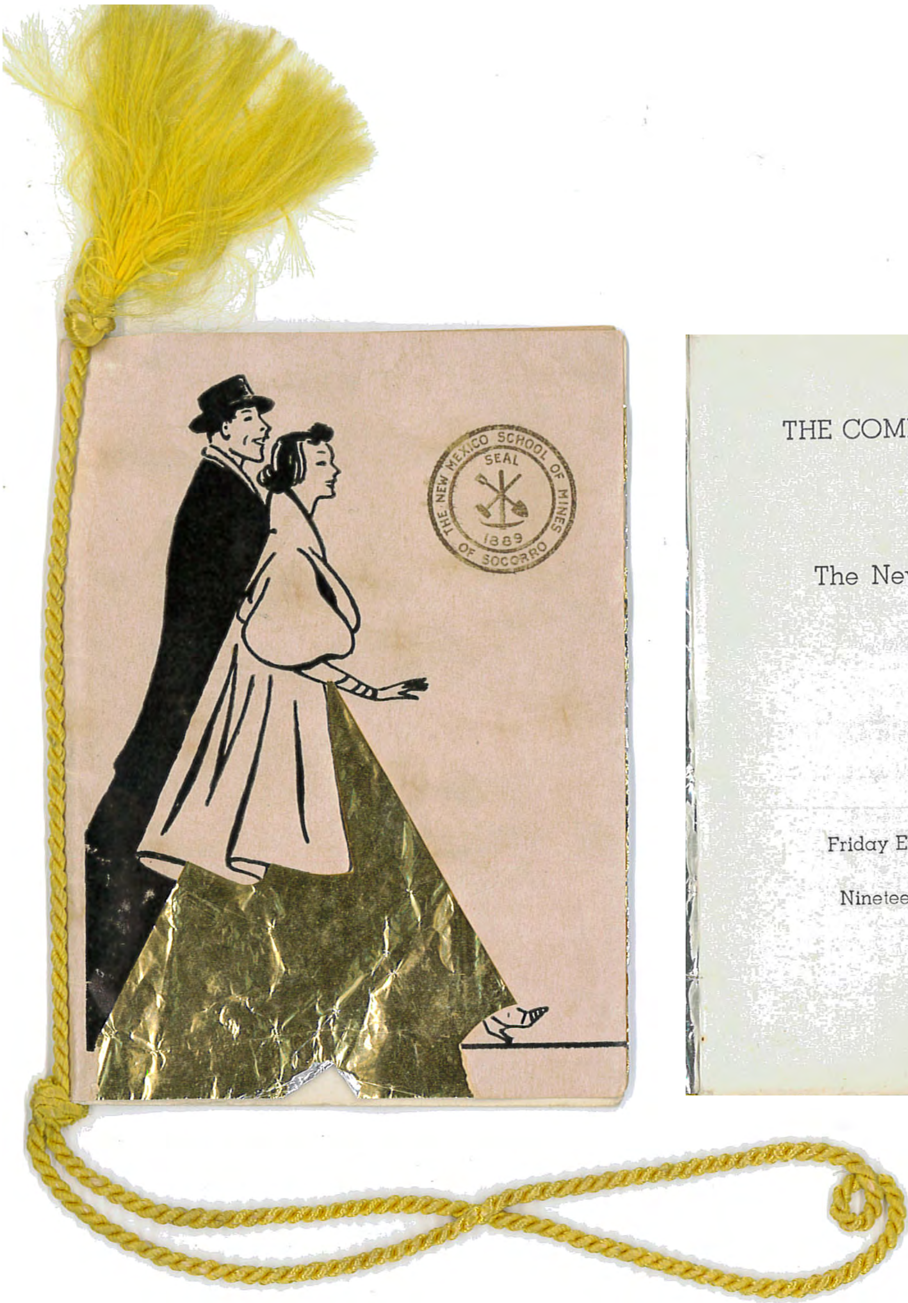



# THE COMMENCEMENT BALL

of

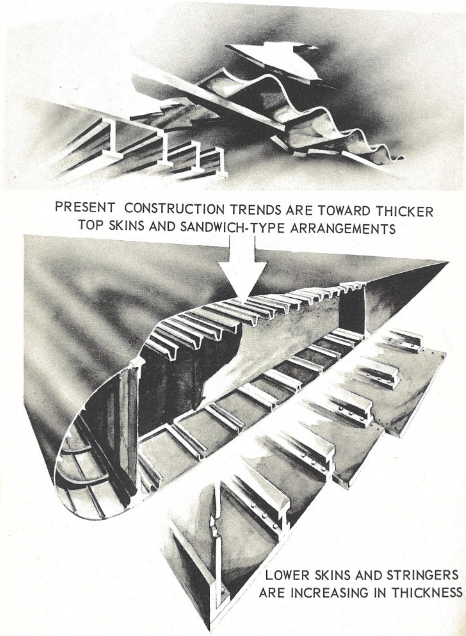
## The New Mexico School of Mines

Friday Evening, May Sixteenth

Nineteen Hundred Forty-one

9:00 P. M.

# TERMINAL BALLISTIC STUDIES OF THE CONTINUOUS ROD AGAINST AIRCRAFT




CONSTRUCTION TRENDS IN MODERN AIRCRAFT STRUCTURE

FIGURE 2






## INTRODUCTION

The purpose of this report is to acquaint the reader with detailed aspects of continuous-rod damage to aircraft structure, and to itemize and plot data pertaining to damage produced by rod hits. A majority of the damage data contained herein relate to rod hits against actual aircraft, the remaining data being from rod hits against "representative targets."

For a target as complex as an aircraft structure, it is difficult to evaluate quantitatively the effect of changing the values of the rod variables upon the total amount of damage produced. To reduce the complexity of the target, and to obtain basic knowledge regarding interaction between rod and structure, isolated bars, plates, etc., were substituted for aircraft in many experiments. See Appendix D. On the other hand, the use of aircraft assemblies for check points against the basic data proved to be advantageous, inasmuch as redistributions of loads within a damaged structure need not be understood, but the effects merely noted. See Appendices A and B.

The airframe of an aircraft is essentially a semirigid assembly of plates or sheets fastened to, and fastening together, longitudinal members (stringers) and transverse members (formers or ribs). See Figure 2. The two primary loads in the airframe, generally considered, are shear and bending. Shear loads are of secondary importance in damage assessment; bending loads (moment) are responsible for nearly all structural failures where rod hits have been made.

A continuous rod striking an aircraft can damage the airframe in five ways: cutting action (accompanied by cracking, spalling, etc.), vaporific pressure, hydraulic impulse, payload detonation, and fuel fire. Fuel fires were treated extensively in NMIMT/RDD/T-918, 21 September 1955. Damage from vaporific effect or hydraulic impulse, or from payload detonation rarely occurs. On the other hand, the likelihood of kills from cutting action is high. Accordingly, this report is concerned in its entirety with structural damage resulting from the cutting action of rods.

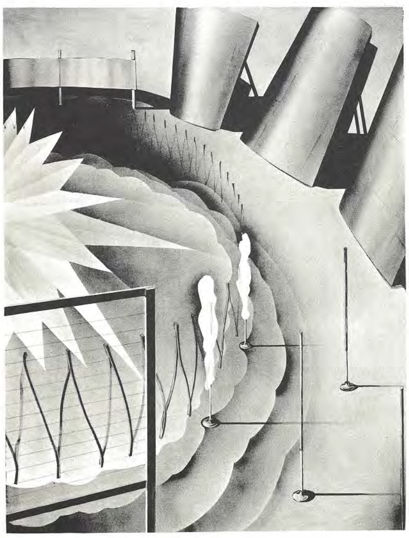
In continuous-rod action, the intent is not literally to sever the airframe by cutting and rending through the application of sheer brute force. Rather, it has been found that the most effective and efficient manner of achieving aircraft failure is to produce a nearly continuous damage line across the target without directly severing any but the most fragile, or lightest, of the structural components. Undamaged stringers, ribs, etc., act as interrupters to fracture lines in aircraft skin; continuous-rod strikes produce damaged stringers, ribs, etc., in an essentially unbroken damage line along the incipient failure line in the skin. In this manner, stress concentrations and load redistributions are caused to exist throughout the width of the structural entity, and failure occurs from a minimum of cutting action. See Figure 3.

In damage assessment at NMIMT, an immediate structural kill has been tabulated for those rod strikes producing a reduction of strength, in bending, equivalent to the load factor assumed for the aircraft. Thus, to accomplish a kill in an aircraft carrying one-fourth the gross weight that is necessary to fail an undamaged airframe (i.e., load factor equal to 4) the rod strike must reduce the strength of the airframe by 75 percent. A reduction of 75 percent in compressive strength in the upper half, or in tensile strength in the lower half, of the wing or fuselage is considered to be adequate to reduce the gross strength of the wing or fuselage by 75 percent. Load factors of 4 to 6 generally have been considered representative of current aircraft, with the value of 4 representing the older, or subsonic, aircraft.






## SHOWING ARENA FOR CONTINUOUS-ROD FIRINGS



ARENA DETAIL

DATA-TAKING BY FIRING AGAINST WIRE SCREENS, FLASH TUBES, PATTERN SHEETS AND AIRCRAFT STRUCTURE

FIGURE 11