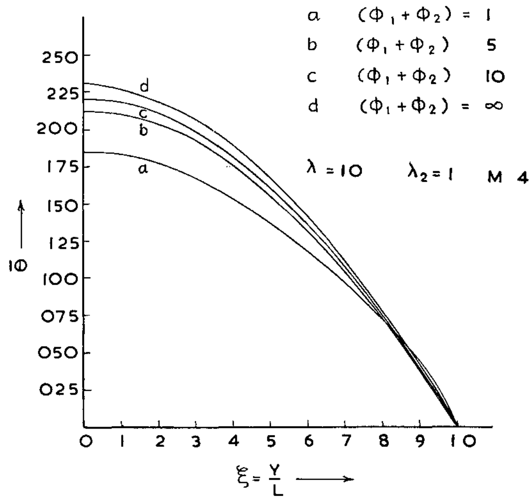

Fig 1 Temperature distribution for the values of ($\phi_1 + \phi_2$) indicated

sum ($\phi_1 + \phi_2$) and not upon the individual values of ϕ_1 and ϕ_2

The temperature profiles are symmetric about the middle of the channel and depend only upon the sum ($\phi_1 + \phi_2$) These profiles decrease when ($\phi_1 + \phi_2$) increases from zero to ϕ_T and increase for ($\phi_1 + \phi_2$) > ϕ_T where ϕ_T is the transitional value given by

$$\frac{\phi_T + 2}{\phi_T M \coth M + 2} = \frac{\left[\dfrac{2\sinh M}{M}(\cosh M - \cosh M\xi)(2\lambda_1 - \lambda_2) + \lambda_2 M(1 - \xi^2)\sinh M \cosh M\right]}{\lambda_1(\cosh 2M - \cosh 2M\xi)}$$

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Effect of Radiation on Upper Limits of Inflammability

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THE study of the limits of inflammability is of importance, not only for minimizing the risk of fires and explosions, but also for a better understanding of the principles of flame propagation For many years, the existence of upper and lower limits of inflammability have been known There have been several efforts to predict these limits analytically,[1 2] but these theories have met with limited success

Egerton and Powling[3] have investigated the effects of radiation losses on upper and lower limits of hydrogen-oxygen mixtures The wall of the combustion tube was blackened in one set of experiments and silvered in another; there was very little difference in the results (less than 0 3% for upper limit) In this note, it is shown experimentally that the upper limit of a propane-air mixture is significantly affected by radiation losses

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Experimental Apparatus

The U S Bureau of Mines has standardized the experimental procedure for determining the upper limit of inflammability as follows[4]:

> The mixture to be tested is contained in a vertical glass tube of not less than 2″ in diameter and not less than 4′ 6″ long The tube is closed at the top and at the moment of testing is opened at the lower end and a naked flame ¾″ to 1″ long is applied If the flame propagates the entire length of the tube, the mixture is judged to be inflammable but not otherwise

The richest fuel-air mixture, at which uniform propagation occurs, defines the upper limit of inflammability

The combustion tube used in this study was a Pyrex tube with a 2-in i d and 4 ft 11 in long There were provisions for evacuating the combustion tube, introducing the test mixture, and mixing the fuel and air A schematic drawing of the apparatus is shown in Fig 1 The top of the combustion tube was closed with an air-tight glass plug A flat piece of glass with a rubber gasket and a mercury seal was used to close the lower end of the combustion tube when evacuating the combustion tube, filling it with fuel and air, and during the mixing of fuel and air Instrument grade propane, having a minimum purity of 99 5%, and dry air were used in the experiments A manometer was used to read the pressure within the combustion tube and, hence, to determine the composition of the mixture In one set of experiments, a gold-coated front-surfaced mirror with a diameter of 2⅛ in was placed ½ in below the lower end of the combustion tube

Test Procedure

The following experiments were conducted to determine the upper limits of inflammability for propane-air mixtures:

Case I Combustion tube is uncoated, glass plug at upper end of tube is uncoated, and lower end of tube is open to the atmosphere This is the standard test as specified by the U S Bureau of Mines

Case II: The inner surface of the combustion tube is silver coated, the glass plug at the upper end of tube is uncoated, and lower end of tube is open to the atmosphere This experimental setup is similar to that used by Egerton and Powling

Case III The inner surface of the combustion tube is silver coated, the inner surface of the plug at the upper end of the tube is silver coated, and a spherical front-surfaced mirror is placed ½ in below lower end of tube at time of ignition

The operating procedure was as follows The tubes leading into the combustion vessel from the propane and air cylinders were filled with their respective gases Refer to Fig 1; stopcocks *a*, *b*, and *c* were opened, and stopcocks *d*, *e*, and *f* were closed The vacuum pump was started, and the lower end of the combustion tube was closed with a glass cover and a mercury seal After the system was evacuated, stopcock *a* was closed and the pump stopped (By observing the manometer, the system was checked for air leaks)

Stopcock e was then opened, and air was admitted When the reading on the manometer reached a predetermined level, stopcock e was closed, and propane was admitted by opening stopcock d When the pressure in the combustion tube reached atmospheric pressure, stopcock d was closed Stopcock c was then closed, and stopcock f was opened The fuel and air were mixed by raising and lowering the mixing funnel for at least 15 min The eddies that were generated in the mixing process were allowed about 5 min to settle The seal at the bottom of the combustion tube was removed, and a naked flame (1 in long) from a microburner was inserted in the lower end of the tube In the third set of experiments (case III), at the moment of ignition, a spherical, front-surfaced mirror was placed about $\frac{1}{2}$ in below the lower end of the tube The richest fuel mixture for which a flame propagates uniformly throughout the entire length of the tube was used to define the upper limit of inflammability Each set of experiments was conducted several times in order to insure reproducible results

Results

The results of this study may be summarized as follows:

Case I: The upper limit of inflammability is 9 50 This is in agreement with the results of Coward and Jones,[5] who also obtained 9 50 for propane-air Since the apparatus used in this test is similar to Coward and Jones' apparatus, these results established confidence in the test procedures

Case II The upper limit of inflammability is 9 83 This upper limit is slightly (3 4%) above that found in case I

Case III: The upper limit of inflammability is 10 5 This value is 10% greater than that of case I

Thus the following may be concluded:

1) Radiation losses have a significant effect on the determination of the upper limit of inflammability for flames that have carbon particles present in their products of combustion (such as propane)

2) Refer to Fig 2 In case I, nearly all of the radiation escapes from the mixture Part of the radiation passes out the open end of the tube, part passes through the pyrex walls, and part is absorbed by the Pyrex walls and reradiated at different wavelengths and in all directions Only a small portion of this radiation is absorbed by the flame In case II, nearly all of the radiation that is reflected by the silver-coated combustion tube is lost through the ends of the tube In case III nearly all of the radiation from the flame is reflected back and forth within the combustion tube and makes many passes through the flame front The hot carbon particles in the flame are responsible for most of the radiation and likewise are responsible for most of the absorption of radiation

3) The standard inflammability test-apparatus has been designed so that conduction losses to the walls are minimized (diameter of the combustion tube must be at least 2 in), but no provision is made to reduce radiation losses An experimental setup such as described under case III does minimize radiation losses and hence gives a truer measure of the absolute upper limits of inflammability

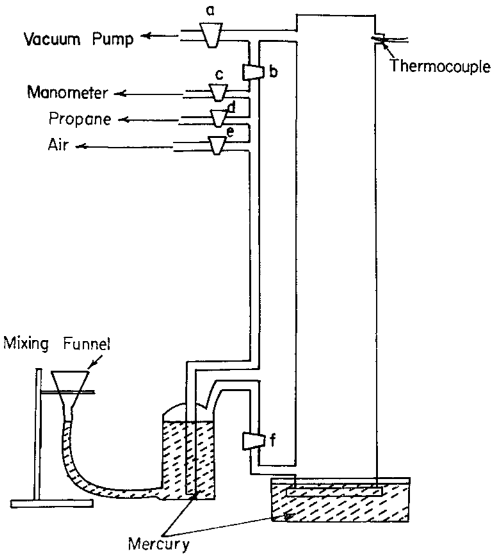

Fig 1 Schematic drawing of apparatus

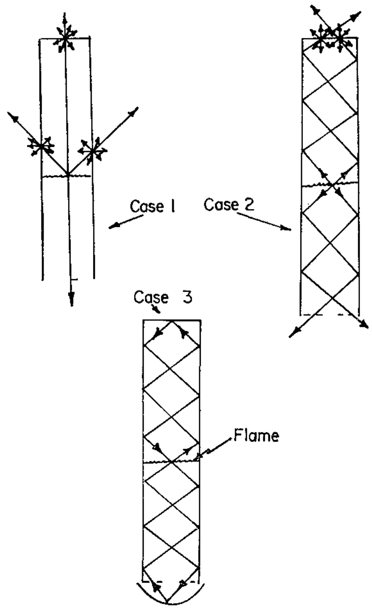

Fig 2 Schematic drawing of radiation from flame

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Flow of Viscoelastic Maxwell Fluid

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Introduction

FLOWS of Newtonian viscous fluid under exponential pressure gradient superposed on steady Poiseuille flow through coaxial cylinders have been discussed by Verma[1] Here we have considered the flow of Maxwell fluid under exponentially decreasing pressure gradient superposed on the steady laminar flow of the same fluid between two coaxial circular cylinders

We know that a viscoelastic fluid of the Maxwell type (i e , a spring and a dash-pot arranged in series) is governed by

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