Qualitative analysis shows [1] that the initial stage of a point-source thermal explosion in a homogeneous stationary gas is characterized by the predominance of radiative heat transfer. This finding is related to the nonlinear dependence of the coefficient of radiative heat transfer \( \kappa \) on the temperature of the gas \( T \). The function \( \kappa(T) \) can be assigned in power form \( \kappa = \lambda n T^{-1} \), where \( \lambda \) is a dimensional constant and \( n > 1 \) is the nonlinearity exponent. In complete agreement with the qualitative conclusions in [1], the author of [2] found by the asymptotic method that for short periods of time after the explosion, radiative heat transfer occurs independently of the motion of the gas and completely determines it. Here, the occurrence of the shock wave in [2] is connected with the convergence of the asymptotic solution on the well-known self-similar solution for a thermal explosion in a non-heat-conducting gas [3]. Conversely, the experimental findings and qualitative analysis of the problem in [1, 4] indicate that an isothermal shock wave can occur within a finite period of time after a thermal explosion. The shock then separated from the region heated by radiation [1], while radiative heat transfer turns out to have a diminishing effect on its motion. The role of heat transfer is negligible far from the site of the explosion, and the motion of the shock becomes self-similar [3]. Using the example of a plane thermal explosion in a nonlinearly heat-conducting ideal gas for the case \( n >> 1 \), here we propose an asymptotic representation of the solution of the above problem which will make it possible to analyze the generation of an isothermal shock wave.

1. Formulation of the Problem and Its Asymptotic Analysis. Let a quantity of thermal energy \( Q = 2Q_0 \) be instantaneously released at the moment of time \( t = 0 \) in the plane \( x = 0 \) in an infinite space filled with a stationary ideal gas having a density \( \rho_0 \), specific heat \( c_v \), and temperature \( T = 0 \). It is convenient to take the following as characteristic parameters of the gas; \( \rho_0 \) is the initial density of the gas; \( T_0 = \frac{T_0 R}{(2n-1)} \) is the temperature (\( R \) is the gas constant, \( a = \frac{(n-1)(n+1)}{2n(n-1)} \)) is the velocity, \( L = \frac{T_0^{3(n-3)}}{c_v \rho_0 V R} \) is the length, \( t_0 = L/V \) is the time. Then the problem of a point-source explosion is described in dimensionless variables by the following system of equations

\[
\begin{align*}
\frac{\partial \rho}{\partial t} + \frac{\partial \rho}{\partial x} = 0, & \quad \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + \frac{\partial T}{\partial x} + \frac{T}{\rho} \frac{\partial \rho}{\partial x} = 0, \\
\frac{\partial T}{\partial t} + \frac{\partial T}{\partial x} + \frac{R}{c_v} T \frac{\partial u}{\partial x} &= \frac{\partial^2 T}{\partial x^2}.
\end{align*}
\]

(1.1)

with the boundary and initial conditions

\[
T = \frac{\partial T^n}{\partial x} = u = 0, \quad \rho = 1 \quad \text{at} \quad x = \pm \infty, \quad t > 0; \tag{1.2}
\]

\[
T = \delta(x), \quad \rho = 1, \quad u = 0 \quad \text{at} \quad t = 0, \quad |x| < \infty. \tag{1.3}
\]
Here, \( p(x, t), u(x, t), T(x, t) \) are the dimensionless density, velocity, and temperature of the gas; \( \delta(x) \) is the Dirac delta function.

It was shown in [1] that one feature of the process at \( n > 1 \) is its localization in space, i.e., there exists a surface \( |x| = x_f(t) \) such that \( T = u = 0, \rho = 1 \) at \( |x| > x_f(x) \). Thus, in regard to continuity the boundary conditions (1.2) are transferred to the surface \( |x| = x_f(t) \):

\[
T = \frac{\partial T}{\partial x} = u = 0, \quad \rho = 1 \quad \text{at} \quad |x| = x_f(t).
\]

It should be noted that the function \( x_f(t) \) is unknown and must be found during solution of the stated boundary-value problem.

If we ignore motion of the gas and assume that \( u \equiv 0, \rho \equiv 1 \), problem (1.1)-(1.4) reduces to the familiar problem of the propagation of heat from an instantaneous planar source [5].

The solution of the latter problem has the form

\[
T(x, t) = t^{-\frac{1}{n-1}} x_f^{\frac{2}{n-1}} \chi(\eta), \quad x_f = c t^{\frac{1}{n+1}},
\]

where \( \chi = a (1 - \eta^2)^{\frac{n-1}{n}}; \quad \eta = \frac{x}{x_f}; \quad c = \left[ \frac{1}{2} B \left( \frac{a}{n-1}, \frac{1}{2} \right) \right]^{-\frac{n-1}{n+1}} \). Then we can use the known temperature \( T \) to evaluate the rate of propagation of hydrodynamic perturbations, which should be close to the isothermal speed of sound \( S = \sqrt{T} \sim t^{-1/(n+1)} \). Comparing it with the characteristic rate of radiant heat transfer \( dx_f/dt \sim t^{-n/(n+1)} \), in accordance with [1] it must be concluded that at \( n > 1 \) radiant heat transfer completely determines the process at \( t \to 0 \).

It also follows from the comparison that in the case of plane symmetry, there is no similitude between the hydrodynamic processes and the process of radiant heat transfer at \( n > 1 \) and \( t \to 0 \) either. Thus there are no self-similar solutions here which are analogous to those constructed in [6].

We will assume that the solution of boundary-value problem (1.1)-(1.4) at the limit at \( t \to 0 \) continuously transforms into solution (1.5), and the initial conditions with respect to the dynamic variables \( u = 0, \rho = 1 \). To construct an asymptotic representation of the solution of problem (1.1-1.4) at \( t \to 0 \), it is convenient to change over to new independent variables \( x, t \to \eta = x/x_f \) and new dependent variables

\[
T = t^{-\frac{1}{n+1}} x_f^{\frac{2}{n+1}} \chi(\eta), \quad \rho = 1 + t^{\delta(n)} y_f(\eta, t),
\]

\[
u = t^{\delta(n)} v_f(\eta, t), \quad x_f = t^{\delta(n)} c(t),
\]

assuming that the functions \( \chi(\eta, t), y(\eta, t), v(\eta, t), c(t) \) and their derivatives have the order \( O(1) \) at \( t \to 0 \). In the formulation of Eqs. (1.6), system of equations (1.1) contains the constants \( \alpha_i = (n - 2)/(n - 1), \alpha_2 = (3 - n)/(n - 1), \beta_1 = (2n - 3)/(n - 1), \beta_2 = (2(2 - n))/(n - 1) \), while system (1.1) appears as follows in the new variables

\[
\frac{2n-1}{n+1} r + \frac{4}{n+1} \frac{\partial r}{\partial \eta} + \frac{\partial v}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial c}{\partial \eta} + \frac{2}{n-1} \frac{\partial \chi}{\partial \eta} = 0,
\]

\[
\frac{2n-1}{n+1} v + \frac{2(2-n)}{n+1} \frac{\partial v}{\partial \eta} + \frac{\partial c}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial r}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial \chi}{\partial \eta} = 0,
\]

\[
\frac{2n-1}{n+1} r + \frac{2(2-n)}{n+1} \frac{\partial r}{\partial \eta} + \frac{\partial v}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial c}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial \chi}{\partial \eta} = 0,
\]

\[
\frac{2n-1}{n+1} v + \frac{2(2-n)}{n+1} \frac{\partial v}{\partial \eta} + \frac{\partial c}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial r}{\partial \eta} + \frac{2(2-n)}{n+1} \frac{\partial \chi}{\partial \eta} \]

System (1.7) must be augmented by boundary conditions which follow from Eqs. (1.3) and (1.4). The above-formulated problem is symmetrical relative to \( \eta = 0 \). Thus, we will henceforth limit ourselves to the region \( \eta > 0 \). Then instead of conditions (1.4) we can write boundary conditions of the following form in the new variables

\[
\chi = \frac{\partial \chi}{\partial \eta} = v = 0, \quad r = 0 \quad \text{at} \quad \eta = 1, \quad t > 0;
\]

\[
\frac{\partial \chi}{\partial \eta} = v = 0 \quad \text{at} \quad \eta = 0, \quad t > 0.
\]