DOUGLAS AIRCRAFT COMPANY, INC.

MTM-622

UNCONVENTIONAL PROPULSION SCHEMES

PART 2 REV. 3-1-55

SANTA MONICA DIVISION

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Astronautics Literature Review Serial 019

GRAVITICS

IONIC PROPULSION

Title: THE GRAVITATIONAL REACTION MOTOR

Author: Arnold G. Guthrie, Tacoma, Washington
Apr. 1947; 13 pages (Price $0.25)

Source: Journal of the American Rocket Society No. 71, September 1947, p. 24

Verbatim Quotation of Book Review:

"An interesting pamphlet on the theory of gravity and its many applications. The repulsion gravitation theory of Le Sage, and the various ideas advanced on gravity, electrical radiations, forces and fields are described.

"Chemical fuels are regarded as practically obsolete and emphasis is placed on discharging atomic particles at high velocities in an electric rocket motor design. A motor consisting of a linear accelerator and an ionizer is found the most possible type of motor for future interplanetary travel."

WBK:
12-13-54

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Astronautics Literature Review Serial 020

ELECTROMAGNETIC PROPULSION

Title: ELECTROMAGNETIC SPACE-SHIP ("ELECTRICAL ESSAY")

Author: J. Slepian

Source: Electrical Engineering, vol. 68 #2, Feb. 1949, p. 145 and #3 March 1949, p. 245

DAC ABSTRACT

In the essay in the February issue Dr. Slepian, eminent authority on electric and electromagnetic theory, with Westinghouse, sets up a puzzling example of what looks like a perfectly good electromagnetic means of levitation without a balancing reaction occurring on the physical system. He pictures a hypothetical machine in which a high frequency alternating current produces an alternating magnetic field between two electromagnets and also a synchronous electrical displacement a.c. in the vacuum gap between two condenser plates. The interaction is then expected to generate a net force upon the magnets.

In the second article the author explains the fallacy of the proposition and demonstrates that the contraption does not get around Newton's law of equal action and reaction: If the magnetic displacement current and the electric field in the condensor gap are taken into account, it is found that they generate a pulsating force acting on the charges, hence on the condenser plates, just exactly offsetting the electromotoric forces exerted on the magnet poles. Hence there is no net force evoked upon the mechanical system as a whole.

DAC COMMENT

Similar reasoning may serve to debunk various other bootstrap proposals of self-contained electromagnetic levitation or propulsion.

Refer also to Serial 021

W.B.Klemperer
12-14-54

Title: ELECTROSTATIC SPACE SHIP - COULOMB'S LAW AND FORCE ON AN ELECTRIC CHARGE ("ELECTRIC ESSAY")

Author: Dr. J. Slepian

Source: Electrical Engineering, vol. 69, No. 2, February, 1950, p. 164, #3, March 1950, p. 247

DAC ABSTRACT

Dr. Slepian, of Westinghouse, presents, under the guise of one of his famous electrical puzzles, a picture of a hypothetical electrostatic propulsion engine consisting of a high frequency circuit through a condenser which has only one of its plates encased in a titanate having a very high dielectric constant. He pretends to deduce a net thrust on the bare plate.

The second article shows the fallacy of the argument.

W. B. Klemperer
12-14-54

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Astronautics Literature Review Serial 022

ELECTRONIC PROPULSION

Title: EINFLUSS DER RAUMLADUNG AUF DIE PHASENFOCUSSIERUNG VON ELECTRONENSTRAHLEN (INFLUENCE OF THE SPACE CHARGE ON THE PHASE FOCUSSING OF ELECTRON BEAMS)

Author: Johannes Labus

Source: Zeitschrift für Naturforschung, vol 3a #1, Jan 1948, p. 52-61

DAC COMMENT

This article deals with the bunching of electrons in a Klystron. No mention at all is made of any application to, or analogy with, space vehicle propulsion. No computation of the momentum imparted to the electron beam is offered.

I therefore conclude that the listing of this article in Koelle-Kaeppler's Literature-Index on Astronautics under the category 761 (Electronic Jet Propulsion Engines) is entirely due to Kaeppeler who interprets it as a contribution to the science of the control of electron jets as eventually applicable to space ship propulsion.

REFERENCE: Klystrons and Microwave Triodes, MIT Radiatron Laboratory Series, by D. R. Hamilton, J. K. Knipp, and J. B. Horner Kuper, 1948

Listings: LIA 761

WBK

December 1954

Title: DIE VERWENDUNG VON KERNENERGIE ZUM RAKETENANTRIEB
(THE APPLICATION OF NUCLEAR ENERGY TO ROCKET PROPULSION)

Author: Dr. Ing. N. Scholz

Source: Weltraumfahrt, vol. 2, April 1951, p. 40 (in German)

DAC ABSTRACT:

This article considers heating of a working gas (hydrogen) by nuclear energy. The author develops the analysis which shows a mass ratio of 5 to be optimum.

Listing: LIA No. 750-11
A-GC No. 1299

WBK
12/3/54

Title: ROCKETS AND OTHER THERMAL JETS USING NUCLEAR ENERGY

Author: Hsue-Shen Tsien

Source: "The Science and Engineering of Nuclear Energy", Vol. II, Chapter 11, 1949 - Addison-Wesley Press

DAC ABSTRACT

The article first recapitulates the fundamental equations of rocket propulsion, then quotes the extension of the theory to the realm of special relativity which may come into play if or when fast fission fragments or neutrons are discharged directionally as propellants. Then he derives the optimum mass ratio (of the order of 5).

The author envisages a rocket motor containing a thermal neutron pile reactor, controlled by a hydrogen cooled cadmium rod, all in a nozzle chamber in which hydrogen gas, admitted through many orifices, is heated to about 6000°R when passing through a U235/238-C reactor.

The performance of such an atomic pile hydrogen rocket weighing 1000 tons but having the same construction weight characteristics as a standard V2 is calculated to be such as to attain over 27000 ft/sec maximum velocity (over 5 times that of a V2) consuming 1% of the atomic fuel it carries aloft.

Listings: LIA 751-1

W. B. Klemperer
12-14-54

Refer also to J. Ackeret, Helvetica Physica Acta 19, 103 (1946), Serial 025

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Astronautics Literature Review

Serial 025

NUCLEAR PROPULSION

Title: ZUR THEORIE DER RAKETEN (ON THE THEORY OF ROCKETS)

Author: J. Ackeret (E.T.H.)

Source: Helvetica Physica Acta, vol. XIX, #2, 8 April 1946
(submitted 22 February 1946)

DAC ABSTRACT (AND COMMENTS)

A very concise summary of the fundamental rocket theory is given in Chapter 1. Chapter 2 contains the extension of the theory of fast rocket motion into the domain of special relativity. Chapter 3 is devoted to preliminary assessment of the possibilities opened up by the advent of the technical mastery of nuclear energy processes. Of the various alternatives of putting nuclear energy to work for rocket propulsion the author (a) dismisses photonic (light pressure) propulsion as unattainable in significant measure with any device limited to technically tolerable temperatures; (b) holds that ion or electron guns expelling charged particles will be frustrated by rapid accumulation of the opposite charge (apparently believing that this charge cannot be made to leak off harmlessly),(c) considers an intermediate heat cycle process the only practical way to exploit nuclear energy for propulsion for interplanetary travel.

W. B. Klemperer
12-17-54

Title: ZUR THEORIE DER PHOTONENRAKETEN
(ON THE THEORY OF THE PHOTON ROCKETS)

Author: E. Sänger

Source: Ingenieur-Archiv, Vol. XXI, 1953, pp. 213 etc. (in German)

DAC COMMENTS

This is a very comprehensive and scholarly treatise of the subject of Photonic Rockets, which are defined as driven by the reactive pressure of directed electromagnetic radiation. It is readily admitted that such rockets are still impossible to design and will be for quite some time. Even if they could be built they could not compete with conventional chemo-thermal rockets for any terrestrial missile purpose, nor even for a satellite feeder vehicle, because of the much poorer ratio of impulse gained per energy spent. For eventual interplanetary and possibly for interstellar travel they are worth considering because of the higher terminal velocity attainable with any given mass ratio. However, formidable technical problems of handling the energy source (a hypothetical controlled nuclear fusion lamp) and devising reflectors of phenomenal perfection remain to be solved. Such a development should only be undertaken as a low priority long range project. Incidentally the author does not consider the danger element associated with a nuclear radiation rocket.

DAC ABSTRACT

1. Introduction

Even if one were to assume that a technical solution for the control of continuous nuclear reactions is at hand, then their exploitation for rocket propulsion would still be frustrated by the lack of means to direct the fast flying fission products into a desired jet. Therefore most serious proposals envisage the alternative that the energy will have to be degraded by heating an inert working fluid which is expelled thermically or by converting the nuclear into electric energy so harnessed as to eject an ionized gas from an ion gun. The author also examines another theoretical possibility, viz. that of so governing the nuclear process that energy is imparted only to a part of the reacting particles which then must attain still higher exhaust velocity while the remaining spent mass is merely dumped. Such "Partial Photon Rockets" will not appear entirely utopistic if and when some one succeeds in devising a nuclear gas discharge lamp in which most of the reaction energy is transformed into photonic radiation which can be directed by reflectors. This principle might lend itself to beating either the specific fuel mass consumption of chemico-thermal rockets or the engine weight of ion rockets. It should produce travel velocities of several hundred kilometers per hour.

2. "Total Rockets"

The author defines two relative quantities, viz. the energy utilization and the impulse exploitation in terms of fractions of the total (relativistic) energy content ($m_o c^2$) of the fuel and of its potential impulse ($m_o c$), and he develops the dynamics of a vehicle system utilizing a fraction of its rest mass as a perfect fuel.

3. "Partial Rockets"

In these the freed energy is not equally distributed over the remaining rest mass, but only imparted to some fraction of it "diabatically". This can be envisaged as being accomplished either with admixture of an inert working fluid or without it. The dynamics of a vehicle so propelled are examined for a logarithmically large range of ratios of inert mass to nuclear reactor mass (such as a uranium pile). The technical difficulties are recognized as immense, so that for the near future exhaust velocities will remain limited to the order of 20 km/sec, at least so long as thermal rocket motors are involved, while some authors believe that 100 to 1000 km/sec may eventually be attainable with ion gun propulsion. The pure photon rocket of equal partial energy utilization (of the order 10^{-3}) may yield a similar impulse per mass spent as the ion rocket but with a thousand-fold energy expenditure per unit impulse generated. Hence the Photon rocket can compete with the ion rocket only if the heat transfer can be kept very much lower in order to be handled safely.

In a section on Flight Performance the author derives formulas for the single stage mass ratio and the attainable velocity in terms of a fraction of the velocity of light for the variety of propulsion schemes discussed both with and without relativistic terms; the findings are illustrated by graphs. The superiority of thermal rockets for high-acceleration tasks is undisputed but for interplanetary journeys with low acceleration requirements (between satellite stations) the ion rocket and the partial photon rocket appear competitive provided the powerplant can be built light enough.

4. "Partial Photon Rockets"

The beaming of photons is a problem in the realm of optics, extending into the regime of X-ray and Gamma rays. While in chemical rockets only about 1% of the energy converted is transferred as heat to the burning chamber wall, ion rockets may have to dissipate as much as 2/3 of the energy handled. For photon rockets only something like 1/30% of the energy can be allowed to be absorbed by its optical system. This calls for reflectors of unprecedented perfection, more than 10 times better than the best visual optical interference mirrors now known. No idea has yet been advanced regarding how much reflectivity might be attained in the gamma ray regime. This is recommended as a new avenue of research.

As to the "lamp" only gas luminosity is considered as a hopeful source of radiation of high enough temperature to do any good. How to excite the gas to luminosity by a controlled nuclear reaction is also still unknown and recommended as a research project.

5. "The Total Photon Rocket"

The total photon rocket is regarded as the ultimate goal but for the time being its technology is still beyond grasp since the essential physical premises are still lacking.

NOTE This article is presumably a scientific version of a more popular paper on the same subject read by the author at the Fourth International Congress in Zurich, Switzerland in August 1953. This paper was reviewed "secondhand" under serial #005a.

Dr. Eugen Sänger is of course well known as one of the pioneers of rocketry. He was born in 1905 in Pressnitz (then in Austria, now in Czechoslovakia), studied Engineering in Vienna and Graz and took a technical doctor's degree at Vienna. He worked in electric power transmission and in aircraft construction. He has published profusely about rocketry ever since 1929, in the forties much jointly with Dr. Irene Bredt whom he married a few years ago. During World War II he was in charge of a large German rocket research laboratory at Trauen in the Lüneburger Heide and later at Ainring. Since the end of the war he has been working in France at Courcelle-sur-Yvette, S. & O. He is Honorary member of many Rocket Societies and in 1952/3 he was president of the International Astronautical Federation.

W. B. Klemperer
1-7-55

Additional Note:

Recently (ref. LIFE magazine of 7 March 1955, p. 28) Dr. Sänger returned to Germany where he is now established as director of a newly founded Rocket Propulsion Research Institute in Stuttgart.

WBK
3-1-55

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Serial 027

IONIC PROPULSION

Title: STATIONEN IN WELTRAUM
(STATIONS IN SPACE)

Author: Hermann Oberth

Source: Raumfahrt-Forschung, edited by H. Gartmann
(Oldenbourg, Munich 1952) p. 155-165

DAC ABSTRACT

In this contribution to Gartmann's Anthology on Astronautic Research, Oberth recapitulates his pet ideas about the various uses to which an Earth Satellite station can be put. In chapter 7 he describes his solar power plant and ion gun propulsion rocket essentially as elaborated in the publications reviewed under serial #001 and 002.

Reference: Ser. 001 and 002

W. B. Klemperer
1-4-55