United Aircraft Research Laboratories

UNITED AIRCRAFT CORPORATION

AD 678333

November 21, 1968

Department of Defense
Advanced Research Projects Agency
Washington, D. C. 20301

Attention: Director

Subject: Program Plan for Contract N00014-66-C0344

Reference: Modification G04 to subject contract dated 22 October 1968

Enclosures: (A) Three (3) copies of United Aircraft Research Laboratories Report G-920479-10

Gentlemen:

In accordance with Section E, Part B, Subsection 1, of the above modification of the subject contract we are transmitting herewith three (3) copies of the subject report, Enclosure A.

Very truly yours,

UNITED AIRCRAFT CORPORATION
Research Laboratories

Anthony J. DeMaria

Anthony J. DeMaria
Senior Principal Scientist
Quantum Physics Laboratory

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EAST HARTFORD, CONNECTICUT 06108

United Aircraft Research Laboratories

UNITED AIRCRAFT CORPORATION

November 21, 1968

Department of Defense
Advanced Research Projects Agency
Washington, D. C. 20301

Attention: Director

ARPA Order No.: 306 A #13
Program Cost Code: 8E30K21
Contractor: United Aircraft Research Laboratories
Effective Date of Contract: 22 October 1968
Amount of Contract: $236,513.00
Contract No.: N00014-66-C0344
Principal Investigator: Dr. Anthony J. DeMaria, Area Code 203, 565-3545
Project Scientist: Dr. William H. Glenn, Area Code 203, 565-5411
Title: Research Investigation of Picosecond Optical Pulse Technology
Subject: Program Plan
Reference: Modification G04 of the subject contract dated 22 October 1968

Gentlemen:

We submit herewith the Program Plan as specified in the above modification.

A) Research Plan

Investigations conducted at the United Aircraft Research Laboratories have successfully demonstrated that saturable absorbers with fast relaxation times can be used to simultaneously Q switch and mode-lock solid state lasers such as ruby and Nd:glass with the resulting production of trains of ultrashort optical pulses of extremely high peak power. Experiments conducted at this laboratory have produced pulses having power in excess of 10^9 watts and time durations less than 10^{-12} seconds. The availability of such pulses should make possible orders of magnitude advances in such fields as optically generated plasmas, nonlinear optics, spectroscopy of solids, liquids and gasses and studies of the transient response of quantum systems. Applications to such areas as optical radar and communication systems, optical information processing and high speed photography also appear promising.

The United Aircraft Research Laboratories have been conducting under the subject contract a theoretical and experimental research program directed toward the advancement of the state of the art of picosecond optical pulse technology. A number of theoretical and experimental programs have been conducted and are still in progress. The above modification to the subject contract will allow further investigations of the areas that are described below. A detailed account of previous accomplishments in these areas under the subject contract is given in United Aircraft Research Laboratories Report G-920479-8, the Second Annual Report under the subject contract.

(a) Analysis of the Propagation of Ultrashort Optical Pulses: A theoretical model has been formulated and can account for certain novel effects that take place when extremely short pulses of coherent light interact with matter. It has been shown that the interaction of an assembly of two-level systems with a light pulse having a duration that is short compared to all relaxation times of these systems can be described in terms of a single nonlinear partial differential equation. The equation is one which also occurs in differential geometry. Techniques available for obtaining particular solutions of this equation may be employed to derive analytical expressions which describe the observed breakup of short pulses as well as the self-induced transparency effect. Analytical solutions describing the propagation of 2π and 4π pulses have been derived and could be generalized to describe the behavior of $2n\pi$ pulses.

Further analytical work will be conducted in this area and experimental attempts to observe the destortion experienced by pulses propagating in various optical media will be made.

(b) Measurement of Nanosecond Fluorescence Decay Time: This accomplishment has demonstrated how ultrashort laser pulses of high peak power may be used to measure nanosecond fluorescent lifetimes. The techniques can be extended to the measurement of subnanosecond decay times.

(c) Light Amplification in Absorbing Media: It has been found that an absorber, driven into saturation by an intense light pulse from a mode locked laser, can amplify a weaker light pulse simultaneously incident upon the medium. A theory has been developed that is capable of predicting a gain coefficient for this effect. It has been found in addition that a novel type of stimulated thermal scattering can occur even in linear absorbers and can also result in gain for a weaker pulse. Gain has been observed experimentally for both linear and nonlinear absorbers. Further work will be conducted on the theory of the stimulated scattering, the theory of the gain in nonlinear absorbers and their relative contributions to the experimentally observed effects.

(d) Adiabatic Inversion of Quantum States: A theoretical investigation of the interaction of an intense, frequency-swept pulse of light (i.e., an optical chirp) with matter has been conducted. The first interesting result to come out of the investigation was the adiabatic inversion of populations between a pair of levels when the frequency of the pulse is swept through their resonant frequency.

The second result was the dependence of the phase of the induced polarization on the direction of the sweep. An experiment to attempt to observe these effects is in progress. In connection with this experiment a 60 MHz frequency swept, Q-switched CO_2 laser has been developed. This should also have application to problems in optical ranging and signal processing.

(e) Optical Rectification of Mode-Locked Laser Pulses at Microwave Frequencies: This accomplishment opens up the possibility of generating millimeter or submillimeter waves with ultrashort optical pulses and obtaining a detector for picosecond pulses because of the broad band response of the optical rectification effect. The detection of optical rectification at approximately 10 GHz has eliminated spurious signals from pyroelectric and acoustic effects, therefore simplifying the detection of this effect. The use of simultaneously Q-switched and mode-locked pulses enables the use of the high sensitivity characteristics of radio receivers in many experiments where signal sensitivity may be a problem.

(f) Mode-locking of Organic Dye Lasers: A laser-pumped organic dye laser has been developed and has resulted in the production of subnanosecond (possibly picosecond) pulses at the dye laser wavelength. Further work in this area should make available picosecond optical pulses throughout the visible portion of the spectrum. The availability of ultrashort pulses at any desired wavelength would greatly increase their applicability to studies of nonlinear optical effects, lifetime measurements, etc. Work has also been conducted on flashlamp pumped dye lasers and such lasers have been successfully operated. It is anticipated that this type of laser will be useful for mode-locking and other experiments involving nonlinear gain processes.

(g) It is anticipated that further developments in the above mentioned areas will open up new experimental possibilities for the investigation of lifetime measurements and coherency effects in optical media. Additional experiments suggested by these developments will be conducted.

B) Milestone Plan

The subject contract is an exploratory research program in a completely new area of investigation. It does not include any hardware development or testing, capability demonstration or equipment delivery. No government furnished equipment or material will be used and no subcontracts will be involved. In view of the nature of the contract it appears that the type of milestones suggested in the above modification are inappropriate. The results of the research will be reported according to the procedure detailed in the modification and it is suggested that the submission of the scheduled reports shall constitute the milestones. These shall consist of

1) Quarterly Management Reports to be submitted on Feb. 15, 1969 and May 15, 1969.

2) Milestone Report to be submitted within six (6) weeks of the receipt of the contract.

3) Interim Special Reports as warranted by events.

4) Program Plan submitted herein.

5) Technical Reports
   a) First Quarterly Report submitted Nov. 10, 1968 prior to receipt of modification G04
   b) Annual Report to be submitted by March 31, 1969 in lieu of Second Quarterly Report
   c) Third Quarterly Report to be submitted by June 30, 1969
   d) Final Report to be submitted by July 31, 1969

6) Field Papers and Special Reports as mutually agreed upon by ARPA, the Office of Naval Research and the United Aircraft Research Laboratories.

C) Manpower Loading Chart

Dr. Anthony J. DeMaria has overall technical responsibility for the subject contract. Drs. W. H. Glenn, G. L. Lamb, Jr., E. B. Treacy, M. E. Mack, and M. J. Brienza are directly responsible for the theoretical and experimental progress.

The total amount of direct engineering labor for the period 1 August 1968 to 31 July 1969 is estimated to be 5320 hours. It is anticipated that this will be expended at an approximately linear rate as shown in the accompanying chart.

D) Other Requirements

No major subcontracts will be involved in the subject contract. No major equipment will be pruchased and no government furnished equipment will be required.

Very truly yours,

UNITED AIRCRAFT RESEARCH
Research Laboratories

Anthony J. DeMaria

Anthony J. DeMaria
Senior Principal Scientist
Quantum Physics Laboratory

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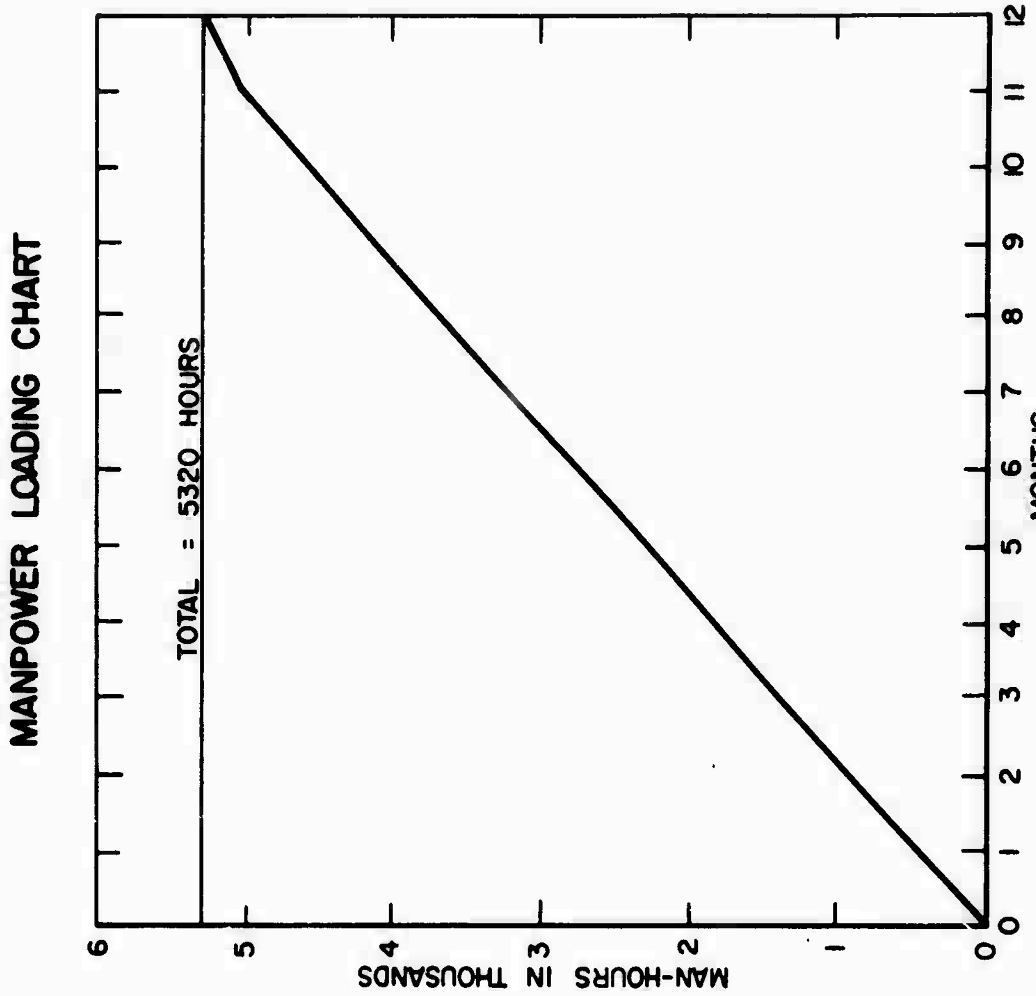
MANPOWER LOADING CHART
TOTAL = 5320 HOURS
MAN-HOURS IN THOUSANDS
0
1
2
3
4
5
6
MONTHS
0
1
2
3
4
5
6
7
8
9
10
11
12