The remaining notation is standard. Indices: c, countercurrent; p, forward current; o, initial value; in, value at the entrance; out, value at the exit; e, positive end of the column; i, negative end of the column.

LITERATURE CITED

1. USA Patent No. 2827171 (1958).
2. D. Frazier, Ind. Eng. Chem., No. 4, 237 (1962).
3. K. Jones and W. Ferry, Isotope Separation by Thermodiffusion [Russian translation], IL, Moscow (1947).
4. K. Aleksander, Usp. Fiz. Nauk, 76, No. 4, 711 (1962).
5. G. D. Rabinovich, R. Ya. Gurevich, and G. I. Bobrova, Thermodiffusion Separation of Liquid Mixtures [in Russian], Nauka i Tekhnika, Minsk (1971).

FREE CONVECTION OF GAS MIXTURE ABOVE A FLAT HORIZONTAL PLATE IN CONSTANT-VELOCITY FLOW

A. A. Pirozhenko

UDC 536.253

The problem of mixed convection for a mixture of viscous heat-conducting gases above a horizontal plate is solved by using the method of integral relations.

§ 1. In the present article the flow of a mixture of heat-conducting gases past a flat horizontal plate heated to a high temperature is considered under the assumption that everywhere in the flow region there exists the derivative $\partial/\partial y \gg \partial/\partial x$. If one carries out the same estimates as in the boundary-layer theory, and bearing in mind that the pressure is a resulting force, that is, it is of the order of the forces applied to the system, the following system of equations governing the proposed flow model is obtained:

$$\frac{\partial \rho v_x}{\partial x} + \frac{\partial \rho v_y}{\partial y} = 0; \tag{1.1}$$

$$\rho v_x \frac{\partial v_x}{\partial x} + \rho v_y \frac{\partial v_x}{\partial y} = -\frac{\partial P}{\partial x} + \frac{\partial}{\partial y} \mu \frac{\partial v_x}{\partial y}; \tag{1.2}$$

$$0 = -\frac{\partial P}{\partial y} + \rho F_y; \tag{1.3}$$

$$\rho v_x \frac{\partial h}{\partial x} + \rho v_y \frac{\partial h}{\partial y} = -\frac{\partial q_y}{\partial y} + v_x \frac{\partial P}{\partial x} + v_y \frac{\partial P}{\partial y} + \mu \left(\frac{\partial v_x}{\partial y} \right)^2; \tag{1.4}$$

$$\rho v_x \frac{\partial c_\alpha}{\partial x} + \rho v_y \frac{\partial c_\alpha}{\partial y} = -\frac{\partial}{\partial y} j_{\alpha y}, \quad \alpha = 1, 2, \ldots, N-1, \tag{1.5}$$

where

$$\sum_{\alpha=1}^{N} c_\alpha = 1, \quad h = \sum_{\alpha=1}^{N} c_\alpha h_\alpha, \quad \left(\frac{\partial h_\alpha}{\partial T} \right)_P = C_{P_\alpha}, \quad \sum_{\alpha=1}^{N} c_\alpha C_{P_\alpha} = \overline{C}_P.$$

If in the original gas mixture the concentration of one gas is much higher than that of the other gases, then by using the independent diffusion approximation and by bearing in mind that the term governing the effect of the pressure diffusion is small, one obtains for the diffusion-flow vector of the α-component

$$\overline{j}_\alpha = -\rho D_{1\alpha} \left(\nabla c_\alpha + \frac{k_{T_\alpha}}{T} \nabla T \right), \tag{1.6}$$

Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 31, No. 3, pp. 523-530, September, 1976. Original article submitted June 30, 1975.

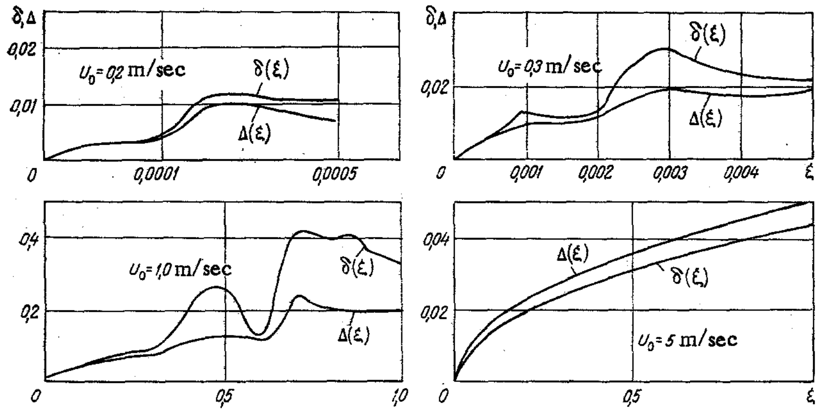

Fig. 1. The dynamic $\delta(\xi)$ and the thermal $\Delta(\xi)$ boundary layers above a horizontal plate at different incoming flow rates; $\delta(\xi)$, $\Delta(\xi)$, m; ξ, m.

and for the heat flux vector

$$\bar{q} = -\varkappa\nabla T + \sum_{\alpha=1}^{N} h_\alpha \bar{j}_\alpha. \tag{1.7}$$

To be able to close the system of equations (1.1)-(1.7) one must add to it the equation of the thermodynamic state of the gas mixture, which in the case of a mixture of thermally nondegenerate gases is given by

$$P = \sum_{\alpha=1}^{N} P_\alpha = \rho R_0 T \sum_{\alpha=1}^{N} \frac{c_\alpha}{M_\alpha} = \rho R_{ef} T. \tag{1.8}$$

The latter is now rewritten in the form of a general function:

$$\rho = \rho(P,\ T,\ c_\alpha), \qquad \alpha = 1,\ 2,\ \ldots,\ N-1. \tag{1.9}$$

In this case one has

$$d\rho = \left(\frac{\partial\rho}{\partial P}\right)_{T,c_\alpha} dP + \left(\frac{\partial\rho}{\partial T}\right)_{P,c_\alpha} dT + \sum_{\alpha=1}^{N-1}\left(\frac{\partial\rho}{\partial c_\alpha}\right)_{T,P,c_\beta\,\beta\neq\alpha} dc_\alpha$$

$$= \alpha\rho dP - \bar{\beta}_T h_0 \rho d\vartheta - \rho\sum_{\alpha=1}^{N-1}\beta_{c_\alpha}(c_{\alpha W} - c_{\alpha 0})\, dc''_\alpha, \tag{1.10}$$

where

$$\vartheta = \frac{h}{h_0} - 1, \quad \bar{\beta}_T = \frac{\beta_T}{C_P}, \quad \beta_{c_\alpha} = -\frac{1}{\rho}\left(\frac{\partial\rho}{\partial c_\alpha}\right)_{T,P,c_\beta\,\beta\neq\alpha}.$$

By introducing the Dorodnitsyn variables

$$\xi = x, \ \eta = \int_0^y \frac{\rho}{\rho_\infty} dy,$$

one can rewrite the original system of equations in the form

$$\frac{\partial v_x}{\partial\xi} + \frac{\partial V_y}{\partial\eta} = 0; \tag{1.11}$$

$$v_x \frac{\partial v_x}{\partial\xi} + V_y \frac{\partial v_x}{\partial\eta} = \frac{g}{\rho}\int_0^y \frac{\partial\rho}{\partial x} dy + \nu_\infty \frac{\partial}{\partial\eta} K \frac{\partial v_x}{\partial\eta}; \tag{1.12}$$

$$v_x \frac{\partial\vartheta}{\partial\xi} + V_y \frac{\partial\vartheta}{\partial\eta} = \nu_\infty \frac{\partial}{\partial\eta}\frac{K}{\mathrm{Pr}}\left[\frac{\partial\vartheta}{\partial\eta} + \sum_{\alpha=1}^{N-1}(\mathrm{Le}_\alpha - 1)\right.$$

$$\times\left(\frac{h_\alpha}{h_0}-\frac{h_N}{h_0}\right)(c_{\alpha W}-c_{\alpha 0})\frac{\partial c''_\alpha}{\partial\eta}\Bigg]+\nu_\infty\frac{\partial}{\partial\eta}\frac{K}{h_0}\Bigg\{\sum_{\alpha=1}^{N-1}\frac{k_{T\alpha}}{\mathrm{Sc}_\alpha}$$

$$\times\frac{(h_\alpha-h_N)}{h}\left[h_0\frac{\partial\vartheta}{\partial\eta}-\sum_{\beta=1}^{N-1}(h_\beta-h_N)(c_{\beta W}-c_{\beta 0})\frac{\partial c''_\beta}{\partial\eta}\right]\Bigg\}-\frac{\Phi_\Sigma}{h_0};\tag{1.13}$$

$$v_x\frac{\partial c''_\alpha}{\partial\xi}+V_y\frac{\partial c''_\alpha}{\partial\eta}=\nu_\infty\frac{\partial}{\partial\eta}\frac{K}{\mathrm{Sc}_\alpha}\frac{\partial c''_\alpha}{\partial\eta}-\frac{\nu_\infty}{(c_{\alpha W}-c_{\alpha 0})}\frac{\partial}{\partial\eta}\frac{K}{\mathrm{Sc}_\alpha}\frac{k_{T\alpha}}{h}$$

$$\times\left[h_0\frac{\partial\vartheta}{\partial\eta}-\sum_{\alpha=1}^{N-1}(h_\alpha-h_N)(c_{\alpha W}-c_{\alpha 0})\frac{\partial c''_\alpha}{\partial\eta}\right].\tag{1.14}$$

In the above

$$\mathrm{Pr}=\frac{\overline{C}_P\mu}{\varkappa};\ \mathrm{Sc}_\alpha=\frac{\mu}{\rho D_{1\alpha}};\ \mathrm{Le}_\alpha=\frac{\rho\overline{C}_P D_{1\alpha}}{\varkappa};\ K=\frac{\mu\rho}{\mu_\infty\rho_\infty};$$

$$\nu_\infty=\frac{\mu_\infty}{\rho_\infty},\quad \Phi_\Sigma=\frac{v_x g}{\rho}\int_0^y\frac{\partial\rho}{\partial x}dy+gv_y-K\nu_\infty\left(\frac{\partial v_x}{\partial\eta}\right)^2;$$

$$V_y=\frac{\rho}{\rho_\infty}v_y+v_x\frac{\partial\eta}{\partial x},\quad P(x,\ y)=P(x,\ 0)-\int_0^y\rho g dy,$$

and one sets approximately $P(x,\ 0)$ = const, h_0 = const.

To obtain a unique solution one has to add to the system of equations (1.11)-(1.14) a system of boundary conditions which for the flow-past problems is given by

$$\eta=0;\quad v_x=0;\quad V_y=0;\quad \vartheta=\vartheta_W;\quad c_\alpha=c_{\alpha W},\quad \alpha=1,\ 2,\ \ldots,\ N-1;$$

$$\eta=\delta;\quad v_x=U_0;$$

$$\eta=\Delta;\quad \vartheta=0;$$

$$\eta=\delta_{c_\alpha};\quad c_\alpha=c_{\alpha_0};\quad \alpha=1,\ 2,\ \ldots,\ N-1.\tag{1.15}$$

§ 2. One seeks the solution of the system of equations (1.11)-(1.14) together with the boundary conditions (1.15) by employing the method of integral relations. By limiting our considerations to the polynomials of the third degree and by regarding Eqs. (1.11)-(1.14) as valid up to the boundary, one obtains, with the use of (1.15),

$$\frac{v_x}{U_0}=[1-(1-\bar\eta)^3];\quad \vartheta=\vartheta_W(1-\bar\eta_T)^3;\quad c''_\alpha=(1-\bar\eta_\alpha)^3;$$

$$\bar\eta=\frac{\eta}{\delta(\xi)};\quad \bar\eta_T=\frac{\eta}{\Delta(\xi)};\quad \bar\eta_\alpha=\frac{\eta}{\delta_{c_\alpha}},\tag{2.1}$$

and to find the unknown thickness of the boundary layers δ, Δ, δ_{c_1}, δ_{c_2}, $\ldots$, $\delta_{c_{N-1}}$ one obtains the following system of ordinary nonlinear differential equations of the first order:

$$\delta\frac{d\delta}{d\xi}=\frac{X_1+X_2}{X_3};\tag{2.2}$$

$$\Delta\frac{d\Delta}{d\xi}=\frac{Y_1+Y_2\delta\frac{d\delta}{d\xi}}{Y_3};\tag{2.3}$$

$$\delta_{c_\alpha}\frac{d\delta_{c_\alpha}}{d\xi}=\frac{Z_{\alpha 1}+Z_{\alpha 2}\delta\frac{d\delta}{d\xi}}{Z_{\alpha 3}};\tag{2.4}$$

$$Y_1=\frac{3\nu_\infty}{U_0}Y_T^3\left[\frac{K_W}{\mathrm{Pr}}-\frac{f_{T1}(Y_T,\ Y_{c_\alpha})}{\vartheta_W}+f_{T2}(Y_{c_\alpha},\ Y_T)\right];$$

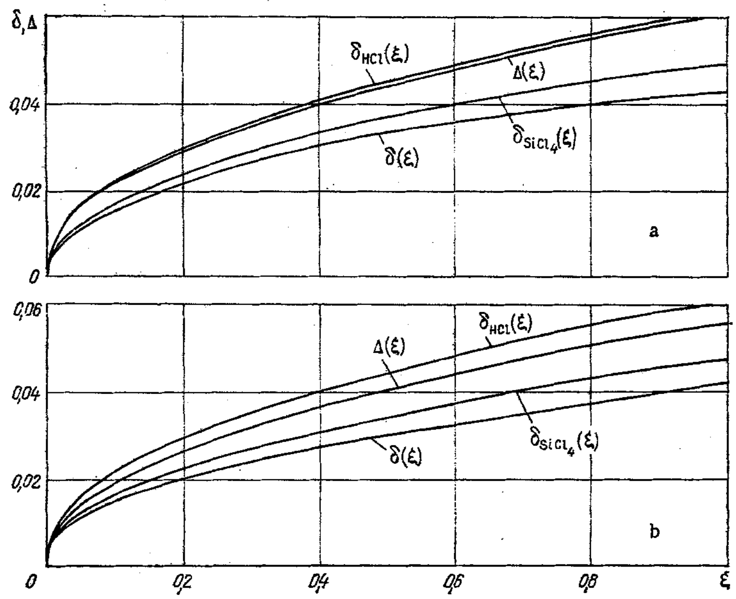

Fig. 2. Dynamic $\delta(\xi)$, thermal $\Delta(\xi)$, and concentration δ_{SiCl_4}, δ_{HCl} boundary layers above the horizontal plate at flow rates $U_0 = 1$ m/sec; a) no thermal diffusion; b) with thermal diffusion $\delta(\xi)$, $\Delta(\xi)$, δ_{HCl}, δ_{SiCl_4}, ξ, m.

$$Y_2=\left(\frac{3}{20}-\frac{1}{10Y_T}+\frac{3}{140Y_T^2}\right);\quad Y_3=\left(\frac{3}{10}-\frac{3}{20Y_T}+\frac{1}{35Y_T^2}\right);$$

$$Z_{\alpha1}=\frac{3\nu_\infty}{U_0}Y_{c_\alpha}^3\left[\frac{K_W}{\mathrm{Sc}_\alpha}-f_D(Y_T,\,Y_{c_\alpha})\right];$$

$$Z_{\alpha2}=\left(\frac{3}{20}-\frac{1}{10Y_{c_\alpha}}+\frac{3}{140Y_{c_\alpha}^2}\right);\quad Z_{\alpha3}=\left(\frac{3}{10}-\frac{3}{20Y_{c_\alpha}}+\frac{1}{35Y_{c_\alpha}^2}\right);$$

$$X_1=3\nu_\infty K_W U_0;\quad X_2=\frac{3}{4}\,\delta\,\frac{\rho_\infty g}{\rho_0}\left[K_T f_G(Y_T,\,Y_{c_\alpha},\,K_T,\,K_{c_\alpha})Y_T^3\frac{Y_1}{Y_3}\right.$$

$$\left.+\sum_{\alpha=1}^{N-1}K_{c_\alpha}f_\alpha(Y_T,\,Y_{c_\alpha},\,K_T,\,K_{c_\alpha})Y_{c_\alpha}^3\frac{Z_{\alpha1}}{Z_{\alpha3}}\right];$$

$$X_3=\frac{3}{28}U_0^2-\frac{3}{4}\,\delta\,\frac{\rho_\infty g}{\rho_0}\left[K_T f_G(Y_T,\,Y_{c_\alpha},\,K_T,\,K_{c_\alpha})Y_T^3\frac{Y_2}{Y_3}\right.$$

$$\left.+\sum_{\alpha=1}^{N-1}K_{c_\alpha}f_\alpha(Y_T,\,Y_{c_\alpha},\,K_T,\,K_{c_\alpha})Y_{c_\alpha}^3\frac{Z_{\alpha2}}{Z_{\alpha3}}\right];$$

$$f_G(Y_T,\,Y_{c_\alpha},\,K_T,\,K_{c_\alpha})=\left\{\left(\frac{2}{3}-\frac{2}{3}Y_T+\frac{Y_T^2}{5}\right)\right.$$

$$+K_T\left(\frac{2}{3}-\frac{13}{6}Y_T+3Y_T^2-\frac{13}{6}Y_T^3+\frac{17}{21}Y_T^4-\frac{Y_T^5}{8}\right)$$

$$+\sum_{\alpha=1}^{N-1}K_{c_\alpha}\left[\frac{2}{3}-\frac{1}{4}\left(\frac{8}{3}+6\frac{Y_{c_\alpha}}{Y_T}\right)Y_T+\frac{1}{5}\left(1+8\frac{Y_{c_\alpha}}{Y_T}\right.\right.$$

$$\left.+6\frac{Y_{c_\alpha}^2}{Y_T^2}\right)Y_T^2-\frac{1}{6}\left(\frac{3Y_{c_\alpha}}{Y_T}+\frac{8Y_{c_\alpha}^2}{Y_T^2}+\frac{2Y_{c_\alpha}^3}{Y_T^3}\right)Y_T^3$$

$$\left.\left.+\frac{1}{7}\left(\frac{3Y_{c_\alpha}^2}{Y_T^2}+\frac{8}{3}\frac{Y_{c_\alpha}^3}{Y_T^3}\right)Y_T^4-\frac{Y_{c_\alpha}^3}{Y_T^3}\frac{Y_T^5}{8}\right]\right\};$$

$$f_\alpha(Y_T,\ Y_{c_\alpha},\ K_T,\ K_{c_\alpha}) = \Bigg\{ \left(\frac{2}{3} - \frac{2}{3} Y_{c_\alpha} + \frac{Y^2_{c_\alpha}}{5} \right)$$

$$+K_T \left[\frac{2}{3} - \frac{1}{4} \left(\frac{8}{3} + \frac{6Y_T}{Y_{c_\alpha}} \right) Y_{c_\alpha} + \frac{1}{5} \left(1 + 8\frac{Y_T}{Y_{c_\alpha}} + 6\frac{Y_T^2}{Y^2_{c_\alpha}} \right) Y^2_{c_\alpha} \right.$$

$$- \frac{1}{6} \left(\frac{3Y_T}{Y_{c_\alpha}} + \frac{8Y_T^2}{Y^2_{c_\alpha}} + \frac{2Y_T^3}{Y^3_{c_\alpha}} \right) Y^3_{c_\alpha} + \frac{1}{7} \left(\frac{3Y_T^3}{Y^2_{c_\alpha}} \right.$$

$$\left.\left. + \frac{8}{3} \frac{Y_T^3}{Y^3_{c_\alpha}} \right) Y^4_{c_\alpha} - \frac{Y_T^3}{Y^3_{c_\alpha}} \frac{Y^5_{c_\alpha}}{8} \right] + \sum_{\beta=1}^{N-1} K_{c_\beta} \left[\frac{2}{3} \right.$$

$$- \frac{1}{4} \left(\frac{8}{3} + \frac{6Y_{c_\beta}}{Y_{c_\alpha}} \right) Y_{c_\alpha} + \frac{1}{5} \left(1 + \frac{8Y_{c_\beta}}{Y_{c_\alpha}} + 6\frac{Y^2_{c_\beta}}{Y^2_{c_\alpha}} \right) Y^2_{c_\alpha}$$

$$- \frac{1}{6} \left(\frac{3Y_{c_\beta}}{Y_{c_\alpha}} + \frac{8Y^2_{c_\beta}}{Y^2_{c_\alpha}} + \frac{2Y^3_{c_\beta}}{Y^3_{c_\alpha}} \right) Y^3_{c_\alpha}$$

$$\left.\left. + \frac{1}{7} \left(\frac{3Y^2_{c_\beta}}{Y^2_{c_\alpha}} + \frac{8}{3} \frac{Y^3_{c_\beta}}{Y^3_{c_\alpha}} \right) Y^4_{c_\alpha} - \frac{Y^3_{c_\beta}}{Y^3_{c_\alpha}} \frac{Y^5_{c_\alpha}}{8} \right] \right\};$$

$$f_{T1}(Y_T,\ Y_{c_\alpha}) = \sum_{\alpha=1}^{N-1} \left\{ \frac{K_0}{\mathrm{Pr}} \left[(\mathrm{Le}_\alpha - 1) \left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) \right]_0 \left(1 - \frac{Y_{c_\alpha}}{Y_T} \right)^2 \right.$$

$$\left. - \frac{K_W}{\mathrm{Pr}} \left[(\mathrm{Le}_\alpha - 1) \left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) \right]_W \right\} \frac{Y_{c_\alpha}}{Y_T} (c_{\alpha W} - c_{\alpha 0});$$

$$f_{T2}(Y_T,\ Y_{c_\alpha}) = \frac{K_W}{(\vartheta_W + 1)} \sum_{\alpha=1}^{N-1} \left[\frac{k_{T\alpha}}{\mathrm{Sc}_\alpha} \left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) \right]_W$$

$$+ \frac{K_0}{\vartheta_W} \sum_{\alpha=1}^{N-1} \left[\frac{k_{T\alpha}}{\mathrm{Sc}_\alpha} \left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) \right]_0 \sum_{\alpha=1}^{N-1} \left[\left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) (c_{\alpha W} - c_{\alpha 0}) \right.$$

$$\left. \times \left(1 - \frac{Y_{c_\alpha}}{Y_T} \right)^2 \frac{Y_{c_\alpha}}{Y_T} \right]_0 - \frac{K_W}{\vartheta_W (\vartheta_W + 1)} \sum_{\alpha=1}^{N-1} \left[\frac{k_{T\alpha}}{\mathrm{Sc}_\alpha} \left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) \right]_W$$

$$\times \sum_{\alpha=1}^{N-1} \left[\left(\frac{h_\alpha}{h_0} - \frac{h_N}{h_0} \right) (c_{\alpha W} - c_{\alpha 0}) \frac{Y_{c_\alpha}}{Y_T} \right]_W;$$

$$f_D(Y_T,\ Y_{c_\alpha}) = \frac{1}{(c_{\alpha W} - c_{\alpha 0})} \left\{ \frac{K}{\mathrm{Sc}_\alpha} \frac{k_{T\alpha}}{\left[\vartheta_W \left(1 - \frac{Y_T}{Y_{c_\alpha}} \right)^3 + 1 \right]} \right.$$

$$\times \left[\left(1 - \frac{Y_T}{Y_{c_\alpha}} \right)^2 \frac{Y_T}{Y_{c_\alpha}} + \sum_{\beta=1}^{N-1} \left(\frac{h_\beta}{h_0} - \frac{h_N}{h_0} \right) (c_{\beta W} - c_{\beta 0}) \right.$$

$$\left.\left. \times \left(1 - \frac{Y_{c_\beta}}{Y_{c_\alpha}} \right)^2 \frac{Y_{c_\beta}}{Y_{c_\alpha}} \right] \right\}_0 - \frac{1}{(c_{\alpha W} - c_{\alpha 0})}$$

$$\times \left\{ \frac{K}{\mathrm{Sc}_\alpha} \frac{k_{T\alpha}}{(\vartheta_W + 1)} \left[\frac{Y_T}{Y_{c_\alpha}} + \sum_{\beta=1}^{N-1} \left(\frac{h_\beta}{h_0} - \frac{h_N}{h_0} \right) (c_{\beta W} - c_{\beta 0}) \frac{Y_{c_\beta}}{Y_{c_\alpha}} \right] \right\}_W;$$

$$Y_T = \frac{\delta(\xi)}{\Delta(\xi)};\ Y_{c_\alpha} = \frac{\delta(\xi)}{\delta_{c_\alpha}(\xi)};\quad K_T = h_0 \langle \bar{\beta}_T \rangle \vartheta_W,\ K_{c_\alpha} = \langle \beta_{c_\alpha} \rangle (c_{\alpha W} - c_{\alpha 0}),$$

where the symbol < > indicates the mean values of the quantities and

$$\delta(0),\quad \Delta(0),\quad \delta_{c_1}(0),\quad \delta_{c_2}(0),\ \ldots,\ \delta_{c_{N-1}}(0)=0. \tag{2.5}$$

The solution of the system of equations (2.2)-(2.5) can be obtained numerically on an electronic computer by employing the standard Runge—Kutta procedure. In the neighborhood of the singular point $\xi = 0$ the known solution [1] was adopted as a solution for the flow of a viscous incompressible gas mixture.

§ 3. The computations of a flow past a horizontal plate were carried out both in the case of the flow of a single-component gas and for a multicomponent gas mixture. In the latter case one considered the flow of the gas mixture H_2—$SiCl_4$—HCl provided that the concentration of H_2 was much higher than that of the two remaining gases.

Computations of the flow of a single-component gas have shown that for small and moderate rates of the incoming flow $U_0 < 1.5$ m/sec there occurs a critical point in the flow laminar state, the thickness of the boundary layers (the dynamic and the thermal one) behaving in an unstable manner. The flow crisis arises the sooner, the lower the incoming flow rate (Fig. 1). With higher incoming flow rates ($U_0 \geq 5$ m/sec) no crisis in the laminar flow was observed for the plate lengths ($l \sim 1.5$ m) under consideration.

To eliminate some possible errors due to the adopted numerical integration method similar variants were also computed by employing the standard Merson procedure. The results did not show any significant disparity.

Of course, such behavior of the boundary layers is due to the interaction of the forced and the free convective motions. The flow region consists of three zones: a zone close to the beginning of the plate where the forced convection dominates, a distant zone where free convection dominates, and an intermediate zone where the forced and the free convections are comparable in strength. The investigation of stability of a similar class of flows is a complex problem and is not considered in the present article. One should only mention that already in [2, 3] the feasibility of the existence of such unsteady flow states was pointed out.

The computations of the flow of a multicomponent gas mixture above a horizontal plate have shown that in the region of moderate flow rates $U_0 > 0.5$ m/sec the existence of diffusion flows exerts a stabilizing effect on the thickness of the boundary layers (Fig. 2a).

The carried-out investigations of the thermodiffusion effect on the boundary layers show that as a result of the thermal diffusion being present there is a reconstruction of the boundary layers (Fig. 2b), primarily by reducing the thickness of the thermal boundary layer which should result, in turn, in a higher heat transfer from plate to gas.

NOTATION

x, y, orthogonal Cartesian coordinates; v_x, v_y, components of the velocity vector; ρ, gas mixture density; T, temperature; h, specific enthalpy; c, mass concentration; P, pressure; μ, dynamic viscosity coefficient; ν, kinematic viscosity coefficient; $D_{1\alpha}$, diffusion coefficient; k_{T_α}, thermodiffusion ratio; $\varkappa$, thermal-conductivity coefficient; $\bar{C}_P$, specific isobaric heat capacity; g, free-fall acceleration; β_T, local isobar compression coefficient; δ, thickness of dynamic boundary layer; Δ, thickness of thermal boundary layer; δ_{c_α}, thickness of concentration boundary layer for α-component; Pr, Prandtl number; Sc_α, Schmidt number; Le_α, Lewis number. Indices: 0, flow parameters outside boundary layer; ∞, flow parameters at infinity; W, parameters on the plate surface; α, β, parameters referring to α-, β-components.

LITERATURE CITED

1. I. P. Ginzburg, Theory of Resistance and Heat Transfer [in Russian], Izd. Leningr. Gos. Univ. (1970).
2. Chia-ch'ia Lin, Theory of Hydrodynamic Stability, Cambridge University Press.
3. H. Schlichting, The Emergence of Turbulence [Russian translation], IL, Moscow (1962).