

## Japanese Aerospace Literature

### This month: Aircraft, Spacecraft, and Laser Propulsion

**A88-38345 Inertial guidance system for the H-I launch vehicle - NICE** NAOTERU NAGAO and SYOZO TANI, *Mitsubishi Heavy Industries Technical Review* (ISSN 0026-6817), Vol. 25, Feb. 1988, pp. 61-73.

This report gives an outline of the NICE (NASDA Inertial-guidance and Control Equipment) inertial guidance system developed for the NASDA H-I launch vehicle, and to proprietary participation in the NICE system's integration support, the development of the flight program, and the data-interface unit. This system provides for first and second stage attitude control, navigation and guidance, second stage tank pressurization control, and vehicle sequencing functions. The functions and performance of the NICE system were perfectly certified through the first flight of the H-I launch vehicle (Test flight #1 mission) on August 13, 1986.

**A88-38312 Light-weight TWT power supply for a multi-beam communications satellite** TAKASHI YAMASHITA, TSUTOMU OGATA, and KATSUHIKO YAMAMOTO, *Electrical Communications Laboratories, Review* (ISSN 0029-067X), Vol. 36, Jan. 1988, pp. 115-119.

This paper describes the design and performance of a light-weight TWT power supply for a multi-beam communications satellite. The switching frequency of the power supply is raised to 100 kHz for weight reduction by applying power MOS FETs and newly developed high-voltage diodes. This weight reduction was achieved by using a simplified control circuit together with a hybrid IC mounting method, a partial potting method for the high-voltage section, and 100 kHz power conversion technology. The newly developed TWT power supply weighs 30 percent less than the conventional TWT power supply.

**A88-38302 A strong shock wave supported by the absorption of laser (for propulsion)** TOSHI FUJIWARA and TAKASHI NISHIWAKI, *Nagoya University, Faculty of Engineering, Memoirs* (ISSN 0027-7657), Vol. 39, no. 1, 1987, pp. 163-179. 5 Refs.

The structure of laser supported detonation (LSD) is investigated analytically by solving one-dimensional gasdynamic equations with allowance for the inverse bremsstrahlung absorption of laser energy incident on the front shock wave. The LSD structure consists of a shock wave heating the low-temperature nonabsorbing propellant gas up to a very high temperature, enabling it to absorb laser radiation, followed by a thick absorption region where the subsonic flow is accelerated by exothermicity to the sonic velocity. The Chapman-Jouguet condition is imposed to determine the propagation velocity of the detonation as an eigenvalue for a given laser intensity.

**A88-37188 Some topics of ASKA's flight test results and its future plan** TOSHIO BANDO, YOSHIO HAYASHI, OSAMU KOBAYASHI, and ISAO KAGEYAMA, *Proceeding of the International Powered Lift Conference and Exposition*, Santa Clara, CA, Dec. 7-10, 1987, (A88-37176 15-01). SAE Paper 872317 presented at the Warrendale, PA, Society of Automotive Engineers, Inc., 1988, pp. 181-187. 11 Refs.

The quiet STOL research airplane ('ASKA') was developed as a research aircraft that would provide high levels of STOL performance at low levels of community noise. The ASKA is a C-1 tactical transport, modified to incorporate an Upper Surface Blowing (USB) type propulsive-lift system. Attention is given to the major subjects in evaluation of a newly developed engine, the actual proof of the structure, confirmation of different avionics systems, and documenting of fundamental flying quality and performance.

**A88-31191 A concept of CO<sub>2</sub>-breathing propulsion engine for planet use** SABURO YUASA and HIROSHI ISODA, *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), Vol. 36, no. 409, 1988, pp. 16-22. 11 Refs.

The purpose of this paper is to assess the feasibility of a CO<sub>2</sub>-breathing engine using metal fuels for planetary use. The heats of reactions between metals and CO<sub>2</sub> were reviewed. Equilibrium compositions and temperatures of the metal-CO<sub>2</sub> flames were calculated. It was confirmed experimentally that Al and Mg could burn in CO<sub>2</sub>. Thermodynamic cycle calculations were carried out to evaluate the performance of a CO<sub>2</sub>-breathing turbojet engine. With these results, it is concluded that metal-fueled CO<sub>2</sub>-breathing turbojet engine with a practicable performance can be developed.

**A88-28954 Design and performance tests of a low power dc arcjet thruster** MICHIO NISHIDA, KEIJI KAITA, and K.-I. TANAKA, *Kyoto University, Faculty of Engineering, Memoirs* (ISSN 0023-6063), Vol. 49, Oct. 1987, pp. 358-369.

This paper describes a quasi-one-dimensional flow model which can be used for the design of an arcjet thruster. Owing to the simplicity of the model, the performance characteristics of the thruster can be calculated easily for finding an optimum configuration suitable for various missions. In order to verify adequacy of the model, a thruster was fabricated and its performance characteristics were measured. The experimental results were compared with the calculation predicted with the model. Both are in satisfactory agreement, and it is concluded that this flow model is a useful tool for the design of the arcjet thruster.

**A88-25854 Proposal of adaptively controlled transmitting array for microwave power transmission in space** K. KOMOYAMA and I. YOKOSHIMA, *Electronics Letters* (ISSN 0013-5194), Vol. 24, Jan. 21, 1988, pp. 87-89. 6 Refs.

An adaptively controlled transmitting antenna array system is proposed for use in microwave energy transmission between spacecraft. Monitoring detectors are used for feedback control of both main beam and sidelobe. Computer simulation shows the possibility of accurate control for the main beam and a sidelobe.

**A88-23319 Development of digital electronic control for aero-engine** TATSUKI SATOH, MINEO KISHIMOTO, MASAHIRO KUROSAKI, and MINORU ARAHATA, *Ishikawajima-Harima Engineering Review* (ISSN 0578-7904), Vol. 27, Sept. 1987, pp. 281-287.

Digital electronic control for aeroengines has been advancing from the development phase into practical applications. Integrated flight and propulsion control may improve the control performance of total aircraft systems. In this paper, the performance improvement of engines and propulsion systems due to the introduction of digital electronic control is explained. An outline of the system configuration is presented, and results of tests on FADEC (Full Authority Digital Electronic Control) systems in the XF3-30 turbofan engine and the TF40 reheat turbofan engine are reviewed.

**A88-19893 Feasibility study on linear-motor-assisted take-off (LMATO) of winged launch vehicle** MAKOTO NAGATOMO, and YOSHIHIRO KYOTANI, (presented as Paper 86-123 at the 37th IAF Congress, Innsbruck, Austria, Oct. 5-11, 1986) *Acta Astronautica* (ISSN 0094-5765), Vol. 15, Nov. 1987, pp. 851-857.

An experimental system for linear-motor-assisted take-off (LMATO) is discussed which consists of the Highly Maneuverable Experimental Space (HIMES) vehicle and a magnetically levitated and propelled MLU-model sled. The MLU vehicles, a train of three cars, are used to accelerate the HIMES vehicle at 0.33 g on a 5-km guide track until it reaches a speed of 300 km/h, at which point the rocket engines of the space vehicle are used to increase the acceleration up to 1 g. The take-off speed for the initial mass of 14 tons is 470 km/h. The LMATO system may have application to the initial acceleration of a vehicle with air-breathing propulsion.

**A88-16002 Laser-assisted propulsion system experiment on Space Flyer Unit** TAKASHI ABE, and TORU SHIMADA, presented as Paper 87-298 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 10 pp. 9 Refs.

The mission objectives and system design of the laser propulsion experiment to be flown aboard the Japanese Space Flyer Unit projected for the mid-1990's are discussed. Both the laser beam transmitter (LBT) and laser-assisted propulsion unit (LAPU) are equipped with a remote sensing system, beam direction system, electrical power system, and thermal control system. The LBT, installed on the SFU exterior, also contains the laser generation system, and the LAPU contains the laser propulsion system. Experimental objectives include testing of the SFU components and evaluation of the laser-transmission performance by beaming the power-reduced laser at the LAPU launched from one of the SFU payload units. Preliminary laboratory CW and repetitively pulsed propulsion experiments are also described.

**A88-15994 Performance of advanced engine cycles in future launcher** H. TANIGUCHI and D. MANSKI, presented as Paper 87-288 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 10 pp.

Earth-to-LEO SSTO booster engine cycle performance has been investigated for the cases of staggered combustion, gas-generator, dual-throat, and gas generator/staged combustion cluster propulsion system configurations. The propellant combinations considered are hydrogen/oxygen, propane/oxygen, and methane/oxygen. The results obtained indicate that the dual-throat engine employing propane/hydrogen/oxygen as propellants possesses the highest payload capability among the present engine cycles.

**A88-15979 Analytical study of space plane powered by Air-Turbo Ramjet with intake air cooler** NOBUHIRO TANATSUGU, YOSHIFUMI INATANI, TAKASHI MAKINO, and TSUYOSHI HIROKI, presented as Paper 87-264 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 10 pp.

The present paper addresses the analytical study on the TSTO launch system assisted by Air-Turbo Ramjet (ATR) with a pre-cooler. The study consists of the preliminary design of ATR propulsion system, the flight path analyses and the conceptual design of the typical TSTO vehicle assisted by ATR. Three types of ATR with the pre-cooler have been designed based on the near-term technology and their performance characteristics have been revealed on the altitude-Mach number map. The flight path analyses have been performed for both the fly-back booster and the orbiter including some optimization between them. On the basis of these results, the ATR assisted TSTO vehicle carrying a payload of 15 tons to LEO has been designed revealing its features on configuration and flight conditions.

**A88-15986 Upper stage solid rocket motors for H-I launch vehicle** SATORU HIRANO, JUNICHI ODA, AKIHIRO EGUCHI, and MICHIO TAKAHASHI, presented as Paper 87-276 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 7 pp.

The development and performance of the two solid propellant upper stage motors (a third stage motor and an apogee kick motor) on the H-I rocket are described. The design and functions of the H-I rocket are examined. The nominal pressure and thrust characteristics of the two motors are graphically presented. The third stage consists of a rubber insulated spherical case, an eight-point star-shaped grain propellant, a tape-wrapped carbon-phenolic cone nozzle, and a pyrogenic ignition system. The apogee kick motor is characterized by a thin-walled elongated case with an ethylene propylene diene monomer insulation, a head-end web grain propellant, and a carbon/carbon composite cone nozzle with an integral tridial igniter. The four test phases for the rocket motors are discussed.

**A88-15985 Development status of the Mu upper stage motors** MASAHIRO KOHNO, JUNJIRO ONODA, TAKUJI MURAKAMI, and AKIRA OBATA, presented as Paper 87-275 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 8 pp. 6 Refs.

Two types of upper stage motors, named KM-D and KM-M, are now under development to mate with the M-3SII launch vehicles. In their design have been incorporated several new technologies: an HMX containing HTPB propellant, a pressure-cured head-end web grain, a throat-plug-type aft-end pyrogen igniter, a 15V-3Cr-3Al-3Sn titanium alloy (KM-D) and a carbon fiber-epoxy filament-wound (KM-M) case, and an extendible exit cone deployed by helical spring extensor (KM-D). Design features of each motor and their development status are reported.

**A88-15991 Development of small LOX/LH2 rocket engine** T. MORI, K. HIGASHINO, K. MIYOSHI, and K. SUZUKI, presented as Paper 87-284 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 9 pp.

A small high-performance LOX/LH2 expander-cycle rocket engine, designed for one-ton-class upper-stage and orbit-transfer vehicle applications, is described. The design and the performance characteristics of the engine components (i.e., the combustion chamber, igniter, valves, LH2 and LOX turbopumps, and the pneumatic system) are discussed, and the results of the component testing are presented. The characteristics of stable conditions, start-up, and performance in vacuum demonstrate the validity of the design. Design diagrams are included.

**A88-15972 Dynamic power generation for solar power satellites** K. KISHIMOTO and M. YASUI, presented as Paper 87-253 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 5 pp.

Dynamic solar power generation for solar power satellites is examined with emphasis on the closed Brayton gas dynamic cycle as the most flexible system. Although, based on current technology, the overall efficiency of the closed Brayton cycle, including concentrator efficiency, does not exceed 20 percent, the system has the major advantage of a wide operating range. It also provides technology for propellant (liquid hydrogen and oxygen) production in space.

**A88-15965 Status of technology for space power system in Japan** M. NAGATOMO, N. TANATSUGU, presented as Paper 87-244 at the 38th IAF International Astronautical Congress, Brighton, England, Oct. 10-17, 1987. 7 pp.

The current status of the space power system technology of Japan is surveyed. Photovoltaic power system, fuel cell power system and solar dynamic power system technologies have been summarized with descriptions of individual subsystems. Types, characteristics and power levels of typical power systems operated in space are described. Satellite power systems for the scientific satellites and application satellites, interplanetary spacecraft and a Spacelab payload are included in this category. As for future planning, a satellite power system with GaAs solar cell, the SFU solar power system and an experimental solar dynamic system are summarized.

**A88-13095 The scramjet - Toward Mach 4-25 flight** NOBUO CHINZEI, GORO MASUYA, *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), Vol. 35, no. 400, 1987, pp. 241-252. 51 Refs.

Technological problems in the development of the scramjet are characterized, and scramjet R&D in the United States and Japan is reviewed. Work from 1960 to 1975 is summarized, including the free-jet engine, the variable geometry engine, the component integration model, and the thermal compression engine. Also considered is work after 1975, including the airframe integrated engine and the dual combustor engine.

**A87-42620 Analysis of discharge plasma in a cusped ion thruster** CHINAMI HAMATANI and YOSHIHIRO ARAKAWA, *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 29, Feb. 1987, pp. 189-206. 15 Refs.

An analytical model for the discharge plasma in a cusped ion thruster is developed. A key feature of this model is that it includes the analytical expressions for electron and ion cusp losses to the chamber wall. Using this model, the wall loss rates can be calculated and the discharge performance (both ion production cost and propellant utilization efficiency) can be predicted more accurately than ever. In addition, the nondimensional parameters associated with thruster geometric design and its operation are obtained, and their effects on the discharge performance are investigated.

**A87-40847 Development of the F3-IHI-30 turbofan engine** *Ishikawajima-Harima Engineering Review* (ISSN 0578-7904), Vol. 27, Jan. 1987, pp. 36-41.

The F3-IHI-30 turbofan engine developed for the XT-4 intermediate trainer is described. The engine is a two-spool, low-bypass-ratio turbofan engine with a thrust of 16.38 kN. The engine was designed and tested in accordance with the modified MIL-E-5007D so that requirements of the intermediate trainer and environmental conditions in Japan are reflected. Through both the preliminary flight rating and qualification tests, it has been demonstrated that the engine can withstand bird and ice ingestion, low-cycle-fatigue, endurance, inlet distortion tests, etc. The flight test of the XT-4 powered by two XF3-30 engines is being successfully conducted. The engine is qualified for series production.

**A87-39630 Continuous operation test of quasi-steady MPD thruster with a ring coil** M. SAKIYAMA, A. IWATA, M. YOSHIWA, R. YOSHIDA, Y. KAGAYA, et al. AIAA Paper 87-1045 presented at the AIAA, DGLR, and JSASS, 19th International Electric Propulsion Conference, Colorado Springs, CO, May 11-13, 1987. 8 pp. 7 Refs.

A new quasi-steady MPD thruster head with a ring coil was developed. Two continuous operation tests were carried out in order to obtain the thermal characteristics of the head in the case with an applied external magnetic field and in the case without it. It is found that the total input heat to the head is not changed so much by applying an external magnetic field to a discharge chamber, but the distribution of the input heat to the anode is changed. The reliability of the MPD thruster was also improved by applying an external magnetic field.

**A87-39266 Basic analyses for optimum propulsion efficiency of a counter rotating ATP (Advanced Turbo Prop)** TOMOARI NAGASHIMA and TAKEICHIRYO HIROSE, *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), Vol. 35, no. 397, 1987, pp. 102-107. 9 Refs.

To clarify the effects of wake contraction, swirl velocity and mutual interactions on the cruising performances of a counter rotating advanced turboprop fundamental analyses based on the generalized momentum theory were carried out. Assuming a linear interaction scheme, the optimum propulsion efficiency and the wake geometry which minimize the total induced losses for a given thrust were established as solutions of a calculus of variations problems. The optimum combinations of operating parameters such as the thrust sharing ratio, the power sharing ratio and the disk area ratio between fore and aft propellers were also specified, and their dependency upon the axial velocity, the total thrust level and the axial spacing were revealed. It was understood that, in addition to the counter-rotating effect of propellers, the upwash effect of the contracted top propeller wake on the outer part of the bottom propeller disk plays a fundamental role for improving the propulsion efficiency of a counter-rotating advanced turboprop.