*R1*BA(INT-1,1)/((X2-X1)**2+R*R+R1*R1*(Z1+1.)**2)
      SUM44=SUM44+4.*R1*BA(INT-1,M)/((X2-X1)**2+R*R+R1*R1*(Z1-1.)**2)
      TSUMX1=(TSUMX1+SUM43+SUM23+R1*BA(INT,1)/((X2+DELTX-X1)**2+R*R+R1
     &**2*(Z1+1.)**2))*DELTX/3.0
      TSUMX2=(TSUMX2+SUM44+SUM24+R1*BA(INT,M)/((X2+DELTX-X1)**2+R*R+R1**
     &2*(Z1-1.)**2))*DELTX/3.0
      X2=0.
      XZSIM=0.
      ND=1
      DO 1  JJ=1,INT
      Z2=-1.0
      ZSIMP=0.
      IND=1
      DO 2  II=1,NINT
      IF(II.LT.3)  GO TO 601
      IF(II-NINT+2)  301,301,401
  401 PARR=(25.0*BA(JJ,II)-48.0*BA(JJ,II-1)+36.0*BA(JJ,II-2)-16.0*BA(
     &JJ,II-3)+3.0*BA(JJ,II-4))/(12.0*DELTZ)
      GO TO 501
  601 PARR=(-25.0*BA(JJ,II)+48.0*BA(JJ,II+1)-36.0*BA(JJ,II+2)+16.0*BA(JJ
     &,II+3)-3.0*BA(JJ,II+4))/(12.0*DELTZ)
      GO TO 501
  301 PARR=(BA(JJ,II-2)-8.0*BA(JJ,II-1)+8.0*BA(JJ,II+1)-BA(JJ,II+2))/(
     &12.0*DELTZ)
  501 FUNC=R1*(Z1-Z2)/((X1-X2)**2+R*R+R1*R1*(Z1-Z2)**2)
      FUNC=FUNC*PARR

      IF(II-NINT)  111,311,311
  311 ZSIMP=ZSIMP+FUNC
      GO TO 2
  111 IF(II-1)  12,12,13
   12 ZSIMP=ZSIMP+FUNC
      GO TO  21
   13 IF(II-IND)  114,116,116
  114 ZSIMP=ZSIMP+4.*FUNC
      GO TO 222
  116 ZSIMP=ZSIMP+2.*FUNC
   21 IND=IND+2
  222 Z2=Z2+DELTZ
    2 CONTINUE
      ZSIMP=ZSIMP*DELTZ/3.0
      IF(JJ-INT)   22,33,33
   33 XZSIM=XZSIM+ZSIMP
      GO TO 1
   22 IF(JJ-1)     422,422,43
  422 XZSIM=XZSIM+ZSIMP
      GO TO 45
   43 IF(JJ-ND)    44,46,44
   44 XZSIM=XZSIM+4.*ZSIMP
      GO TO 42
   46 XZSIM=XZSIM+2.*ZSIMP
   45 ND=ND+2
   42 X2=X2+DELTX
    1 CONTINUE
```

```
      XZSIM=XZSIM*DELTX/3.0
      INT2=(INT-1)/2+1
      ND=1
      ZXSIM=0.
      Z2=-1.
      DO 91    II=1,NINT
      XSIMP=0.
      X2=0.0
      IND=1
      DO 92    JJ=1,INT
      IF(JJ.LT.3)   GO TO61
      IF(JJ-INT+2)   31,31,41
41    PARB1=(25.0*BA(JJ,II)-48.0*BA(JJ-1,II)+36.0*BA(JJ-2,II)-16.0*BA(
     $JJ-3,II)+3.0*BA(JJ-4,II))/(12.0*DELTX)
      GO TO 51
61    PARB1=(-25.0*BA(JJ,II)+48.0*BA(JJ+1,II)-36.0*BA(JJ+2,II)+16.0*BA
     $(JJ+3,II)-3.0*BA(JJ+4,II))/(12.0*DELTX)
      GO TO 51
31    PARB1=(BA(JJ-2,II)-8.0*BA(JJ-1,II)+8.0*BA(JJ+1,II)-BA(JJ+2,II))
     $/(12.*DELTX)
51    FUNC1=R1*(X1-X2)/((X1-X2)**2+R*R+R1*R1*(Z1-Z2)**2)
      FUNC1=FUNC1*PARB1
      IF(JJ-INT)        84,34,34
34     XSIMP=XSIMP+FUNC1
      GO TO 92
84    IF(JJ-1)   82,82,83
82    XSIMP=XSIMP+FUNC1
      GO TO 87
83    IF(JJ-IND)   184,86,184
184   XSIMP=XSIMP+4.*FUNC1
      GO TO 229
86    XSIMP=XSIMP+2.*FUNC1
87    IND=IND+2
229   X2=X2+DELTX
92    CONTINUE
      XSIMP=XSIMP*DELTX/3.0
      IF(II-NINT)  52,151,151
151   ZXSIM=ZXSIM+XSIMP
      GO TO 91
52    IF(II-1)   53,53,54
53    ZXSIM=ZXSIM+XSIMP
      GO TO 57
54    IF(II-ND)   55,56,55
55    ZXSIM=ZXSIM+4.*XSIMP
      GO TO 58
56    ZXSIM=ZXSIM+2.*XSIMP
57    ND=ND+2
58    Z2=Z2+DELTZ
91    CONTINUE
      ZXSIM=ZXSIM*DELTZ/3.0
      B1(I,K)=1.+(X1*TSUMW1+(1.-X1)*TSUMW2+(Z1+1.)*TSUMX1+(1.-Z1)*
     $TSUMX2+XZSIM+ZXSIM)*R-1.0+AAA
      PI(I,K)=B1(I,K)/AAA
      DILES(I,K)=(AAA-(1.0-R0)*B1(I,K))/R0
      DILESQ(I,K)=(1.0-(1.0-R0)*BI(I,K))/R0
      Z1=Z1+DELTZ
6     CONTINUE
      X1=X1+DELTX
4     CONTINUE
```

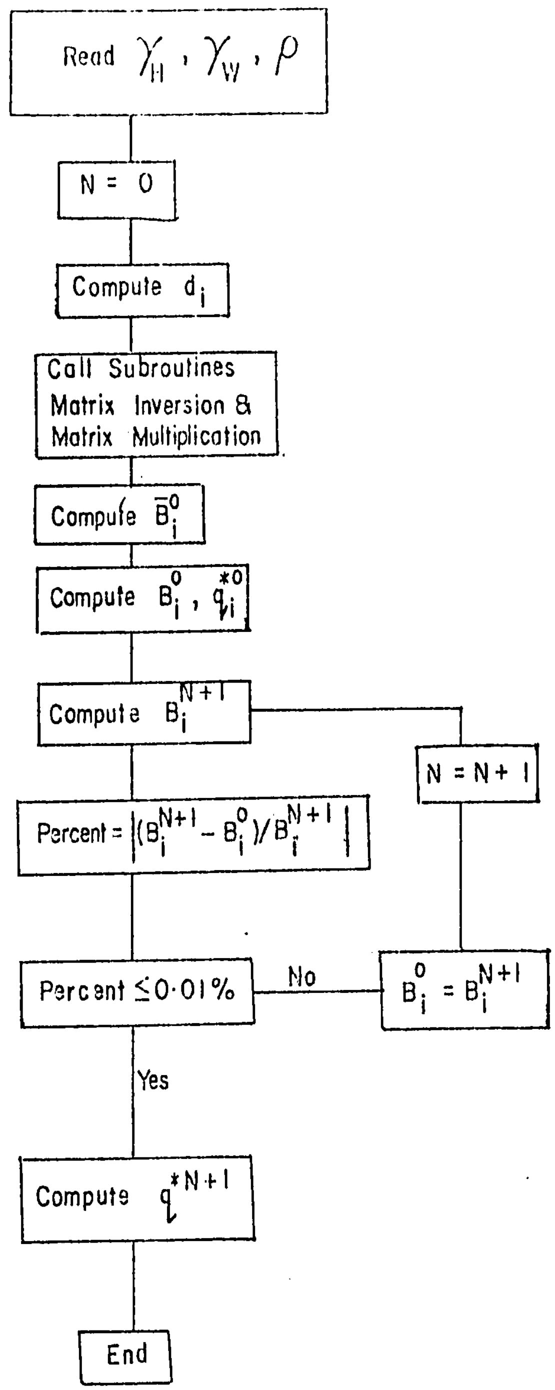
```
      WRITE (3,67) [illegible]
 67   FORMAT (1H ,'DEV. OF [illegible] CALIBRATION [illegible]',/)
      DO 310  I=1,IMF
      DO 310  K=1,NIMF
      PERCEN(I,K)=[illegible]((BI(I,K)-DA(I,K))/BI(I,K))
      DIF(I,K)=[illegible](I,K)
      [illegible]
 310  CONTINUE
      IF([illegible]) GO TO [illegible]
      IF([illegible]) GO TO [illegible]
      WRITE (3,[illegible])
 [illegible] FORMAT (T20,'[illegible]',T[illegible],'[illegible]',T[illegible],'[illegible]',T[illegible],'
     &PERCENTAGE')
      DO  [illegible]  I=1,IMF
      DO  [illegible]  K=1,NIMF
      WRITE(3,[illegible]) I,K,BI(I,K),CI(I,K),DIFFSQ(I,K),DIFFS(I,K),
     &PERCEN(I,K)
 [illegible] FORMAT (1H ,'B(',I2,',',I5,')=',F9.6,2X,T20,F12.9,T50,F12.9,T70,
     &F12.9,T90,F12.9)
 [illegible] CONTINUE
      GO TO [illegible]
 [illegible] DO  65  I=1,IMF
      DO 65  K=1,NIMF
      WRITE(3,64 ) I,K,BI(I,K),CI(I,K),DIFFSQ(I,K),DIFFS(I,K),
     &PERCEN(I,K)
 64   FORMAT (1H ,'B(',I2,',',I5,')=',F9.6,2X,T29,F12.9,T50,F12.3,T70,
     &F12.9,T90,F12.9)
 65   CONTINUE
      CALL  TOTALQ (DELRS ,TOTQ,IMF,NIMF,DELTZ,DELTX)
      WRITE(3,580)  TOTQ
 580  FORMAT (/,' P IS NOT CONSTANT, TOTAL H. T. /UNIT AREA=',F13.8)
      WRITE (3,585)
 585  FORMAT (///,'END END END END END END END END ',///)
      IF(IR.LT.10) GO TO 220
      RETURN
      END

C       SUBROUTINE FOR MATRIX INVERSION
        SUBROUTINE MATINV(A,N)
        IMPLICIT REAL*8(A-H,O-Z)
        DIMENSION INDEX(50,2),A(N,N)
        DO 102 I=1,N
 102    INDEX(I,1)=0
        II=0
 103    AMAX=-1.
        DO 110 I=1,N
        IF(INDEX(I,1))110,111,110
 111    DO 112 J=1,N
        IF(INDEX(J,1))112,113,112
 113    TEMP=DABS(A(I,J))
        IF(TEMP-AMAX)112,112,114
 114    IROW=I
        ICOL=J
        AMAX=TEMP
 112    CONTINUE
 110     CONTINUE
        IF(AMAX)225,116,116
 116  INDEX(ICOL,1)=IROW
        IF(IROW-ICOL)119,118,119
 119    DO 120 J=1,N
        TEMP=A(IROW,J)
        A(IROW,J)=A(ICOL,J)
 120    A(ICOL,J)=TEMP
        II=II+1
        INDEX(II,2)=ICOL
 118    PIVOT=A(ICOL,ICOL)
        A(ICOL,ICOL)=1.
        PIVOT=1./PIVOT
        DO 121 J=1,N
 121    A(ICOL,J)=A(ICOL,J)*PIVOT
        DO 122 I=1,N
        IF(I-ICOL)123,122,123
 123    TEMP=A(I,ICOL)
        A(I,ICOL)=0.
        DO 124 J=1,N
 124    A(I,J)=A(I,J)-A(ICOL,J)*TEMP
 122    CONTINUE
        GO TO 103
 125    ICOL=INDEX(II,2)
        IROW=INDEX(ICOL,1)
```

```
      DO 124 I=1,N
      TEMP=A(I,IROW)
      A(I,IROW)=A(I,ICOL)
124   A(I,ICOL)=TEMP
      II=II-1
225   IF(II)126,127,126
116   WRITE(6,1001)
1001  FORMAT(1H0,5X,11H ZERO PIVOT)
127   CONTINUE
      RETURN
      END


C     SUBROUTINE FOR MATRIX MULTIPLICATION
      SUBROUTINE MATMUL(A,B,C,M,N,K)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(M,N), B(N,K), C(M,K)
      DO 21 I=1,M
      DO 21 J=1,K
      C(I,J)=0.
      DO 20 L=1,N
   20 C(I,J)=C(I,J)+A(I,L)*B(L,J)
   21 CONTINUE
      RETURN
      END


      SUBROUTINE  TOTALQ (BA,TOTQ,INT,NINT,DELTZ,DELTX)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION BA(41,41)
      TOTQ=0.0
      NP=1
      TTSUM=0.0
      DO 1  I=1,INT
      J=1
      TSUM1=0.0
      SUM2=0.0
      SUM4=0.0
      SUM2=SUM2+BA(I,J)
2     SUM4=SUM4+4.0*BA(I,J+1)
      IF(J-NINT+2)  7,3,7
7     SUM2=SUM2+2.0*BA(I,J+2)
      J=J+2
      GO TO 2
3     SUM4=SUM4+BA(I,NINT)
      TSUM1=(SUM2+SUM4)*DELTZ/3.0
      IF (I-INT)  11,12,12
12    TTSUM=TTSUM+TSUM1
      GO TO 1
11    IF (I-1)  13,13,14
13    TTSUM=TTSUM+TSUM1
      GO TO 1
14    IF(I-NP)  16,15,16
15    TTSUM=TTSUM+2.0*TSUM1
      GO TO 1
16    TTSUM=TTSUM+4.0*TSUM1
      NP=NP+2
1     CONTINUE
      TOTQ=TTSUM*DELTX/(2.0*3.0)
      RETURN
      END
```


Read γ_H , γ_W , ρ
N = 0
Compute d_i
Call Subroutines
Matrix Inversion &
Matrix Multiplication
Compute $\bar{B}_i^0$
Compute B_i^0 , q_i^{*0}
Compute B_i^{N+1}
N = N + 1
Percent = $\left|(B_i^{N+1} - B_i^0)/B_i^{N+1}\right|$
Percent $\leq 0.01\%$
No
$B_i^0 = B_i^{N+1}$
Yes
Compute q^{*N+1}
End

Appendix 5

SAMPLE CALCULATION

A system of two parallel plates having identical and constant temperature distribution is considered. For example, $\gamma_{L2}=0.5$, $\gamma_{H}=0.5$, $\gamma_{W2}=1.0$, $\rho_1=0.9$, $\rho_2=0.1$ and $\gamma_{W1}=2.0$

From Figure 36 , $\bar{B}_1^o(X_1=0)=2.430$, $\bar{B}_1^o(X_1=1)=1.359$, $\bar{B}_1^o(Z_1=-1)=\bar{B}_1^o(Z_1=1)=1.068$, $\bar{B}_2^o(X_2=0)=1.006$, $\bar{B}_2^o(X_2=1)=1.013$ and $\bar{B}_2^o(Z_2=-1)=\bar{B}_2^o(Z_2=1)=1.011$.

Let $E_{R1}=\epsilon_1\sigma T_1^4$ and $E_{R2}=\epsilon_2\sigma T_2^4$, then $E_1(X_1,Z_1)/E_{R1}$ and $E_2(X_2,Z_2)/E_{R2}$ in Equations (22) are equal to 1.

The zero-order solutions of surfaces 1 and 2 at (0.5,0) and (0.3,0.3) respectively, can be calculated by substituting all the above values in Equations (22). The results are $B_1^o(0.5,0)=3.732$ and $B_2^o(0.3,0.3)=1.010$. $q_1^{*o}(0.5,0)=0.696$ and $q_2^{*o}(0.3,0.3)=0.914$ are calculated using Equation (26). If the zero-order solution is acceptable, the total heat flux can be evaluated by using Equations (28)

$$Q_1^{*o}=1-\frac{\epsilon_2}{4\pi}\left[g_1\bar{B}_2^o(X_2=0)+g_2\bar{B}_2^o(X_2=1)+g_3\bar{B}_2^o(Z_2=-1)+g_4\bar{B}_2^o(Z_2=1)\right]$$

$$Q_2^{*o}=1-\frac{\epsilon_1}{4\pi}\left[g_5\bar{B}_1^o(X_1=0)+g_6\bar{B}_1^o(X_1=1)+g_7\bar{B}_1^o(Z_1=-1)+g_8\bar{B}_1^o(Z_1=1)\right]$$

From Table 27, $g_1=0.1143$, $g_2=0$, $g_3=g_4=0.0189$, $g_5=0.1654$, $g_6=0.2919$ and $g_7=g_8=0.0757$. Substituting g_i into Equations (28), one can obtain

$Q_1^{*o}=0.862$

$Q_2^{*o}=0.904$

References

1. Y. P. Chang and Lunardini, V. J., "A Rapid Iteration Method for Radiant Heat Exchange," Journal of Heat Transfer, Trans. ASME, Series C,91, (4), 581, 1969.

2. E. M. Sparrow and A. Haji-Sheikh, "A Generalized Variational Method for Calculating Radiant Interchange Between Surfaces," J. of Heat Transfer, Trans. ASME, Series C, 87,103-109, 1965.

3. E. R. G. Eckert and R. Drake, "Heat and Mass Transfer," McGraw-Hill Book Company, Inc., New York, N. Y., 1959.

4. E. M. Sparrow, et al, "Analysis, Results and Interpretation for Radiation Between Some Simply Arranged Gray Surfaces," J. of Heat Transfer, Trans. ASME, Series C, 83, 207-214, 1961.

5. E. M. Sparrow, "Application of Variational Methods to Radiation Heat Transfer Calculations," J. of Heat Transfer, Trans. ASME, Series C, 82, 375-380, 1960.

6. E. M. Sparrow and J. L. Gregg, "Radiant Interchange Between Circular Disks Having Arbitrarily Different Temperatures," J. of Heat Transfer, Trans. ASME, Series C, 83, 494-502,1961.

7. E. M. Sparrow and V. K. Jonsson, "Absorption and Emission Characteristics of Diffuse Spherical Enclosures," J. of Heat Transfer, Tran. ASME, Series C, 84, 188-189,1962.

8. E. M. Sparrow, "Radiant Absorption Characteristics of Concave Cylindrical Surfaces," J. of Heat Transfer, Trans. ASME, Series C, 84, 283-293, 1962.

9. C. M. Usiskin and R. Siegel, "Thermal Radiation From a Cylindrical Enclosure With Specified Wall Heat Flux," J. of Heat Transfer, Trans. ASME, Series C, 84, 283-293, 1962.

10. Hildebrand, F. B., "Methods of Applied Mathematics," Prentice-Hill, Inc., New Jersey, 1952.

11. Hildebrand, F. B., "Advanced Calculus for Applications," Prentice-Hill, Inc., New Jersey, 1962.

Table 2. Local radiosity for T=const., ϵ =0.9, W/L=0.5, H/L=2

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.006	1.006	1.006	1.006	1.006	1
Z.S.	X=0	1.0067	1.0067	1.0066	1.0066	1.0066	1.0065	1.0064	1.0063	1.0062	1.0061	1.0060	
E.S.		1.0067	1.0067	1.0066	1.0066	1.0066	1.0065	1.0064	1.0063	1.0062	1.0061	1.0060	
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.006	1.006	1.006	
Z.S.	X=0.1	1.0069	1.0069	1.0069	1.0068	1.0068	1.0067	1.0067	1.0066	1.0065	1.0064	1.0062	
E.S.		1.0069	1.0069	1.0069	1.0068	1.0068	1.0067	1.0067	1.0066	1.0065	1.0064	1.0062	
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.006	
Z.S.	X=0.2	1.0071	1.0071	1.0071	1.0071	1.0070	1.0069	1.0069	1.0068	1.0067	1.0065	1.0064	
E.S.		1.0071	1.0071	1.0071	1.0071	1.0070	1.0069	1.0069	1.0068	1.0067	1.0066	1.0064	
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	
Z.S.	X=0.3	1.0073	1.0073	1.0072	1.0072	1.0071	1.0071	1.0070	1.0069	1.0068	1.0067	1.0066	
E.S.		1.0073	1.0073	1.0072	1.0072	1.0072	1.0071	1.0070	1.0069	1.0068	1.0067	1.0066	
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	
Z.S.	X=0.4	1.0074	1.0074	1.0073	1.0073	1.0072	1.0072	1.0071	1.0070	1.0069	1.0068	1.0066	
E.S.		1.0074	1.0074	1.0073	1.0073	1.0072	1.0072	1.0071	1.0070	1.0069	1.0068	1.0066	
V.M.		1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007	
Z.S.	X=0.5	1.0074	1.0074	1.0074	1.0073	1.0073	1.0072	1.0071	1.0070	1.0070	1.0068	1.0067	
E.S.		1.0074	1.0074	1.0074	1.0073	1.0073	1.0072	1.0071	1.0070	1.0069	1.0068	1.0067	

V.M. = Variational Method Z.S. = Zero-order Solution E.S. = Exact Solution N.T. = No. of Iterations

Table 3. Local radiosity for T = const., ϵ =0.5, W/L=0.5, H/L=2

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.034	1.034	1.034	1.034	1.034	1.033	1.033	1.033	1.032	1.031	1.031	1
Z.S.	X=0	1.0342	1.0342	1.0340	1.0339	1.0336	1.0333	1.0330	1.0325	1.0320	1.0315	1.0309	
E.S.		1.0343	1.0342	1.0341	1.0340	1.0337	1.0334	1.0330	1.0326	1.0321	1.0316	1.0310	
V.M.		1.035	1.035	1.035	1.035	1.035	1.034	1.034	1.034	1.033	1.032	1.032	
Z.S.	X=0.1	1.0355	1.0354	1.0353	1.0352	1.0349	1.0346	1.0342	1.0337	1.0332	1.0327	1.0320	
E.S.		1.0356	1.0355	1.0354	1.0352	1.0350	1.0347	1.0343	1.0338	1.0333	1.0327	1.0321	
V.M.		1.036	1.036	1.036	1.036	1.036	1.035	1.035	1.035	1.034	1.033	1.032	
Z.S.	X=0.2	1.0365	1.0365	1.0364	1.0362	1.0359	1.0356	1.0352	1.0347	1.0342	1.0336	1.0330	
E.S.		1.0366	1.0336	1.0365	1.0363	1.0360	1.0357	1.0353	1.0348	1.0343	1.0337	1.0330	
V.M.		1.037	1.037	1.037	1.037	1.037	1.036	1.036	1.035	1.035	1.034	1.034	
Z.S.	X=0.3	1.0373	1.0373	1.0372	1.0370	1.0367	1.0363	1.0359	1.0354	1.0349	1.0343	1.0336	
E.S.		1.0374	1.0374	1.0372	1.0370	1.0368	1.0364	1.0360	1.0355	1.0350	1.0344	1.0337	
V.M.		1.038	1.038	1.037	1.037	1.037	1.037	1.036	1.036	1.035	1.035	1.034	
Z.S.	X=0.4	1.0378	1.0378	1.0376	1.0374	1.0372	1.0368	1.0364	1.0359	1.0353	1.0347	1.0340	
E.S.		1.0379	1.0378	1.0377	1.0375	1.0372	1.0369	1.0365	1.0360	1.0354	1.0348	1.0341	
V.M.		1.038	1.038	1.038	1.037	1.037	1.037	1.036	1.036	1.035	1.035	1.034	
Z.S.	X=0.5	1.0380	1.0379	1.0378	1.0376	1.0373	1.0370	1.0365	1.0360	1.0355	1.0349	1.0342	
E.S.		1.0380	1.0380	1.0379	1.0377	1.0374	1.0370	1.0366	1.0361	1.0356	1.0349	1.0343	

Table 4. Local radiosity for T = const., ϵ =0.1, W/L=0.5, H/L=2

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.064	1.064	1.063	1.063	1.063	1.062	1.061	1.060	1.059	1.058	1.057	2
Z.S.	X=0	1.0632	1.0631	1.0629	1.0626	1.0622	1.0616	1.0609	1.0601	1.0592	1.0583	1.0572	
E.S.		1.0635	1.0634	1.0632	1.0629	1.0625	1.0619	1.0612	1.0604	1.0595	1.0585	1.0574	
V.M.		1.066	1.066	1.066	1.065	1.065	1.064	1.063	1.063	1.062	1.060	1.059	
Z.S.	X=0.1	1.0656	1.0655	1.0653	1.0650	1.0645	1.0639	1.0632	1.0624	1.0614	1.0604	1.0592	
E.S.		1.0659	1.0658	1.0656	1.0653	1.0648	1.0642	1.0635	1.0627	1.0617	1.0607	1.0595	
V.M.		1.068	1.068	1.068	1.067	1.067	1.066	1.065	1.064	1.063	1.062	1.061	
Z.S.	X=0.2	1.0675	1.0674	1.0673	1.0670	1.0664	1.0658	1.0651	1.0642	1.0632	1.0621	1.0609	
E.S.		1.0679	1.0678	1.0676	1.0672	1.0667	1.0661	1.0654	1.0645	1.0635	1.0624	1.0612	
V.M.		1.069	1.069	1.069	1.069	1.068	1.067	1.067	1.066	1.065	1.064	1.063	
Z.S.	X=0.3	1.0690	1.0689	1.0687	1.0683	1.0678	1.0672	1.0664	1.0655	1.0645	1.0634	1.0622	
E.S.		1.0693	1.0692	1.0690	1.0686	1.0681	1.0675	1.0667	1.0658	1.0648	1.0637	1.0625	
V.M.		1.070	1.070	1.070	1.069	1.069	1.068	1.068	1.067	1.066	1.065	1.063	
Z.S.	X=0.4	1.0699	1.0698	1.0696	1.0692	1.0687	1.0680	1.0673	1.0664	1.0653	1.0642	1.0629	
E.S.		1.0702	1.0701	1.0699	1.0695	1.0690	1.0684	1.0676	1.0667	1.0656	1.0645	1.0632	
V.M.		1.070	1.070	1.070	1.070	1.069	1.069	1.068	1.067	1.066	1.065	1.064	
Z.S.	X=0.5	1.0702	1.0701	1.0699	1.0695	1.0690	1.0683	1.0675	1.0666	1.0656	1.0645	1.0632	
E.S.		1.0705	1.0704	1.0702	1.0698	1.0693	1.0686	1.0679	1.0669	1.0659	1.0647	1.0635	

Table 5. Local radiosity for T=const., ϵ =0.9, W/L=0.5, H/L=0.5

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.037	1.036	1.036	1.035	1.033	1.031	1.029	1.027	1.024	1.020	1.017	2
Z.S.	X=0	1.0345	1.0343	1.0339	1.0333	1.0323	1.0311	1.0296	1.0278	1.0258	1.0237	1.0214	
E.S.		1.0349	1.0348	1.0344	1.0337	1.0327	1.0315	1.0299	1.0281	1.0261	1.0239	1.0216	
V.M.		1.044	1.043	1.043	1.042	1.040	1.038	1.036	1.033	1.031	1.027	1.024	
Z.S.	X=0.1	1.0422	1.0420	1.0415	1.0407	1.0395	1.0380	1.0361	1.0339	1.0314	1.0287	1.0258	
E.S.		1.0428	1.0426	1.0421	1.0413	1.0401	1.0385	1.0366	1.0343	1.0318	1.0290	1.0261	
V.M.		1.049	1.049	1.048	1.047	1.046	1.044	1.042	1.039	1.036	1.033	1.029	
Z.S.	X=0.2	1.0487	1.0485	1.0479	1.0470	1.0456	1.0438	1.0416	1.0390	1.0361	1.0329	1.0296	
E.S.		1.0494	1.0492	1.0486	1.0477	1.0462	1.0444	1.0422	1.0359	1.0366	1.0333	1.0299	
V.M.		1.053	1.053	1.052	1.051	1.050	1.048	1.046	1.043	1.040	1.037	1.033	
Z.S.	X=0.3	1.0534	1.0532	1.0526	1.0515	1.0500	1.0480	1.0456	1.0427	1.0395	1.0360	1.0323	
E.S.		1.0543	1.0540	1.0534	1.0523	1.0507	1.0487	1.0462	1.0433	1.0401	1.0365	1.0327	
V.M.		1.056	1.056	1.055	1.054	1.052	1.051	1.048	1.046	1.043	1.039	1.036	
Z.S.	X=0.4	1.0562	1.0559	1.0553	1.0542	1.0526	1.0505	1.0479	1.0449	1.0415	1.0378	1.0339	
E.S.		1.0571	1.0569	1.0562	1.0550	1.0534	1.0513	1.0486	1.0456	1.0421	1.0383	1.0344	
V.M.		1.056	1.056	1.056	1.055	1.053	1.051	1.049	1.047	1.044	1.040	1.037	
Z.S.	X=0.5	1.0571	1.0568	1.0562	1.0550	1.0534	1.0513	1.0487	1.0456	1.0422	1.0384	1.0345	
E.S.		1.0580	1.0578	1.0571	1.0559	1.0543	1.0521	1.0494	1.0463	1.0428	1.0390	1.0349	

Table 6. Local radiosity for T = const., ∈ =0.5, W/L=0.5, H/L=0.5

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.226	1.224	1.220	1.214	1.204	1.193	1.179	1.162	1.144	1.123	1.101	5
Z.S.	X=0	1.1959	1.1951	1.1929	1.1890	1.1836	1.1766	1.1681	1.1580	1.1467	1.1345	1.1216	
E.S.		1.2123	1.2114	1.2088	1.2045	1.1983	1.1905	1.1810	1.1699	1.1575	1.1441	1.1301	
V.M.		1.268	1.267	1.263	1.256	1.247	1.235	1.221	1.205	1.186	1.166	1.144	
Z.S.	X=0.1	1.2396	1.2387	1.2359	1.2312	1.2245	1.2158	1.2051	1.1926	1.1784	1.1629	1.1467	
E.S.		1.2603	1.2597	1.2565	1.2511	1.2434	1.2336	1.2216	1.2077	1.1920	1.1751	1.1575	
V.M.		1.303	1.302	1.298	1.291	1.282	1.270	1.256	1.239	1.221	1.201	1.179	
Z.E.	X=0.2	1.2766	1.2755	1.2723	1.2668	1.2590	1.2489	1.2364	1.2217	1.2051	1.1870	1.1681	
E.S.		1.3025	1.3012	1.2974	1.2911	1.2821	1.2706	1.2565	1.2401	1.2216	1.2017	1.1810	
V.M.		1.329	1.328	1.324	1.317	1.308	1.296	1.282	1.265	1.247	1.227	1.204	
Z.S.	X=0.3	1.3034	1.3022	1.2986	1.2925	1.2839	1.2727	1.2590	1.2428	1.2245	1.2045	1.1836	
E.S.		1.3332	1.3318	1.3276	1.3205	1.3106	1.2978	1.2821	1.2639	1.2434	1.2213	1.1983	
V.M.		1.345	1.344	1.340	1.333	1.324	1.312	1.298	1.281	1.263	1.242	1.220	
Z.S.	X=0.4	1.3191	1.3179	1.3141	1.3077	1.2986	1.2868	1.2723	1.2552	1.2359	1.2149	1.1929	
E.S.		1.3515	1.3500	1.3456	1.3381	1.3276	1.3140	1.2974	1.2781	1.2565	1.2331	1.2088	
V.M.		1.350	1.239	1.345	1.338	1.329	1.317	1.303	1.287	1.268	1.248	1.226	
Z.S.	X=0.5	1.3243	1.3230	1.3191	1.3126	1.3034	1.2914	1.2766	1.2593	1.2396	1.2183	1.1959	
E.S.		1.3576	1.3561	1.3515	1.3439	1.3332	1.3193	1.3025	1.2828	1.2608	1.2370	1.2123	

Table 7. Local radiosity for T = const. ϵ =0.1, W/L=0.5, H/L=0.5

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.522	1.518	1.509	1.492	1.470	1.442	1.408	1.369	1.326	1.278	1.227	8
Z.S.	X=0	1.4083	1.4067	1.4020	1.3940	1.3827	1.3681	1.3503	1.3294	1.3058	1.2802	1.2534	
E.S.		1.4880	1.4859	1.4797	1.4693	1.4547	1.4361	1.4137	1.3878	1.3590	1.3231	1.2960	
V.M.		1.620	1.617	1.607	1.591	1.569	1.541	1.507	1.468	1.424	1.377	1.326	
Z.S.	X=0.1	1.4995	1.4975	1.4917	1.4818	1.4679	1.4497	1.4275	1.4013	1.3718	1.3396	1.3058	
E.S.		1.6018	1.5992	1.5914	1.5783	1.5601	1.5366	1.5083	1.4755	1.4389	1.3997	1.3590	
V.M.		1.703	1.689	1.690	1.674	1.651	1.623	1.589	1.550	1.507	1.459	1.403	
Z.S.	X=0.2	1.5765	1.5743	1.5675	1.5560	1.5398	1.5187	1.4927	1.4621	1.4275	1.3898	1.3503	
E.S.		1.7008	1.6977	1.6885	1.6731	1.6515	1.6239	1.5904	1.5515	1.5083	1.4618	1.4137	
V.M,		1.675	1.761	1.762	1.736	1.713	1.685	1.651	1.612	1.569	1.521	1.470	
Z.S.	X=0.3	1.6323	1.6298	1.6223	1.6097	1.5918	1.5685	1.5398	1.5060	1.4679	1.4263	1.3827	
E.S.		1.7747	1.7713	1.7610	1.7438	1.7198	1.6889	1.6515	1.6083	1.5601	1.5083	1.4547	
V.M.		1.803	1.800	1.790	1.774	1.752	1.723	1.690	1.651	1.607	1.560	1.509	
Z.S.	X=0.4	1.6651	1.6625	1.6546	1.6412	1.6223	1.5977	1.5675	1.5319	1.4917	1.4479	1.4020	
E.S.		1.8195	1.8158	1.8049	1.7866	1.7610	1.7282	1.6885	1.6426	1.5914	1.5365	1.4797	
V.M.		1.816	1.813	1.803	1.787	1.765	1.736	1.703	1.664	1.620	1.573	1.522	
Z.S.	X=0.5	1.6759	1.6732	1.6651	1.6516	1.6323	1.6073	1.5765	1.5404	1.4995	1.4549	1.4083	
E.S.		1.8343	1.8306	1.8195	1.8008	1.7747	1.7413	1.7008	1.6540	1.6018	1.5459	1.4880	

Table 8. Local radiosity for T = const., ϵ =0.9, W/L=0.5, H/L=0.1

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		1.059	1.059	1.059	1.060	1.060	1.059	1.057	1.052	1.044	1.032	1.014	3
Z.S.	X=0	1.0512	1.0512	1.0511	1.0510	1.0507	1.0502	1.0493	1.0477	1.0444	1.0377	1.0250	
E.S.		1.0528	1.0528	1.0527	1.0525	1.0521	1.0516	1.0506	1.0488	1.0453	1.0382	1.0263	
V.M.		1.089	1.090	1.090	1.090	1.091	1.090	1.088	1.083	1.075	1.063	1.044	
Z.S.	X=0.1	1.0881	1.0880	1.0879	1.0877	1.0873	1.0866	1.0853	1.0828	1.0774	1.0656	1.0444	
E.S.		1.0918	1.0917	1.0916	1.0913	1.0908	1.0900	1.0884	1.0856	1.0797	1.0671	1.0453	
V.M.		1.102	1.102	1.103	1.103	1.103	1.102	1.100	1.096	1.088	1.075	1.057	
Z.S.	X=0.2	1.0977	1.0976	1.0975	1.0972	1.0967	1.0959	1.0944	1.0914	1.0853	1.0722	1.0493	
E.S.		1.1026	1.1026	1.1024	1.1021	1.1015	1.1004	1.0986	1.0953	1.0885	1.0744	1.0506	
V.M.		1.105	1.105	1.106	1.106	1.106	1.105	1.103	1.099	1.091	1.078	1.060	
Z.S.	X=0.3	1.1003	1.1003	1.1001	1.0998	1.0993	1.0983	1.0967	1.0936	1.0873	1.0739	1.0507	
E.S.		1.1058	1.1057	1.1055	1.1051	1.1045	1.1034	1.1015	1.0979	1.0908	1.0764	1.0522	
V.M.		1.104	1.104	1.105	1.105	1.106	1.105	1.103	1.098	1.090	1.078	1.059	
Z.S.	X=0.4	1.1012	1.1011	1.1010	1.1006	1.1001	1.0992	1.0975	1.0943	1.0879	1.0744	1.0551	
E.S.		1.1069	1.1068	1.1066	1.1062	1.1055	1.1044	1.1024	1.0987	1.0915	1.0770	1.0527	
V.M.		1.104	1.104	1.104	1.105	1.105	1.104	1.102	1.097	1.089	1.077	1.059	
Z.S.	X=0.5	1.1014	1.1014	1.1012	1.1009	1.1003	1.0993	1.0977	1.0945	1.0881	1.0746	1.0512	
E.S.		1.1071	1.1071	1.1069	1.1065	1.1058	1.1046	1.1026	1.0989	1.0917	1.0772	1.0528	

Table 9 Local radiosity for T = constant , W/L = 0.5, H/L = 0.1 and ϵ = 0.5

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.	X=0	1.450	1.450	1.451	1.450	1.445	1.432	1.404	1.357	1.282	1.170	1.013	10
Z.S.		1.3160	1.3158	1.3153	1.3142	1.3124	1.3094	1.3040	1.2941	1.2741	1.2322	1.1601	
E.S.		1.3980	1.3975	1.3961	1.3933	1.3888	1.3817	1.3705	1.3519	1.3202	1.2643	1.1800	
V.M.	X=0.1	1.719	1.720	1.720	1.720	1.715	1.701	1.674	1.627	1.551	1.440	1.282	
Z.S.		1.5431	1.5429	1.5421	1.5407	1.5382	1.5339	1.5260	1.5105	1.4775	1.4044	1.2741	
E.S.		1.7291	1.7283	1.7258	1.7212	1.7135	1.7012	1.6812	1.6478	1.5889	1.4828	1.3202	
V.M.	X=0.2	1.842	1.842	1.843	1.842	1.837	1.824	1.796	1.749	1.674	1.562	1.404	
Z.S.		1.6023	1.6021	1.6012	1.5994	1.5965	1.5913	1.5819	1.5638	1.5260	1.4451	1.3040	
E.S.		1.8557	1.8546	1.8514	1.8455	1.8357	1.8200	1.7947	1.7529	1.6812	1.5564	1.3705	
V.M.	X=0.3	1.883	1.883	1.882	1.883	1.878	1.864	1.837	1.790	1.715	1.603	1.445	
Z.S.		1.6186	1.6182	1.6173	1.6154	1.6121	1.6065	1.5965	1.5774	1.5382	1.4555	1.3124	
E.S.		1.9037	1.9026	1.8989	1.8922	1.8811	1.8636	1.8357	1.7901	1.7135	1.5821	1.3888	
V.M.	X=0.4	1.888	1.889	1.890	1.889	1.884	1.870	1.843	1.796	1.721	1.609	1.410	
Z.S.		1.6240	1.6237	1.6226	1.6207	1.6172	1.6114	1.6012	1.5817	1.5421	1.4590	1.3153	
E.S.		1.9228	1.9216	1.9177	1.9106	1.8989	1.8805	1.8514	1.8044	1.7258	1.5920	1.3961	
V.M.	X=0.5	1.887	1.888	1.888	1.888	1.883	1.869	1.842	1.794	1.720	1.608	1.450	
Z.S.		1.6254	1.6251	1.6240	1.6220	1.6186	1.6127	1.6023	1.5828	1.5431	1.4598	1.3160	
E.S.		1.9280	1.9268	1.9223	1.9155	1.9037	1.8850	1.8557	1.8082	1.7291	1.5947	1.3980	

Table 10. Local radiosity for T = const., ϵ =0.1, W/L=0.5, H/L=0.1

		Z=0	Z=0.1	Z=0.2	Z=0.3	Z=0.4	Z=0.5	Z=0.6	Z=0.7	Z=0.8	Z=0.9	Z=1	N.T.
V.M.		3.100	3.089	3.053	2 986	2.880	2.7196	2.489	2.165	1.724	1.137	0.371	8
Z.S.	X=0	1.7420	1.7415	1.7402	1.7377	1.7335	1.7263	1.7138	1.6906	1.6435	1.5453	1.3760	
E.S.		2.5238	2.5195	2.5063	2.4828	2.4471	2.3955	2.3227	2.2197	2.0717	1.8569	1.5764	
V.M.		4.453	4.442	4.406	4.340	4.233	4.073	3.842	3.519	3.078	2.491	1.724	
Z.S.	X=0.1	2.2751	2.2746	2.2728	2.2694	2.2636	2.2534	2.2349	2.1986	2.1210	1.9495	1.6435	
E.S.		4.0042	3.9958	3.9699	3.9240	3.8535	3.7512	3.6055	3.3975	3.0959	2.6531	2.0717	
V.M.		5.218	5.206	5.170	5.104	4.997	4.837	4.606	4.283	3.842	3.255	2.489	
Z.S.	X=0.2	2.4142	2.4135	2.4114	2.4074	2.4003	2.3882	2.3662	2.3237	2.2349	2.0445	1.7138	
E.S.		4.8186	4.8071	4.7717	4.7090	4.6123	4.4741	4.2776	4.0002	3.6055	3.0420	2.3227	
V.M.		5.609	5.597	5.561	5.495	5.389	5.228	4.997	4.674	4.233	3.646	2.880	
Z.S.	X=0.3	2.4522	2.4515	2.4492	2.4447	2.4371	2.4239	2.4003	2.3556	2.2636	2.0695	1.7335	
E.S.		5.2417	5.2282	5.1866	5.1130	5.0008	4.8395	4.6130	4.2969	3.8535	3.2310	1.4471	
V.M.		5.782	5.770	5.734	5.668	5.561	5.401	5.170	4.847	4.406	3.820	3.053	
Z.S.	X=0.4	2.4650	2.4643	2.4618	2.4572	2.4492	2.4355	2.4114	2.3658	2.2728	2.0775	1.7402	
E.S.		5.4466	5.4320	5.3869	5.3074	5.1866	5.0135	4.7717	4.4365	3.9699	3.3199	2.5063	
V.M.		5.829	5.818	5.782	5.715	5.609	5.449	5.218	4.894	4.453	3.866	3.100	
Z.S.	X=0.5	2.4683	2.4675	2.4650	2.4603	2.4522	2.4385	2.4142	2.3684	2.2751	2.0796	1.7420	
E.S.		5.5077	5.4928	5.4466	5.3652	5.2417	5.0650	4.8186	4.4777	4.0042	3.3461	2.5238	

Table 11. Local radiosity and heat flux for ρ =0.9,

W/L=0.5, H/L=2, $T=T_0(1+(T_1/T_0-1)X)$ and $T_1/T_0=0.5$

$B=J/E_0$		X=0	X=0.2	X=0.4	X=0.6	X=0.8	X=1	N.T.
Z.S.	Z=0.0	1.01595	0.67914	0.43902	0.27485	0.16844	0.10416	4
E.S.		1.02646	0.68355	0.43710	0.26669	0.15447	0.08506	
Z.S.	Z=0.2	1.01587	0.67904	0.43890	0.27472	0.16831	0.10403	
E.S.		1.02635	0.68344	0.43698	0.26658	0.15437	0.08497	
Z.E.	Z=0.4	1.01562	0.67873	0.43854	0.27433	0.16791	0.10364	
E.S.		1.02602	0.68309	0.43663	0.26625	0.15407	0.08471	
Z.S.	Z=0.6	1.01521	0.67822	0.43796	0.27370	0.16725	0.10300	
E.S.		1.02548	0.68252	0.43607	0.26571	0.15357	0.08428	
Z.S.	Z=0.8	1.01465	0.67753	0.43717	0.27284	0.16637	0.10213	
E.S.		1.02475	0.68176	0.43530	0.26498	0.15291	0.08370	
Z.S.	Z=1.0	1.01398	0.67669	0.43619	0.27178	0.16528	0.10105	
E.S.		1.02386	0.68082	0.43436	0.26408	0.15209	0.08298	
$q^*=q/E_0$								
Z.S.	Z=0.0	0.99823	0.65354	0.40633	0.23624	0.12528	0.05787	
E.S.		0.99706	0.65305	0.40654	0.23715	0.12684	0.05999	
Z.S.	Z=0.2	0.99824	0.65355	0.40634	0.23625	0.12530	0.05789	
E.S.		0.99707	0.65306	0.40656	0.23716	0.12685	0.06000	
Z.S.	Z=0.4	0.99826	0.65359	0.40638	0.23630	0.12534	0.05793	
E.S.		0.99711	0.65310	0.40660	0.23719	0.12688	0.06003	
Z.S.	Z=0.6	0.99831	0.65364	0.40645	0.23637	0.12542	0.05800	
E.S.		0.99717	0.65316	0.40666	0.23725	0.12694	0.06008	
Z.S.	Z=0.8	0.99837	0.65372	0.40654	0.23646	0.12551	0.05810	
E.S.		0.99725	0.65325	0.40674	0.23734	0.12701	0.06014	
Z.S.	Z=1.0	0.00845	0.65381	0.40665	0.23653	0.12564	0.05822	
E.S.		0.99735	0.65335	0.40685	0.23744	0.12710	0.06022	

Table 12. Local radiosity and heat flux for ρ =0.5,

W/L=0.5, H/L=2, $T=T_o(1+(T_1/T_o-1)X)$ and T_1/T_o=0.5

$B=J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0	1.00835	0.66839	0.42546	0.25895	0.15078	0.08531	3
E.S.		1.01431	0.67094	0.42445	0.25445	0.14300	0.07465	
Z.S.	Z=0.2	1.00830	0.66834	0.42539	0.25888	0.15070	0.08523	
E.S.		1.01425	0.67087	0.42439	0.25439	0.14295	0.07460	
Z.S.	Z=0.4	1.00817	0.66817	0.42520	0.25867	0.15049	0.08502	
E.S.		1.01407	0.67069	0.42420	0.25421	0.14279	0.07446	
Z.S.	Z=0.6	1.00795	0.66690	0.42488	0.25833	0.15013	0.08467	
E.S.		1.01378	0.67038	0.42389	0.25392	0.14252	0.07423	
Z.S.	Z=0.8	1.00766	0.66753	0.42446	0.25786	0.14965	0.08420	
E.S.		1.01339	0.66997	0.42348	0.25352	0.14216	0.07392	
Z.S.	Z=1.0	1.00730	0.66708	0.42393	0.25729	0.14906	0.08361	
E.S.		1.01290	0.66946	0.42297	0.25304	0.14172	0.07353	
$q^*=q/E_o$								
Z.S.	Z=0	0.99165	0.64381	0.39374	0.22125	0.10842	0.03970	
E.S.		0.98569	0.64126	0.39475	0.22575	0.11620	0.05035	
Z.S.	Z=0.2	0.99170	0.64386	0.39381	0.22132	0.10850	0.03977	
E.S.		0.98575	0.64133	0.39482	0.22581	0.11625	0.05040	
Z.S.	Z=0.4	0.99183	0.64403	0.39400	0.22153	0.10871	0.03998	
E.S.		0.98593	0.64151	0.39500	0.22599	0.11641	0.05054	
Z.S.	Z=0.6	0.99205	0.64430	0.39432	0.22187	0.10907	0.04033	
E.S.		0.98622	0.64182	0.39531	0.22629	0.11668	0.05077	
Z.S.	Z=0.8	0.99234	0.64467	0.39474	0.22234	0.10955	0.04080	
E.S.		0.98661	0.64223	0.39572	0.22668	0.11704	0.05108	
Z.S.	Z=1.0	0.99270	0.64512	0.39527	0.22291	0.11014	0.04139	
E.S.		0.98710	0.64274	0.39623	0.22716	0.11748	0.05147	

Table 13. Local radiosity and heat flux for ρ =0.1, W/L=0.5, H/L=2, $T=T_0(1+(T_1/T_0-1)X)$ and $T_1/T_0=0.5$

$B = J/E_0$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0	1.00157	0.65846	0.41268	0.24379	0.13376	0.06670	
								2
E.S.		1.00279	0.65899	0.41249	0.24289	0.13220	0.06486	
Z.S.	Z=0.2	1.00156	0.65845	0.41267	0.24377	0.13375	0.06698	
E.S.		1.00278	0.65898	0.41248	0.24288	0.13219	0.06485	
Z.S.	Z=0.4	1.00154	0.65842	0.41263	0.24373	0.13370	0.06694	
E.S.		1.00247	0.65894	0.41244	0.24284	0.13216	0.06482	
Z.S.	Z=0.6	1.00150	0.65837	0.41257	0.24366	0.13363	0.06687	
E.S.		1.00269	0.65888	0.41238	0.24279	0.13211	0.06478	
Z.S.	Z=0.8	1.00144	0.65829	0.41248	0.24357	0.13354	0.06678	
E.S.		1.00261	0.65880	0.41230	0.24271	0.13204	0.06472	
Z.S.	Z=1.0	1.00137	0.65821	0.41238	0.24346	0.13343	0.06667	
E.S.		1.00251	0.65870	0.41220	0.24262	0.13195	0.06464	
$q^* = q/E_0$								
Z.S.	Z=0.0	0.98586	0.63485	0.38190	0.20694	0.09217	0.02202	
E.S.		0.97491	0.63010	0.38360	0.21500	0.10617	0.04129	
Z.S.	Z=0.2	0.98594	0.63495	0.38201	0.20706	0.09229	0.02215	
E.S.		0.97501	0.63021	0.38371	0.21511	0.10627	0.04137	
Z.S.	Z=0.4	0.98617	0.63524	0.38235	0.20743	0.09267	0.02252	
E.S.		0.97532	0.63054	0.38404	0.21542	0.10655	0.04162	
Z.S.	Z=0.6	0.98655	0.63571	0.38290	0.20803	0.09330	0.02314	
E.S.		0.97583	0.63108	0.38458	0.21593	0.10702	0.04202	
Z.S.	Z=0.8	0.98706	0.63635	0.38364	0.20885	0.09414	0.02397	
E.S.		0.97653	0.63180	0.38530	0.21662	0.10764	0.04256	
Z.S.	Z=1.0	0.98768	0.63714	0.38456	0.20985	0.09518	0.0250	
E.S.		0.97737	0.63269	0.38619	0.21747	0.10841	0.04324	

Table 14. Local radiosity and heat flux for ρ =0.9

$W/L=0.5$, $H/L=0.5$, $T=T_o(1+(T_1/T_o-1)X)$ and $T_1/T_o=0.5$.

$B = J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0.0	1.13593	0.90247	0.71212	0.54829	0.40893	0.29003	6
E.S.		1.26159	0.99359	0.74365	0.51519	0.32608	0.18366	
Z.S.	Z=0.2	1.13352	0.89847	0.70740	0.54370	0.40502	0.28708	
E.S.		1.25712	0.98769	0.73771	0.51029	0.32262	0.18162	
Z.S.	Z=0.4	1.12618	0.88624	0.69301	0.52971	0.39308	0.27816	
E.S.		1.24362	0.96985	0.71982	0.49558	0.31233	0.17557	
Z.S.	Z=0.6	1.11378	0.86549	0.66865	0.50602	0.37286	0.26320	
E.S.		1.22117	0.94005	0.69019	0.47144	0.29554	0.16579	
Z.S.	Z=0.8	1.09674	0.83684	0.63511	0.47337	0.34496	0.24277	
E.S.		1.19085	0.89969	0.65039	0.43931	0.27336	0.15296	
Z.S.	Z=1.0	1.07667	0.80298	0.59548	0.43473	0.31189	0.21865	
E.S.		1.15568	0.85289	0.60456	0.40253	0.24805	0.13836	
$q^* = q/E_o$								
Z.S.	Z=0.0	0.98490	0.62873	0.37599	0.20586	0.09856	0.03721	
E.S.		0.97094	0.61860	0.37248	0.20953	0.10777	0.04904	
Z.S.	Z=0.2	0.98516	0.62917	0.37651	0.20637	0.09900	0.03755	
E.S.		0.97143	0.61926	0.37314	0.21008	0.10815	0.04926	
Z.S.	Z=0.4	0.98598	0.63053	0.37811	0.20792	0.10032	0.03854	
E.S.		0.97293	0.62124	0.37513	0.21171	0.10930	0.04994	
Z.S.	Z=0.6	0.98736	0.63283	0.38082	0.21055	0.10257	0.04020	
E.S.		0.97543	0.62455	0.37842	0.21440	0.11116	0.05102	
Z.S.	Z=0.8	0.98925	0.63602	0.38454	0.21418	0.10567	0.04247	
E.S.		0.97879	0.62903	0.38285	0.21767	0.11363	0.05245	
Z.S.	Z=1.0	0.99148	0.63978	0.38895	0.21847	0.10935	0.04515	
E.S.		0.98270	0.63423	0.38794	0.22205	0.11644	0.05407	

Table 15. Local radiosity and heat flux for ρ =0.5,

W/L=0.5, H/L=0.5, $T=T_o(1+(T_1/T_o-1)X)$ and $T_1/T_o=0.5$

$B = J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0.0	1.06013	0.77249	0.55445	0.38824	0.26509	0.151572	6
E.S.		1.11982	0.80741	0.55466	0.35533	0.20931	0.11069	
Z.S.	Z=0.2	1.05902	0.77058	0.55219	0.38606	0.26324	0.17430	
E.S.		1.11785	0.80488	0.55220	0.35338	0.20798	0.10993	
Z.S.	Z=0.4	1.05564	0.76475	0.54533	0.37942	0.25758	0.17000	
E.S.		1.11185	0.79718	0.54476	0.34750	0.20402	0.10764	
Z.S.	Z=0.6	1.04993	0.75488	0.53371	0.36819	0.24801	0.16281	
E.S.		1.10176	0.78415	0.53227	0.33775	0.19748	0.10392	
Z.S.	Z=0.8	1.04207	0.74124	0.51733	0.35272	0.23481	0.15299	
E.S.		1.08797	0.76626	0.51528	0.32459	0.18874	0.09899	
Z.S.	Z=1.0	1.03282	0.72514	0.49885	0.33442	0.21916	0.14138	
E.S.		1.07181	0.74526	0.49545	0.30933	0.17863	0.09331	

$q^* = q/E_o$							
Z.S.	Z=0.0	0.93987	0.53974	0.26475	0.09196	-0.00589	-0.05072
E.S.		0.88018	0.50479	0.26454	0.12487	0.04989	0.01431
Z.S.	Z=0.2	0.94098	0.54162	0.26701	0.09414	-0.00403	-0.04930
E.S.		0.88215	0.50732	0.26700	0.12682	0.05122	0.01507
Z.S.	Z=0.4	0.94436	0.54745	0.27387	0.10078	0.00162	-0.04500
E.S.		0.88815	0.51502	0.27444	0.13270	0.05518	0.01736
Z.S.	Z=0.6	0.95007	0.55732	0.28549	0.11201	0.01119	-0.03781
E.S.		0.89824	0.52805	0.28693	0.14245	0.06172	0.02108
Z.S.	Z=0.8	0.95793	0.57096	0.30147	0.12748	0.02439	-0.02799
E.S.		0.91203	0.54594	0.30393	0.15561	0.07047	0.02601
Z.S.	Z=1.0	0.96718	0.58706	0.32035	0.14578	0.04004	-0.01638
E.S.		0.92819	0.56694	0.32375	0.17037	0.03057	0.03169

Table 16. Local radiosity and heat flux for ρ =0.1,

W/L=0.5, H/L=0.5, $T=T_o(1+(T_1/T_o-1)X)$ and T_1/T_o=0.5

$B = J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0.0	1.00961	0.67624	0.43504	0.26622	0.15373	0.08321	4
E.S.		1.02057	0.68161	0.43340	0.25843	0.14193	0.06983	
Z.S.	Z=0.2	1.00942	0.67590	0.43464	0.26585	0.15341	0.08296	
E.S.		1.02024	0.68120	0.43302	0.25814	0.14174	0.06972	
Z.S.	Z=0.4	1.00886	0.67489	0.43344	0.26469	0.15242	0.08220	
E.S.		1.01924	0.67995	0.43185	0.25725	0.14115	0.06939	
Z.S.	Z=0.6	1.00790	0.67316	0.43141	0.26274	0.15076	0.08093	
E.S.		1.01754	0.67781	0.42986	0.25575	0.14019	0.06885	
Z.S.	Z=0.8	1.00657	0.67078	0.42861	0.26005	0.14848	0.07919	
E.S.		1.01519	0.67482	0.42712	0.25370	0.13887	0.06812	
Z.S.	Z=1.0	1.00502	0.66797	0.42532	0.25688	0.14576	0.07714	
E.S.		1.0124	0.67128	0.42388	0.25130	0.13733	0.06728	
$q^* = q/E_o$								
Z.S.	Z=0.0	0.91352	0.47488	0.18068	0.00499	-0.08756	-0.12386	
E.S.		0.81487	0.42651	0.19538	0.07512	0.01863	-0.00343	
Z.S.	Z=0.2	0.91519	0.47788	0.18423	0.00840	-0.08466	-0.12160	
E.S.		0.81782	0.43018	0.19883	0.07776	0.02037	-0.00244	
Z.S.	Z=0.4	0.92030	0.48703	0.19505	0.01878	-0.07582	-0.11476	
E.S.		0.82682	0.44145	0.20937	0.08579	0.02561	0.00051	
Z.S.	Z=0.6	0.92895	0.50256	0.21333	0.03634	-0.06088	-0.10333	
E.S.		0.84212	0.46074	0.22727	0.09926	0.03434	0.00538	
Z.S.	Z=0.8	0.94085	0.52397	0.23847	0.06051	-0.04028	-0.08773	
E.S.		0.86328	0.48760	0.25197	0.11768	0.04616	0.01190	
Z.S.	Z=1.0	0.95486	0.54925	0.26815	0.08911	-0.01586	-0.06930	
E.S.		0.88831	0.51946	0.28113	0.13931	0.06000	0.01950	

Table 17. Local radiosity and heat flux for ρ =0.5,

$W/L=0.5$, $H/L=0.1$, $T=T_o(1+(T_1/T_o-1)X)$ and $T_1/T_o=0.5$

$B = J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0.0	1.10661	0.96856	0.70888	0.51478	0.37536	0.23322	10
E.S.		1.31732	1.19183	0.79661	0.48155	0.18167	0.10599	
Z.S.	Z=0.2	1.10646	0.96729	0.70767	0.51408	0.37499	0.23263	
E.S.		1.31607	1.18949	0.79444	0.48003	0.26286	0.10566	
Z.S.	Z=0.4	1.10574	0.96269	0.70345	0.51148	0.37357	0.23062	
E.S.		1.31132	1.18052	0.78644	0.47453	0.25969	0.10451	
Z.S.	Z=0.6	1.10305	0.95122	0.69336	0.50440	0.36910	0.22586	
E.S.		1.29848	1.15633	0.76630	0.46125	0.25219	0.10193	
Z.S.	Z=0.8	1.09177	0.91849	0.66427	0.47983	0.34964	0.21186	
E.S.		1.26027	1.08655	0.71347	0.42789	0.23371	0.09605	
Z.S.	Z=1.0	1.04639	0.81350	0.56565	0.38679	0.26447	0.16325	
E.S.		1.14466	0.88949	0.57599	0.34373	0.18750	0.08229	
$q^* = q/E_o$								
Z.S.	Z=0.0	0.89339	0.34364	0.11032	-0.03458	-0.11616	-0.10822	
E.S.		0.68268	0.12037	0.02259	-0.00135	-0.00455	0.01901	
Z.S.	Z=0.2	0.89354	0.34491	0.11153	-0.03388	-0.11579	-0.10763	
E.S.		0.68393	0.122714	0.02476	0.00017	-0.00366	0.01934	
Z.S.	Z=0.4	0.89426	0.34951	0.11575	-0.03128	-0.11437	-0.10562	
E.S.		0.68868	0.13168	0.03276	0.00567	-0.00049	0.02049	
Z.S.	Z=0.6	0.89695	0.36098	0.12584	-0.02420	-0.10990	-0.10086	
E.S.		0.70152	0.15587	0.05290	0.01895	0.00701	0.02307	
Z.S.	Z=0.8	0.90823	0.39371	0.15493	0.00037	-0.09044	-0.08686	
E.S.		0.73973	0.22565	0.10573	0.05231	0.02549	0.02895	
Z.S.	Z=1.0	0.95361	0.49870	0.25355	0.09341	-0.00527	-0.03825	
E.S.		0.85534	0.42271	0.24321	0.13647	0.07167	0.04721	

Table 18. Local radiosity and heat flux for ρ =0.1,

W/L=0.5, H/L=0.1, $T=T_o(1+(T_1/T_o-1)X)$ and T_1/T_o=0.5

$B = J/E_o$		X=0.0	X=0.2	X=0.4	X=0.6	X=0.8	X=1.0	N.T.
Z.S.	Z=0.0	1.01539	0.70852	0.45875	0.28406	0.16795	0.09141	5
E.S.		1.04457	0.72227	0.45436	0.26719	0.14447	0.06751	
Z.S.	Z=0.2	1.01538	0.70828	0.45852	0.28394	0.16790	0.09130	
E.S.		1.04448	0.72214	0.45425	0.26711	0.14443	0.06749	
Z.S.	Z=0.4	1.01529	0.70741	0.45775	0.28351	0.16770	0.09094	
E.S.		1.04410	0.72159	0.45379	0.26681	0.14425	0.06741	
Z.S.	Z=0.6	1.01491	0.70531	0.45598	0.28238	0.16708	0.09013	
E.S.		1.04295	0.71987	0.45246	0.26596	0.14378	0.06722	
Z.S.	Z=0.8	1.01320	0.69966	0.45117	0.27852	0.16423	0.08785	
E.S.		1.03866	0.71335	0.44788	0.26316	0.14224	0.06668	
Z.S.	Z=1.0	1.00620	0.68251	0.43547	0.26400	0.15126	0.08016	
E.S.		1.02213	0.68868	0.43166	0.25349	0.13698	0.06504	
$q^* = q/E_o$								
Z.S.	Z=0.0	0.86149	0.18431	-0.03275	-0.15555	-0.21556	-0.19770	
E.S.		0.59883	0.06054	0.00674	-0.00373	-0.00426	0.01743	
Z.S.	Z=0.2	0.86162	0.18650	-0.03071	-0.15448	-0.21509	-0.19674	
E.S.		0.59968	0.06175	0.00779	-0.00301	-0.003836	0.01763	
Z.S.	Z=0.4	0.86242	0.19430	-0.02376	-0.15061	-0.21332	-0.19350	
E.S.		0.60308	0.06667	0.01190	-0.00027	-0.00226	0.01832	
Z.S.	Z=0.6	0.86584	0.21318	-0.00782	-0.14038	-0.20775	-0.18616	
E.S.		0.61345	0.08216	0.02389	0.00737	0.00202	0.02003	
Z.S.	Z=0.8	0.88118	0.26404	0.03550	-0.10564	-0.18205	-0.16565	
E.S.		0.65208	0.14081	0.06509	0.03253	0.01582	0.02486	
Z.S.	Z=1.0	0.94422	0.41844	0.17677	0.02503	-0.06530	-0.09646	
E.S.		0.80081	0.36291	0.21108	0.1196	0.06316	0.03965	

Table 19. Local radiosity and heat flux for ρ =0.1

$W/L=0.5$, $H/L=2$, $T=T_0(1+X(1-Z)(T_1/T_0-1)/2)$ and $T_1/T_0=0.5$

$B = J/E_0$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.00235	1.00295	1.00346	1.00384	1.00408	1.00418	2
E.S.		1.00408	1.00431	1.00440	1.00434	1.00415	1.00385	
Z.S.	X=0.2	1.00295	0.92597	0.85348	0.78528	0.72115	0.66093	
E.S.		1.00431	0.92691	0.85399	0.78533	0.72076	0.66014	
Z.S.	X=0.4	1.00346	0.85348	0.72108	0.60478	0.50318	0.41497	
E.S.		1.00440	0.85399	0.72113	0.60436	0.50232	0.41371	
Z.S.	X=0.6	1.00384	0.78528	0.60478	0.45760	0.33932	0.24585	
E.S.		1.00434	0.78533	0.60436	0.45672	0.33801	0.24415	
Z.S.	X=0.8	1.00408	0.72115	0.50318	0.33932	0.21973	0.13556	
E.S.		1.00415	0.72076	0.50232	0.33801	0.21799	0.13346	
Z.S.	X=1.0	1.00418	0.66093	0.41497	0.24585	0.13556	0.06851	
E.S.		1.00385	0.66014	0.41371	0.24415	0.13346	0.06608	
$q^* = q/E_0$								
Z.S.	X=0.0	0.97883	0.97342	0.96887	0.96547	0.96332	0.96238	
E.S.		0.96327	0.96126	0.96044	0.96092	0.96264	0.96537	
Z.S.	X=0.2	0.97342	0.88996	0.81212	0.74001	0.67359	0.61259	
E.S.		0.96126	0.88147	0.80760	0.73955	0.67707	0.61973	
Z.S.	X=0.4	0.96887	0.81212	0.67417	0.55391	0.45009	0.36129	
E.S.		0.96044	0.80760	0.67379	0.55769	0.45782	0.37260	
Z.S.	X=0.6	0.96547	0.74001	0.55391	0.40278	0.28233	0.18839	
E.S.		0.96092	0.73955	0.55769	0.41073	0.29417	0.20366	
Z.S.	X=0.8	0.96332	0.67359	0.45009	0.28233	0.16061	0.07599	
E.S.		0.96264	0.67707	0.45782	0.29417	0.17620	0.09433	
Z.S.	X=1.0	0.96238	0.61259	0.36129	0.18839	0.07599	0.00843	
E.S.		0.96537	9.61973	0.37260	0.20366	0.09433	0.03029	

Table 20. Local radiosity and heat flux for ρ =0.5,

W/L=0.5, H/L=2, $T=T_o 1+X(1-Z)(T_1/T_o-1)/2)$ and $T_1/T_o=0.5$

$B = J/E_o$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.01243	1.01545	1.01797	1.01984	1.02099	1.02145	3
E.S.		1.02095	1.02211	1.02258	1.02231	1.02134	1.01978	
Z.S.	X=0.2	1.01545	0.94107	0.87073	0.80405	0.74080	0.68084	
E.S.		1.02211	0.94571	0.87319	0.80428	0.73886	0.67689	
Z.S.	X=0.4	1.01797	0.87073	0.74055	0.62580	0.52504	0.43700	
E.S.		1.02258	0.87319	0.74073	0.62370	0.52077	0.43076	
Z.S.	X=0.6	1.01984	0.80405	0.62580	0.48018	0.36272	0.26937	
E.S.		1.02231	0.80428	0.62370	0.47578	0.35618	0.26094	
Z.S.	X=0.8	1.02099	0.74080	0.52504	0.36272	0.24393	0.15988	
E.S.		1.02134	0.73886	0.52077	0.35618	0.23533	0.14950	
Z.S.	X=1.0	1.02145	0.68084	0.43700	0.26937	0.15988	0.09298	
E.S.		1.01978	0.67689	0.43076	0.26094	0.14950	0.08094	
$q^* = q/E_o$								
Z.S.	X=0.0	0.98758	0.98455	0.98203	0.98016	0.97910	0.97855	
E.S.		0.97905	0.97789	0.97742	0.97769	0.97866	0.98022	
Z.S.	X=0.2	0.98455	0.90366	0.82797	0.75744	0.69198	0.63136	
E.S.		0.97789	0.89903	0.82551	0.75722	0.69392	0.63531	
Z.S.	X=0.4	0.98203	0.82797	0.69224	0.57359	0.47070	0.38220	
E.S.		0.97742	0.82551	0.69206	0.57569	0.47498	0.38844	
Z.S.	X=0.6	0.98016	0.75744	0.57359	0.42406	0.30452	0.21083	
E.S.		0.97769	0.75722	0.57569	0.42846	0.31106	0.21926	
Z.S.	X=0.8	0.97901	0.69198	0.47070	0.30452	0.18370	0.09932	
E.S.		0.97866	0.69392	0.47498	0.31106	0.19230	0.10970	
Z.S.	X=1.0	0.97855	0.63136	0.38220	0.21083	0.09932	0.03202	
E.S.		0.98022	0.63531	0.38844	0.21926	0.10970	0.04406	

Table 21. Local radiosity and heat flux for ρ =0.9,

W/L=0.5, H/L=2, $T=T_o(1+X(1-Z)(T_1/T_o-1)/2)$ and T_1/T_o=0.5

$B = J/E_o$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.02361	1.02908	1.03363	1.03695	1.03894	1.03966	4
E.S.		1.03876	1.04091	1.04180	1.04131	1.03952	1.03665	
Z.S.	X=0.2	1.02908	0.95735	0.88915	0.82398	0.76153	0.70171	
E.S.		1.04091	0.96557	0.89348	0.82433	0.75802	0.69463	
Z.S.	X=0.4	1.03363	0.88915	0.76119	0.64797	0.54798	0.45999	
E.S.		1.04180	0.89348	0.76146	0.64417	0.54030	0.44883	
Z.S.	X=0.6	1.03695	0.82398	0.64797	0.50387	0.38715	0.29382	
E.S.		1.04131	0.82433	0.64417	0.49598	0.37545	0.27876	
Z.S.	X=0.8	1.03894	0.76153	0.54798	0.38715	0.26910	0.18506	
E.S.		1.03952	0.75802	0.54030	0.37545	0.25372	0.16652	
Z.S.	X=1.0	1.03966	0.70171	0.45999	0.29382	0.18506	0.11822	
E.S.		1.03665	0.69463	0.44883	0.27876	0.16652	0.09672	
$q^* = q/E_o$								
Z.S.	X=0.0	0.99738	0.99677	0.99626	0.99589	0.99567	0.99559	
E.S.		0.99569	0.99545	0.99536	0.99541	0.99561	0.99593	
Z.S.	X=0.2	0.99677	0.91848	0.84492	0.77595	0.71138	0.65103	
E.S.		0.99545	0.91757	0.84444	0.77591	0.71177	0.65182	
Z.S.	X=0.4	0.99626	0.84492	0.71142	0.59433	0.49230	0.40400	
E.S.		0.99536	0.84444	0.71139	0.59475	0.49316	0.40524	
Z.S.	X=0.6	0.99589	0.77595	0.59433	0.44637	0.32767	0.23413	
E.S.		0.99541	0.77591	0.59475	0.44725	0.32897	0.23580	
Z.S.	X=0.8	0.99567	0.71138	0.49230	0.32767	0.20767	0.12344	
E.S.		0.99561	0.71177	0.49316	0.32897	0.20938	0.12550	
Z.S.	X=1.0	0.99559	0.65103	0.40400	0.23413	0.12344	0.05631	
E.S.		0.99593	0.65182	0.40524	0.23580	0.12550	0.05870	

Table 22. Local radiosity and heat flux for ρ =0.1,

W/L=0.5, H/L=0.5, $T=T_0(1+X(1-Z)(T_1/T_0-1)/2)$ and T_1/T_0=0.5

$B = J/E_0$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.00856	1.01568	1.01960	1.02029	1.01848	1.01485	3
E.S.		1.01806	1.02447	1.02701	1.02576	1.02144	1.01485	
Z.S.	X=0.2	1.01568	0.94855	0.88101	0.81296	0.74526	0.67866	
E.S.		1.02447	0.95571	0.88565	0.81471	0.74409	0.67483	
Z.S.	X=0.4	1.01960	0.88101	0.75428	0.63804	0.53215	0.43641	
E.S.		1.02701	0.88565	0.75506	0.63491	0.52589	0.42831	
Z.S.	X=0.6	1.02029	0.81296	0.63804	0.49093	0.36845	0.26760	
E.S.		1.02576	0.81471	0.63491	0.48322	0.35772	0.25605	
Z.S.	X=0.8	1.01848	0.74526	0.53215	0.36845	0.24536	0.15496	
E.S.		1.02144	0.74409	0.52589	0.35772	0.23209	0.14167	
Z.S.	X=1.0	1.01485	0.67866	0.43641	0.26760	0.15496	0.08364	
E.S.		1.01485	0.67483	0.42831	0.25605	0.14167	0.07062	
$q^* = q/E_0$								
Z.S.	X=0.0	0.92301	0.85888	0.82361	0.81738	0.83366	0.86639	
E.S.		0.83746	0.77974	0.75690	0.76812	0.80704	0.86631	
Z.S.	X=0.2	0.85888	0.68672	0.56435	0.49086	0.45662	0.45306	
E.S.		0.77974	0.62232	0.52261	0.47507	0.46709	0.48757	
Z.S.	X=0.4	0.82361	0.56435	0.37538	0.25456	0.18933	0.16834	
E.S.		0.75690	0.52261	0.36840	0.28275	0.24569	0.24121	
Z.S.	X=0.6	0.81738	0.49086	0.25456	0.10285	0.02019	-0.00739	
E.S.		0.76812	0.47507	0.28275	0.17221	0.11676	0.09654	
Z.S.	X=0.8	0.83366	0.45662	0.18933	0.02019	-0.07009	-0.09867	
E.S.		0.80704	0.46709	0.24569	0.11676	0.04933	0.02095	
Z.S.	X=1.0	0.86639	0.45306	0.16834	-0.07393	-0.09867	-0.12773	
E.S.		0.86631	0.48757	0.24121	0.09654	0.02095	-0.01057	

Table 23. Local radiosity and heat flux for ρ =0.5,

$W/L=0.5$, $H/L=0.5$, $T=T_0(1+X(1-Z)(T_1/T_0-1)/2)$ and $T_1/T_0=0.5$

$B=J/E_0$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.05426	1.09344	1.1149	1.11822	1.10685	1.08435	5
E.S.		1.10595	1.14439	1.16044	1.15352	1.12761	1.08830	
Z.S.	X=0.2	1.09344	1.07354	1.03068	0.96469	0.88039	0.78245	
E.S.		1.14439	1.12075	1.06752	0.98604	0.88384	0.76911	
Z.S.	X=0.4	1.11490	1.03068	0.93208	0.81758	0.69172	0.55898	
E.S.		1.16044	1.06752	0.95200	0.81647	0.67096	0.52505	
Z.S.	X=0.6	1.11822	0.96469	0.81758	0.67221	0.53008	0.39280	
E.S.		1.15352	0.98604	0.81647	0.64658	0.48556	0.34076	
Z.S.	X=0.8	1.10685	0.88039	0.69172	0.53008	0.39063	0.26936	
E.S.		1.12761	0.88384	0.67096	0.48556	0.33063	0.20704	
Z.S.	X=1.0	1.08435	0.78245	0.55898	0.39280	0.26936	0.17694	
E.S.		1.08830	0.76911	0.52505	0.34076	0.20704	0.11488	
$q^*=q/E_0$								
Z.S.	X=0.0	0.94574	0.90656	0.88510	0.88178	0.89315	0.91565	
E.S.		0.89405	0.85561	0.83956	0.84648	0.87239	0.91170	
Z.S.	X=0.2	0.90656	0.77120	0.66801	0.59681	0.55240	0.52975	
E.S.		0.85561	0.72398	0.63118	0.57546	0.54894	0.54309	
Z.S.	X=0.4	0.88510	0.66801	0.50070	0.38181	0.30402	0.26022	
E.S.		0.83956	0.63118	0.48078	0.38292	0.32479	0.29415	
Z.S.	X=0.6	0.88178	0.59681	0.38181	0.23204	0.13717	0.08740	
E.S.		0.84648	0.57546	0.38292	0.25767	0.18168	0.13944	
Z.S.	X=0.8	0.89315	0.55240	0.30402	0.13717	0.03699	-0.01016	
E.S.		0.87239	0.54894	0.32479	0.18168	0.09700	0.05216	
Z.S.	X=1.0	0.91565	0.52975	0.26022	0.08740	-0.01016	-0.05194	
E.S.		0.91170	0.54309	0.29415	0.13944	0.05216	0.01012	

Table 24. Local radiosity and heat flux for ρ =0.9,

$W/L=0.5$, $H/L=0.5$, $T=T_o(1+X(1-Z)(T_1/T_o-1)/2)$ and $T_1/T_o=0.5$

$B=J/E_o$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.12387	1.20305	1.24626	1.25197	1.22618	1.17580	8
E.S.		1.23350	1.32035	1.35887	1.34492	1.28665	1.19826	
Z.S.	X=0.2	1.20305	1.24203	1.23000	1.16589	1.05819	0.91594	
E.S.		1.32035	1.36684	1.34388	1.24955	1.09929	0.91427	
Z.S.	X=0.4	1.24626	1.23000	1.16672	1.05381	0.90018	0.71535	
E.S.		1.35887	1.34388	1.25906	1.10505	0.90342	0.68004	
Z.S.	X=0.6	1.25197	1.16589	1.05381	0.91003	0.74036	0.55157	
E.S.		1.34492	1.24955	1.10505	0.91361	0.69789	0.48184	
Z.S.	X=0.8	1.22618	1.05819	0.90012	0.74036	0.57774	0.41258	
E.S.		1.28665	1.09929	0.90342	0.69789	0.49817	0.31891	
Z.S.	X=1.0	1.17580	0.91594	0.71535	0.55157	0.41258	0.29023	
E.S.		1.19826	0.91427	0.68004	0.48184	0.31891	0.19139	
$q^*=q/E_o$								
Z.S.	X=0.0	0.98624	0.97744	0.97264	0.97200	0.97487	0.98047	
E.S.		0.97406	0.96441	0.96013	0.96168	0.96815	0.97797	
Z.S.	X=0.2	0.97744	0.88685	0.80705	0.73796	0.67842	0.62723	
E.S.		0.96441	0.87298	0.79440	0.72866	0.67385	0.62741	
Z.S.	X=0.4	0.97264	0.80705	0.66636	0.54924	0.45318	0.37563	
E.S.		0.96013	0.79440	0.65610	0.54354	0.45281	0.37955	
Z.S.	X=0.6	0.97200	0.73796	0.54924	0.40124	0.28843	0.20549	
E.S.		0.96168	0.72866	0.54354	0.40085	0.29315	0.21324	
Z.S.	X=0.8	0.97487	0.67842	0.45318	0.28843	0.17338	0.09816	
E.S.		0.96815	0.67385	0.45281	0.29315	0.18222	0.10857	
Z.S.	X=1.0	0.98047	0.62723	0.37563	0.20549	0.09816	0.03720	
E.S.		0.97797	0.62741	0.37955	0.21324	0.10857	0.04818	

Table 25. Local radiosity and heat flux for ρ =0.5

W/L=0.5, H/L=0.1, $T=T_o(1+X(1-Z)(T_1/T_o-1)/2)$ and $T_1/T_o=0.5$

$B = J/E_o$		Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S.	X=0.0	1.07559	1.19859	1.20099	1.19487	1.18387	1.11110	10
E.S.		1.17258	1.34832	1.35882	1.34592	1.31493	1.14983	
Z.S.	X=0.2	1.19859	1.36240	1.29426	1.21295	1.12009	0.89409	
E.S.		1.34832	1.63135	1.54992	1.42480	1.27297	0.90251	
Z.S.	X=0.4	1.20099	1.29426	1.16409	1.03165	0.89979	0.65218	
E.S.		1.35882	1.54992	1.36820	1.15584	0.93932	0.59495	
Z.S.	X=0.6	1.19487	1.21295	1.03165	0.86834	0.72283	0.47657	
E.S.		1.34592	1.42480	1.15584	0.88723	0.64798	0.36428	
Z.S.	X=0.8	1.18387	1.12009	0.89979	0.72283	0.58117	0.35288	
E.S.		1.31493	1.27297	0.93932	0.64798	0.41898	0.20515	
Z.S.	X=1.0	1.11110	0.89409	0.65218	0.47657	0.35288	0.20911	
E.S.		1.14983	0.90251	0.59495	0.36428	0.20515	0.09059	
$q^* = q/E_o$								
Z.S.	X=0.0	0.92441	0.80141	0.79901	0.80513	0.81613	0.88890	
E.S.		0.82742	0.65168	0.64118	0.65408	0.68507	0.85017	
Z, .	X=0.2	0.80141	0.48234	0.40444	0.34855	0.31270	0.41811	
E.S.		0.65168	0.21339	0.14877	0.13670	0.15981	0.40969	
Z.S.	X=0.4	0.79901	0.40444	0.26870	0.16774	0.09595	0.16702	
E.S.		0.64118	0.14877	0.06459	0.04355	0.05642	0.22425	
Z.S.	X=0.6	0.80513	0.34855	0.16774	0.03591	-0.05558	0.00363	
E.S.		0.65408	0.13670	0.04355	0.01702	0.01927	0.11592	
Z.S.	X=0.8	0.81613	0.31270	0.09595	-0.05558	-0.15355	-0.09368	
E.S.		0.68507	0.15981	0.05642	0.01927	0.00865	0.05405	
Z.S.	X=1.0	0.88890	0.41811	0.16702	0.00363	-0.09368	-0.08411	
E.S.		0.85017	0.40969	0.22425	0.11592	0.05405	0.03441	

Table 26. Local radiosity and heat flux for ρ =0.1

W/L=0.5, H/L=0.1, $T=T_o(1+(1-Z)(T_1/T_o-1)X/2)$ and T_1/T_o=0/5

$B = J/E_o$	Z=1.0	Z=0.6	Z=0.2	Z=-0.2	Z=-0.6	Z=-1.0	N.T.
Z.S. X=0.0	1.01053	1.03160	1.03173	1.03044	1.02850	1.01802	4
E.S.	1.02566	1.04857	1.04905	1.04758	1.04459	1.02262	
Z.S. X=0.2	1.03160	0.99550	0.92285	0.85157	0.78186	0.69601	
E.S.	1.04857	1.01215	0.93528	0.85977	0.78664	0.69006	
Z.S. X=0.4	1.03173	0.92285	0.78976	0.66974	0.56231	0.45010	
E.S.	1.04905	0.93528	0.79287	0.66440	0.55041	0.43364	
Z.S. X=0.6	1.03044	0.85157	0.66974	0.51885	0.39538	0.27931	
E.S.	1.04758	0.85977	0.66440	0.50188	0.37002	0.25561	
Z.S. X=0.8	1.02850	0.78186	0.56231	0.39538	0.27161	0.16641	
E.S.	1.04459	0.78664	0.55041	0.37002	0.23748	0.13883	
Z.S. X=1.0	1.01802	0.69601	0.45010	0.27931	0.16641	0.08801	
E.S.	1.02262	0.69006	0.43364	0.25561	0.13883	0.06599	
$q^* = q/E_o$							
Z.S. X=0.0	0.90526	0.71559	0.71445	0.72606	0.74352	0.83785	
E.S.	0.76907	0.56287	0.55858	0.57176	0.59866	0.79642	
Z.S. X=0.2	0.71559	0.26421	0.18779	0.14332	0.12721	0.29688	
E.S.	0.56287	0.11430	0.07596	0.06961	0.08419	0.35050	
Z.S. X=0.4	0.71445	0.18779	0.05609	-0.03073	-0.08207	0.04509	
E.S.	0.55858	0.07596	0.02815	0.01741	0.02507	0.19323	
Z.S. X=0.6	0.72606	0.14332	-0.03073	-0.14842	-0.22219	-0.11280	
E.S.	0.57176	0.06961	0.01741	0.00431	0.00636	0.10052	
Z.S. X=0.8	0.74352	0.12721	-0.08207	-0.22219	-0.30639	-0.20168	
E.S.	0.59866	0.08419	0.02507	0.00636	0.00082	0.04658	
Z.S. X=1.0	0.83785	0.29688	0.04509	-0.11280	-0.20168	-0.16706	
E.S.	0.79642	0.35050	0.19323	0.10052	0.04658	0.03108	

Table 27

The constants, g_i, of Equations (28) for $L_2/L_1=0.5$, $W_2/L_1=1.0$ and $H/L_1=0.5$

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.17684874	0.0	0.057[illegible]9581	0.01355203	0.02181772	0.01141916
0.2	0.17627995	0.0	0.05706392	0.02701330	0.04349367	0.02282556
0.4	0.17397158	0.0	0.05682029	0.05332967	0.08534756	0.04543622
0.6	0.17002166	0.0	0.05593948	0.07812117	0.12590476	0.06712736
0.8	0.16454957	0.0	0.05356144	0.10041856	0.16254067	0.08569823
1.0	0.15703837	0.0	0.04872829	0.11923995	0.19433610	0.09745654
1.2	0.14831154	0.0	0.04173647	0.13409505	0.22233252	0.10014746
1.4	0.13946352	0.0	0.03436959	0.14533790	0.24515932	0.09623478
1.6	0.13052758	0.0	0.02798157	0.15380119	0.26388693	0.08954101
1.8	0.12203019	0.0	0.02288725	0.16028137	0.27924318	0.08239406
2.0	0.11432055	0.0	0.01892582	0.16536340	0.29191866	0.07570327
2.2	0.10725682	0.0	0.01584673	0.16944386	0.30248600	0.06972553
2.4	0.10087141	0.0	0.01343145	0.17278913	0.31139348	0.06447094
2.6	0.09510873	0.0	0.01151326	0.17558106	0.31898416	0.05986393
2.8	0.08990472	0.0	0.00996989	0.17794682	0.32551941	0.05593138
3.0	0.08519616	0.0	0.00871240	0.17997760	0.33119920	0.05227438
3.2	0.08092474	0.0	0.00767575	0.18174033	0.33617763	0.04912476
3.6	0.07703838	0.0	0.00681190	0.18328518	0.34057561	0.04632089
4.0	0.07024411	0.0	0.00546777	0.18586618	0.34798383	0.04155452
4.4	0.06431557	0.0	0.00448366	0.18793780	0.35299280	0.03766271
4.8	0.05962947	0.0	0.00374735	0.18963819	0.35895275	0.03442957
5.2	0.05541762	0.0	0.00317052	0.19105949	0.36311847	0.03170316
5.6	0.05175296	0.0	0.00271983	0.19226555	0.36666625	0.02937417
6.0	0.04853674	0.0	0.00235882	0.19330205	0.36972392	0.02736225
6.4	0.04559268	0.0	0.00206509	0.19420256	0.37238641	0.02560715
6.8	0.04316046	0.0	0.00182295	0.19499228	0.37472566	0.02406289
7.2	0.04089199	0.0	0.00162098	0.19569056	0.37679713	0.02269377
7.6	0.03884844	0.0	0.00145079	0.19631245	0.37864431	0.02147160
8.0	0.03699820	0.0	0.00130604	0.19686988	0.38030177	0.02037423
8.4	0.03531524	0.0	0.00118191	0.19737241	0.38179730	0.01938304
8.8	0.03377799	0.0	0.00107446	0.19782778	0.38315352	0.01849417
9.2	0.03236842	0.0	0.00098137	0.19824234	0.38438905	0.01765458
9.6	0.03107132	0.0	0.00089971	0.19862137	0.38551930	0.01691452
10.0	0.02987381	0.0	0.00082785	0.19896925	0.38655719	0.01622549

Table 28

The constants, g_i, of Equations (28) for $L_2/L_1=0.5$, $W_2/L_1=1.0$ and $H/L_1=1.0$

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.09150670	0.0	0.03693534	0.00568254	0.01261580	0.00738727
0.2	0.09124197	0.0	0.03673983	0.01132975	0.02516709	0.01469399
0.4	0.09018996	0.0	0.03593494	0.02237772	0.04977423	0.02874795
0.6	0.08846517	0.0	0.03452906	0.03286947	0.07328370	0.04142359
0.8	0.08612282	0.0	0.03247941	0.04255544	0.09524104	0.05196704
1.0	0.08325737	0.0	0.02984025	0.05124255	0.11527214	0.05968047
1.2	0.08000194	0.0	0.02679547	0.05882892	0.13317568	0.06340911
1.4	0.07651123	0.0	0.02361951	0.06531815	0.14891322	0.06613461
1.6	0.07293445	0.0	0.02057026	0.07079984	0.16259033	0.06597486
1.8	0.06939321	0.0	0.01781303	0.07540969	0.17440577	0.06412691
2.0	0.06597273	0.0	0.01541387	0.07929263	0.18459818	0.06165546
2.2	0.06272455	0.0	0.01337134	0.08258114	0.19340680	0.05803759
2.4	0.05967433	0.0	0.01165060	0.08538690	0.20104978	0.05502204
2.6	0.05683004	0.0	0.01020573	0.08780041	0.20771569	0.05106970
2.8	0.05418866	0.0	0.00899128	0.08989360	0.21356270	0.04905117
3.0	0.05174087	0.0	0.00796691	0.09172334	0.21872179	0.04700147
3.2	0.04947419	0.0	0.00709863	0.09333465	0.22330005	0.04543121
3.6	0.04737485	0.0	0.00635857	0.09476334	0.22738551	0.04323827
4.0	0.04362320	0.0	0.00517707	0.09718201	0.23435416	0.03934573
4.4	0.04038297	0.0	0.00428906	0.09914948	0.24006734	0.03602306
4.8	0.03758625	0.0	0.00360726	0.10077995	0.24432941	0.03313679
5.2	0.03510086	0.0	0.00307366	0.10215256	0.24835592	0.03073694
5.6	0.03292840	0.0	0.00264887	0.10332366	0.25230296	0.02860770
6.0	0.03100177	0.0	0.00230555	0.10433439	0.25528596	0.02674440
6.4	0.02928287	0.0	0.00202434	0.10521549	0.25789193	0.02510162
6.8	0.02774076	0.0	0.00179124	0.10599031	0.26018761	0.02364434
7.2	0.02635015	0.0	0.00159594	0.10667695	0.26222497	0.02234321
7.6	0.02509019	0.0	0.00143075	0.10728963	0.26404507	0.02117535
8.0	0.02394362	0.0	0.00128982	0.10783966	0.26568073	0.02012116
8.4	0.02289603	0.0	0.00116863	0.10833618	0.26715853	0.01916505
8.8	0.02193529	0.0	0.00106369	0.10878662	0.26850619	0.01830551
9.2	0.02105116	0.0	0.00097223	0.10919711	0.26972363	0.01753006
9.6	0.02023493	0.0	0.00089203	0.10957273	0.27084379	0.01677018
10.0	0.01947913	0.0	0.00082133	0.10991774	0.27187316	0.01609915

Table 29

The constans, g_i, of Equations (28) for $L_2/L_1=0.5$, $W_2/L_1=1.0$ and $H/L_1=2.0$

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.03315310	0.0	0.01540122	0.00179210	0.00483852	0.00309025
0.2	0.03310023	0.0	0.01533500	0.00357816	0.00966193	0.00613400
0.4	0.03289095	0.0	0.01507366	0.00710849	0.01920426	0.01205393
0.6	0.03254984	0.0	0.01465089	0.01054591	0.02851389	0.01759106
0.8	0.03208798	0.0	0.01408564	0.01385052	0.03749024	0.02253701
1.0	0.03151996	0.0	0.01340348	0.01698974	0.04605016	0.02680699
1.2	0.03086290	0.0	0.01263479	0.01993969	0.05413124	0.03032349
1.4	0.03013529	0.0	0.01181290	0.02268568	0.06169311	0.03307259
1.6	0.02935577	0.0	0.01096643	0.02522179	0.06871663	0.03509256
1.8	0.02854195	0.0	0.01012553	0.02754966	0.07520131	0.03645190
2.0	0.02770962	0.0	0.00931110	0.02967681	0.08116165	0.03724439
2.2	0.02687224	0.0	0.00853866	0.03161480	0.08662330	0.03757918
2.4	0.02604070	0.0	0.00781793	0.03337764	0.09161766	0.03752606
2.6	0.02522346	0.0	0.00715364	0.03498036	0.09618160	0.03719890
2.8	0.02442579	0.0	0.00654689	0.03643808	0.10035190	0.03664255
3.0	0.02365506	0.0	0.00599622	0.03776533	0.10416498	0.03597733
3.2	0.02291112	0.0	0.00549859	0.03897567	0.10765545	0.03519098
3.6	0.02219661	0.0	0.00505007	0.04008149	0.11085542	0.03434045
4.0	0.02085312	0.0	0.00428309	0.04202306	0.11649857	0.03255147
4.4	0.01963829	0.0	0.00366158	0.04366553	0.12129605	0.03075726
4.8	0.01853009	0.0	0.00315585	0.04506800	0.12540379	0.02903376
5.2	0.01752403	0.0	0.00274161	0.04627640	0.12896382	0.02741614
5.6	0.01660997	0.0	0.00239972	0.04732649	0.13206115	0.02591699
6.0	0.01577611	0.0	0.00211525	0.04824621	0.13477978	0.02453695
6.4	0.01501937	0.0	0.00187666	0.04905761	0.13718246	0.02327053
6.8	0.01432558	0.0	0.00167498	0.04977819	0.13931940	0.02210974
7.2	0.01368951	0.0	0.00150324	0.05042203	0.14123111	0.02104533
7.6	0.01310480	0.0	0.00135596	0.05100048	0.14295050	0.02006826
8.0	0.01256586	0.0	0.00122884	0.05152283	0.14450455	0.01916093
8.4	0.01206782	0.0	0.00111844	0.05199672	0.14591553	0.01834242
8.8	0.01160643	0.0	0.00102201	0.05242849	0.14720197	0.01757358
9.2	0.01117794	0.0	0.00093733	0.05282344	0.14837940	0.01687200
9.6	0.01077910	0.0	0.00086260	0.05318602	0.14946091	0.01621697
10.0	0.01040702	0.0	0.00079635	0.05352001	0.15045759	0.01560843

Table 30

The constant, g_i, of Equations (28) for L_2/L_1=1.0, W_2/L_1=1.0 and H/L_1=0.5

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.17684674	0.17684874	0.11419162	0.01768487	0.01768487	0.01141916
0.2	0.17627995	0.17627995	0.11412785	0.03525598	0.03525598	0.02282554
0.4	0.17397158	0.17397158	0.11364057	0.06958861	0.06958861	0.04545622
0.6	0.17002166	0.17002166	0.11187897	0.10201297	0.10201297	0.06712776
0.8	0.16434957	0.16434957	0.10712289	0.13147961	0.13147961	0.08369329
1.0	0.15703807	0.15703807	0.09745658	0.15703802	0.15703802	0.09745654
1.2	0.14851154	0.14851154	0.08347294	0.17821379	0.17821379	0.10016749
1.4	0.13946352	0.13946352	0.06873915	0.19524886	0.19524886	0.09623476
1.6	0.13052758	0.13052758	0.05596315	0.20884406	0.20884406	0.08954101
1.8	0.12209019	0.12209019	0.04577449	0.21976227	0.21976227	0.08239406
2.0	0.11432055	0.11432055	0.03785165	0.22864103	0.22864103	0.07570327
2.2	0.10725682	0.10725682	0.03169346	0.23596493	0.23596493	0.06972558
2.4	0.10087141	0.10087141	0.02686290	0.24209130	0.24209130	0.06447094
2.6	0.09510873	0.09510873	0.02302652	0.24728261	0.24728261	0.05986895
2.8	0.08990472	0.08990472	0.01993979	0.25173312	0.25173312	0.05583136
3.0	0.08519616	0.08519616	0.01742480	0.25558840	0.25558840	0.05227438
3.2	0.08092474	0.08092474	0.01535149	0.25895908	0.25895908	0.04912476
3.6	0.07703838	0.07703838	0.01362379	0.26193040	0.26193040	0.04632189
4.0	0.07024411	0.07024411	0.01093540	0.26692751	0.26692751	0.04155452
4.4	0.06451557	0.06451557	0.00896732	0.27096530	0.27096530	0.03766271
4.8	0.05962947	0.05962947	0.00748469	0.27429547	0.27429547	0.03442957
5.2	0.05541782	0.05541782	0.00634063	0.27708898	0.27708898	0.03170214
5.6	0.05175296	0.05175296	0.00543966	0.27946590	0.27946590	0.02937417
6.0	0.04853674	0.04853674	0.00471763	0.28151299	0.28151299	0.02736225
6.4	0.04569268	0.04569268	0.00413019	0.28329449	0.28329449	0.02560715
6.8	0.04316046	0.04316046	0.00364589	0.28485897	0.28485897	0.02406289
7.2	0.04089199	0.04089199	0.00324197	0.28624384	0.28624384	0.02269377
7.6	0.03884844	0.03884844	0.00290158	0.28747838	0.28747838	0.02147169
8.0	0.03699820	0.03699820	0.00261208	0.28858583	0.28858583	0.02037425
8.4	0.03531524	0.03531524	0.00236382	0.28958485	0.28958485	0.01939381
8.8	0.03377799	0.03377799	0.00214932	0.29049065	0.29049065	0.01848413
9.2	0.03236842	0.03236842	0.00196273	0.29131570	0.29131570	0.01766459
9.6	0.03107132	0.03107132	0.00179942	0.29207034	0.29207034	0.01691452
10.0	0.02987381	0.02987381	0.00165566	0.29276322	0.29276322	0.01622549

Table 31

The constants, g_i, of Equations (28) for $L_2/L_1=1.0$, $W_2/L_1=1.0$ and $H/L_1=1.0$

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.09150670	0.09150670	0.07307068	0.00915067	0.00915067	0.00738707
0.2	0.09124197	0.09124197	0.07347966	0.01824339	0.01824339	0.01460598
0.4	0.09018996	0.09018996	0.07186989	0.03607598	0.03607598	0.02874795
0.6	0.08846517	0.08846517	0.06905600	0.05307908	0.05307908	0.04143359
0.8	0.08612282	0.08612282	0.06495882	0.06889824	0.06889824	0.05196704
1.0	0.08325737	0.08325737	0.05968049	0.08325735	0.08325735	0.05968047
1.2	0.08000194	0.08000194	0.05359094	0.09600230	0.09600230	0.06420911
1.4	0.07651123	0.07651123	0.04723903	0.10711568	0.10711568	0.06613461
1.6	0.07293445	0.07293445	0.04114051	0.11669509	0.11669509	0.06592480
1.8	0.06939321	0.06939321	0.03562607	0.12490773	0.12490773	0.06412630
2.0	0.06597273	0.06597273	0.03082774	0.13194541	0.13194541	0.06165546
2.2	0.06272455	0.06272455	0.02674268	0.13799397	0.13799397	0.05863399
2.4	0.05967433	0.05967433	0.02330119	0.14321834	0.14321834	0.05592284
2.6	0.05683004	0.05683004	0.02041146	0.14775805	0.14775805	0.05306979
2.8	0.05418866	0.05418866	0.01798257	0.15172819	0.15172819	0.05035117
3.0	0.05174087	0.05174087	0.01593381	0.15522257	0.15522257	0.04780142
3.2	0.04947419	0.04947419	0.01419726	0.15831735	0.15831735	0.04543121
3.6	0.04737485	0.04737485	0.01271714	0.16107443	0.16107443	0.04323827
4.0	0.04362320	0.04362320	0.01035414	0.16576809	0.16576809	0.03934573
4.4	0.04038297	0.04038297	0.00857312	0.16960841	0.16960841	0.03602960
4.8	0.03756825	0.03756825	0.00721452	0.17280468	0.17280468	0.03318677
5.2	0.03510086	0.03510086	0.00614732	0.17550424	0.17550424	0.03072560
5.6	0.03292840	0.03292840	0.00529774	0.17781331	0.17781331	0.02860776
6.0	0.03100177	0.03100177	0.00461110	0.17981017	0.17981017	0.02674440
6.4	0.02928287	0.02928287	0.00404868	0.18155371	0.18155371	0.02510187
6.8	0.02774076	0.02774076	0.00358248	0.18308896	0.18308896	0.02354437
7.2	0.02635015	0.02635015	0.00319189	0.18445096	0.18445096	0.02234301
7.6	0.02509019	0.02509019	0.00286151	0.18566735	0.18566735	0.02117515
8.0	0.02394362	0.02394362	0.00257964	0.18676020	0.18676020	0.02012116
8.4	0.02289603	0.02289603	0.00233727	0.18774736	0.18774736	0.01916560
8.8	0.02193529	0.02193529	0.00212734	0.18864341	0.18864341	0.01829554
9.2	0.02105116	0.02105116	0.00194445	0.18946037	0.18946037	0.01750006
9.6	0.02023493	0.02023493	0.00176466	0.19020826	0.19020826	0.01677018
10.0	0.01947913	0.01947913	0.00164267	0.19089545	0.19089545	0.01609915

Table 32

The constants, g_i, of Equations (28) for $L_2/L_1=1.0$, $W_2/L_1=1.0$ and $H/L_1=2.0$

W_1/L_1	g_1	g_2	g_3, g_4	g_5	g_6	g_7, g_8
0.1	0.03315310	0.03315310	0.03080246	0.00331531	0.00331531	0.00308025
0.2	0.03310023	0.03310023	0.03067000	0.00662004	0.00662004	0.00613407
0.4	0.03289095	0.03289095	0.03014733	0.01315638	0.01315638	0.01205392
0.6	0.03254984	0.03254984	0.02930178	0.01952990	0.01952990	0.01756106
0.8	0.03208798	0.03208798	0.02817127	0.02567038	0.02567038	0.02253701
1.0	0.03151996	0.03151996	0.02680695	0.03151995	0.03151995	0.02680695
1.2	0.03086290	0.03086290	0.02526958	0.03703546	0.03703546	0.03032342
1.4	0.03013529	0.03013529	0.02362400	0.04218940	0.04218940	0.03317357
1.6	0.02935577	0.02935577	0.02193286	0.04696921	0.04696921	0.03507256
1.8	0.02854195	0.02854195	0.02025106	0.051375	0.05137549	0.03643191
2.0	0.02770962	0.02770962	0.01862220	0.05541923	0.05541923	0.03774439
2.2	0.02687224	0.02687224	0.01707736	0.05911890	0.05911890	0.03757013
2.4	0.02604070	0.02604070	0.01563586	0.06249765	0.06249765	0.03752616
2.6	0.02522346	0.02522346	0.01430727	0.06558098	0.06558098	0.03719901
2.8	0.02442679	0.02442679	0.01309377	0.06839499	0.06839499	0.03666055
3.0	0.02365506	0.02365506	0.01199245	0.07096516	0.07096516	0.03597733
3.2	0.02291112	0.02291112	0.01099719	0.07331556	0.07331556	0.03519093
3.6	0.02219661	0.02219661	0.01010014	0.07546846	0.07546846	0.03434048
4.0	0.02085812	0.02085812	0.00855618	0.07926082	0.07926082	0.03255147
4.4	0.01963829	0.01963829	0.00732316	0.08248079	0.08248079	0.03075726
4.8	0.01853009	0.01853009	0.00631169	0.08523840	0.08523840	0.02908376
5.2	0.01752403	0.01752403	0.00548323	0.08762011	0.08762011	0.02741514
5.6	0.01660997	0.01660997	0.00479944	0.08969382	0.08969382	0.02591499
6.0	0.01577811	0.01577811	0.00423051	0.09151299	0.09151299	0.02453698
6.4	0.01501937	0.01501937	0.00375332	0.09312003	0.09312003	0.02327058
6.8	0.01432558	0.01432558	0.00334996	0.09454880	0.09454880	0.02210974
7.2	0.01368951	0.01368951	0.00300648	0.09582657	0.09582657	0.02104533
7.6	0.01310480	0.01310480	0.00271193	0.09697549	0.09697549	0.02006924
8.0	0.01256586	0.01256586	0.00245768	0.09801369	0.09801369	0.01916993
8.4	0.01206782	0.01206782	0.00223688	0.09895612	0.09895612	0.01834242
8.8	0.01160643	0.01160643	0.00204402	0.09981523	0.09981523	0.01757058
9.2	0.01117794	0.01117794	0.00187467	0.10060142	0.10060142	0.01687290
9.6	0.01077910	0.01077910	0.00172521	0.10132346	0.10132346	0.01621697
10.0	0.01040702	0.01040702	0.00159270	0.10198880	0.10198880	0.01560843

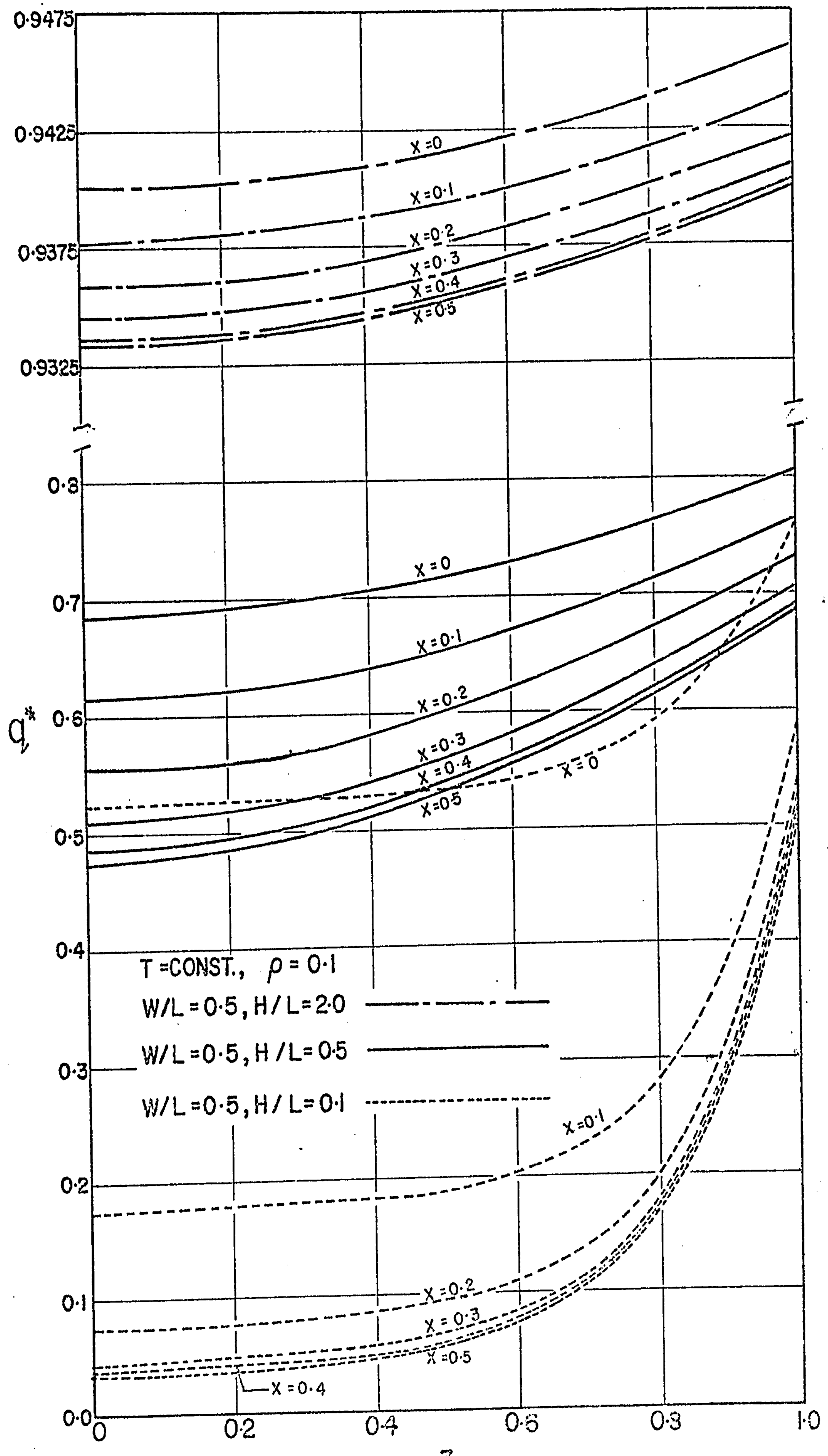


Figure 3 Local heat flux versus position for parallel plate system with $\rho=0.1$

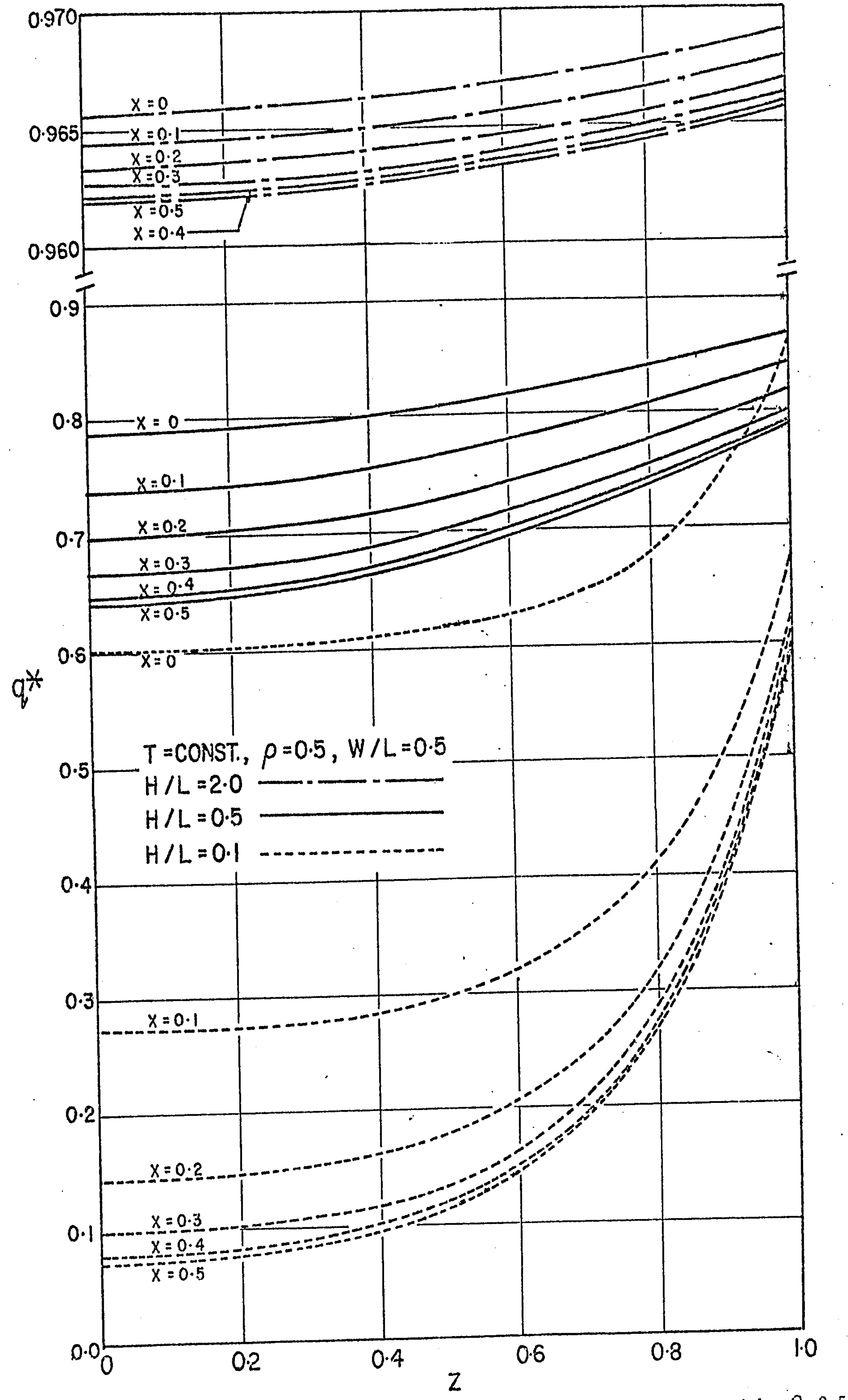


Figure 4 Local heat flux versus position for parallel plate systsm with $\rho = 0.5$

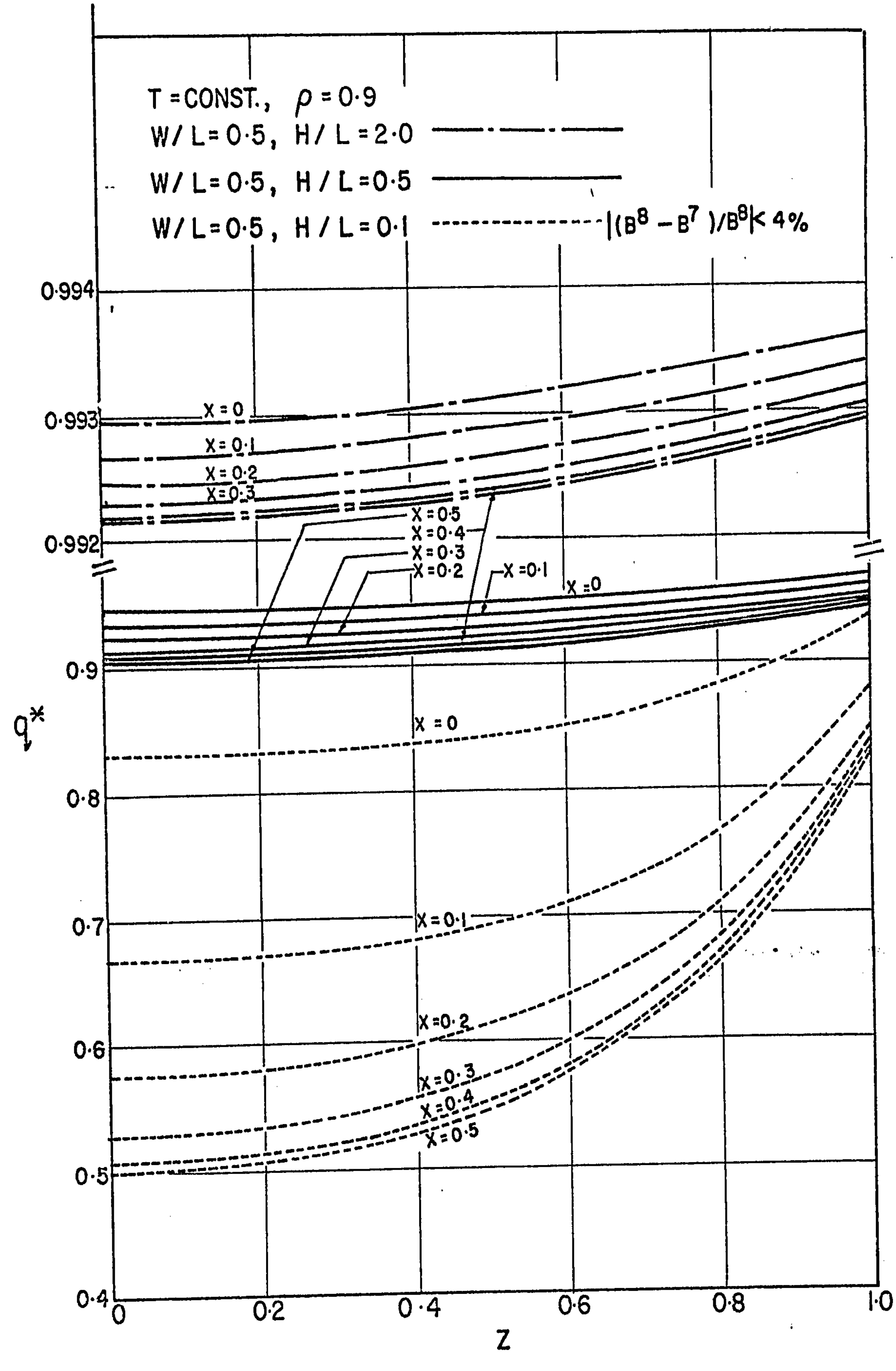


Figure 5 Local heat flux versus position for parallel plate system with $\rho = 0.9$

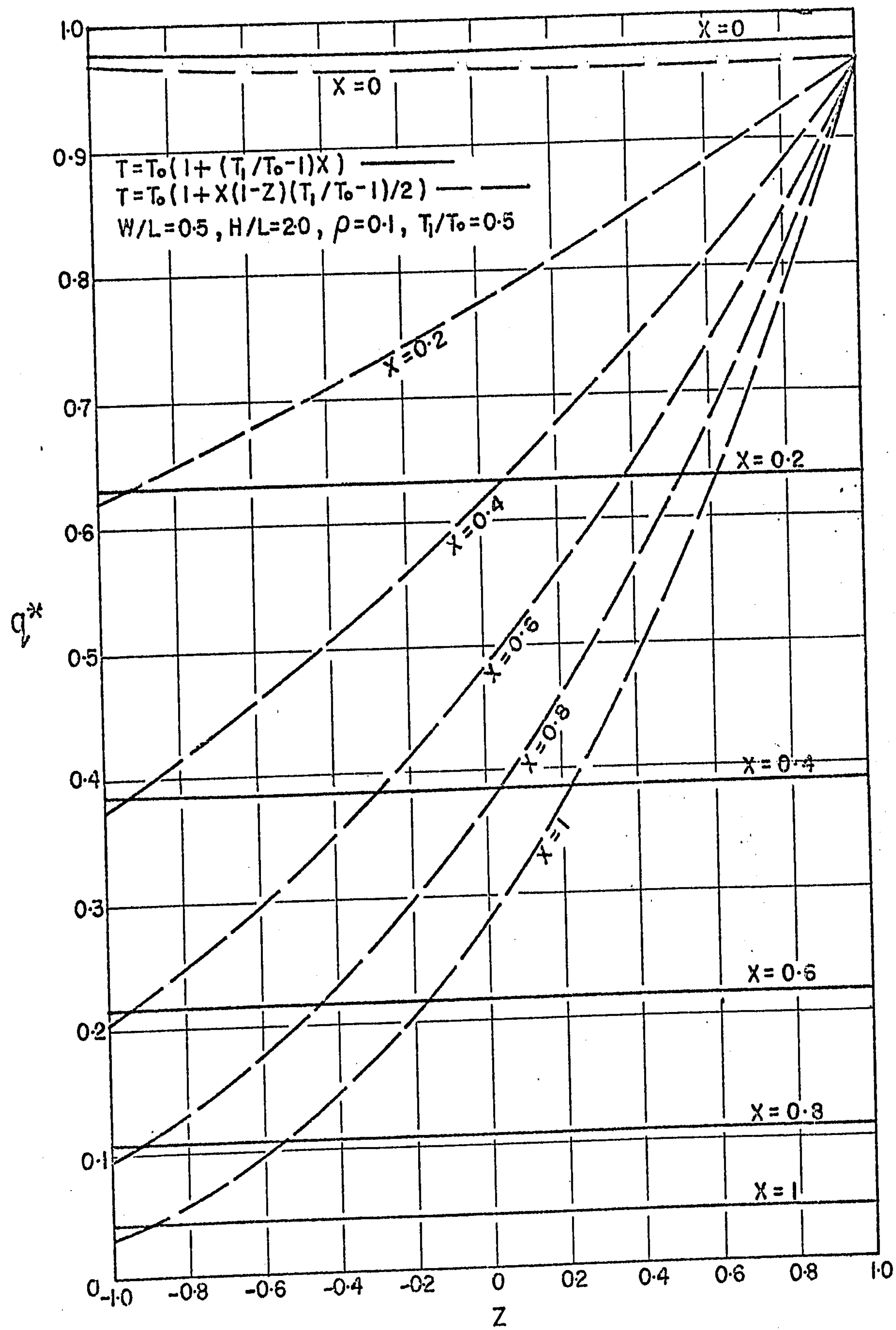


Figure 6 Local heat flux versus position for parallel plate system

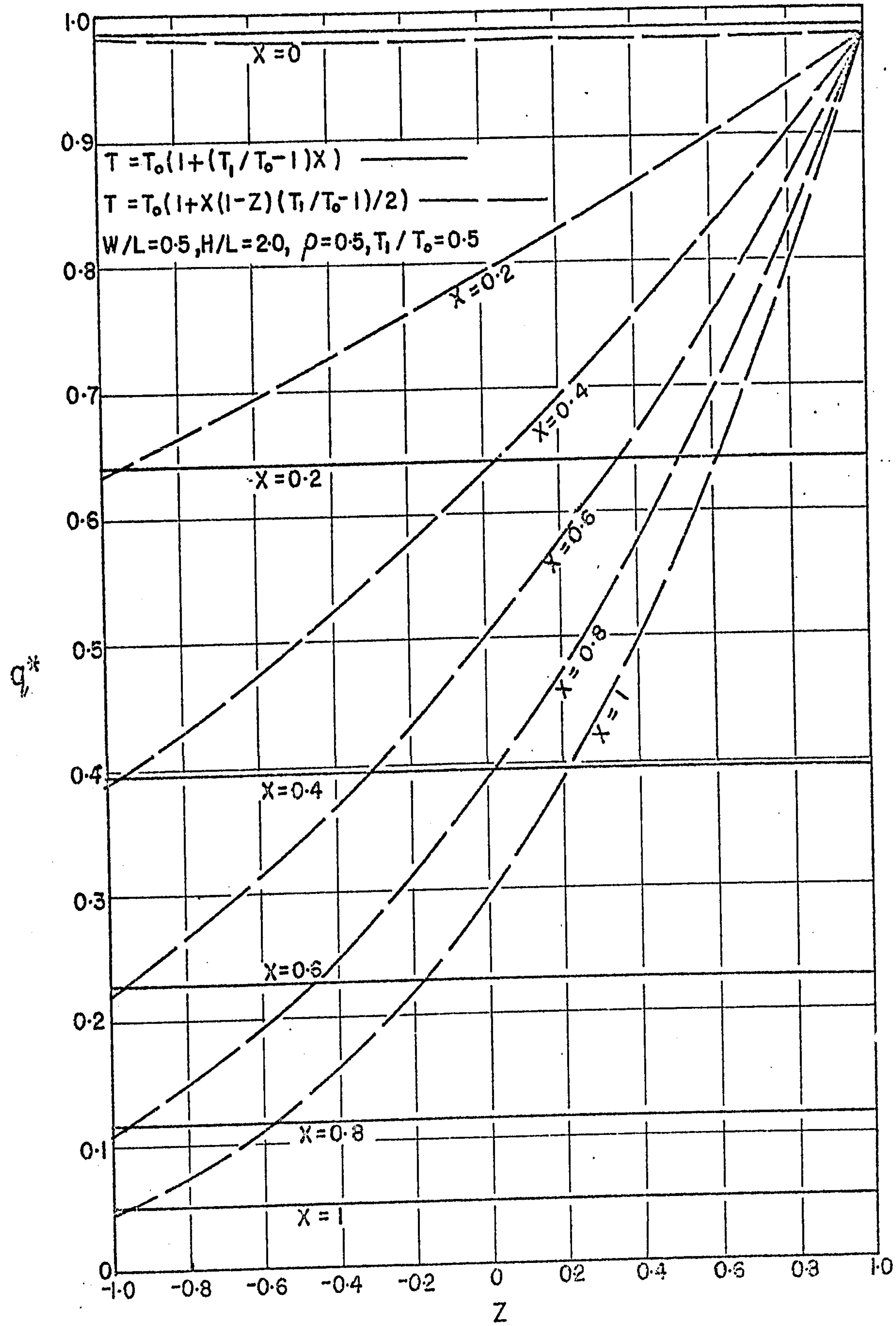


Figure 7 Local heat flux versus position for parallel plate system

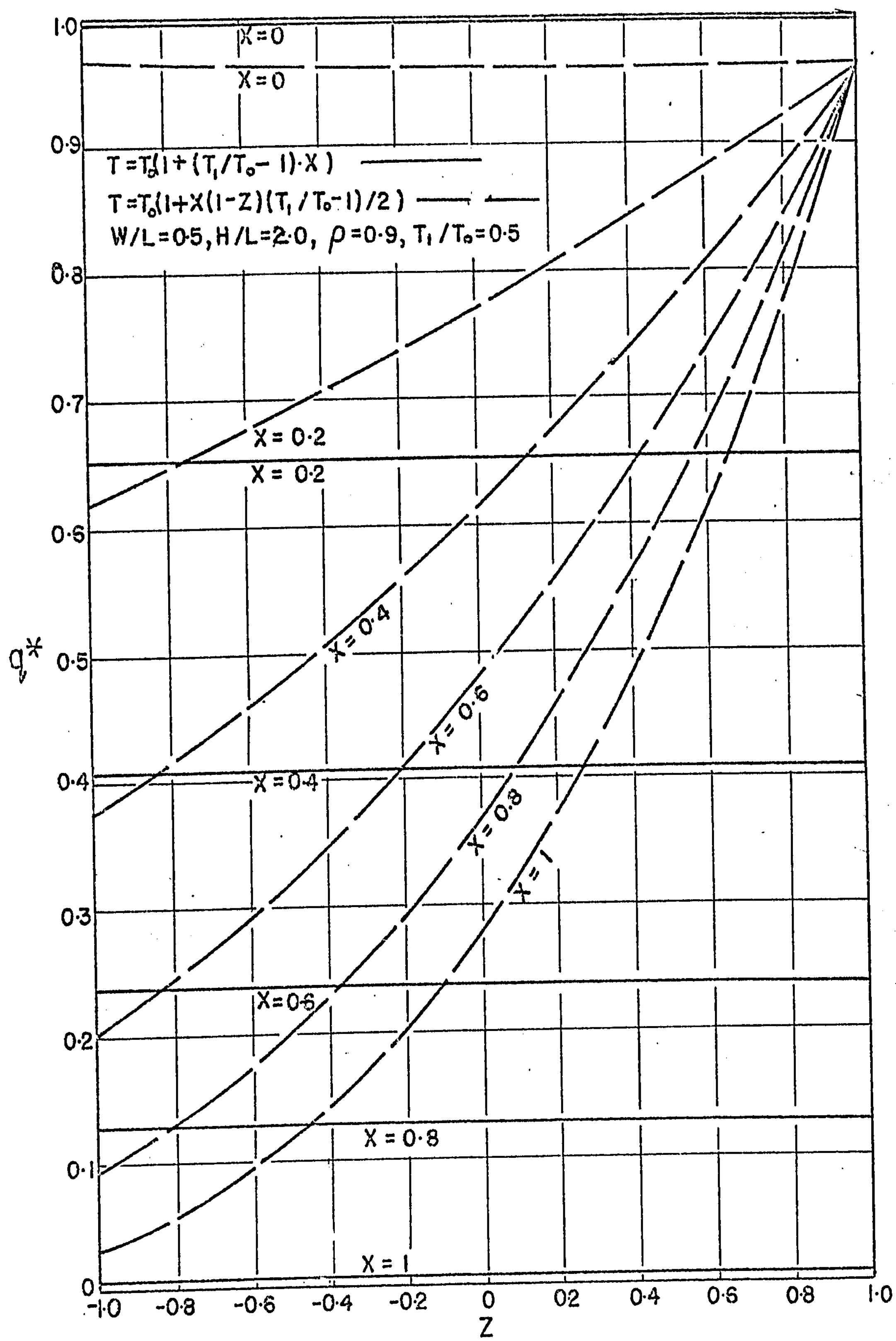


Figure 8 Local heat flux versus position for parallel plate system

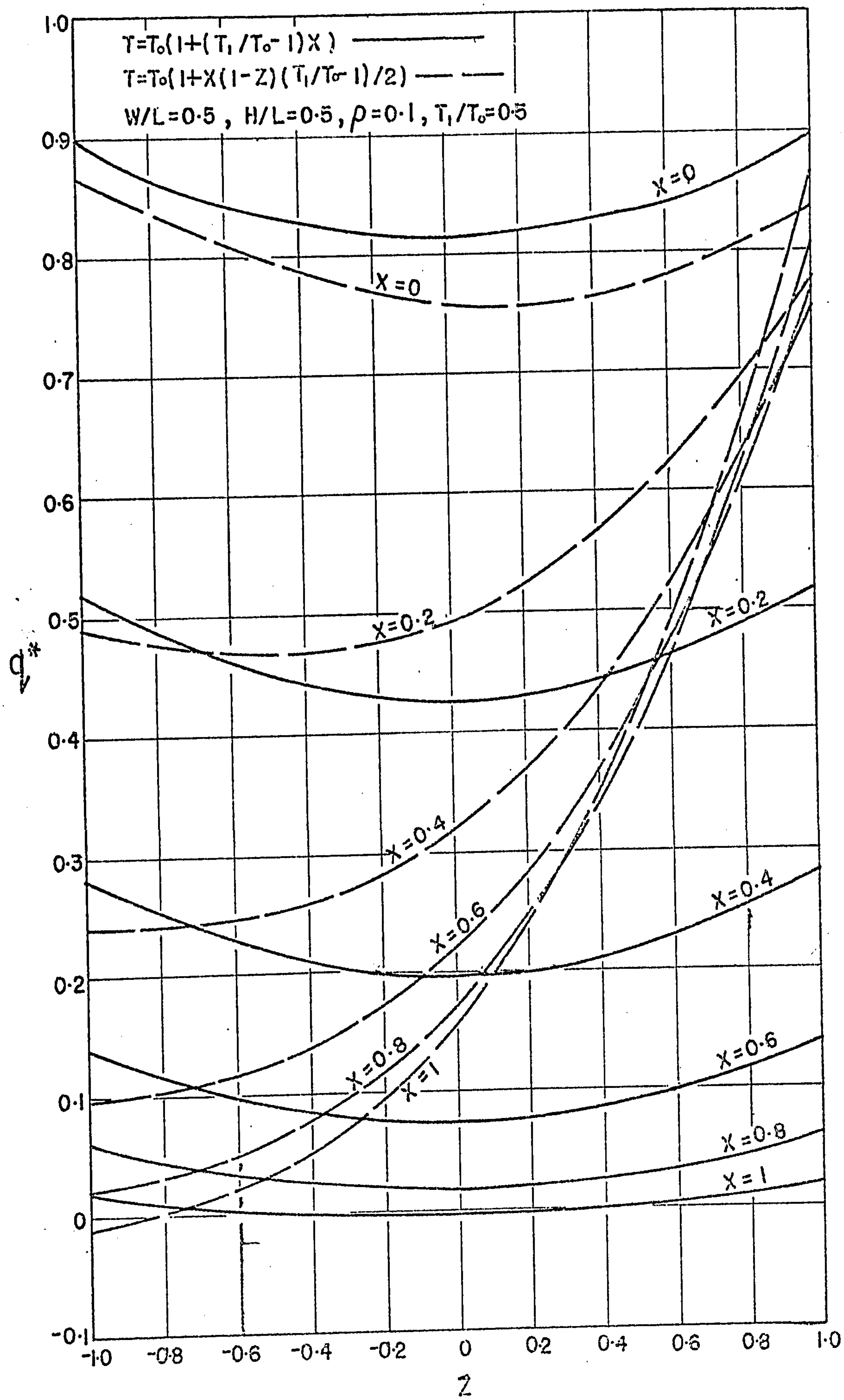


Figure 9 Local heat flux versus position for parallel plate system

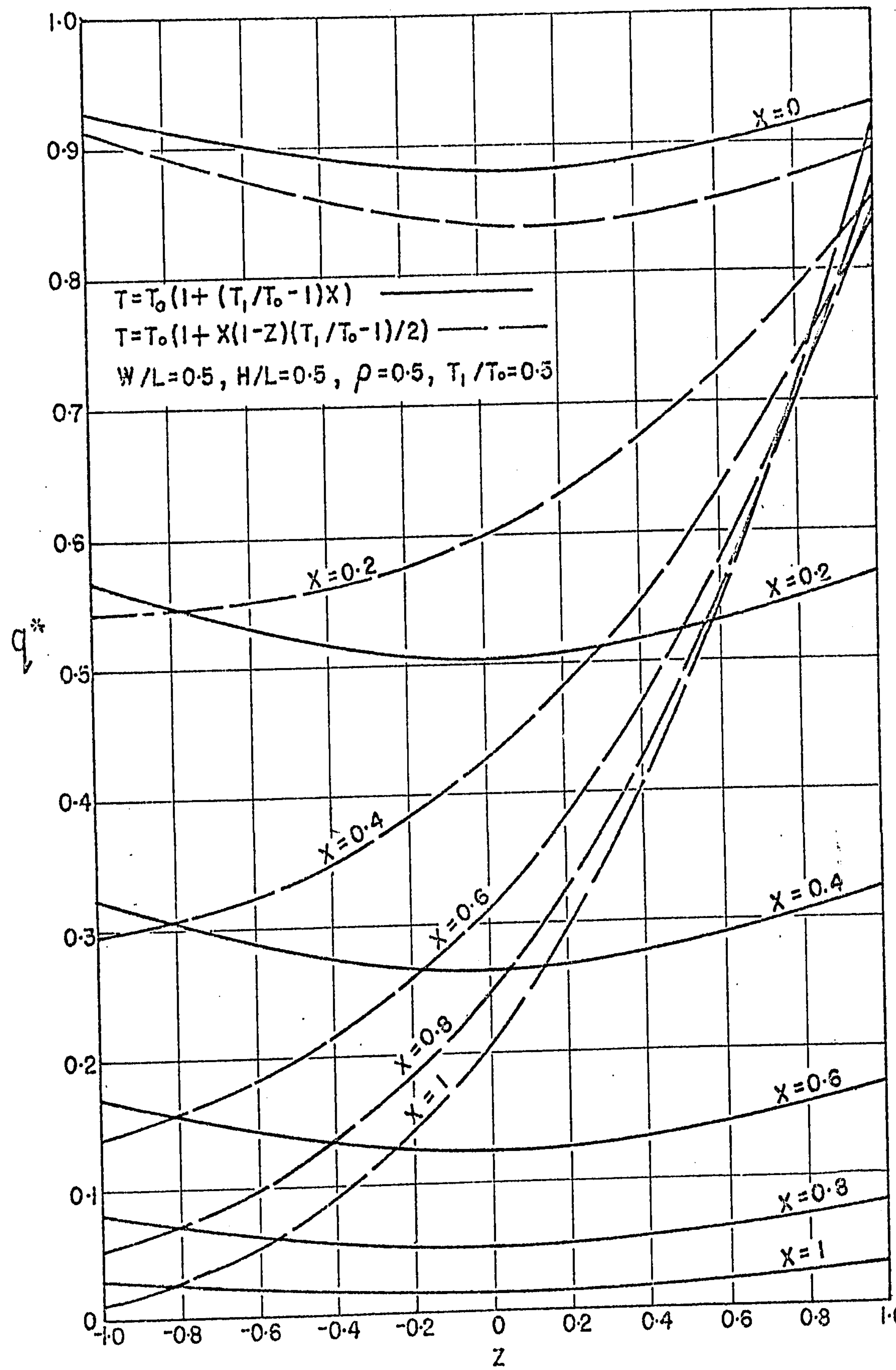


Figure 10 Local heat flux versus position for parallel plate system

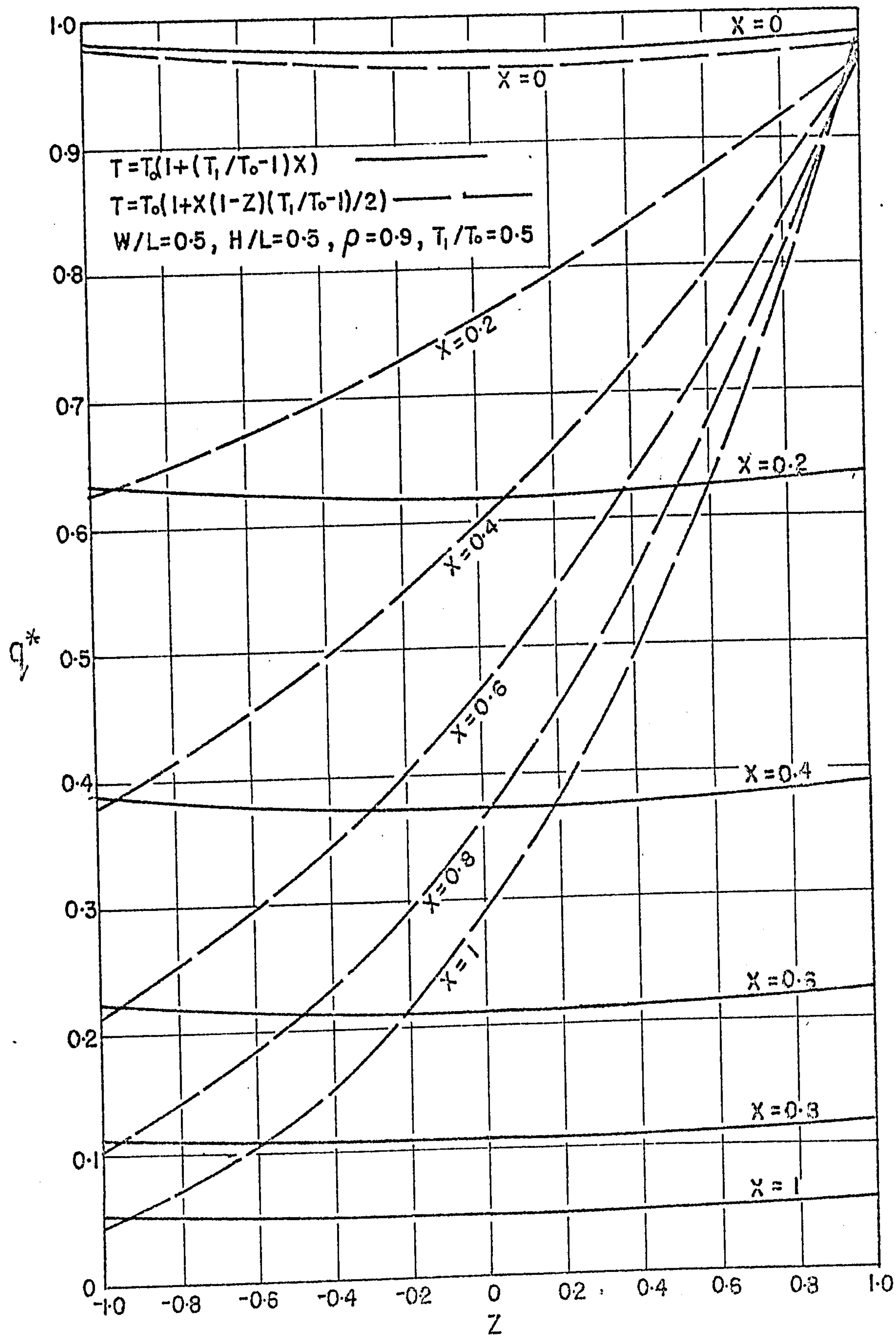


Figure 11 Local heat flux versus position for parallel plate system

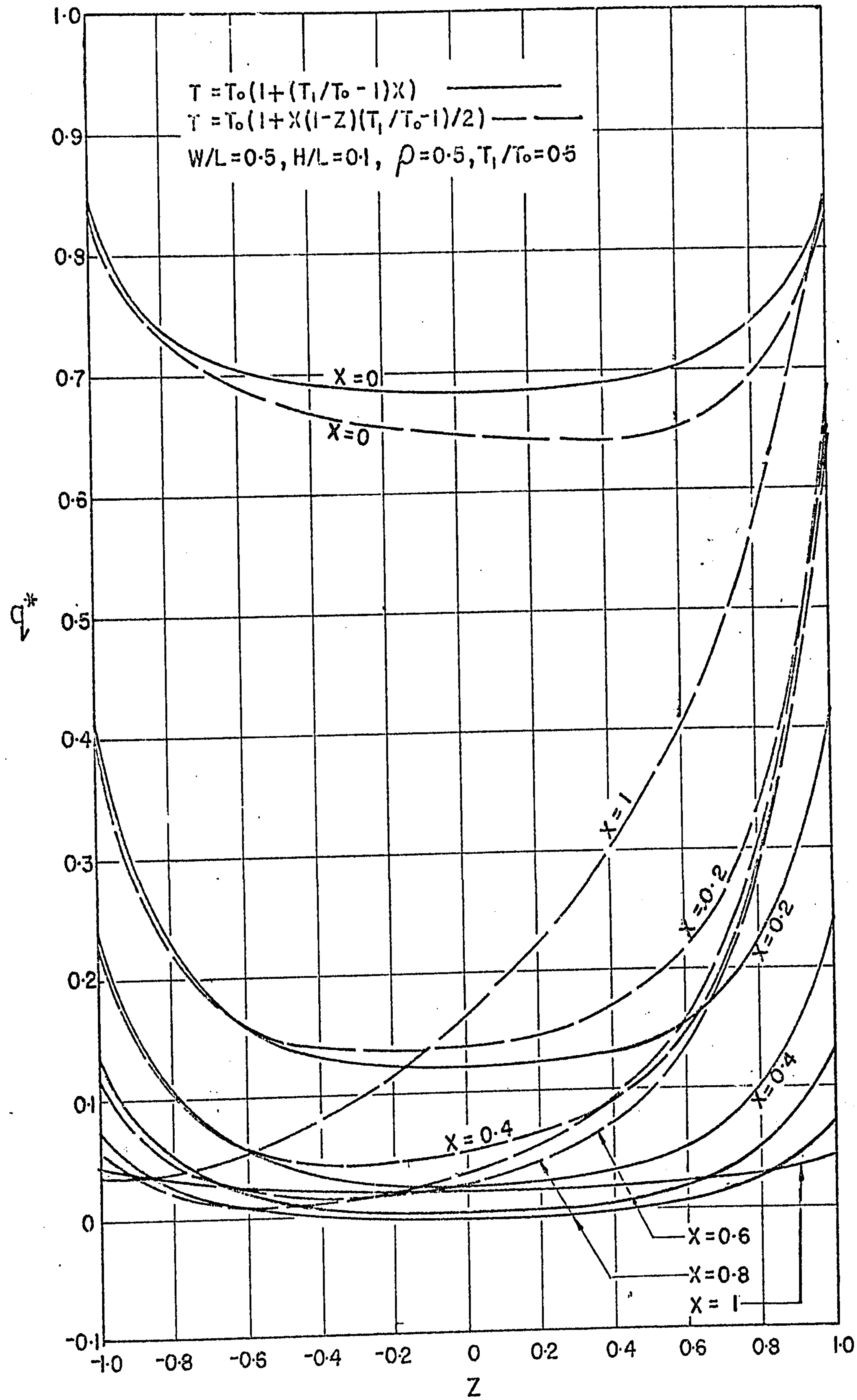


Figure 12 Local heat flux versus position for parallel plate system

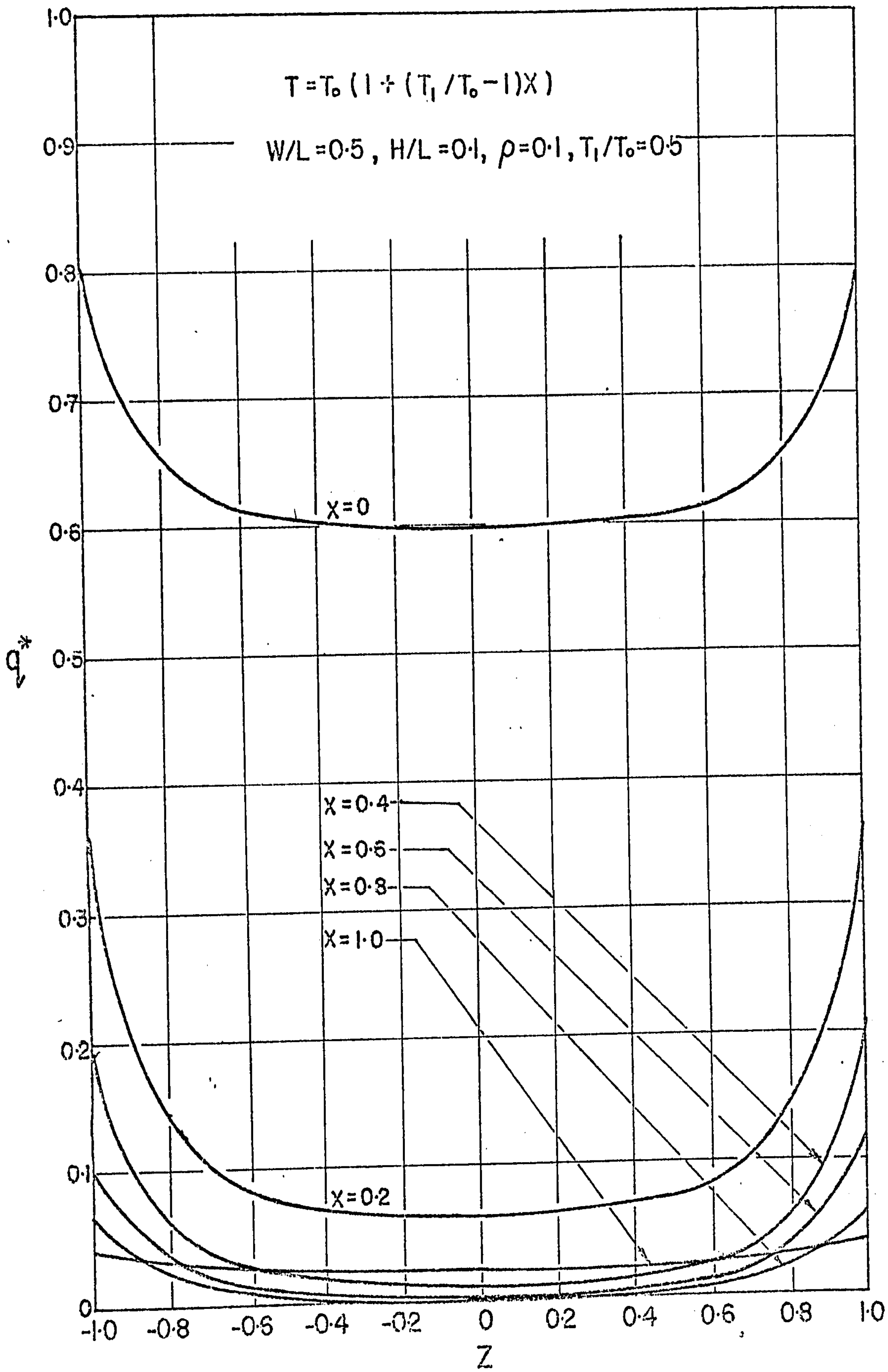


Figure 13 Local heat flux versus position for parallel plate system

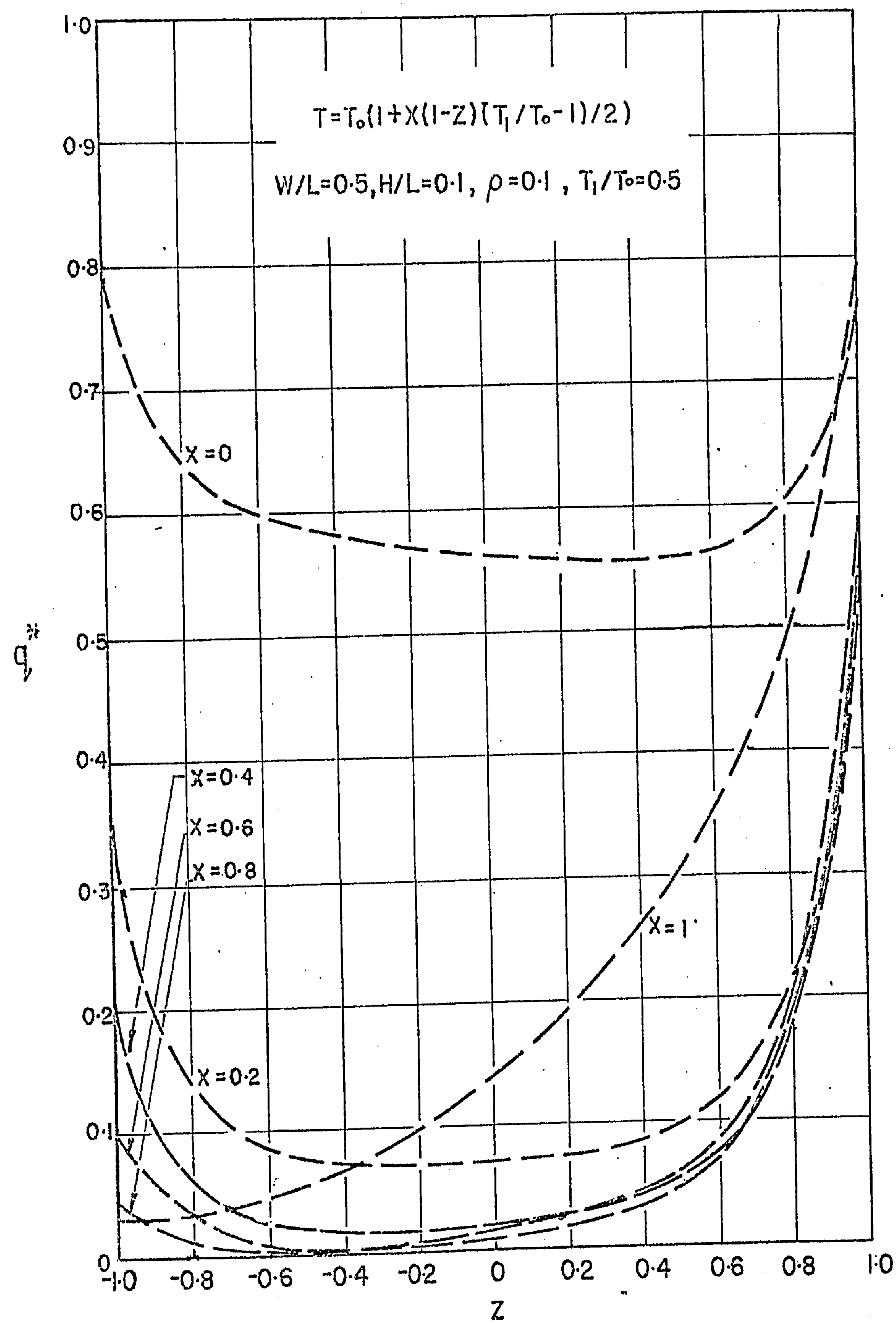


Figure 14 Local heat flux versus position for parallel plate system

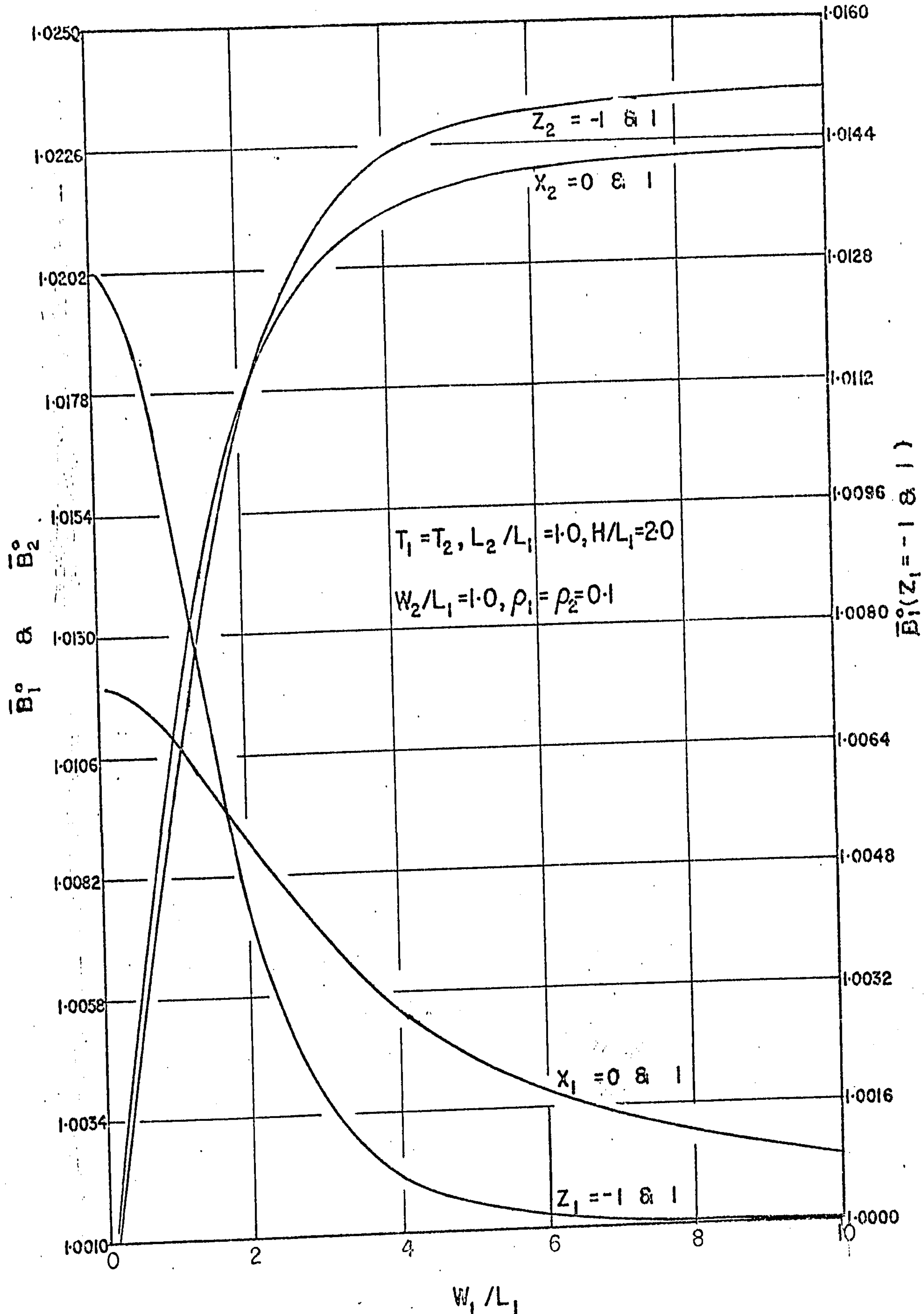


Figure 15 Zero-order mean radiosity versus width to length ratio

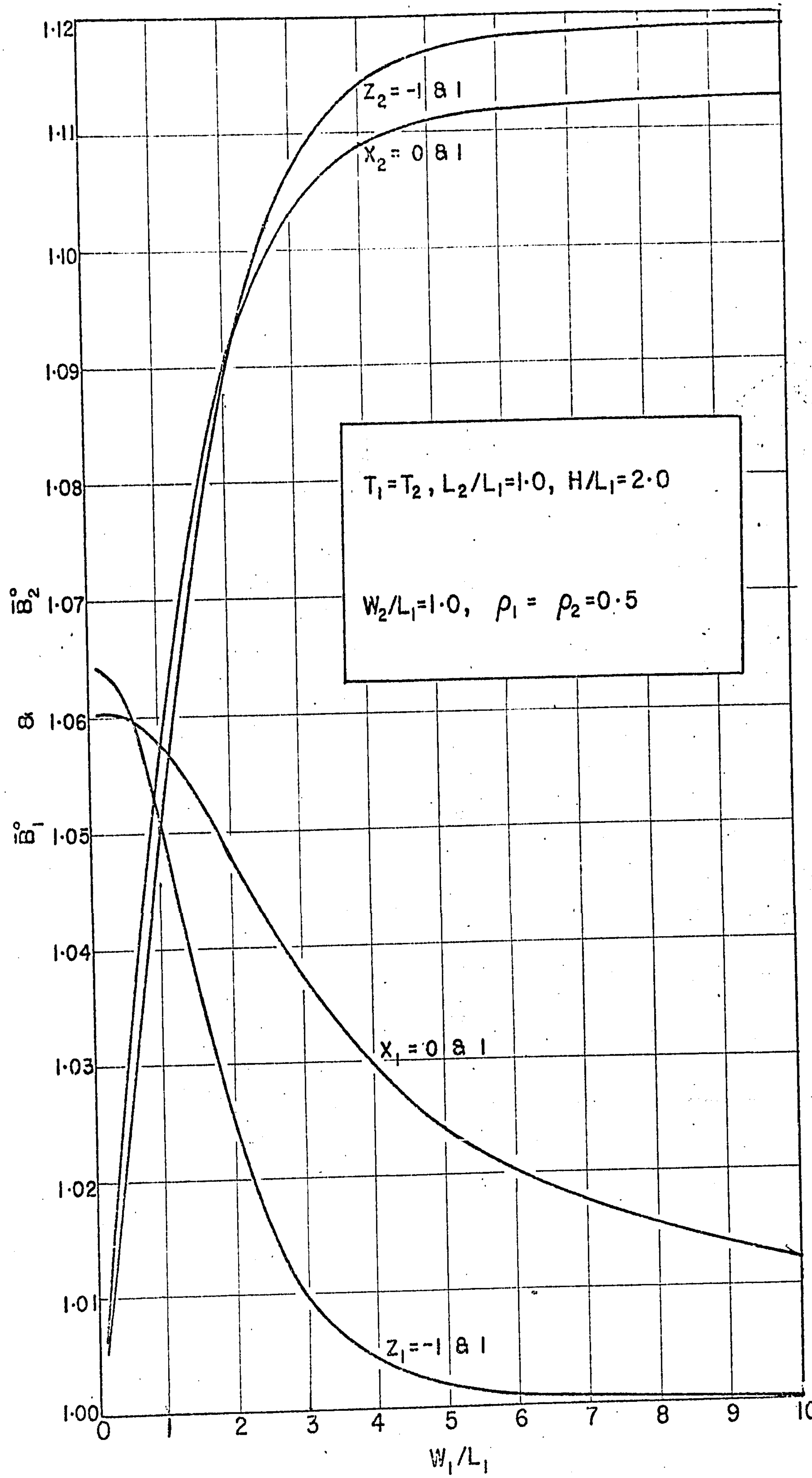


Figure 16 Zero-order mean radiosity versus width to length ratio

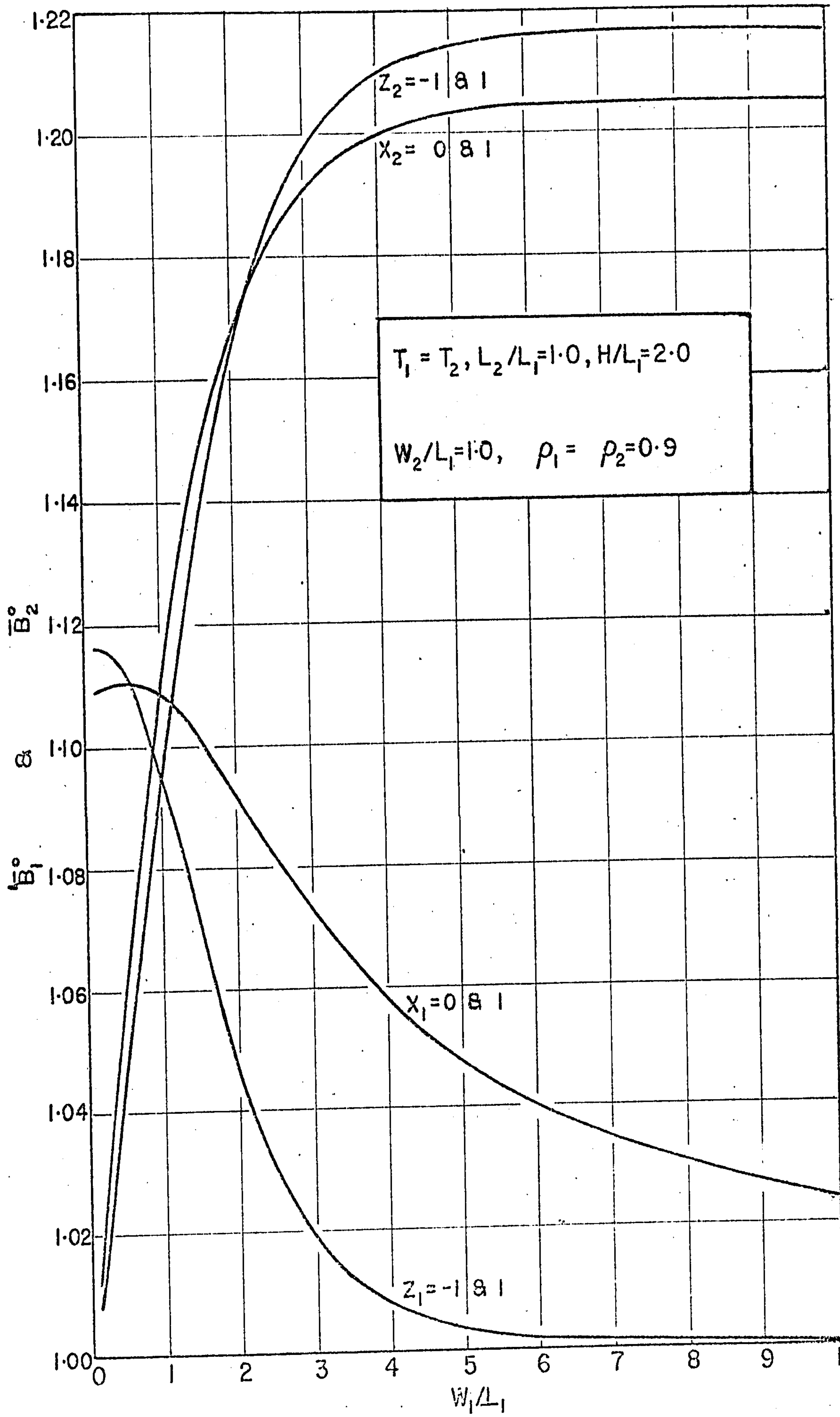


Figure 17 Zero-order mean radiosity versus width to length ratio

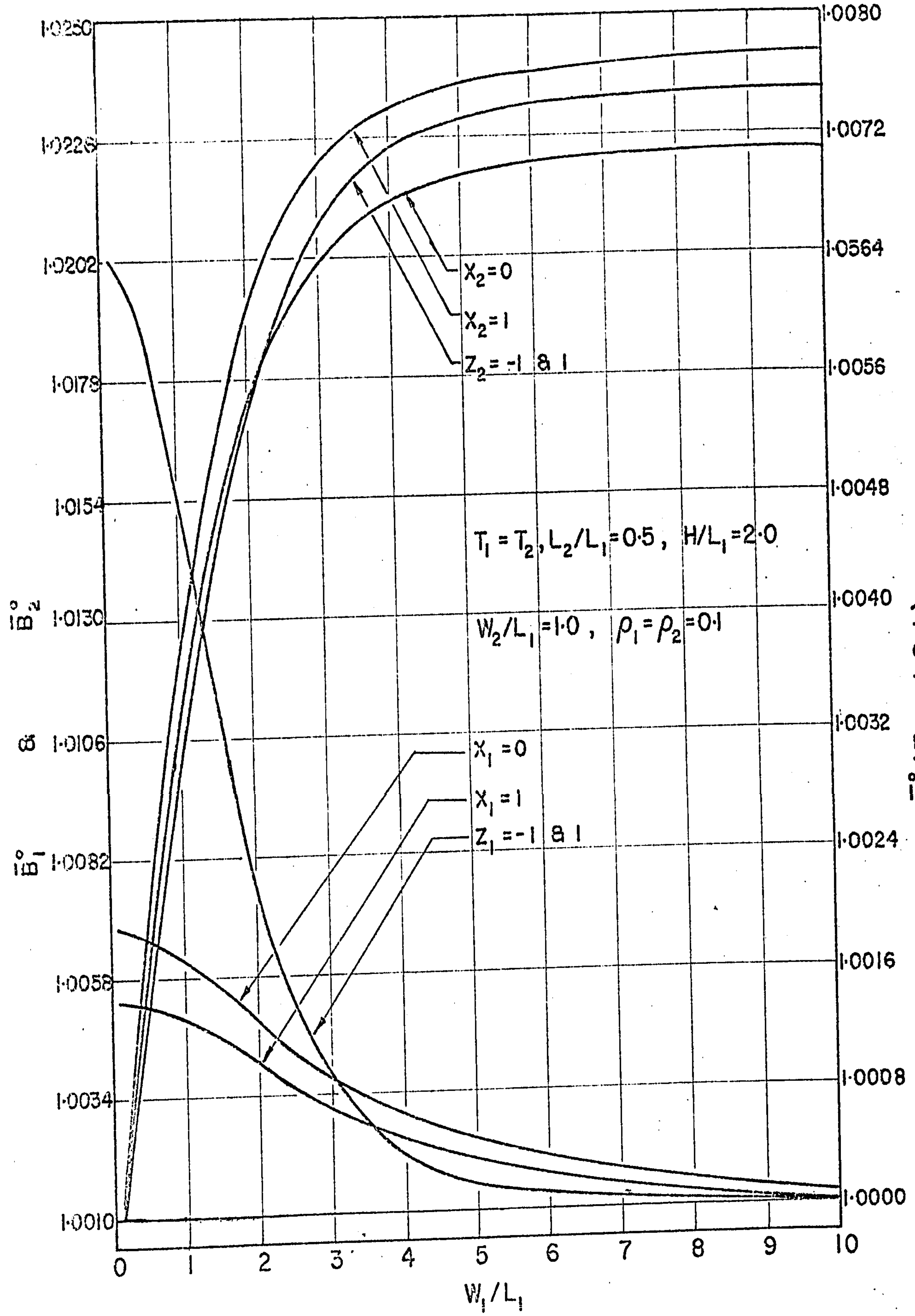


Figure 18 Zero-order mean radiosity versus width to length ratio

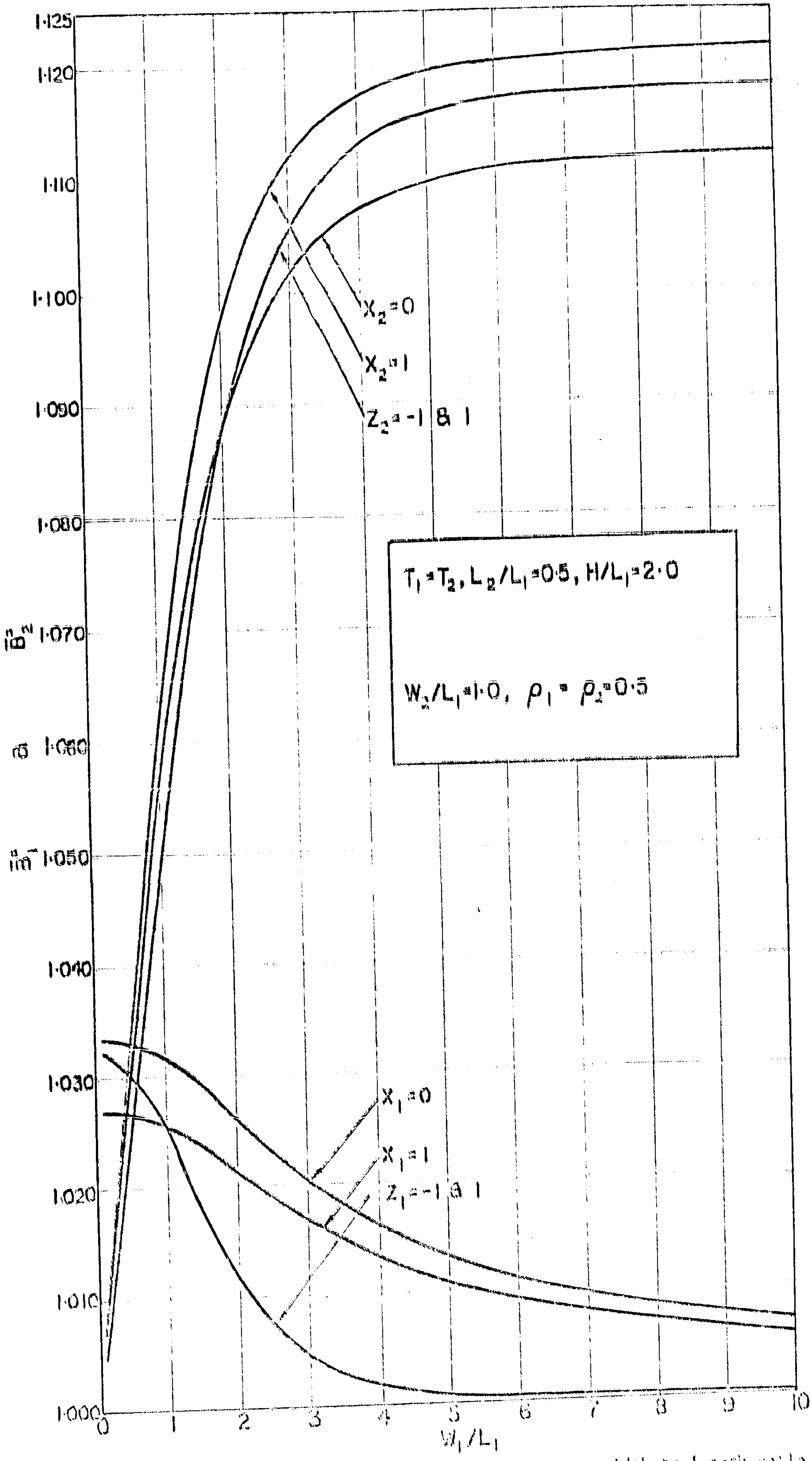


Figure 19 Zero-order mean radiosity versus width to length ratio

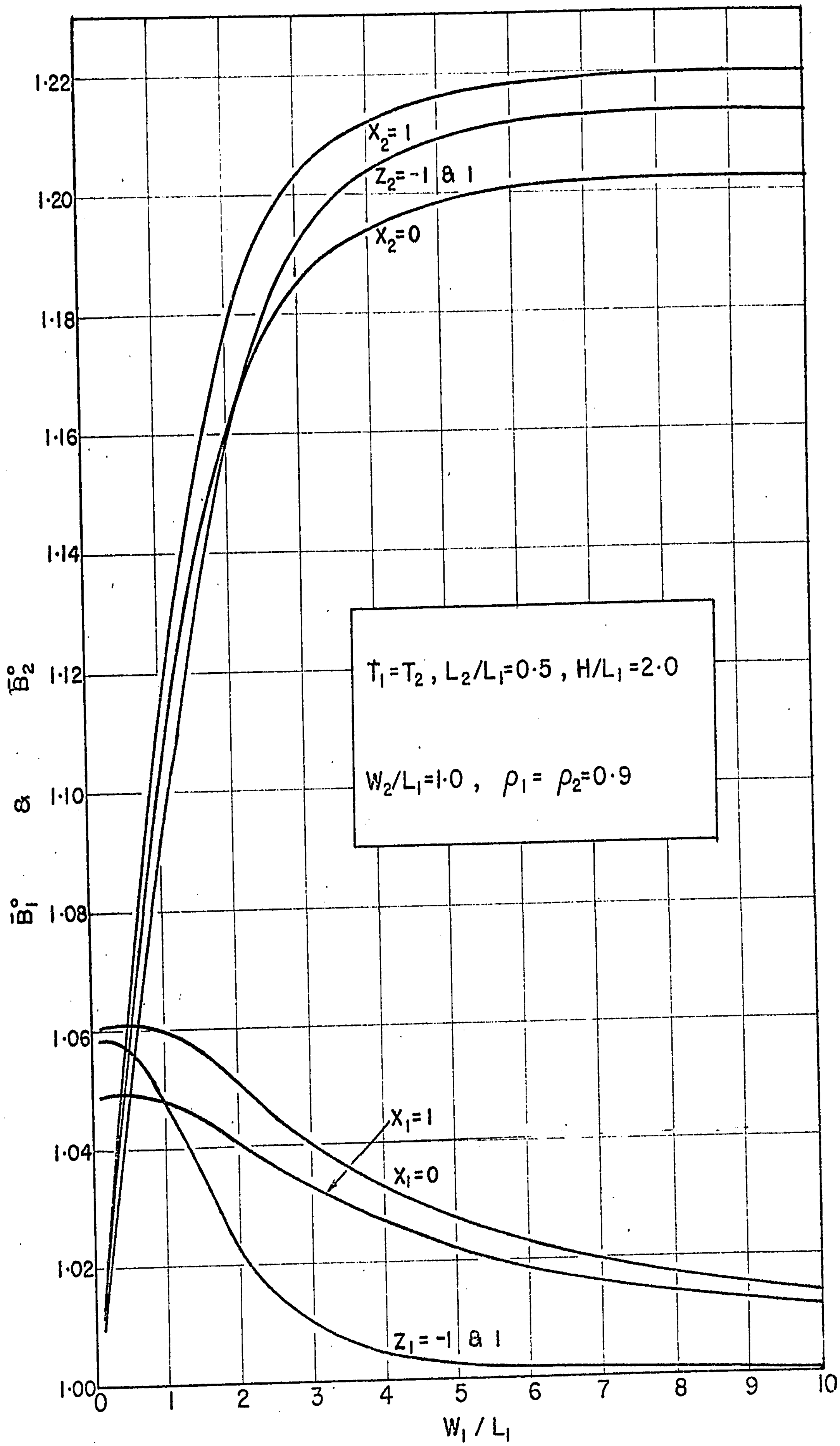


Figure 20 Zero-order mean radiosity versus width to length ratio

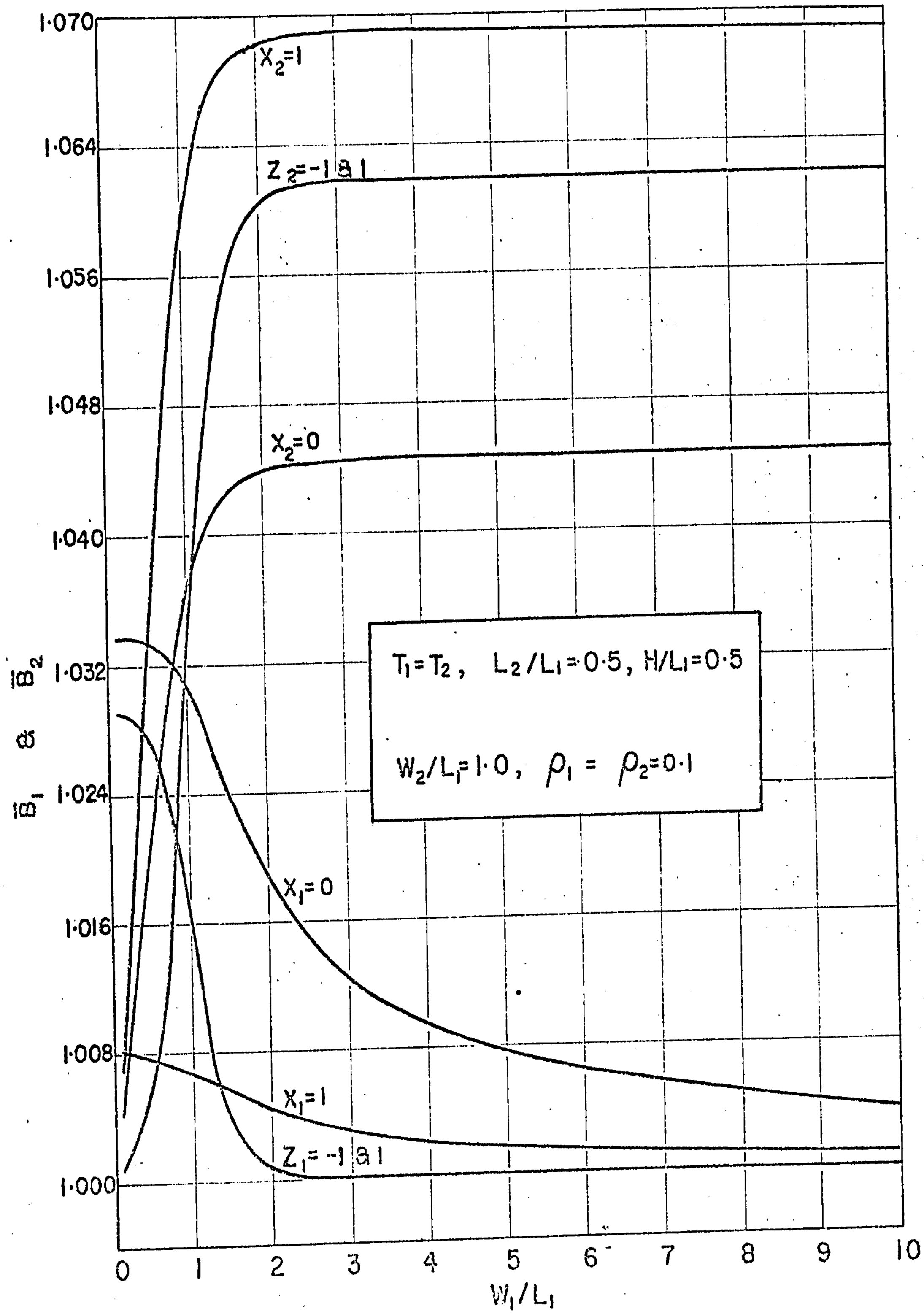


Figure 21 Zero-order mean radiosity versus width to length ratio

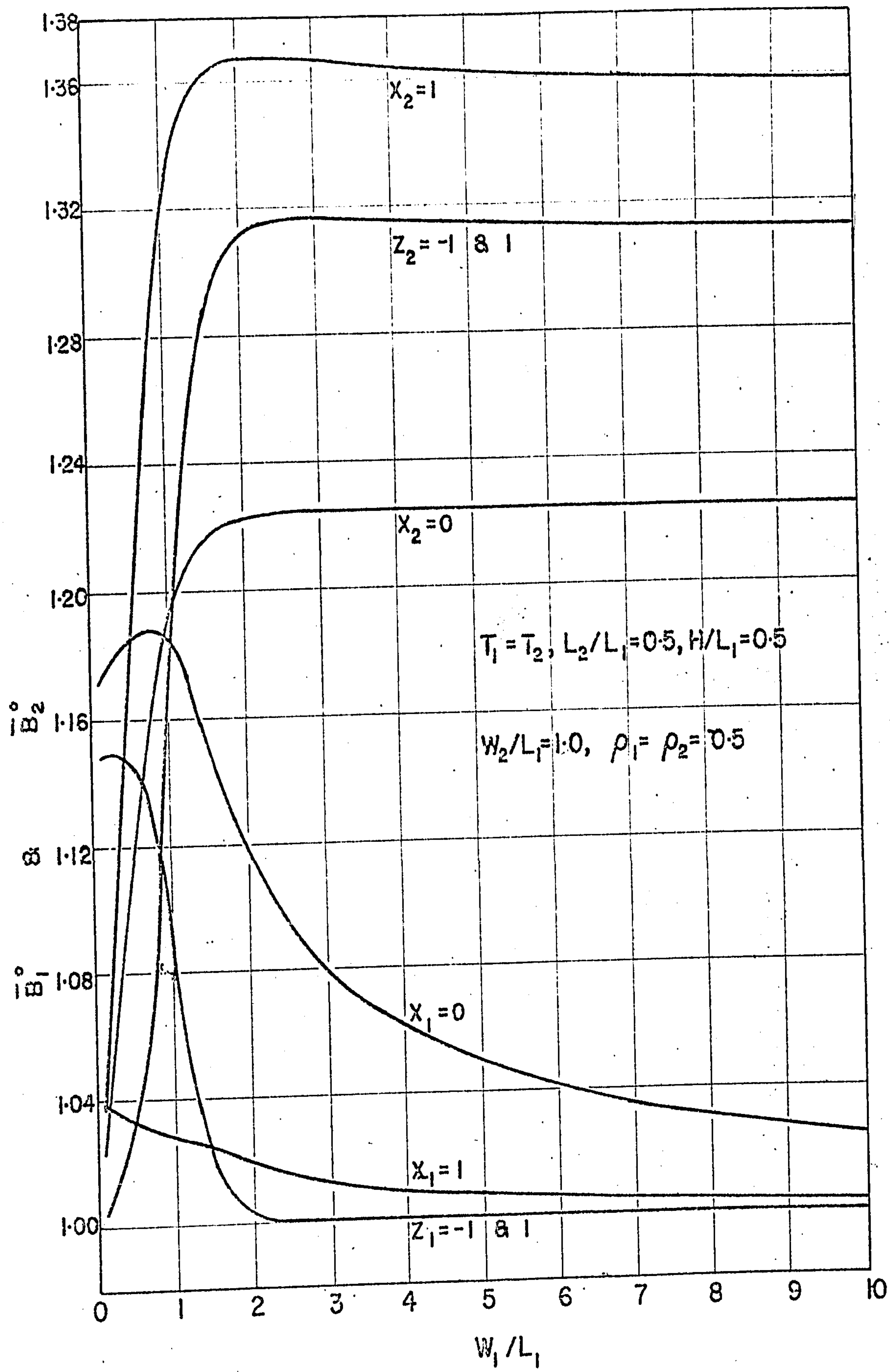


Figure 22 Zero-order mean radiosity versus width to length ratio

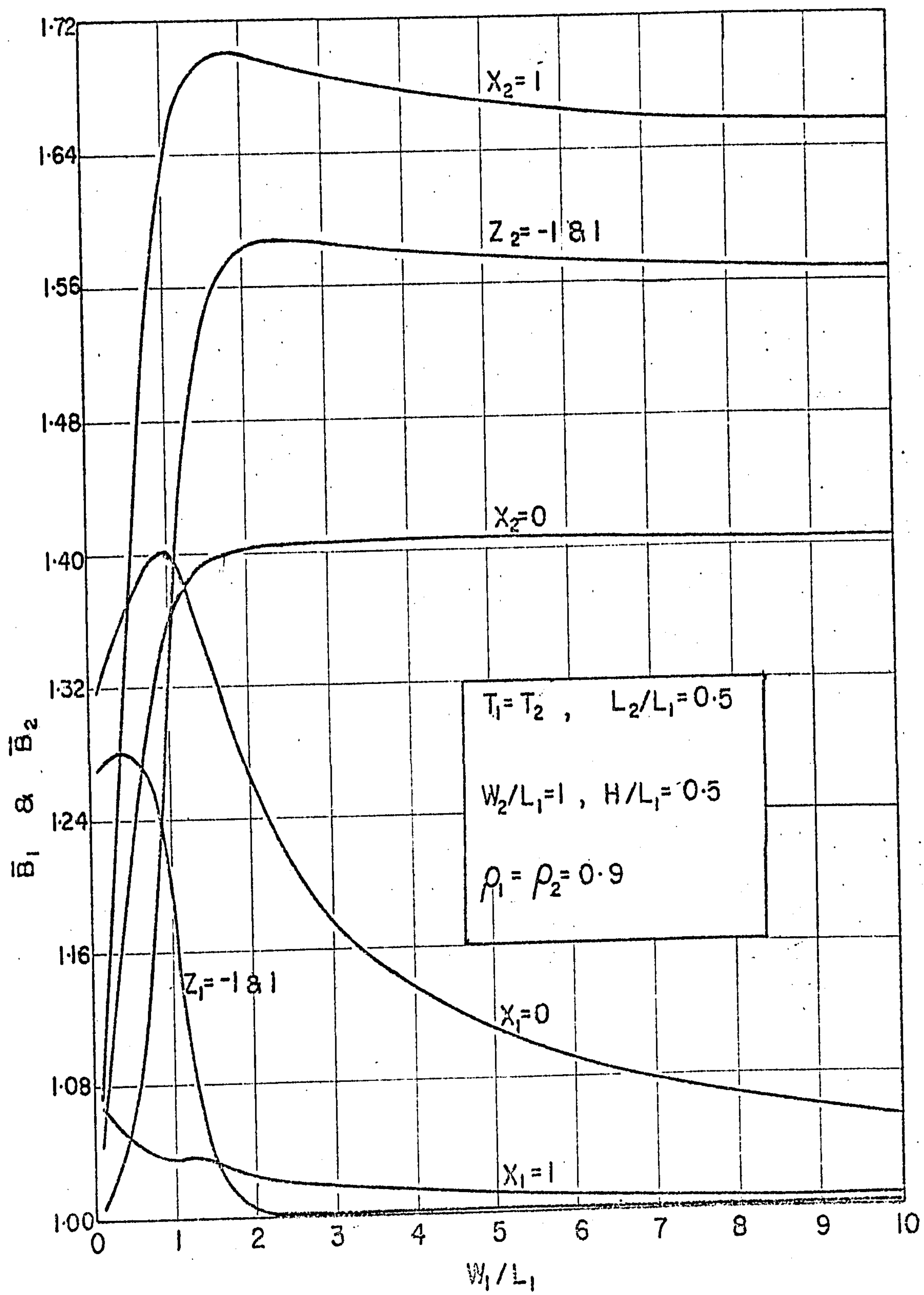


Figure 23 Zero-order mean radiosity versus width to length ratio

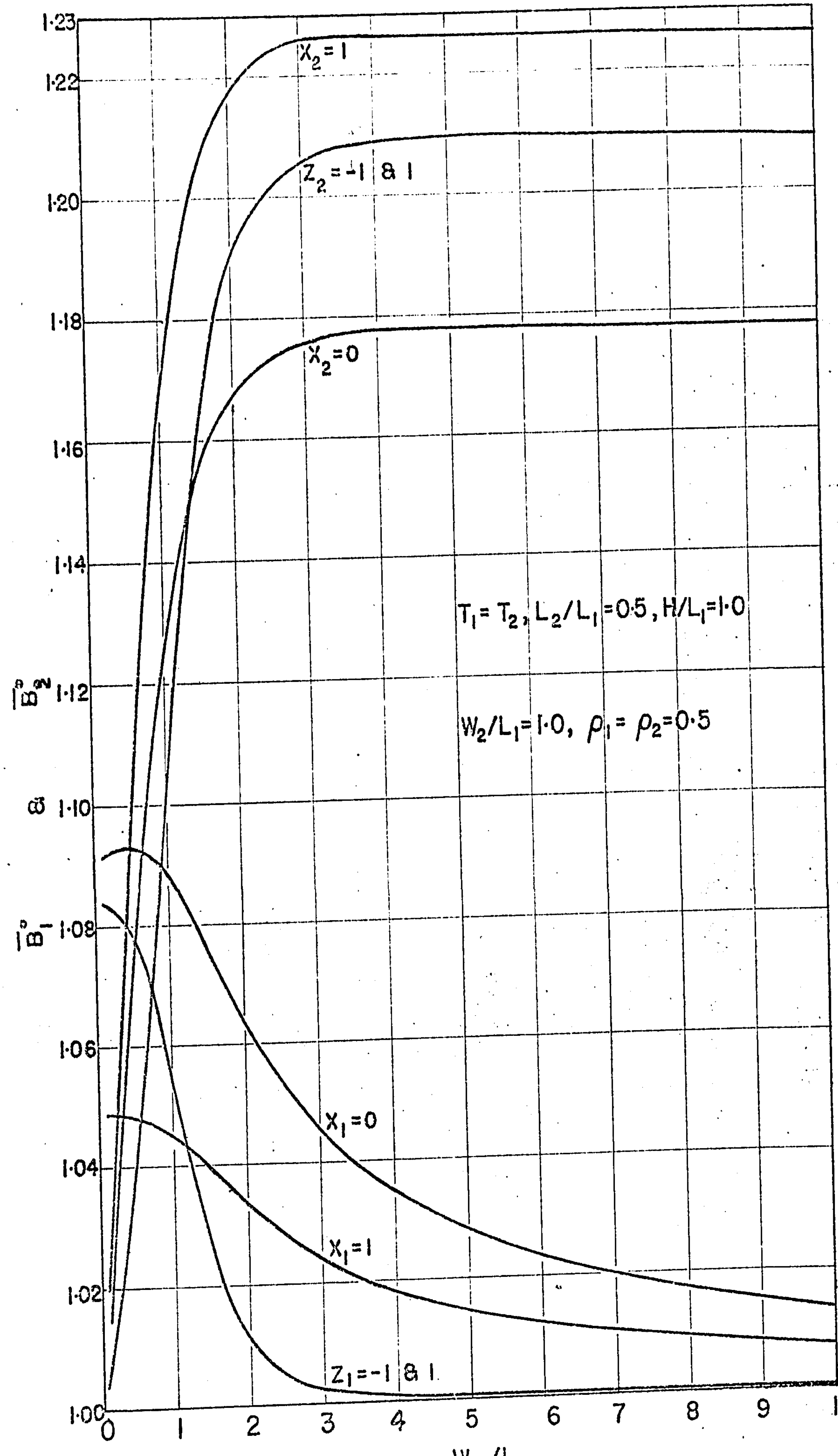


Figure 24 Zero-order mean radiosity versus width to length ratio

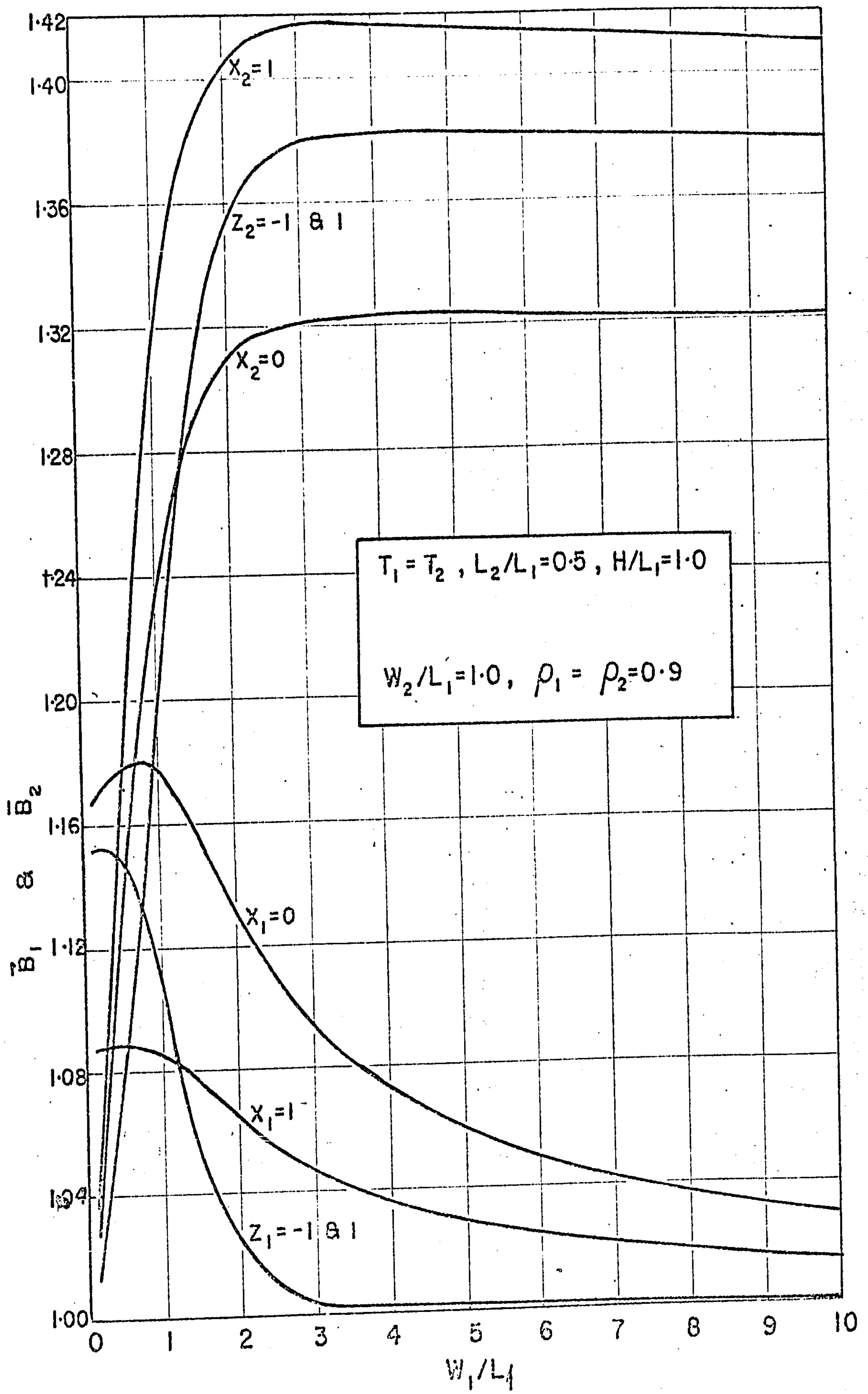


Figure 25 Zero-order mean radiosity versus width to length ratio

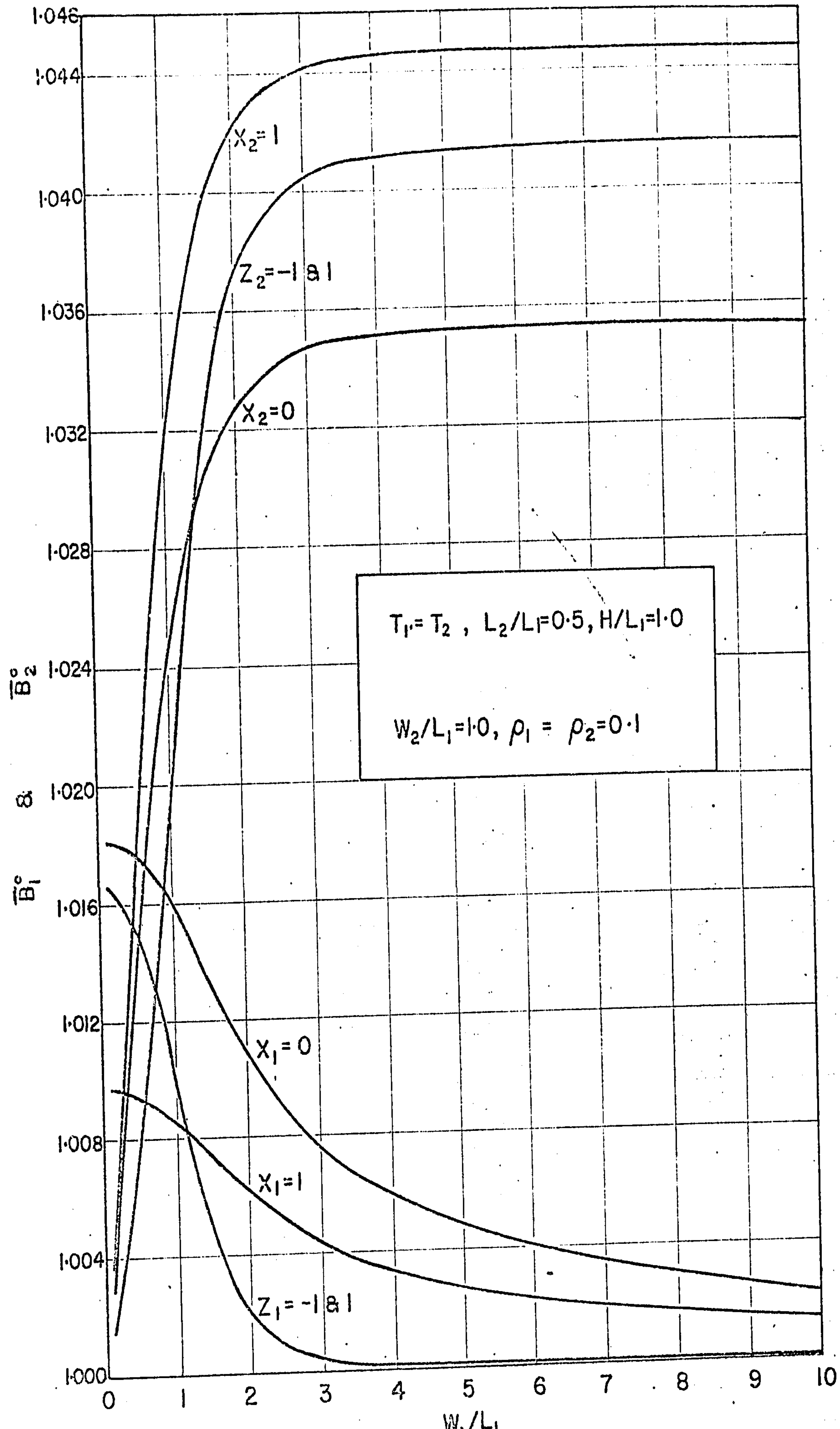


Figure 26 Zero-order mean radiosity versus width to length ratio

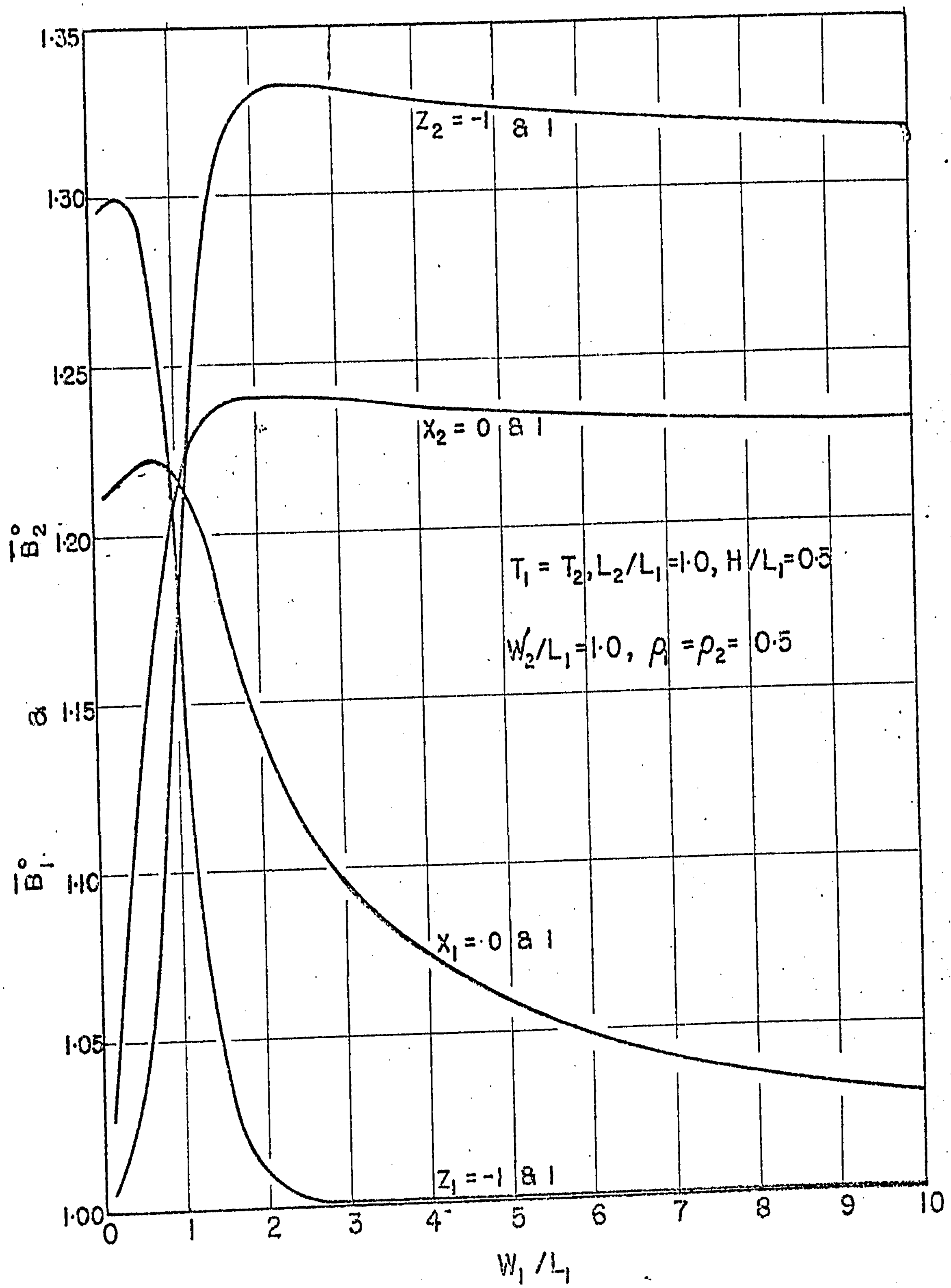


Figure 27 Zero-order mean radiosity versus width to length ratio

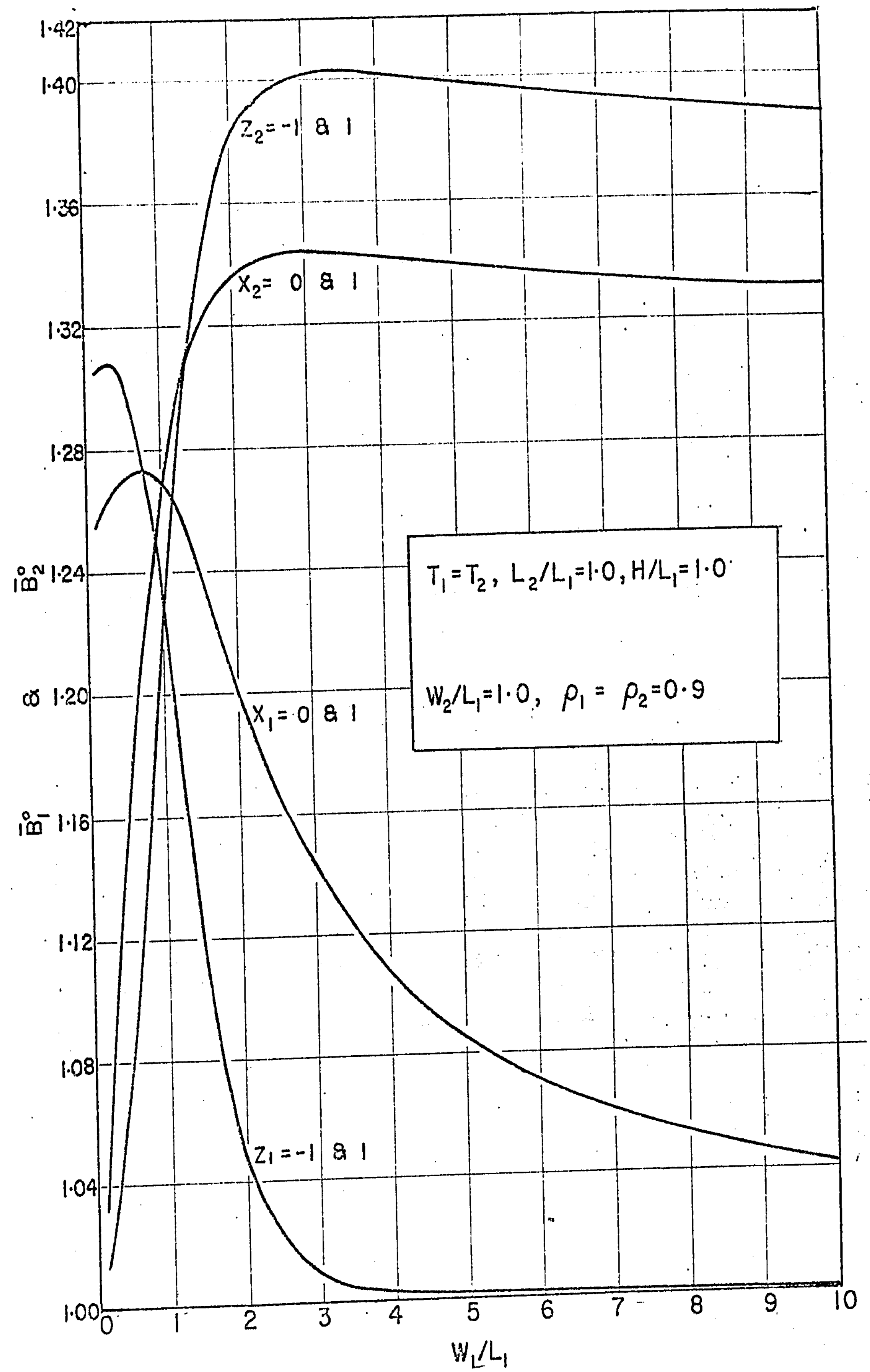


Figure 23 Zero-order mean radiosity versus width to length ratio

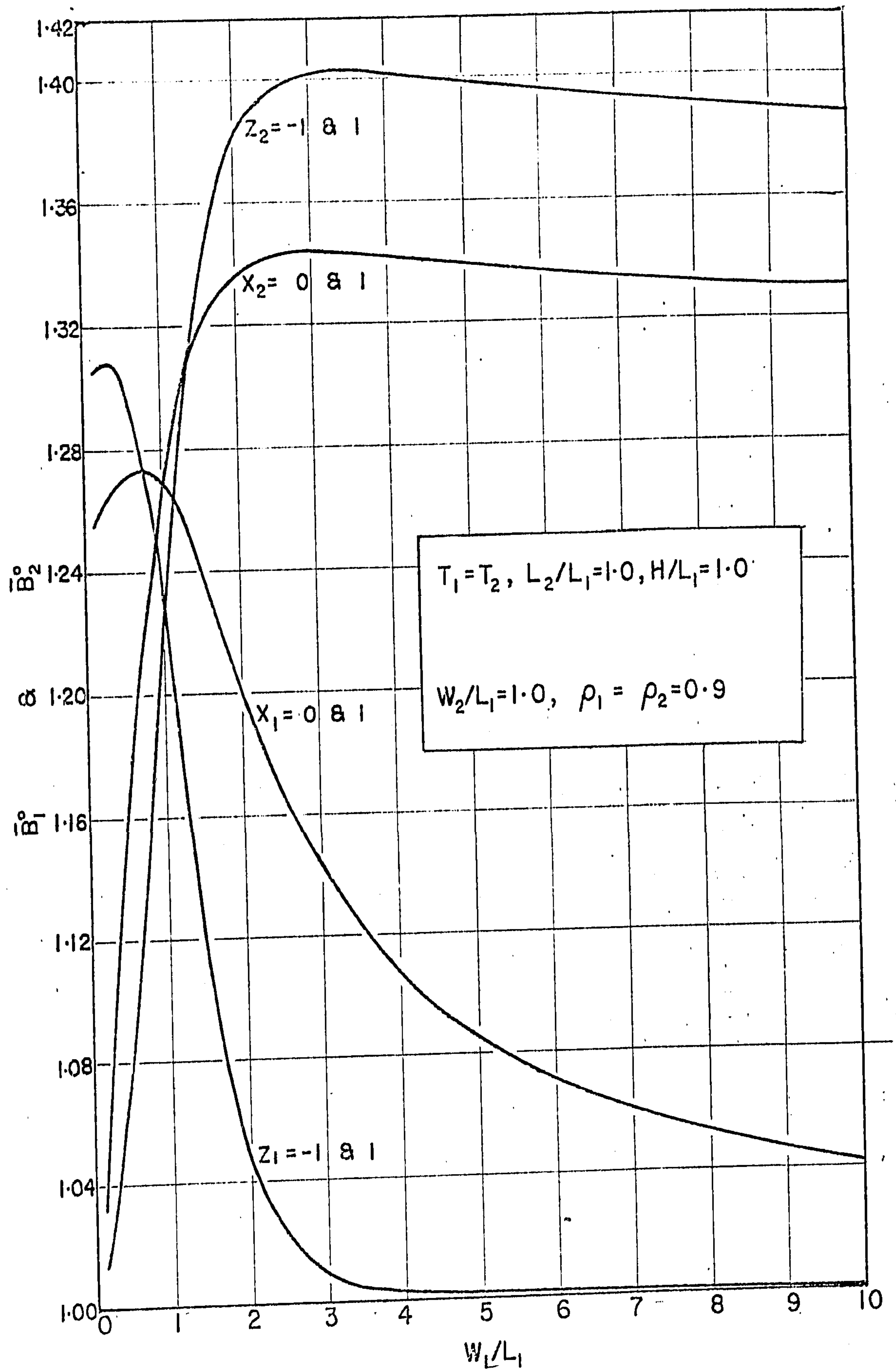


Figure 23 Zero-order mean radiosity versus width to length ratio

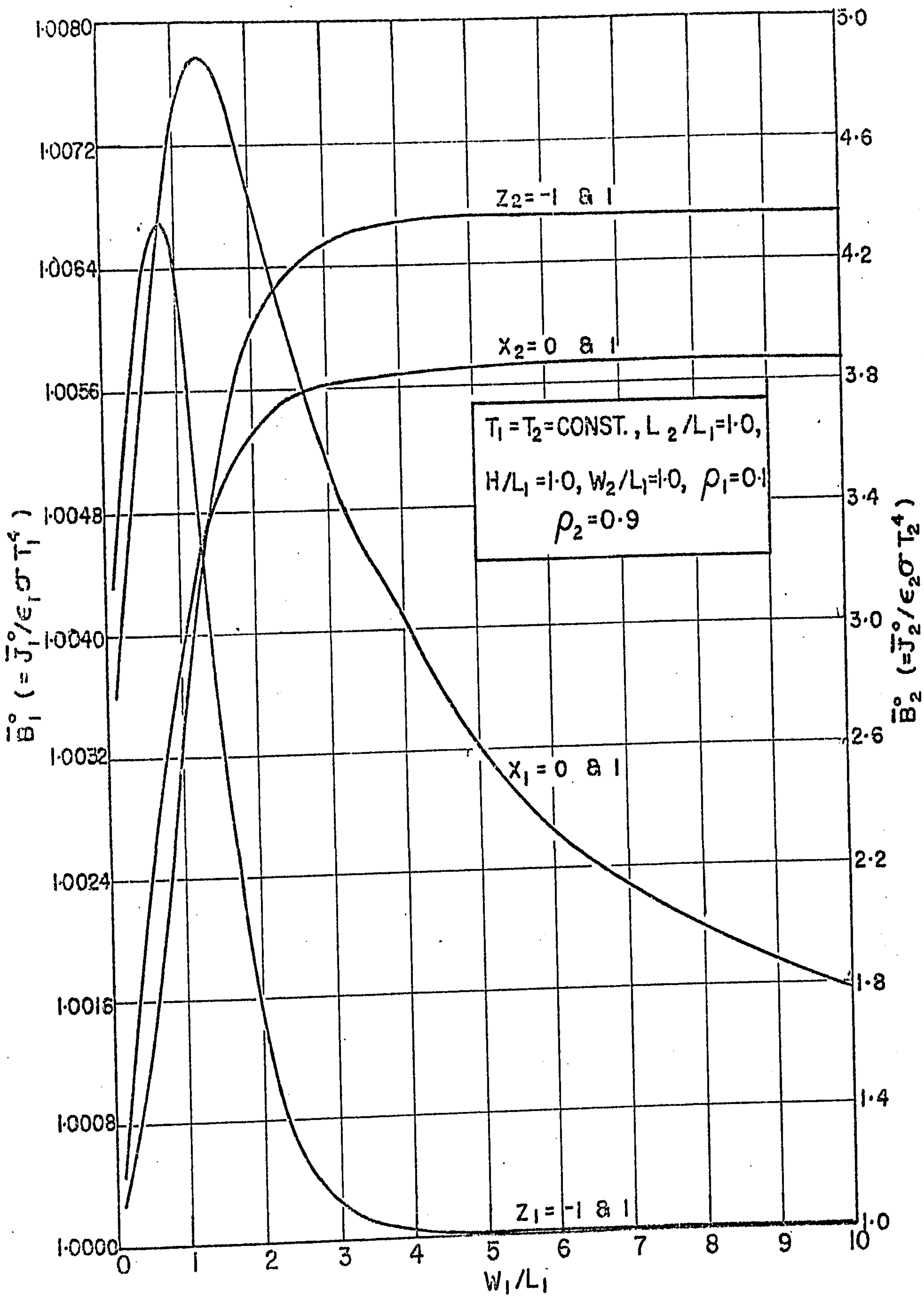


Figure 30 Zero-order mean radiosity versus width to length ratio

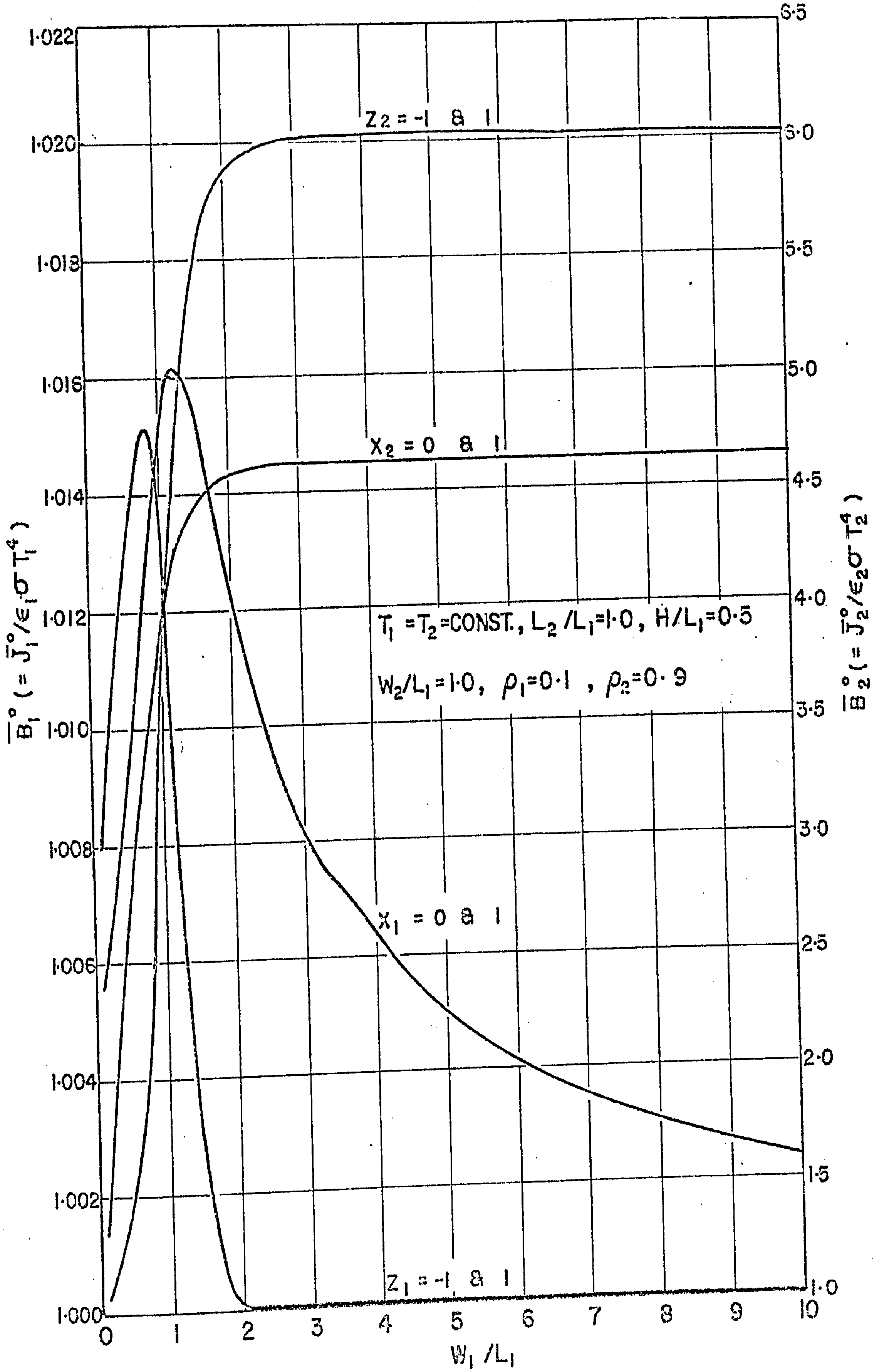


Figure 31 Zero-order mean radiosity versus width to length ratio

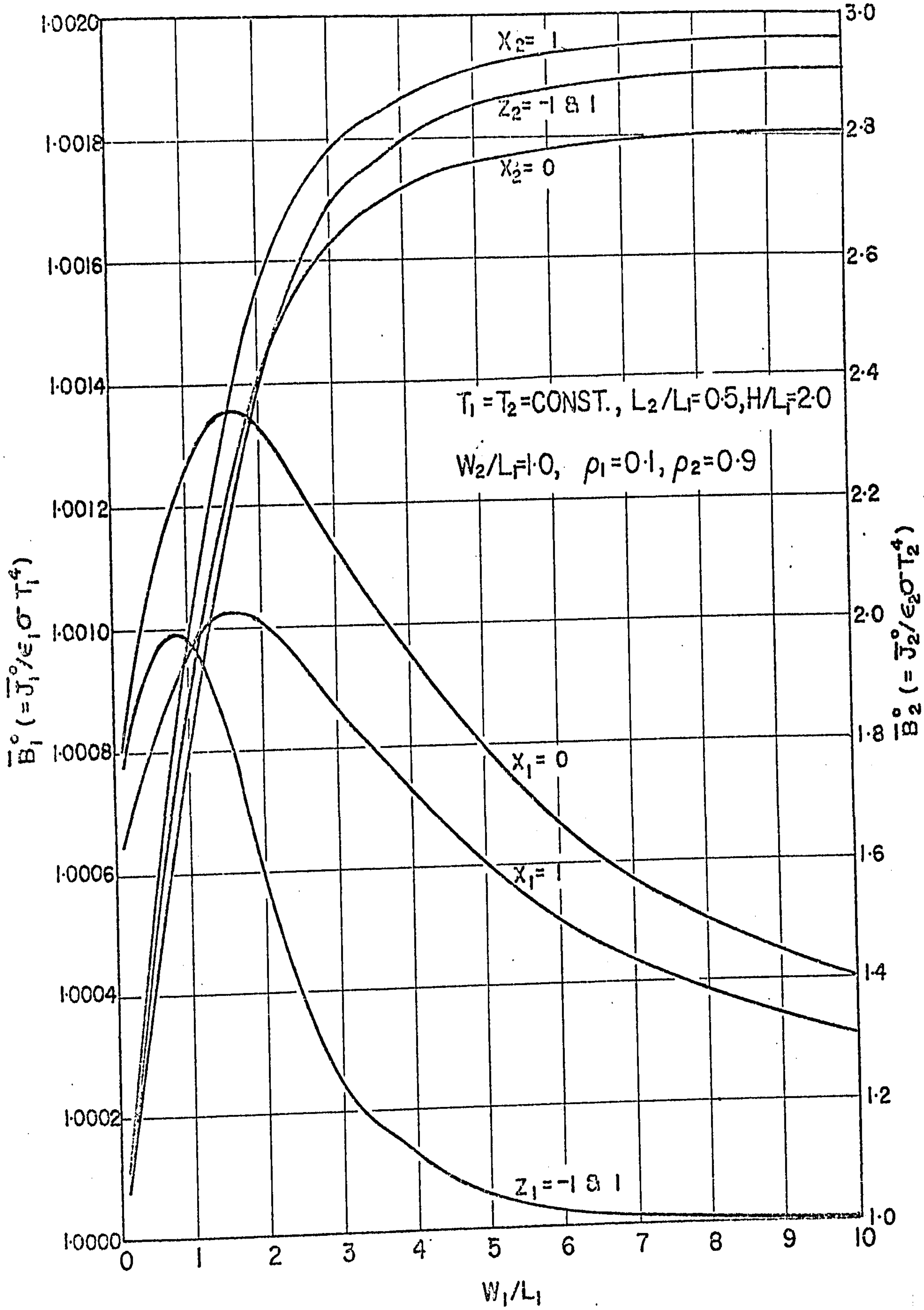


Figure 32 Zero-order mean radiosity versus width to length ratio

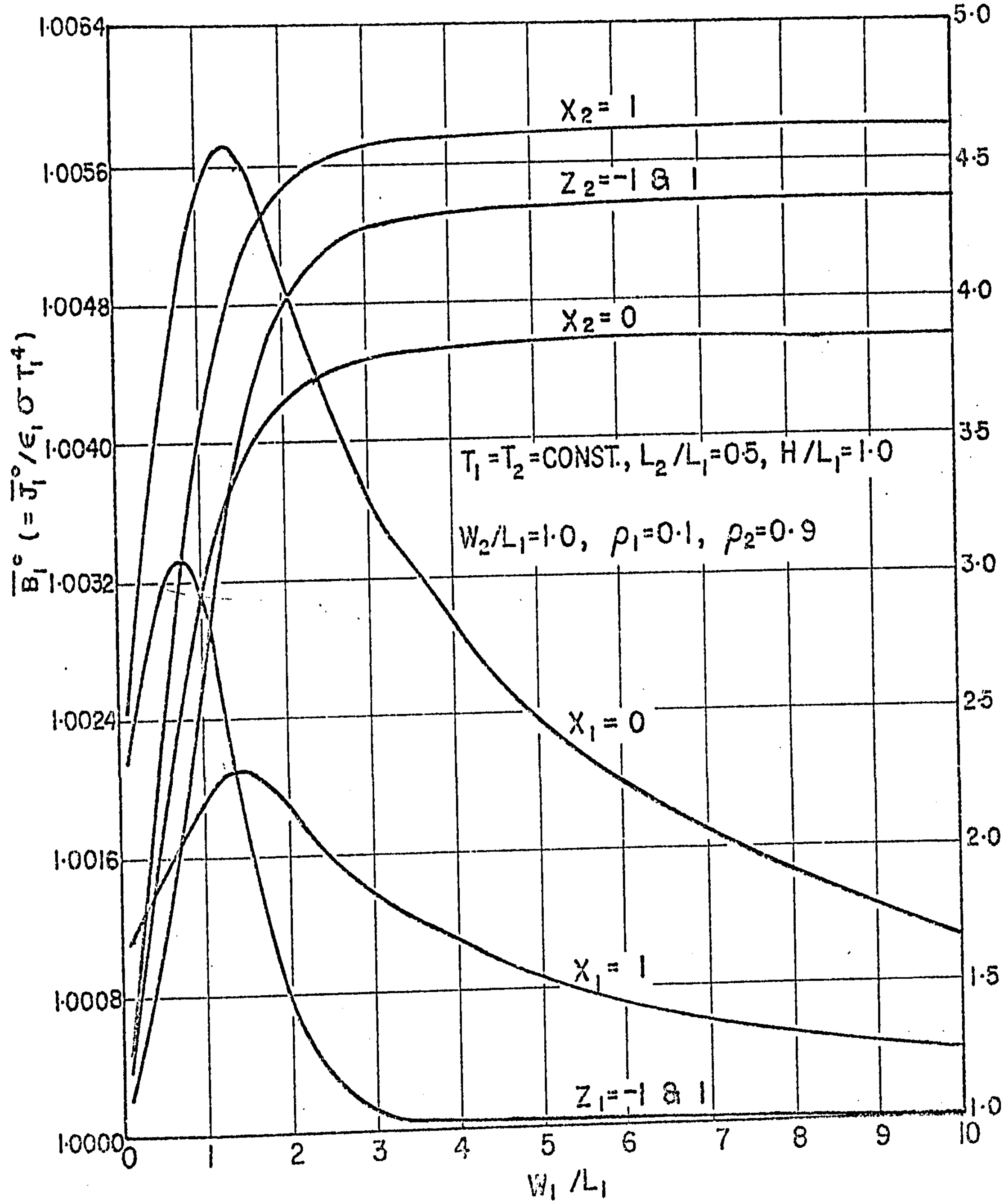


Figure 33 Z Zero-order mean radiosity versus width to length ratio

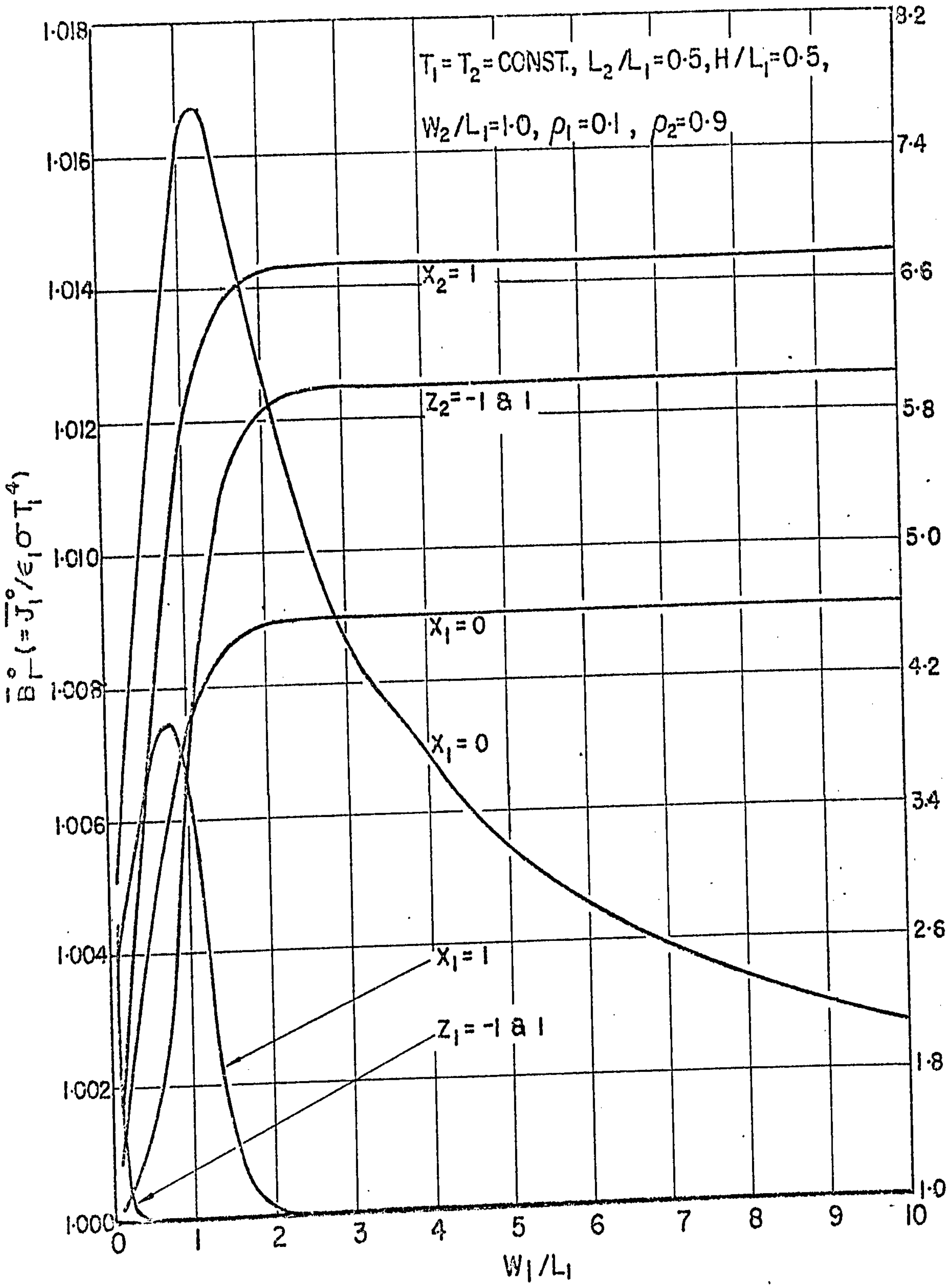


Figure 34 Zero-order mean radiosity versus width to length ratio

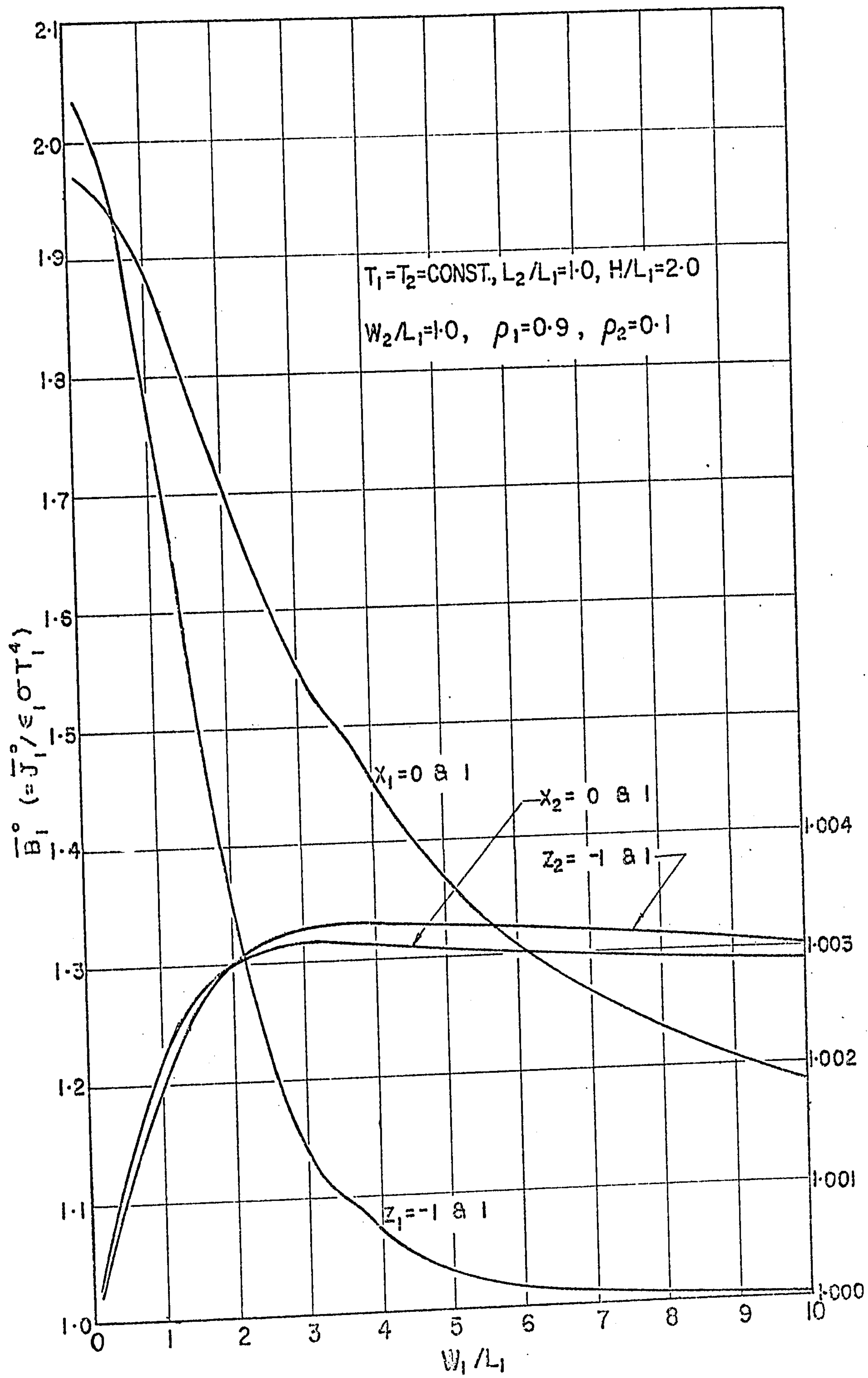


Figure 35 Zero-order mean radiosity versus width to length ratio

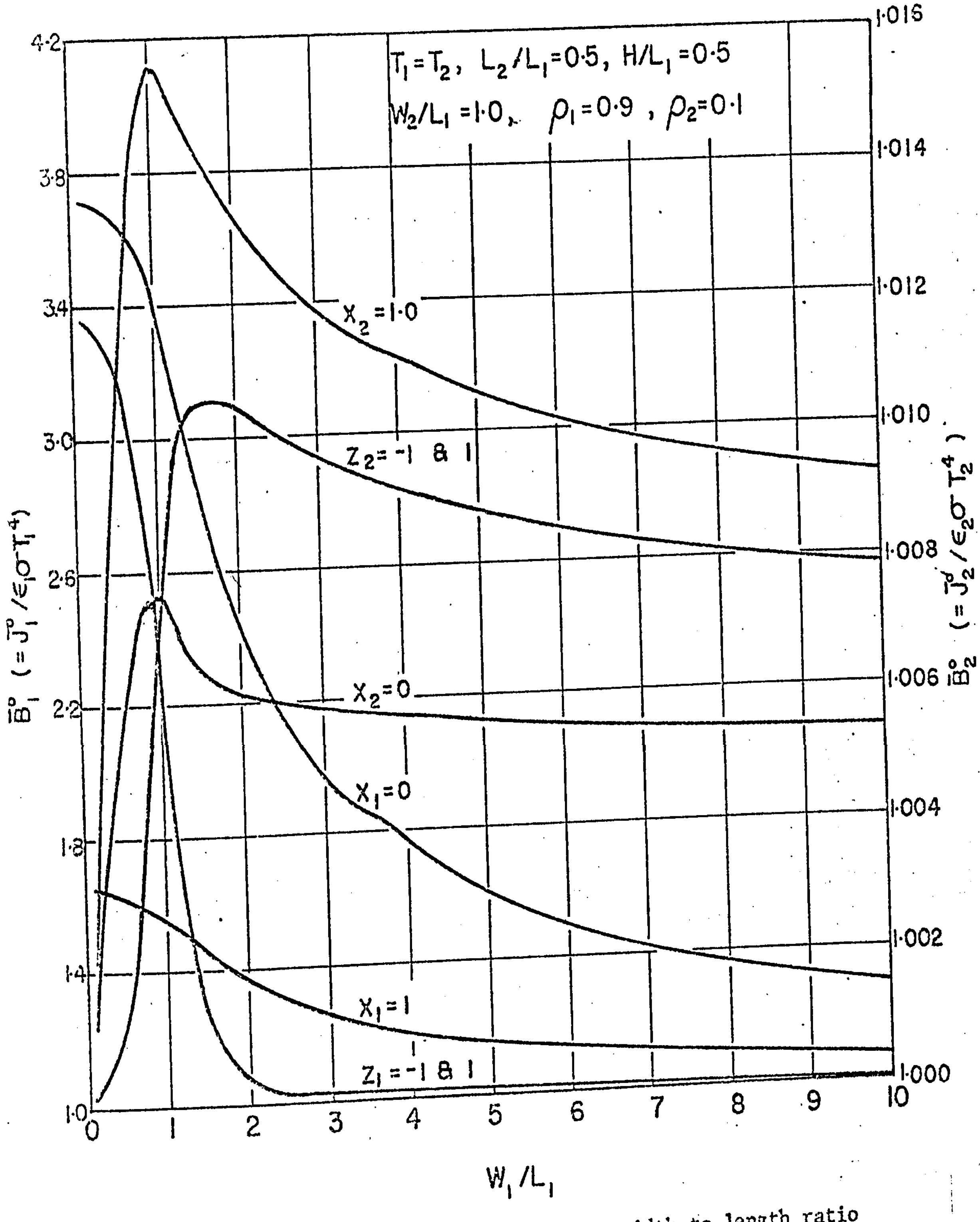


Figure 36 Zero-order mean radiosity versus width to length ratio

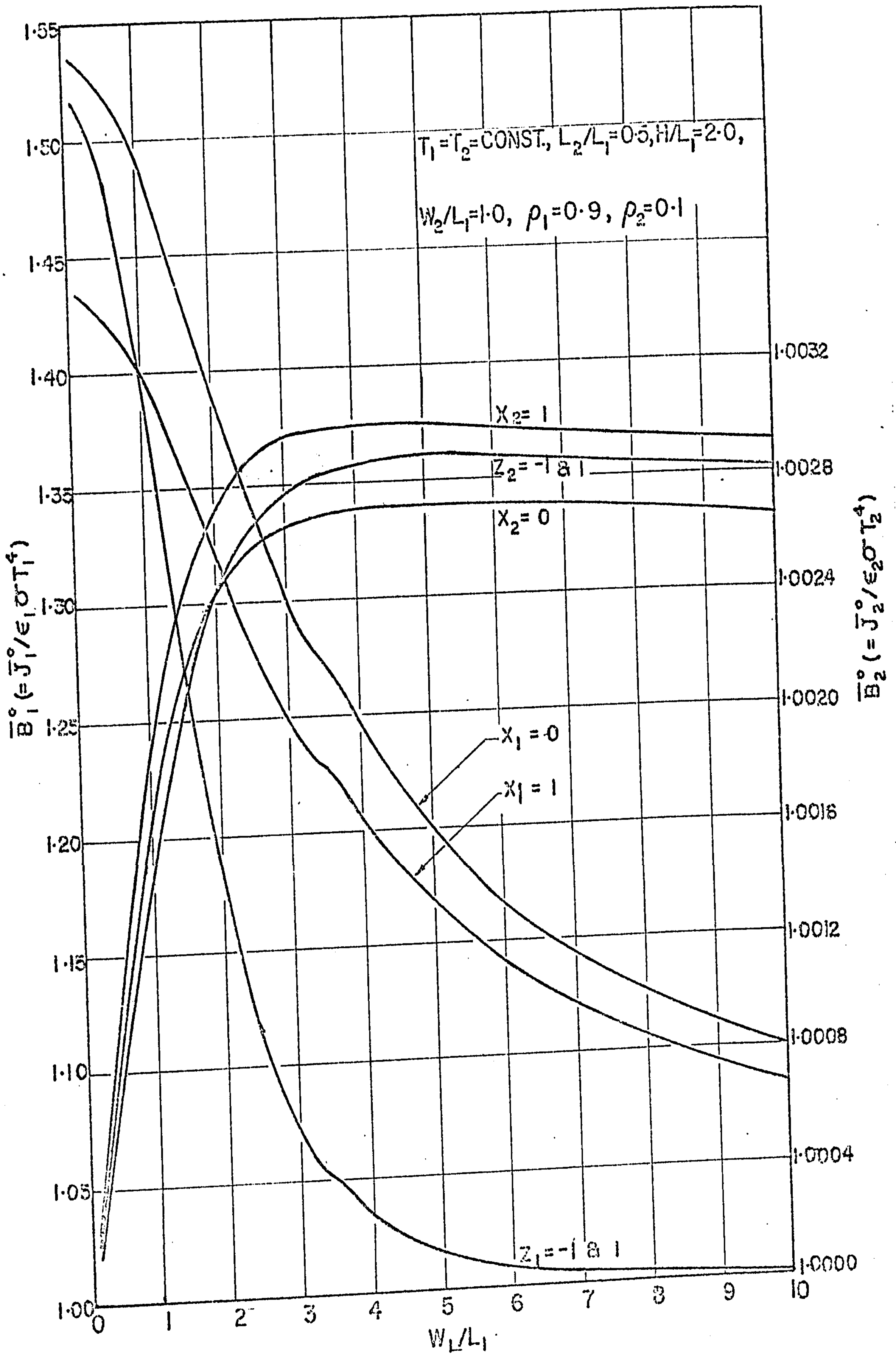


Figure 37 Zero-order mean radiosity versus width to length ratio

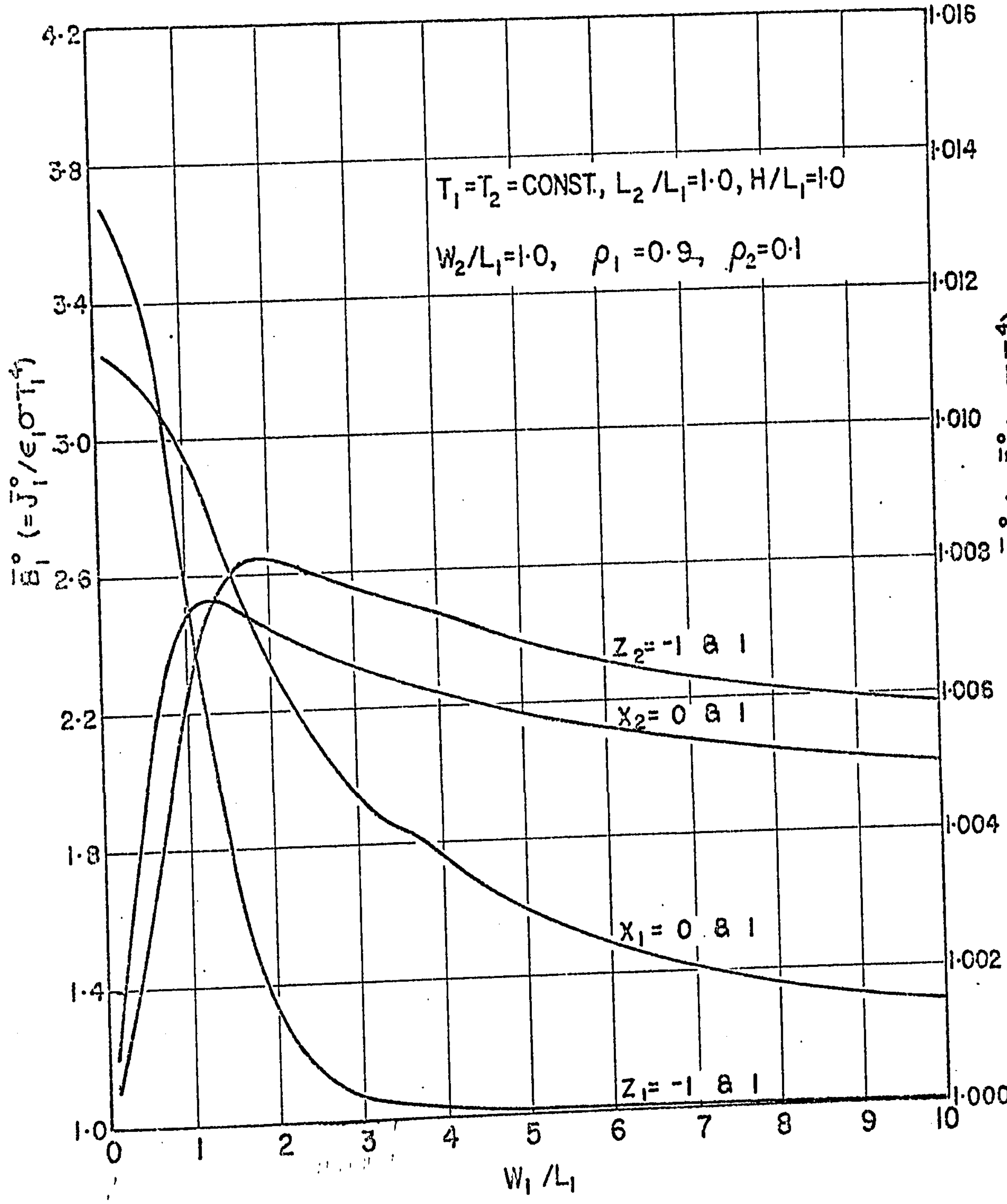


Figure 38 Zero-order mean radiosity versus width to length ratio

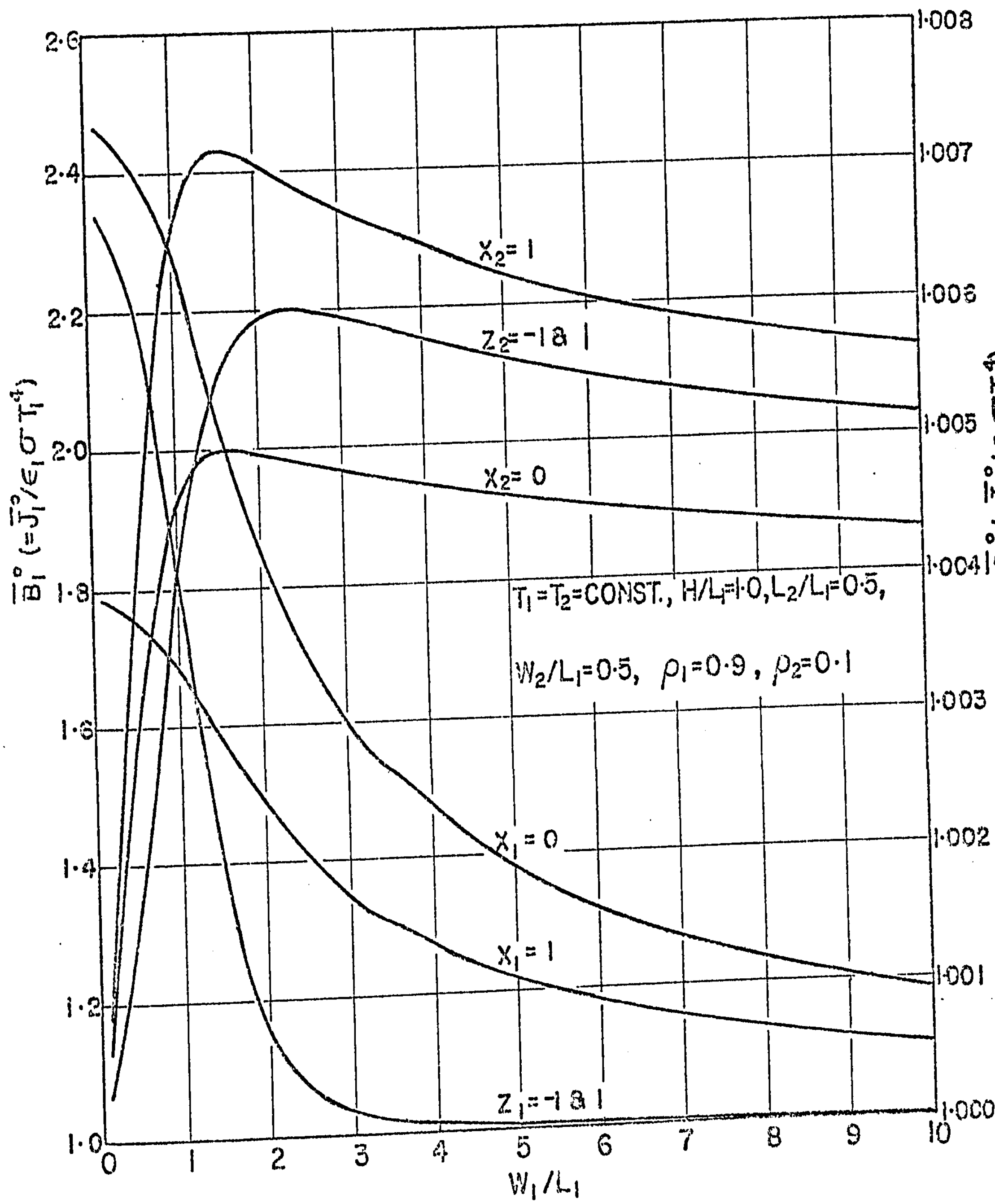


Figure 39 Zero-order mean radiosity versus width to length ratio

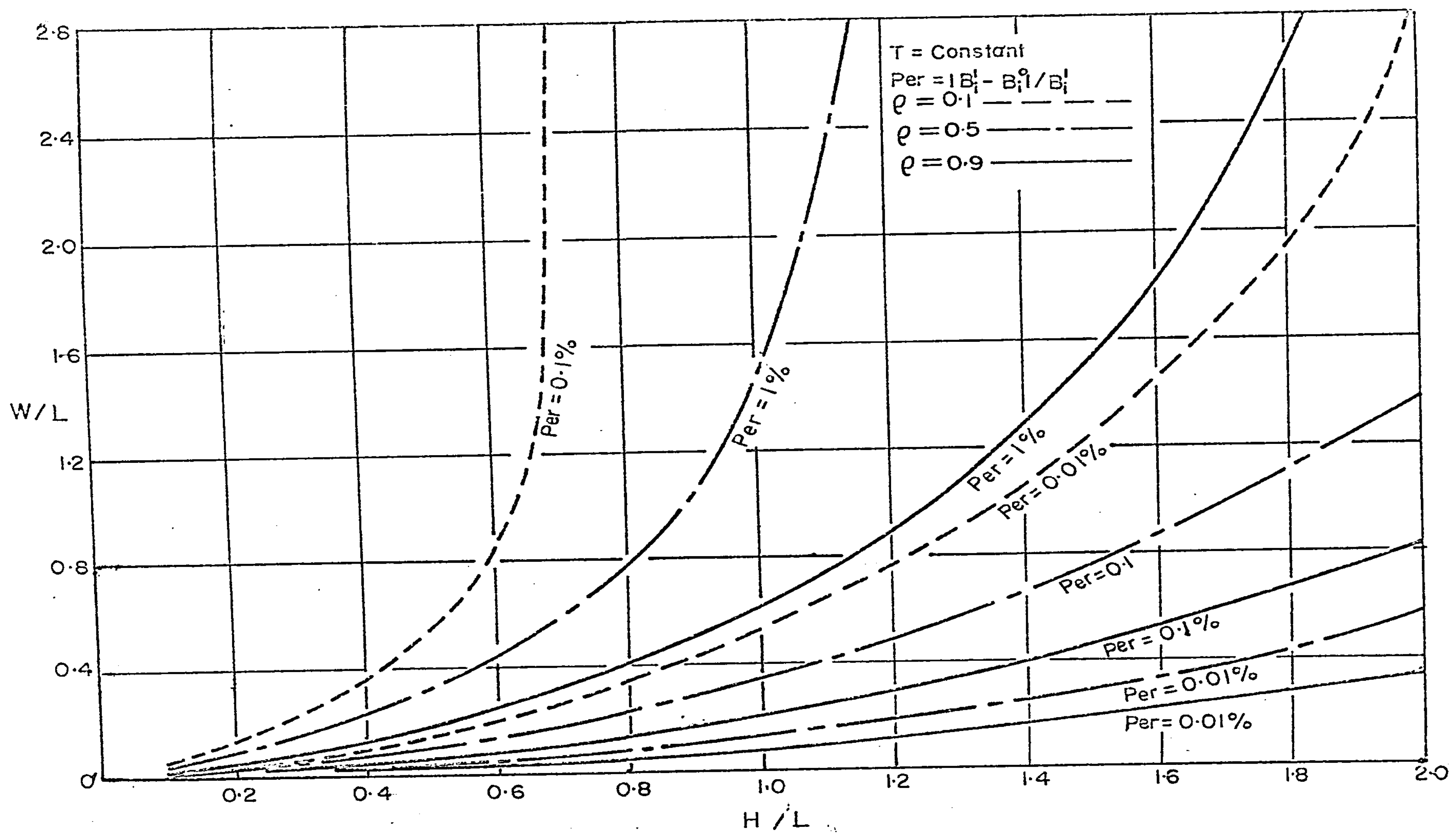


Fig. 40 Limits of validity of zero-order solution

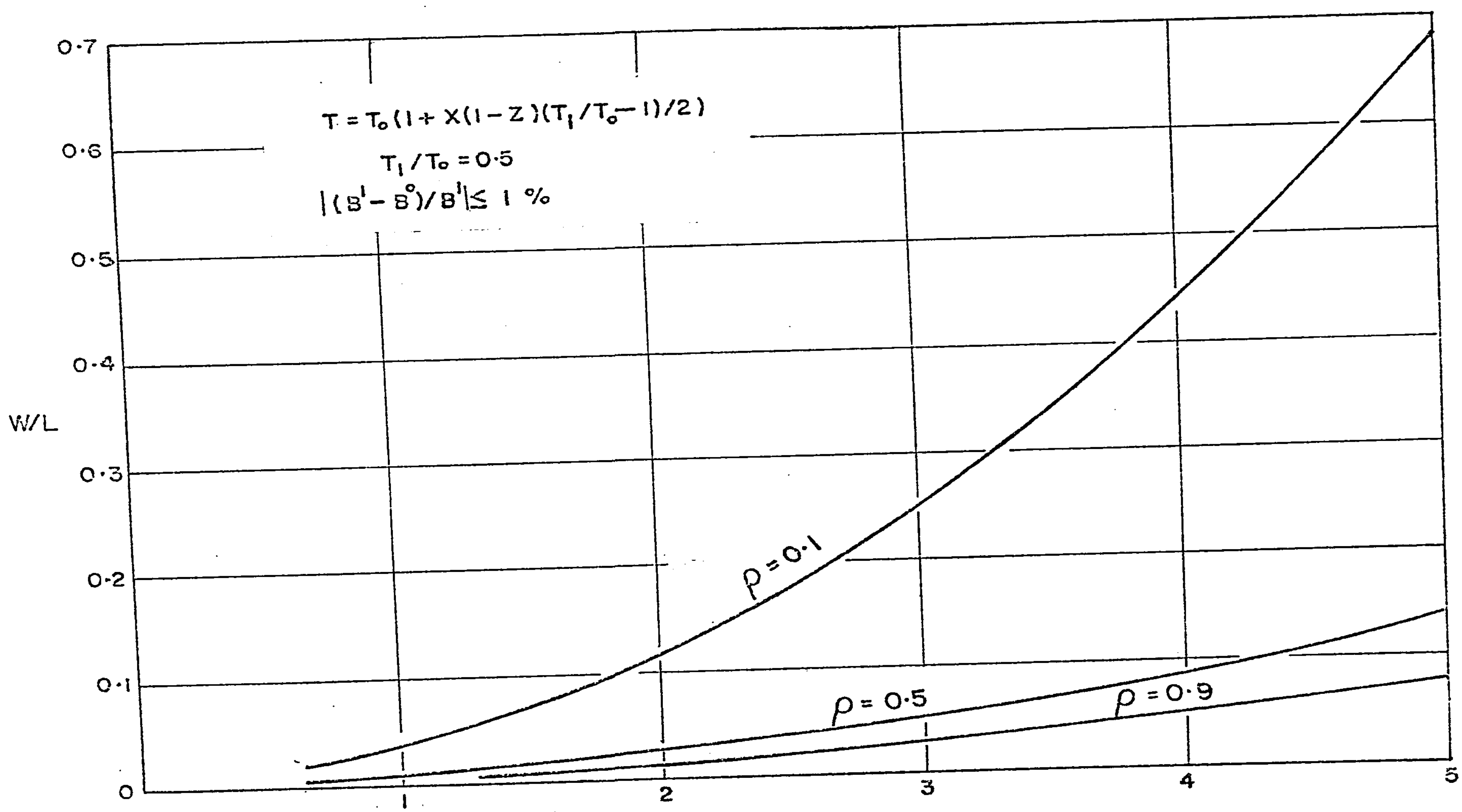


Fig. 42 Limits of validity of zero-order solution

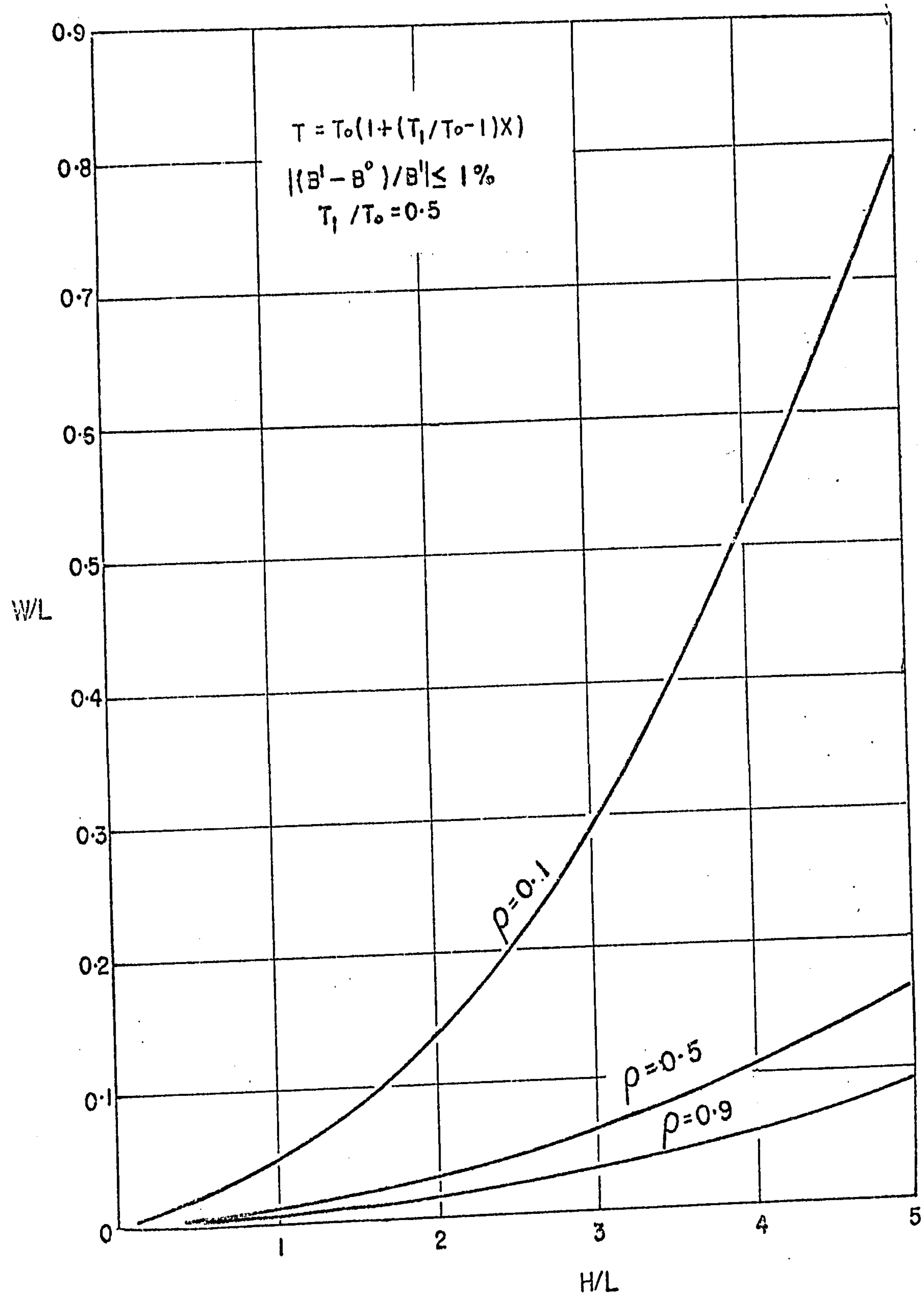


Fig. 41 Limits of validity of zero-order solution