Many of the major problems of the aircraft of the future are old problems in new dress.

The first technical report of the National Advisory Committee for Aeronautics, written in 1915 by Dr. J. C. Hunsaker, present NACA Chairman, dealt with the problem of the stability of an airplane in free flight.

The then current high-speed military airplane was the Curtiss J N2 with a maximum speed of about 85 mph and a minimum speed of about 43 mph.

"The problems of stability and control of current and future aircraft are describable in the same conceptual framework...which Hunsaker applied in NACA Report No. 1. There are, however, great changes in the superstructure, in what Bryan described as the approximations to the air pressures to which the planes and other parts of the machine are subjected. For our future airplanes we must assure stability not at speeds of 40 to 60 mph, but at speeds extending from 100 to 1000 mph or more..."

H. L. Dryden, January 7, 1955
This booklet contains reproductions of the charts used to illustrate the presentations at the NACA’S 1955 Triennial Inspection at the Ames Aeronautical Laboratory. Space has been provided for those who wish to take notes.

STATIC STABILITY Section 1
DYNAMIC STABILITY Section 2
SIMULATORS AS AN AID TO FLIGHT RESEARCH Section 3
AIRPLANE FLEXIBILITY Section 4
TRANSONIC RESEARCH Section 5
HYPERSONIC RESEARCH Section 6
RESEARCH ON TAKE-OFF AND LANDING Section 7
UNITARY PLAN WIND TUNNELS Section 8
JET AIRCRAFT CRASH-FIRE RESEARCH Section 9
CRASH IMPACT SURVIVAL
STATIC STABILITY

LIFTING WING PRODUCES VORTEXES

TREND IS TO SLENDER AIRPLANES WITH SHORT WINGS
FUSELAGE ALSO PRODUCES VORTEXES

FUSELAGE VORTEX INFLUENCES STABILITY IN YAW
SHOCK WAVES ARE GENERATED AT SUPersonic SPEEDs

NACELLE SHOCK WAVES INFLUENCE STABILITY IN YAW
DYNAMIC STABILITY

PITCHING OSCILLATIONS OF TYPICAL AIRPLANES

ANGLE OF PITCH

DISTANCE, MILES

ELEVATOR ANGLE

HIGH-SPEED DESIGNS SACRIFICE DAMPING

DAMPING

DESIGN MACH NUMBER
ANALYSIS OF AIRPLANE BEHAVIOR

TECHNIQUES FOR STABILITY RESEARCH

OSCILLATION TESTS IN WIND TUNNELS
STEADY ROLLING TESTS IN WIND TUNNELS
SPECIAL WIND TUNNELS WITH CURVED FLOW
FREE-FLIGHT TEST RANGES
ROCKET-PROPELLED MODELS
PILOTED AIRPLANES
TRENDS IN WEIGHT DISTRIBUTION

LENGTHWISE DISTRIBUTION
OF WEIGHT

SPANWISE DISTRIBUTION
OF WEIGHT

DESIGN MACH NUMBER

TRENDS IN ROLL AND YAW RATES

YAW OSCILLATIONS PER SECOND

MAXIMUM ROLL REVOLUTIONS PER SECOND

DESIGN MACH NUMBER
**SIMULATORS AS AN AID TO FLIGHT RESEARCH**

**AIRPLANE MOTION SIMULATED**

- **ELEVATOR ANGLE**
  - UP
  - DOWN
- **Nose Up**
- **PITCH ATTITUDE**
  - NOSE UP
  - NOSE DOWN

**INPUT BY PILOT**

**RESPONSE OF AIRPLANE**

**RESPONSE OF SIMULATOR**

**TIME**

**EQUATIONS FOR AIRPLANE PITCHING MOTIONS**

**TWO GENERAL EQUATIONS OF MOTION:**

\[
\begin{align*}
\mathbf{m} \ddot{V}(x-y) &= Z_2 \alpha + Z_3 \dot{\alpha} \\
\mathbf{I}_n \ddot{\theta} &= M_y \dot{\theta} + N_\alpha \alpha + M_\alpha \dot{\alpha} + M_d \dot{d}
\end{align*}
\]

**SOLUTION FOR PITCH ATTITUDE DUE TO ELEVATOR MOTION:**

\[
\phi = -\dot{\alpha} + k_1 \alpha + k_2 \dot{\alpha} + k_3 \theta + k_4 \dot{\theta}
\]

\[
= \left( -\dot{\alpha} + k_1 \alpha + k_2 \dot{\alpha} + k_3 \theta + k_4 \dot{\theta} \right) \sin \omega t
\]

\[
= \frac{1}{2} \left[ \frac{1}{2} + \frac{\omega^2}{2} \left( \frac{1}{k_1} - \frac{1}{k_2} \right) \right] \sin \omega t
\]

Section 3
USE OF SIMULATOR FOR CONTROL RESEARCH

SIMULATES:
- MASS
- INERTIA
- AERODYNAMICS
- SIGHT
- TARGET

USE OF SIMULATOR FOR PITCH-UP RESEARCH

ANALOG COMPUTER SIMULATES:
- Mass
- Inertia
- AERODYNAMICS

STICK POSITION SIGNALS

- ANGLE OF ATTACK TO HYDRAULIC RAM INPUT

Section 3
ELEVATOR CONTROL COMPARED TO ALL-MOVING-TAIL CONTROL

- Stick Position
- Pitch Attitude
- Time

ELEVATOR-CONTROLLED
ALL-MOVING-TAIL

Section 3
AIRPLANE FLEXIBILITY

NACA AEROELASTIC RESEARCH
B-47 AIRPLANE

AEREOELASTICITY

 Loads               Stability & Control

 Langley Aeronautical Laboratory

 High Speed Flight Station

 Ames Aeronautical Laboratory

 Data for Lighter & Safer Structures

 Data Determining Handling Qualities & Stat. Stability Required

 Data for Improving Autopilot, Stability & Control

 Future Transport & Bombers

INSTRUMENTATION

■ PILOT INPUT AND AIRPLANE RESPONSE
■ PILOT CONTROLS
■ CONTROL SURFACES
■ AIRPLANE MOVEMENT
■ STRUCTURAL LOADS
■ STRAIN GAGES
■ BEND AND TWIST
■ OPTIGRAPH CAMERAS ACCELEROMETER
TYPICAL OSCILLOGRAPH RECORD

BENDING AND TWISTING OF WING IN FLIGHT

TWIST

BEND

PREDICTED

MEASURED

5 SECONDS
TRANSONIC RESEARCH

TRANSONIC TESTING IN FLIGHT

SWEPT-BACK WINGS ARE SUBJECT TO PITCH-UP

MACH NUMBER = .98

PITCHING MOMENT
NOSE DOWN • NOSE UP

LIFT

Section 5
MODIFICATION OF SWEPT WINGS ALLEVIATES PITCH-UP

14-FOOT TRANSONIC WIND TUNNEL
HYPERSONIC RESEARCH

FLIGHT PATHS OF HYPERSONIC AIRCRAFT

TRANSPIRATION COOLING

INTERNAL COOLING

TRANSPERSION COOLING

TEMPERATURE

COOLANT FLOW RATE
ELECTRICAL ANALOGY OF HEAT FLOW

THERMAL CIRCUIT
- HEAT FLOW IN
- HEAT FLOW OUT

ELECTRICAL CIRCUIT
- CURRENT FLOW IN
- CURRENT FLOW OUT

CONDITIONS FOR ANALOG CALCULATIONS

ALT 40,000 FT

6 FT
5°

3 MINUTES ACCELERATION

M = 3.0

M = 9
WING SURFACE TEMPERATURE DISTRIBUTIONS
RESEARCH ON TAKE-OFF AND LANDING
SLIPSTREAM REDIRECTION

PLAIN FLAPS

BOUNDARY-LAYER CONTROL

BOUNDARY-LAYER CONTROL WITH SLAT
UNITARY PLAN WIND TUNNELS

UNITARY PLAN WIND TUNNELS

LANGLEY
4 FOOT SUPERSONIC WIND TUNNEL

LEWIS
10 FOOT SUPERSONIC WIND TUNNEL

11-STAGE AXIAL-FLOW COMPRESSOR

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Section 8
JET AIRCRAFT CRASH-FIRE RESEARCH

TURBOJET CUT AWAY

Section 9
CRASH IMPACT SURVIVAL

NACA EXPERIMENTAL FLEXIBLE SEAT
IMPACT FROM REAR

IMPACT SWING

SWINGING PLATFORM

TARGET

Section 9
ATTENUATION OF CRASH LOAD BY FLEXIBLE SEAT

CHEST ACCELERATION

Rear Facing Seats

Rigid Seat

Flexible Seat

Section 9
NOTES:
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