NASA
National Aeronautics and Space Administration

General Aviation Technology Program

Release No: 78-41
April 1978

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CONTENTS

April 1978

NASA GENERAL AVIATION RESEARCH

AND TECHNOLOGY PROGRAM

Objectives of the NASA General Aviation Research and Technology program are:

- To provide new technology for improvements in safety and efficiency
- Reduction of the environmental impact of general aviation aircraft
- To insure that an adequate base of new technology exists to support the continued growth in the utility of the light airplane

Flight Efficiency

In aerodynamics, emphasis has been placed on airfoil development, resulting in significant improvements in performance in all speed ranges.

Most recently a new medium speed airfoil family has been developed for use on small executive and business airplanes powered by turbofans or turbopropellers.

Beginning with the NASA-developed low-speed GA(W)-1 airfoil, (now known as LS(1) -- 0413), and using the design technology developed for high-speed supercritical airfoils, a new airfoil has been derived with improved aerodynamic characteristics at cruise. This airfoil appears to provide excellent performance up to a Mach number slightly higher than 0.7. Wind tunnel tests are underway to verify its low-speed, high-lift characteristics.

To assist the general aviation industry, an airfoil design institute has been established at Ohio State University to provide optimized point-design airfoils for industry customers.

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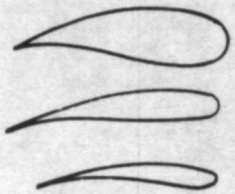
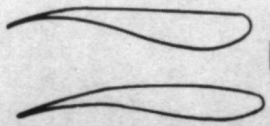
AERODYNAMIC EFFICIENCY

AIRFOILS



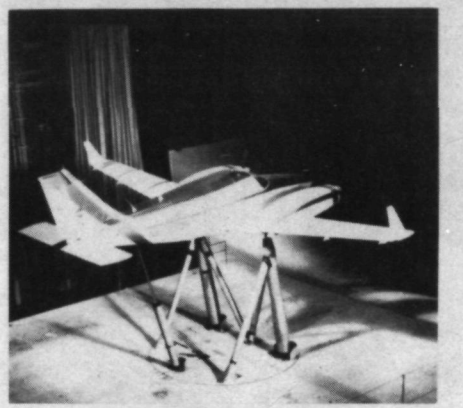
LOW SPEED

MEDIUM SPEED

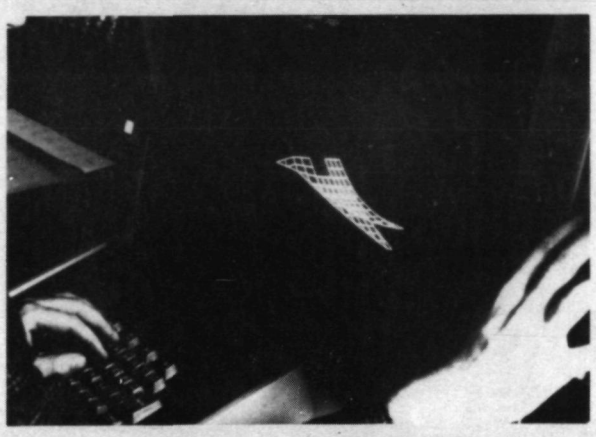


HIGH SPEED

CONFIGURATIONS



ATLIT



DESIGN INSTITUTE

SKY ROCKET

In addition to the airfoil, many other elements in the design of an aircraft contribute to its aerodynamic efficiency. A number of these factors are being examined as part of the advanced technology light twin (ATLIT) program. The ATLIT has demonstrated the effectiveness of a new technology wing including full-span flaps and spoiler roll control. Means for reducing interference drag between the wing and fuselage have been evaluated in the full-scale wind tunnel. Addition of winglets has the potential for improving climb performance.

Propulsion efficiency is equal in importance to aerodynamics in the overall effort to reduce fuel consumption. Research was completed on a hydrogen enrichment concept using a TIO-542 fuel-injected turbo-supercharged engine. It was found that significant improvements in fuel consumption were achievable by a combination of leaning out the mixture and advancing the spark without hydrogen injection. A 10 to 12 per cent reduction in fuel consumption was obtained relative to the standard factory setting of spark advance and fuel flow. Improvements in carbon monoxide and unburned hydrocarbon emissions were also noted. Results of this work are under active consideration by the engine manufacturers for application to new production engines.

Avionic Research

To be effective as a transportation mode, the airplane must have the capability to interact with the traffic control system as well as provide navigation, guidance, stabilization and systems management functions necessary for safe, reliable operations in adverse weather.

As the aircraft and the air system in which it must operate have become more complex, the cost of providing these functions has grown to very high levels.

NASA has a significant effort underway to reduce the complexity and cost of these functions. The objective is to provide information required for the design of low-cost, advanced avionic systems applicable to general aviation in the 1980s and beyond.

Results of recent studies have been integrated into specifications for final systems design, fabrication and installation on a twin engine general aviation aircraft for flight evaluation in 1979 and 1980.

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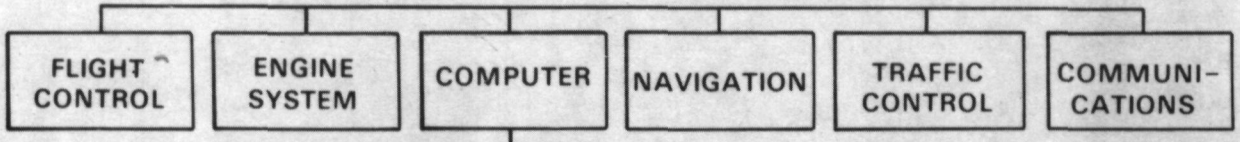
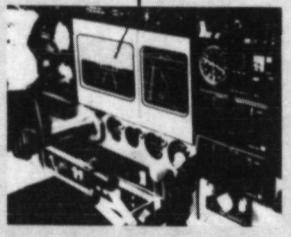
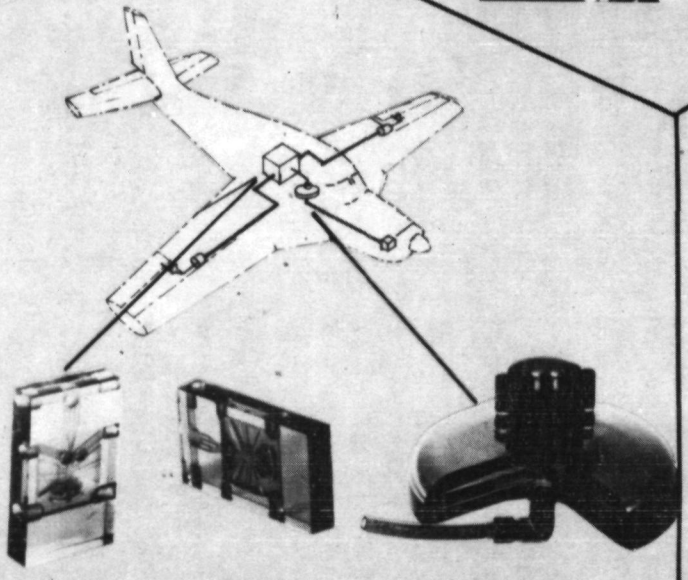
ADVANCED AVIONICS

INTEGRATED SYSTEM ARCHITECTURE

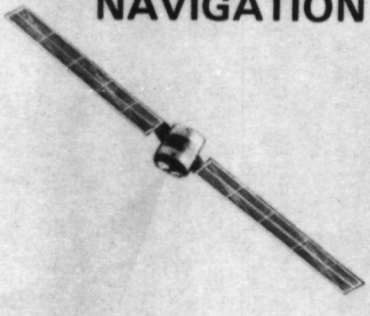


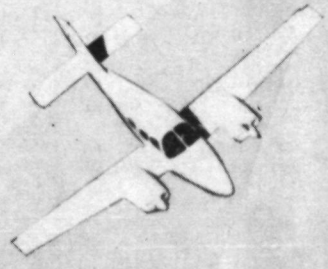


LOW COST FLUIDIC WING LEVELER



NEW CAPABILITY SATELLITE NAVIGATION





Supporting the general aviation advanced avionics program, are related activities in electro-fluidics technology, navigation/communications technology and stall onset sensor development. Wind tunnel and flight tests of a fluidic rudder and fluidic wing tips have been documented and a fluidic wing-leveler/turn-coordinator was successfully flight tested in a U-3 test aircraft.

Continued tests of upgraded fluidic control surfaces are planned and a three-axis electro-fluidic autopilot will undergo simulator tests. A "satellite-in-runway" GPS landing guidance concept will be investigated for potential general aviation application. A number of flight IFR aids are currently under consideration.

Agricultural Aircraft

In addition to transportation of people and goods, light aircraft are employed in a wide range of special activities. Of particular interest is use of aircraft in agriculture. NASA is defining key technical problems limiting accuracy and efficiency of the aerial application of agricultural materials.

Initial efforts are emphasizing interactions between the aircraft flow field and the material being applied. A computer program has been developed to permit analysis of the effects of changes to the aircraft on the trajectories of particles released in the aircraft wake. Model testing techniques, including scaled particles, have been developed using a vortex facility.

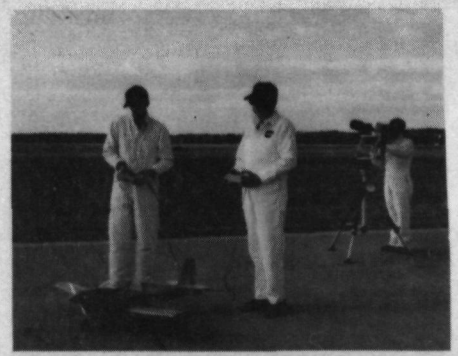
Safety

Safety is receiving considerable emphasis within the NASA general aviation program. Principal areas of concentration include the automatic pilot advisory system (APAS), structural crashworthiness, stall/spin research and investigation of alternate fuels such as automotive gasoline for aircraft.

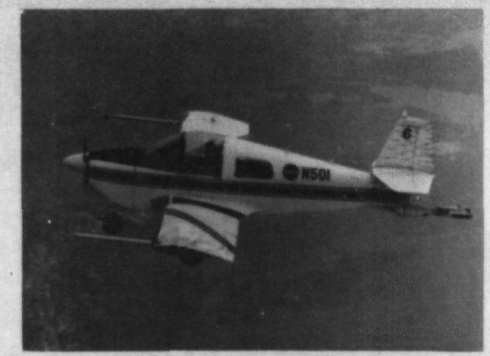
Technology is being developed for a low-cost computer-aided system to provide automated airport and traffic advisories. The APAS system would service all aircraft equipped with standard NAV-COM systems. It consists of a conventional radar, meteorological sensors and synthesized voice messages under control of a mini-computer.

GENERAL AVIATION STALL/SPIN RESEARCH PROGRAM

SPIN TUNNEL

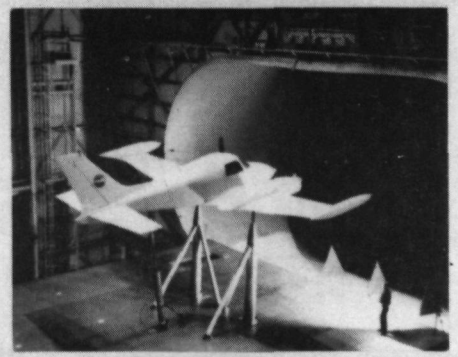


RADIO-CONTROLLED MODELS

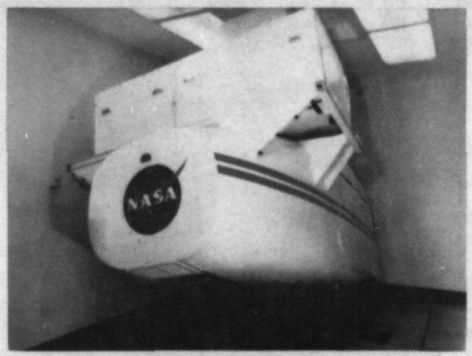


FLIGHT TESTS

WIND-TUNNEL MODELS

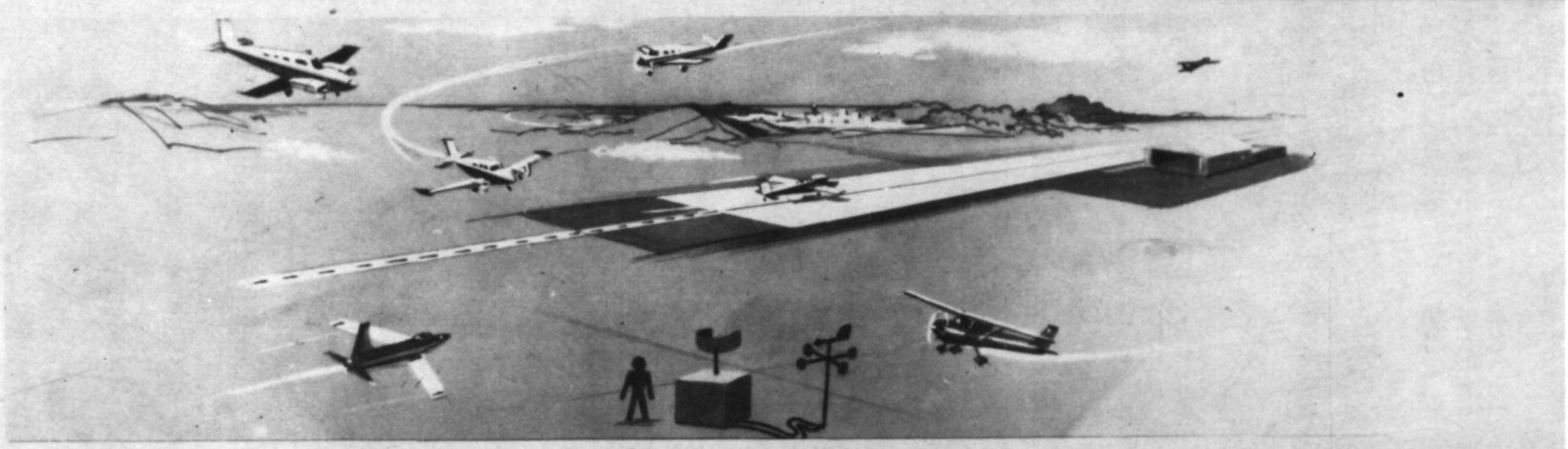


FULL-SCALE
WIND-TUNNEL TESTS

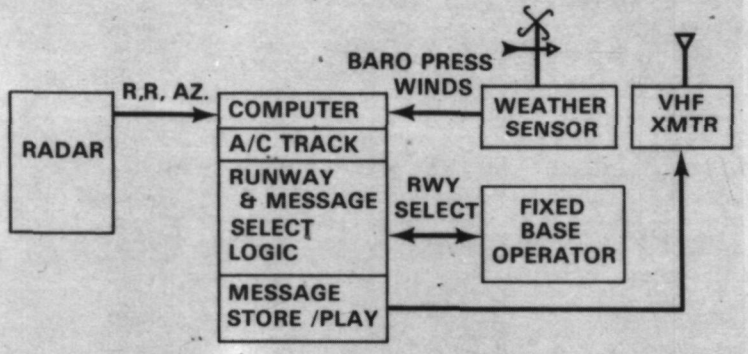


SIMULATION

AUTOMATIC PILOT ADVISORY SYSTEM



SYSTEM CONCEPT



COMPUTER GENERATED VOICE BROADCAST

TYPICAL MESSAGE FORMATS

(MESSAGE TIME 15 SEC.)	.....TRAFFIC ADVISORY ... HYDE FIELD ... ...DEPARTING AIRCRAFT ONE MILE NORTH... ...ARRIVING AIRCRAFT TURNING BASE ...ARRIVING AIRCRAFT TWO MILE WEST ...ARRIVING AIRCRAFT THREE MILES NORTHEAST, HEADING TWO NINER ZERO (HEADING GIVEN WHEN GREATER THAN *30° FROM RADIAL TO /FROM AIRPORT*)
(MESSAGE TIME 12 SEC.)	.....AIRPORT ADVISORY...HYDE FIELD ... ...ACTIVE RUNWAY TWO...TWO...WIND...THIRTEEN KNOTS FROM TWO ONE ZERO ...ALTIMETER... TWO NINER POINT NINER FOUR
MESSAGE TIME 13 SEC.)	.....COLLISION WARNING... HYDE FIELD ... ...AIRCRAFT THREE MILES NORTHEAST HEADING TWO TWO ZERO HAS THREAT THREE O'CLOCK ONE MILE... ...AIRCRAFT TWO MILES NORTH HEADING ONE TWO ZERO HAS THREAT TEN O'CLOCK ONE MILE...

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Airport advisories would be broadcast every two minutes to all planes operating in the vicinity of an airport, disclosing the name of the airfield, the active runway, local weather conditions, the position and direction of departing and arriving aircraft and cautionary and collision avoidance warnings.

Airport advisory systems tests and demonstrations are underway, and the pilot advisory system demonstration is scheduled for August 1978 at NASA's Wallops Flight Center, Wallops Island, Va.

Improved structural crashworthiness is the objective of the joint NASA/FAA program. The program consists of experimental, analytical and design elements, all leading to substantial improvements in occupant crash survivability.

Emphasis is placed on developing a capability for predicting the dynamic response of aircraft structure during impact. This is especially important in designing future aircraft to insure that the space surrounding the occupant maintains sufficient integrity during a crash.

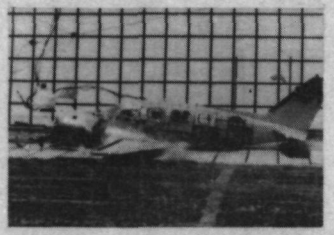
Current finite element structural analysis methods do not accommodate large nonlinear deflections. In conjunction with the FAA, NASA is currently extending a finite element analysis capability into that region.

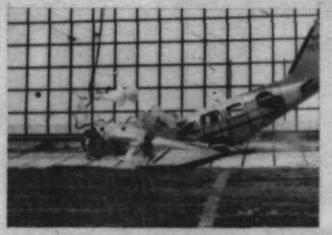
Full-scale crash tests have provided an extensive data base on maintenance of cabin integrity and livable volume for a variety of crash conditions. Together with the finite element analysis, this will provide a basis for designing more crashworthy structures. Concurrent with improved prediction will be introduction of energy-absorbing structural concepts.

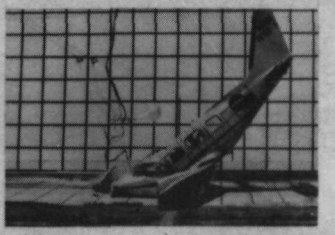
A major near-term improvement in crash survivability can be made in general aviation seats and passenger restraints. NASA has developed an analytical simulation which is an extension of an FAA technique for predicting the dynamic behavior of the seat and occupant coupled with a variety of restraining systems. Concurrent with this, selected energy absorbing seat concepts are moving into the design and development phase.

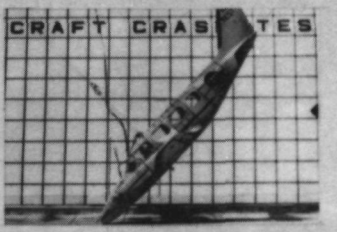
Much controversy has been raised over the various grades of aviation gasoline available for piston engines and possible use of automotove fuel in some less critical areas. While some data and experience exist on the viability of using fuel other than factory specified aviation gasoline, it is not well documented, nor generally accepted.

IMPROVED CRASHWORTHINESS





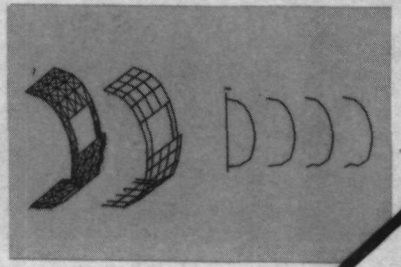


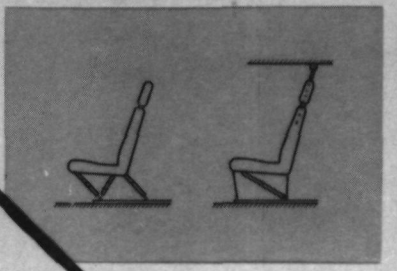


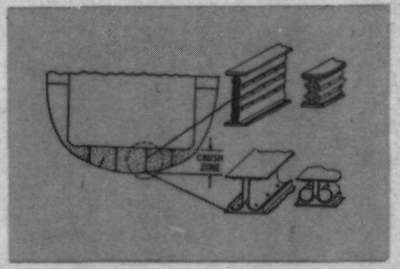
NON LINEAR FINITE ELEMENT ANALYSIS

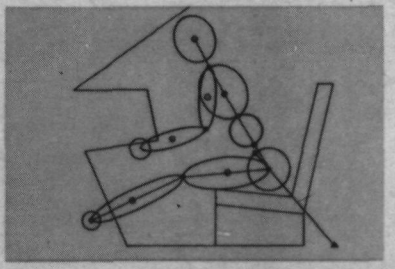
FULL SCALE TESTING

ENERGY ABSORBING, SEATS









ENERGY ABSORBING CONCEPTS

MAN-SEAT SIMULATION

The NASA program will conduct accelerated life cycle tests on several representative piston engines to determine tolerance of the engines to the various fuels. Complete documentation will be maintained on component wear and performance throughout the program.

Environmental Impact

The noise and exhaust emissions generated by light aircraft operations are perceived as major factors effecting the growth and health of small community airports.

Reducing this environmental impact continues to be a high priority objective of NASA's aeronautical program. The noise and pollution programs are intended to provide through basic research the knowledge and understanding necessary to reduce noise and exhaust pollution levels from aircraft engines. This information will assist the industry and the regulatory agencies in meeting future noise goals.

Research is being carried out on propeller noise generation. Flight test data have been generated on the effects of atmospheric turbulence on propeller blade loading and the resulting impact on propeller noise. Since this effect changes between flight and ground operations, it has been one of the limiting factors in the ability to predict flight noise levels from static ground measurements. Future work will evaluate the effects of blade speed and configuration on noise and in combining the aerodynamic and acoustic performance aspects of propellers for overall optimization. A new program jointly sponsored by EPA and NASA has been initiated to evaluate general aviation propellers.

The Quiet, Clean General Aviation Turbofan program has progressed to the detailed design phase. During 1978 and 1979, engine testing will be underway with delivery of the engine to NASA for further test and evaluation.

In the clean combustor program for general aviation, an engine demonstration program has been initiated to verify low emission combustor concepts of the airblast fuel injection and premix/prevaporization type combustors. Bench testing of these concepts shows that significant emissions reduction is possible. This will allow future engines to meet EPA 1979 goals.

NOISE REDUCTION

PROPELLERS

UNSTEADY BLADE LOADING

TURBINES

AVCO LYCOMING

GARRETT AIRESEARCH

QUIET CLEAN GENERAL AVIATION TURBOFAN (QCGAT)

EMISSION REDUCTION

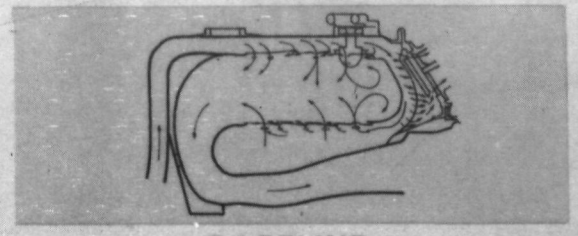
TURBINES (T-1)
EPA REGULATIONS 1 JAN 1979

HC 1.6
CO 9.4
NOx 3.7
} LB/1000LB THRUST/LTO

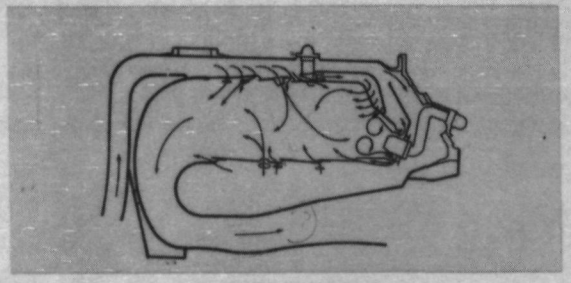
PISTON ENGINES (P-1)
EPA REGULATIONS 31 DEC 1979

HC .0019
CO .042
NOx .0010
} LB/1000HP/LTO

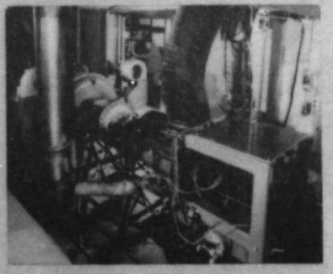
CLEAN COMBUSTION



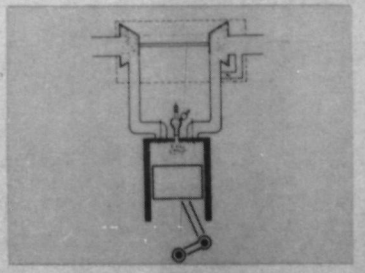
BASELINE



PREVAPORIZATION



ENGINE TESTS



COMBUSTION PROCESSES

Research is continuing on low emission piston engines. Lean burning was demonstrated on piston engines, resulting in lower emissions levels, as previously described. Advanced high energy ignition systems, fuel injection systems and variable-valve timing promise even further reductions and are being investigated, both in NASA facilities and by contractors.

Summary

General aviation research is receiving strong and growing support within NASA. Problems and concerns of the industry are being addressed in research programs.

Results from several recent programs are being used by industry in designing new aircraft. While many technical problems remain, mechanisms for developing solutions through NASA research exist.

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