R E P O R T R E S U M E S

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PHOTO-OPTICS--A SURVEY TO DETERMINE THE FEASIBILITY OF OFFERING A JUNIOR COLLEGE PROGRAM FOR PHOTO-OPTICS INSTRUMENTATION TECHNICIANS.

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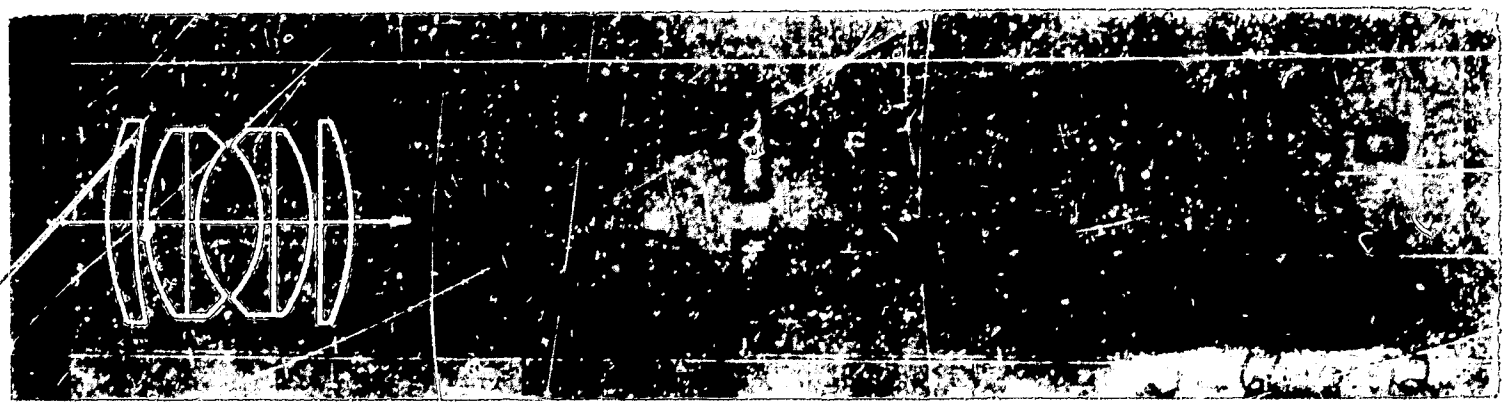
IN ORDER TO DETERMINE CALIFORNIA'S NEEDS FOR TRAINING OF PHOTO-OPTICS INSTRUMENTATION TECHNICIANS, PERSONAL INTERVIEWS WERE CONDUCTED IN 100 FIRMS AND AGENCIES MANUFACTURING OR USING SUCH EQUIPMENT. IT WAS DETERMINED THAT THE TRAINING NEEDED COULD SUITABLY BE PROVIDED AT THE JUNIOR COLLEGE LEVEL AND THAT COSTS WOULD NOT BE PROHIBITIVE. SPECIFIC SUBJECT AREAS REQUIRED FOR TRAINING INCLUDE MATHEMATICS THROUGH TRIGONOMETRY, DRAFTING, PHYSICS, OPTICS, PHOTO PROCESSING, BASIC ELECTRONICS, AND MECHANICAL ASSEMBLY, PLUS ENGLISH, COMMUNICATION, AND REPORT WRITING. EMPLOYMENT POSITIONS ARE ESTIMATED AT 450 IN THE STATE, WITH OVER 600 ADDITIONAL NEEDED IN THE NEXT 5 YEARS. COOPERATIVE WORK-STUDY PROGRAMS WERE APPROVED BY THE INTERVIEWER. LOS ANGELES, CITRUS-PASADENA, AND FOOTHILL-SAN MATEO AREAS WERE IDENTIFIED AS SUITABLE FOR SUCH PROGRAMS. INCLUDED ARE DETAILED DISCUSSIONS, A BIBLIOGRAPHY, JOB DESCRIPTIONS, AND INFORMATION AS TO CURRENT OFFERINGS IN RELATED FIELDS. (WO)



A SURVEY TO DETERMINE THE FEASIBILITY OF OFFERING A JUNIOR COLLEGE PROGRAM FOR PHOTO-OPTICS INSTRUMENTATION TECHNICIANS

CALIFORNIA STATE DEPARTMENT OF EDUCATION

MAX RAFFERTY
SUPERINTENDENT OF
PUBLIC INSTRUCTION

SACRAMENTO, 1964

PHOTO-OPTICS

A SURVEY TO DETERMINE THE FEASIBILITY OF OFFERING A JUNIOR COLLEGE PROGRAM FOR PHOTO-OPTIC INSTRUMENTATION TECHNICIANS

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

BY

Richard Cooper, Instructor of Physics

Diablo Valley College

THE COVER:

Shadowgraph showing shock fronts and air disturbance around model in wind tunnel.

BUREAU OF INDUSTRIAL EDUCATION
CALIFORNIA STATE DEPARTMENT OF EDUCATION

FOREWORD

California has been in the forefront of development in the new technologies that are contributing to progress in the space age. In the recording of missile tests and the development and production of precision optical systems, a new class of technician has emerged, the photo-optics instrumentation technician. Until the present time, no schools in California have offered training for this field of work, nor has any concrete information been available regarding training needs. This survey was undertaken to determine the number of persons who need such training and the type of program needed, as well as areas in which the need is great enough to justify setting up appropriate programs.

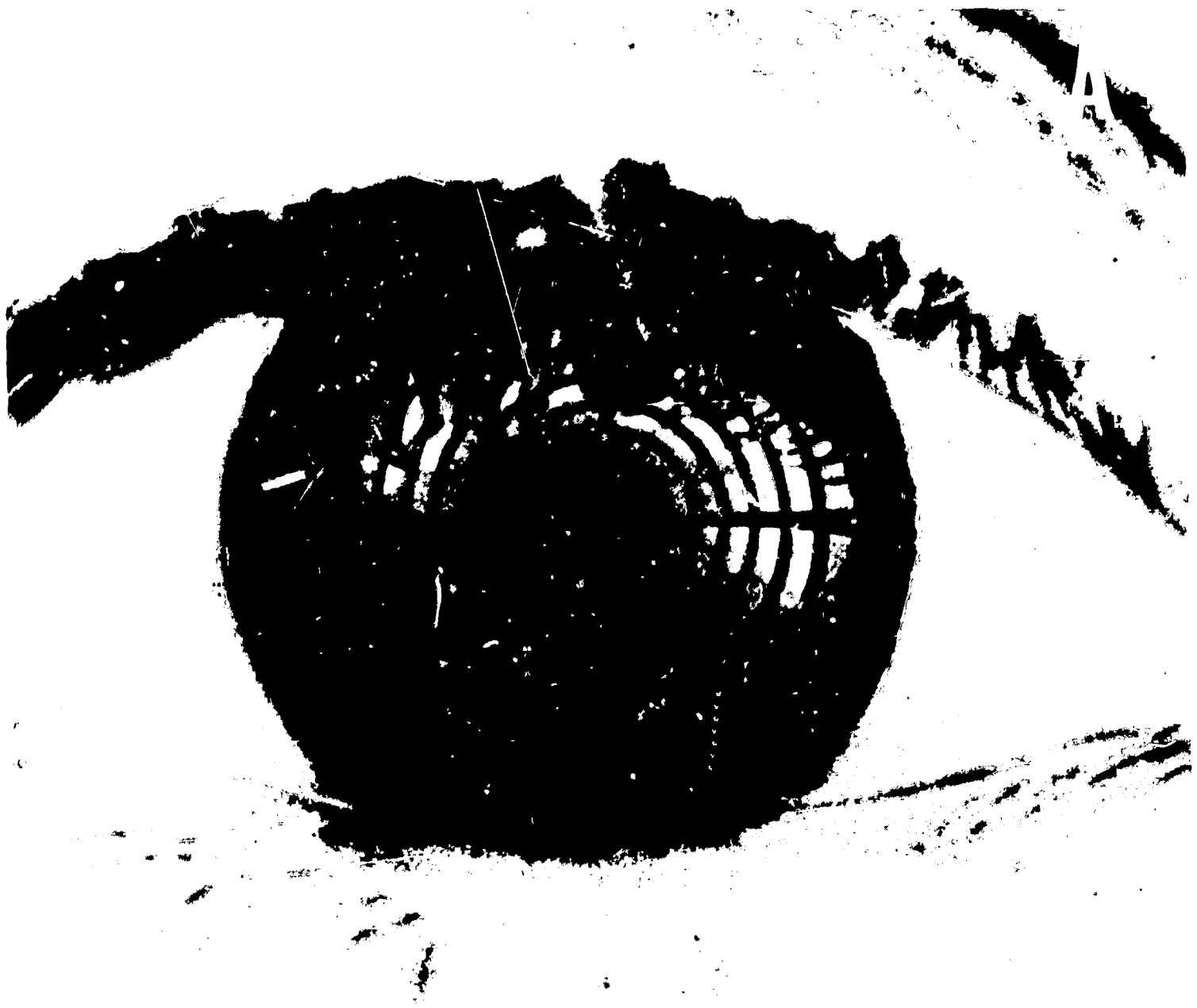
This project was undertaken jointly by the California State Department of Education, Bureau of Industrial Education, and Diablo Valley College, Contra Costa Junior College District, with funds provided under the National Defense Education Act, Title VIII. Russell P. Journigan of the Bureau of Industrial Education coordinated the project. Acknowledgment is made to the Society of Photographic Instrumentation Engineers, whose cooperation in the conduct of the survey was of immeasurable benefit.

Max Rafferty

Superintendent of Public Instruction

CONTENTS

Distortion of eyeball due to acceleration in centrifuge. Pictures were taken to determine the amount and kind of distortion that cause blurring of vision under high G forces. Comparison of Pictures A and B (before and during acceleration, respectively) showed that blurred vision was caused by flood of tears from open tear duct rather than by eyeball distortion.



OBJECTIVES

General Purpose

The purpose of this survey was to determine the feasibility of offering a two-year junior college training program for the photo-optics instrumentation technician (POIT). This person is described as a technician with sufficient photographic and optical knowledge to aid in photo-optics equipment design, setup, and evaluation; data-taking; and quality control. He is to be differentiated from the optician, whose primary responsibility is the grinding and polishing of optical materials, and the photo-lab technician, whose primary responsibility is the processing of film.

Specific Objectives

The specific objectives of this survey were to determine the following:

- The kinds of work POIT's do.
- The levels of skills necessary for the performance of their duties.
- The educational and vocational backgrounds of those technicians presently employed in the field.
- The kinds of training programs provided for these technicians in the establishments where they are currently employed.
- The kinds of establishments where they work: governmental, medical, educational, industrial.
- The present need for POIT's and the geographical location of the need.
- The anticipated need for POIT's within the next five years.
- The cost of equipment that might be necessary to offer a junior college program in this field.
- The possibilities for a cooperative work-study program.
- The textbooks, periodicals, teaching aids, and other published and filmed materials that are currently available.

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METHODS

Personal interviews with 100 firms and agencies involved in or connected with the aerospace industry were used to obtain information for this survey. Use was made of the OPTICAL INDUSTRY DIRECTORY, 1962, the PHOTO METHODS FOR INDUSTRY DIRECTORY, 1962-63, and the professional soceties listed in Appendix B. Questionnaires sent by mail were not used, as originally intended, because the initial personal interviews indicated considerable difficulty in communicating to the interviewee the type of technician with whom the survey was concerned.

Both manufacturers and users of photo-optics instrumentation equipment were interviewed. Manufacturers may be classified as producers of optical components such as lenses, prisms, mirrors, reticules, sensors, fiber optics, and laser equipment as well as producers of high-speed, pulse, and time sequence cameras. Users consist of field agencies involved in sled, satellite, aircraft, and missile tracking, and firms engaged in research on lasers, infrared and ultraviolet receptors, and fiber optics. (See Appendix G for questionnaire used as a basis for interviews.)

Attempts were made to interview men in personnel, the supervisors of technicians, and the technicians themselves. Since individual interviews consumed over an hour, it was quite often not possible in any one firm to contact persons in all three of these catagories. When a choice of contact had to be made, the technicians' supervisors were chosen as interviewees. A number of times, when the initial contact was made with the personnel department, the interviewer was told there were no POIT's working in the firm. Personnel was often not aware of the firm's use of or its present and future need for POIT's. Subsequent contacts with supervisors of technicians uncovered a number of them in the firm. Supervisors pointed out that since there is no educational institution training this kind of technician, he is usually trained on the job and quite often retains the personnel title he had prior to undergoing the training. In a typical situation where the job description of a POIT does not describe his work, the title and description of "Electronic Technician," for example, might be assigned. A considerable number of firms illustrate this anomaly.

The variety of occupational titles below exemplifies the difficulty of discovering the POIT within large firms.

FIRMS' OCCUPATIONAL TITLES FOR THE POIT

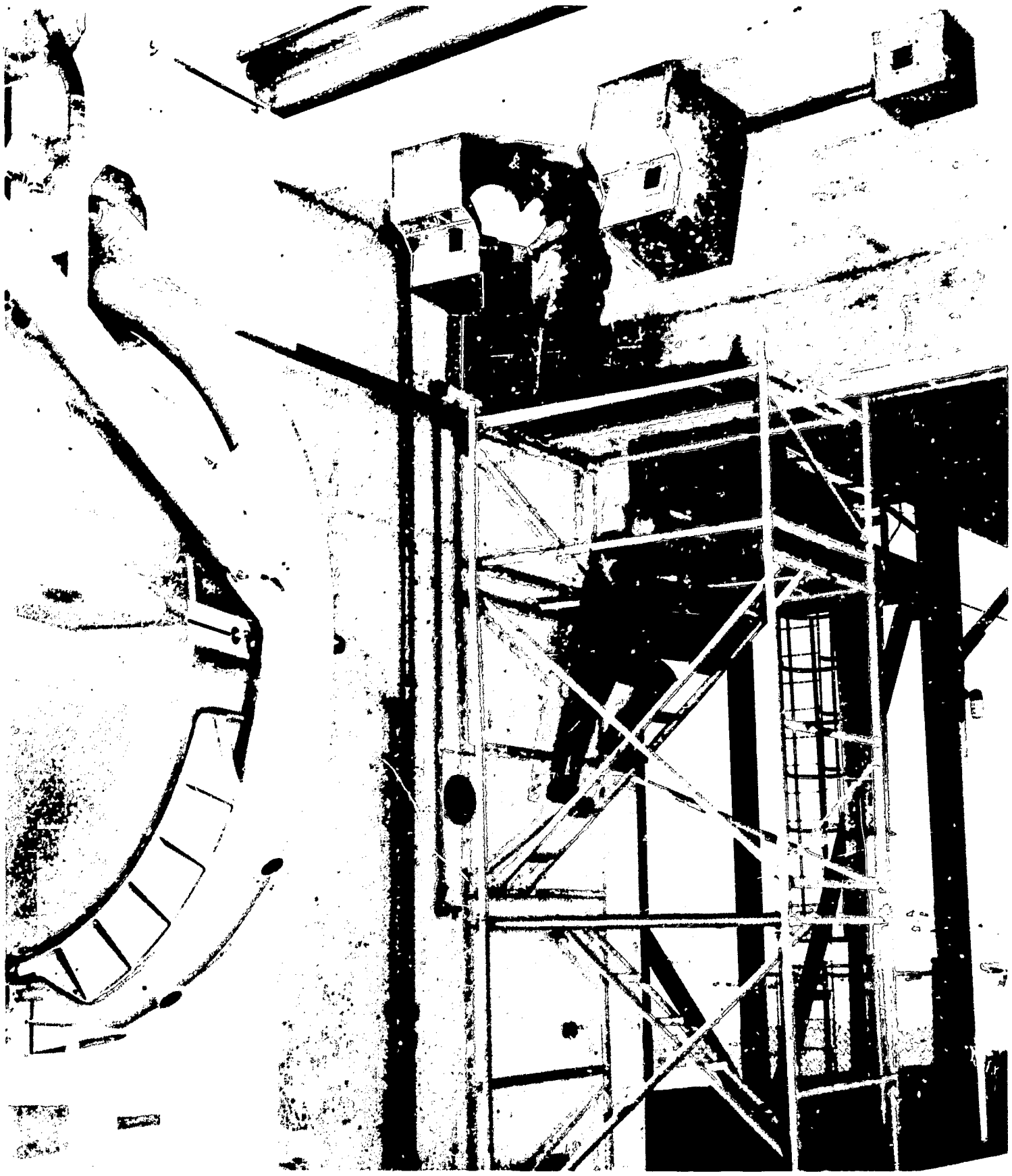
photo instrumentation technician
photo instrumentation technologist
junior and senior technician
technician A, B, C, etc.
field service engineer
lab analyst
lab technician
process technician
lab technician specialists
photo-mechanical technician
production technician
development technician
electromechanical technician
optical data-gathering technician
scientific photographer
glass blower
camera technicia..
instrument technician
electronic technician
cameraman
technical associate
optical worker
experimental technician
photo-resist technician
sight technician
research mechanic
equipment tester
mechanical technician
machinist
shop personnel
camera repairman

NAMES SUGGESTED BY INTERVIEWEES FOR THE POIT

photo-optics instrumentation technician
optical instrument technician
optics technician
optical systems technician
instrumentation technician
electro-optical technician
optical lab technician
scientific photographer

RESULTS

Special-purpose camera stands devised to protect cameras during firing



General Description

Photo-optics instrumentation can be described as the science of acquiring qualitative and quantitive engineering data by utilizing visible light and infrared, ultraviolet, and X-ray radiation portions of the electromagnetic radiation spectrum. This data acquisition involves the use of components that direct the energy being measured and components that receive and record the directed energy. Energy directors include lens-prism-mirror systems and electronic and magnetic devices. Energy receptors usually consist of a photographic medium (film), although use is also being made of perforated or magnetic tape.

Kinds of Work

For the purposes of this survey, POIT employment has been divided into three types: field and range technician, research technician, and production and quality control technician.

- Field and Range Technician.(See Appendix D, Job Descriptions 1 through 7). Field data are usually gathered by accurately placed tracking units (see illustrations on pages 5 and 21) that follow moving objects such as satellites, missiles, aircraft, and sleds, recording their position and performance. The field and range technician assists in design, fabrication, and assembly of photographic instrumentation complexes; designs and sketches special-purpose stands for cameras (see illustration on page 9) coordinates with supplier, customer, and engineering personnel to establish camera requirements for specific tests; determines equipment, film, camera coverage; devises and installs photo-circuitry; installs, boresights, loads, checks, and tests remotely controlled high-speed, normal-speed, pulse, and special-effects camera circuits; physically positions the instruments for tests; operates the optical tracking devices; disassembles, cleans, aligns, reassembles, and collimates the optics used in the data recording instruments; analyzes instrumentation film footage to determine if the film meets the required test specifications and if the processing procedures were correct; assists in evaluating new equipment; and reads and writes various

reports. He sometimes operates various precision machines in the optical machine shop.

- Research Technician. This technician assists in development, design, and construction of special instrumentation. He measures the properties of various materials with the use of electro-optical and mechanical equipment. He usually works with one engineer or physicist and utilizes a variety of electrical, mechanical, and optical devices to gather data. Job descriptions were not available, since the type of work varied according to the projects of the engineer or physicist.

- Production and Quality Control Technician. (See Appendix D, Job Descriptions 8 through 11.) The technician in this group produces optical components to tolerances of millimicrons and angular measurements of a second of arc; examines lenses for internal strain, seed, or flaws; determines resolution and distortion curves; performs necessary mathematical calculations from specifications and blueprints; and assembles and mounts optical elements. He is sometimes used in a supervisory and sales capacity.

Levels of Skill

Table I indicates the number of responses by interviewees concerning the amount of knowledge needed on the job. The similarity of responses for all three types of technicians points up a common educational background necessary for the performance of their duties. The qualitative responses made by a preponderant number of interviewees while filling out this portion of the survey instrument warrant reporting.

"Technicians should have more lab work, less theory."

"Basic principles should be stressed over specific applications."

"A good knowledge of high precision measurements is essential. They should have an intuitive feeling for a second of arc and the difficulties involved in obtaining this accuracy."

"More emphasis should be placed on English, communication, report writing."

"A four-year technologist program and an optical engineering program are needed in addition to a two-year technician program."

The POIT apparently, from these responses, needs mathematics through trigonometry, drafting, elementary physics, optics (including optics lab beyond that given in elementary physics), a knowledge of photographic processing, basic electronics, and practice in mechanical assembly. In addition, he needs a course in communication and technical report writing.

Interviewees for field technicians placed less emphasis on optics and more on photographic disciplines, i.e., color photography and camera repair. They also expressed a need for a course or courses in high-speed instrumentation. Interviewees for research technicians indicated a necessity for more depth in most disciplines than did interviewees for production and field technicians.

The interviewer asked if an electronics program supplemented by optics courses would be a satisfactory educational background. While some interviewees replied that it would, most replied that this would be too much specialization in electronics. A typical junior college photographic program supplemented by special optics courses was ruled out by interviewees as too much specialization in photography. (For junior college photography programs, see Appendix F.) Over 85 percent of the people interviewed agreed that a broad background rather than a specialist's background was preferred for the POIT. Interviewees were about equally divided on the ability of women to perform the technician's tasks. Reasons for negative responses included the heavy equipment which must be lifted and state legislation prohibiting more than a 48-hour work week.

Table I

MATHEMATICAL AND TECHNICAL KNOWLEDGE APPLIED BY THE POIT

RESPONSE SCALE: 0-none 1-little 2-a fair amount 3-a great deal 4-thoroughly

SUBJECT	NUMBER OF RESPONSES																					
	Field						Prod. & Q.C.						Research						Total Group					
	0	1	2	3	4	avg	0	1	2	3	4	avg	0	1	2	3	4	avg	0	1	2	3	4	avg
algebra	0	4	9	13	2	2.5	0	2	9	11	14	3.0	0	2	4	6	2	2.6	0	8	22	30	18	2.7
geometry	0	2	6	16	4	2.8	0	2	7	17	10	3.0	0	4	3	5	2	2.4	0	8	16	38	16	2.8
trigonometry	0	2	20	4	2	2.2	0	10	16	9	1	2.0	0	5	5	2	2	2.1	0	17	41	15	5	2.1
solid geometry	2	18	6	2	0	1.3	4	21	10	1	0	1.2	2	6	4	2	0	1.4	8	45	20	5	0	1.2
blueprint reading and/or drafting	0	6	13	5	4	2.3	1	3	6	14	12	3.9	1	5	2	4	2	2.1	2	14	21	23	18	2.5
chemistry, basic	3	18	5	2	0	1.2	5	13	13	3	2	1.6	2	7	5	0	0	1.2	10	38	23	5	2	1.4
electricity, basic	0	2	6	18	2	2.4	0	7	9	13	7	2.6	0	1	7	4	2	2.5	0	10	22	35	11	2.6
electronics, fundamentals	0	0	12	15	1	2.6	2	8	11	9	6	2.3	0	0	5	2	7	3.1	2	8	28	26	14	2.5
electronics, advanced	6	14	8	0	0	1.1	12	8	10	6	0	1.3	0	8	0	6	0	1.9	18	30	18	12	0	1.3
heat	10	14	2	2	0	0.9	9	14	7	4	2	1.3	1	3	4	4	2	2.2	20	31	13	10	4	1.3
light	0	0	10	9	9	3.0	0	2	5	13	16	3.2	0	1	1	5	7	3.2	0	3	16	27	32	3.1
sound	10	10	5	3	0	1.0	13	17	6	0	0	0.8	6	4	3	1	0	0.9	29	31	14	4	0	0.9
geometric optics	0	2	11	11	4	2.6	0	2	2	10	22	3.4	0	0	4	6	4	3.0	0	4	17	27	30	2.9
physical optics	2	4	16	6	0	1.9	0	7	11	10	8	2.5	0	2	5	2	5	2.7	2	13	32	18	13	2.3

optical tooling	4	19	1	4	0	1.2	5	11	2	15	3	2.0	0	4	4	4	2	2.3	9	34	7	23	5	1.8
optical alignment	1	5	15	3	4	2.1	2	0	8	11	15	3.0	0	1	0	7	6	3.3	3	6	23	21	25	2.8
optical instrumentation design layouts	6	9	7	1	5	1.6	2	8	18	8	0	1.9	0	2	6	2	4	2.6	8	19	31	11	9	1.9
elementary lens computation	6	9	4	7	2	1.6	6	10	10	7	3	1.8	0	2	6	4	2	2.4	12	21	20	18	7	1.8
optical lab testing or instrument evaluation	6	6	8	7	1	1.7	3	5	1	25	2	2.5	0	1	5	5	3	2.7	9	12	14	37	6	2.2
optical ray tracing	12	11	1	1	3	1.0	3	17	8	5	3	1.7	0	1	3	4	6	3.1	15	29	12	10	12	1.7
photographic processing	0	6	8	12	2	2.4	4	4	8	8	12	2.6	0	6	5	2	1	1.9	4	16	21	22	15	2.3
color photography	2	2	15	7	2	2.2	10	5	19	1	1	1.4	2	6	6	0	0	1.2	14	13	40	8	3	1.7
photometry	2	20	4	2	0	1.2	7	7	17	3	2	1.6	2	4	0	7	1	2.1	11	31	21	12	3	1.6
sensitometry	5	15	7	1	0	1.1	8	9	13	3	3	1.6	6	0	5	1	2	1.5	19	24	25	5	5	1.4
radiometry	13	12	3	0	0	0.6	17	4	11	3	1	1.1	0	2	3	7	2	2.6	30	18	17	10	3	1.2
camera repair	0	2	5	15	6	2.9	14	12	2	5	3	1.2	8	2	1	3	0	0.9	22	16	8	23	9	1.8
photogrammetry	15	9	4	0	0	0.6	24	8	2	1	1	0.5	5	5	4	0	0	0.9	44	22	10	1	1	0.6
mechanics	0	0	18	4	6	2.6	4	6	10	4	12	2.4	0	2	10	2	0	2.0	4	8	38	10	18	2.4
surveying	0	15	10	3	0	1.6	27	5	2	2	0	0.4	6	4	3	1	0	0.9	33	24	15	6	0	0.9
astronomy	13	11	3	1	0	0.7	16	15	5	0	0	0.7	6	3	3	2	0	1.1	35	29	11	3	0	0.8
metallurgy	8	17	3	0	0	0.8	12	20	4	0	0	0.8	4	7	3	0	0	0.9	24	44	10	0	0	0.8
strength of materials	9	11	8	0	0	1.0	15	15	4	2	0	0.8	3	7	1	3	0	1.3	27	33	13	5	0	0.9
shop tools	0	9	15	1	3	1.9	2	7	17	7	3	2.0	0	3	4	6	2	2.5	2	18	36	14	8	2.1
tool design	16	10	2	0	0	0.5	16	10	6	2	2	1.0	5	7	2	0	0	0.8	37	27	10	2	2	0.8

Educational and Vocational Backgrounds

At present, no public school in the nation offers a two-year technical program for the type of technician covered by this survey. The U.C.L.A. Engineering Extension in 1959 offered an evening course in ENGINEERING APPLICATIONS OF PHOTOGRAPHIC INSTRUMENTATION in which 69 people in the field enrolled. (Course description is given in Appendix E.) Of these students, 43 percent had no formal education beyond high school, and 70 percent had none beyond the second year of college. Assuming these 70 percent were mostly POIT's, it can be concluded that they recognized a lack of formal education in photo-optics instrumentation, and that any training program inaugurated should make provisions for training the present POIT as well as the future one. U.C.L.A. Engineering Extension will probably not offer this course again, since upon review of the course content and results, they decided that it is not their function to offer occupationally oriented courses at this level.

Interviewees also expressed a critical lack of optical engineering programs in the nation, the University of Rochester being the only institution offering a four-year program for the optical engineer. Some of the technicians had degrees that would allow them to perform engineering work if qualified technicians were available to replace them.

Below is a list of vocational or educational backgrounds that occurred at least twice, at different locations:

VOCATIONAL OR EDUCATIONAL BACKGROUNDS

camera repair experience	electronics technician
photographic military school	portrait photographer
electron vacuum tube technologist	tool and die maker
test range tracker helper	apprentice machinist
Hollywood movie industry	farm hand
marine navigation mechanic	gunsmith
directly from high school	industrial technologist
as a result of job reduction	watchmaker
M.S. Science Education	electrical engineer
A.S. Arts and Sciences	chemist

Kinds of Work Training Programs

Training for research and production and quality control technicians consists exclusively of on-the-job training. Engineers and physicists are required to take time out from their work to explain concepts and methods to individual technicians. Training for field technicians consists mainly of on-the-job training, although some camera companies offer short courses on care and maintenance of their respective cameras. Most firms used a tuition refund program to encourage technicians to continue their educations in the evenings, and two companies allowed released time for this purpose.

Interviewees strongly favored a junior college training program for POIT's, since few of the agencies contacted are equipped or prepared to meet their own training needs.

Kinds of Establishments

Field technicians work in the military service, federal civil service, government contract range service, and aircraft and missile industries. Production and quality control technicians work for manufacturers of optical goods, mechanical-electro-optical systems and components, semiconductors, and cameras. Research technicians work mainly at firms doing research on the infrared portion of the electromagnetic spectrum, lasers, and fiber optics. Some technicians are used in medical research and in educational research agencies. A few are employed by data reduction firms.

Present and Future Need

Through the use of the OPTICAL INDUSTRY DIRECTORY, the PHOTO METHODS IN INDUSTRY DIRECTORY, and membership rosters of the Society of Photographic Instrumentation Engineers and the Optical Society of America, approximately 70 percent of the agencies in the state using photo-optical instrumentation technicians were contacted. The figures in Table II were tabulated from the results of these contacts.

Interviewees expressed difficulty in predicting the need within the next five years because of changing markets. To avoid

Table II

POIT NEED BY JUNIOR COLLEGE DISTRICT AND STATEWIDE*

KEY a- presently employed b- presently needed c- needed within next 5 years

JUNIOR COLLEGE DISTRICT	Field			Prod. & Q.C.			Research			Total Group		
	a	b	c	a	b	c	a	b	c	a	b	c
Citrus	30	3	33	1	2	2	3	2	3	33	7	38
Foothill	49	9	52	7	3	22	8	2	9	64	14	83
Los Angeles	80	2	77	36	9	56	13	1	10	129	12	143
Pasadena	18	1	18	9	1	5	3	0	3	30	2	26
San Mateo	6	1	5	19	7	45	1	0	1	26	8	51
Statewide**	268	25	272	101	31	169	31	6	30	400	62	471

*Only those districts where a plus c exceed 30 are included.
**Figures do not include military personnel. Personnel at the military bases contacted stated that approximately 170 military POIT's are stationed in the state, with an estimated five-year need of 260 more.

the possibility of inaugurating a training program when little need exists, the interviewer requested that five-year predictions made by the interviewees be conservative.

Two factors that indicate an expanding future need for POIT's are the accelerating space program, which utilizes photo-optics, and the amount of research being done on lasers. During 1962 the federal government spent $13,000,000 in support of laser research and is spending quadruple that amount this year. An increasing number of POIT's will be needed for production work related to lasers in the near future.

Cost of Equipment

Analysis of responses and comments by interviewees and Table I indicate that the POIT would require core courses in drafting, electronics, photography, and optics. The drafting and electronics equipment now existing in most junior colleges would be sufficient for POIT training. Extra equipment would be needed for the photography and optics courses.

In addition to the photographic equipment already possessed by the junior college photographic departments, high-speed camera equipment and accessories in the 200-8000 frames per second range would need to be obtained. Interviewees suggested that this equipment can be purchased through military surplus at a greatly reduced rate. Camera manufacturers also suggested the possibility of supplying schools with klieg lights, photometers, high-speed cameras, and similar items, on a permanent loan basis as a means of advertising their products. If none of the above methods is used to obtain equipment, the probable cost for new purchases is $9,000.

Much of the optics equipment for POIT courses is routine equipment in junior college physics departments. In addition, however, since experience in optics fabrication is necessary for POIT training, an optics fabrication laboratory would need to be equipped. A year ago, one optics fabrication manufacturer offered to equip a junior college laboratory completely at no cost to the junior college. The offer was not accepted at that time because the junior college believed the need for this course did not warrant its inauguration. Precluding

military surplus equipment and permanently loaned equipment from optics manufacturers, the cost of equipping an optics fabrication laboratory (6-inch maximum diameter) is estimated as $25,000.

Possibility for Cooperative Work-Study Program

Interviewees were quite receptive to the suggestion of a cooperative work-study program. A few of the larger firms pointed out that this might be the only way they could obtain graduates from a junior college program. Seniority rules and union agreements require them to promote from the ranks. Their method of utilizing a junior college technician program would be to enroll selected employees in the program. Most firms indicated good possibilities for summer employment and part-time work, as this is already established policy.

Textbooks, Periodicals, Teaching Aids, and Other Published and Filmed Materials

Instructional materials available for use in POIT training are listed in Appendix C. Comments have been made regarding their usability, or describing their contents.

RECOMMENDATIONS

In the 70 percent of the California firms and agencies that were contacted, more than 400 photo-optics instrumentation technicians (POIT's) are at present employed. The remaining 30 percent of firms and agencies probably employ at least 150 more. The conservative prediction of the agencies contacted is that at least 470 additional POIT's will be needed within the next five years. The remaining firms and agencies can be estimated to need perhaps 175 more.

The POITs' required minimum educational background can be suitably provided at the junior college level. The cost of such a program for those institutions already offering courses in physics, electronics, and photography would not be prohibitive.

- A POIT curriculum should therefore be developed. The research, quality control, and field technician can all be provided with the same program, subject to minor variations in the last year or last semester.

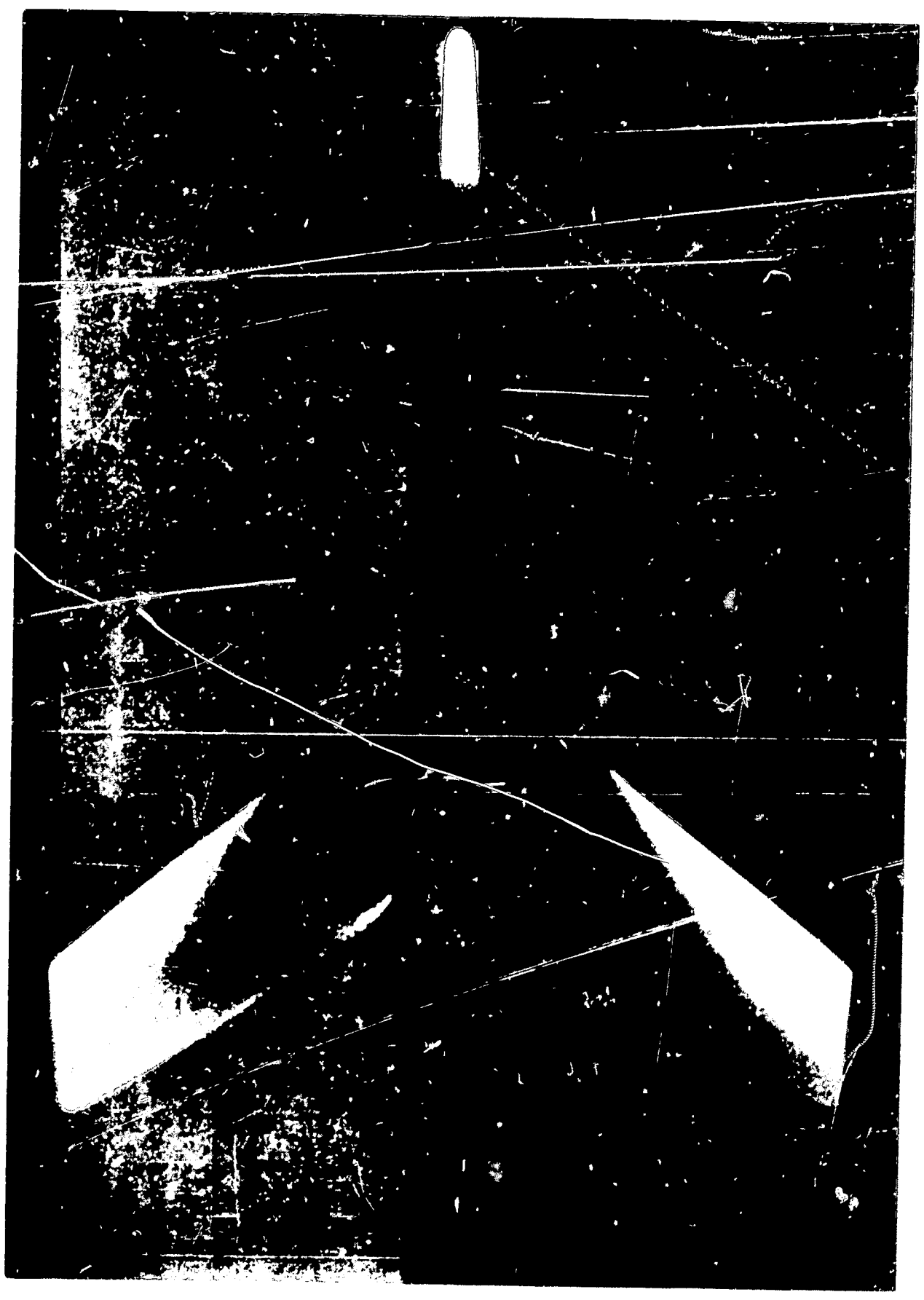
- According to geographical need, Los Angeles, Citrus-Pasadena, and Foothill-San Mateo are three likely areas where programs can be inaugurated. Cooperative work-study plans should be investigated in further detail at these locations.

- Since the present ratio of optical engineers to POIT's in California is at least one to one, the state college or university system should investigate the possibility of developing an optical engineering program.

- A high-speed photo instrumentation course should be offered at the locations mentioned above to help train the POIT's already employed in the field.

APPENDIX

Infrared photograph showing areas of most intense heat at "mach" speeds



APPENDIX A

Firms and Agencies Contacted

Aerojet General Corp., Azusa
Aerospace Corp., El Segundo
Amelco, Inc., Mountain View
Ampco, San Carlos
Applied Physics Corp., Monrovia

Applied Research Laboratories, Inc., Glendale
Bach Auricon, Inc., Hollywood
Beattie-Coleman, Inc., Anaheim
Beckman Instruments, Inc., Palo Alto
Beckman & Whitley, Inc., San Carlos

Benson-Lehner Corp., Van Nuys
Birns & Sawyer Cine Equipment Co., Hollywood
Boller and Chivens, Inc., South Pasadena
Burton Manufacturing Co., Northridge
California State Department of Employment, Los Angeles

Camera Equipment Co., Hollywood
Chadwick Helmuth Co., Monrovia
Cinerama Camera Corp., Los Angeles
Colortran Industries, Burbank
Consolidated Electrodynamics Corp., Pasadena

Consolidated Systems Corp., Monrovia
Davidson Optronics, Inc., West Covina
Douglas Aircraft Co., Inc., Santa Monica
Dynametric, Inc., Pasadena
Edwards Air Force Base

Electro-Optical Instruments, Inc., Monrovia
Electro-Optical Systems, Inc., Pasadena
Fairchild Camera and Instrument Corp., Los Angeles
Fairchild Semiconductor, Palo Alto
F M A, Inc., El Segundo

Giannini Scientific Corp., Santa Ana
Hayward Scientific Glass Corp., Whittier
Herron Optical Co., Los Angeles
Hewlett-Packard Co., Palo Alto
Hoffman Electronics Corp., El Monte

Hollywood Film Co., Hollywood
Houston Fearless Corp., Los Angeles
Hughes Aircraft Co., Laser Products, Malibu
Hughes Aircraft Co., Infrared Laboratory, Culver City
Hycon Manufacturing Co., Monrovia

I B M Corp., Palo Alto
ITEK Corp., Palo Alto
I. T. T. Federal Laboratories, San Fernando
Jet Propulsion Laboratory, Pasadena
Keim Precision Mirrors Corp., Glendale

Kentron Co., Range Systems Division, Point Mugu
Kiernan Optics, Monrovia
Korad Corp., Santa Monica
Landsverk Electrometer Co., Glendale
Litton Industries, San Carlos

Lockheed Aircraft Corp., Burbank, Santa Cruz, Sunnyvale, and Palo Alto
L-W Photo Inc., Van Nuys
Mark Systems, Inc., Santa Clara
D. B. Milliken Co., Arcadia
Mitchell Camera Corp., Glendale

Moviola Manufacturing Co., Hollywood
National Aeronautics and Space Administration, Ames Research Center, Moffet Field
North American Aviation, Inc., Anaheim
Northridge Research, Inc., Northridge
Northrop Corp., Palos Verdes

Nortronics, Division of Northrop Corp., Hawthorne
Nuclear Research Instruments, Berkeley
Optics Technology, Inc., Belmont
Pacific Optical Corp., Inglewood
Pancro Mirrors, Inc., Los Angeles

Par Products Corp., Santa Monica
Philco Corp., Palo Alto
Photo-Sonics, Inc., Burbank
Rand Corp., Santa Monica
Raytheon Co., Semi-Conductor Division, Mountain View

Red Lake Laboratories, Inc., Sunnyvale
Richardson Camera Co., Inc., Burbank
Scientific Optical Division of Cetron Electronic Corp., Arcadia
Signetics Corp., Sunnyvale
Siliconix, Inc., Sunnyvale

Simpson Optical, Carpinteria
Space Technology Laboratories, Inc., Redondo Beach
Spectra-Physics, Inc., Mountain View
Stanford Medical School, Palo Alto
Stanford Research Institute, Menlo Park

Sylvania Electronic Defense Laboratories, Mountain View
Technical Instruments Co., San Francisco
Technicolor Corp., Burbank
Teledyne, Inc., Mountain View
Thompson Optical Engineering Co., Los Angeles

Traid Corp., Encino
U.S. Naval Ordinance Test Station, China Lake
U.S. Navy Missile and Astronautics Center, Point Mugu
U.S. Navy Radiological Defense Laboratory, Hunters Point, San Francisco
United Technology Center, Division of United Aircraft Corp., Sunnyvale

University Extension, University of California, Berkeley and Los Angeles
University of California, Department of Psychology
University of California Radiation Laboratory, Berkeley
Urban Engineering Co., Los Angeles
Wallin Optical Systems, Inc., Tarzana

Westinghouse Electrical Corp., Sunnyvale
Vandenberg Air Force Base
Varian Associates, Palo Alto
Vought Camera Co., Los Angeles

APPENDIX B

Professional Societies Contacted

American Society of Training Directors

Optical Society of America

Society of Biological Photographers

Society for Information Display

Society of Photographic Instrumentation Engineers

Society of Motion Picture and Television Engineers

Society of Photographic Scientists and Engineers

Technical Association of Graphic Arts

APPENDIX C

Textbooks, Periodicals, Teaching Aids, and Other Published and Filmed Material

Books

Andrews, Charles L. Optics of the Electromagnetic Spectrum. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1960. (Reference text in optics from electrical engineering point of view.)

Baker, Robert H. Astronomy. Princeton, N.J.: D. Van Nostrand Co., Inc., 1959.

Born, Max, and Emil Wolfe. Principles of Optics. New York: Pergamon Press, Inc., 1959.

Bracey, R. J. The Technique of Optical Instrument Design. London: English Universities Press, Ltd., 1960.

Carroll, John S. (ed.). Photo-Lab-Index. New York: Morgan & Morgan, Publishers, 1960. (Supplements issued regularly.)

Chesterman, William D. The Photographic Study of Rapid Events. Fair Lawn, N.J.: Oxford University Press, 1951.

Cox, Arthur. Optics: The Technique of Definition. London: Focal Press, Ltd., 1961. (Can be used for optics course beyond physics. No calculus.)

Ffron, Alexander. Light. New York: John F. Rider Publisher, Inc., 1958. (Paperback.)

Habell, Kenneth J., and Arthur Cox. Engineering Optics. London: Sir Isaac Pitman & Sons, Ltd., 1948. (No calculus.)

Hardy, Arthur, and Fred H. Perrin. Principles of Optics. McGraw-Hill Book Co., Inc., 1932.

Hyzer, William G. Engineering and Scientific High-Speed Photography. New York: The Macmillan Co., 1962.

Jacobs, Donald H. Fundamentals of Optical Engineering. New York: McGraw-Hill Book Co., Inc., 1943.

James, T. H., and George C. Higgins. Fundamentals of Photographic Theory. New York: Morgan & Morgan, Inc., Publishers, 1960. (Highly recommended.)

Jenkins, Francis A., and Harvey E. White, Fundamentals of Optics. New York: McGraw-Hill Book Co., Inc., 1957.

Johnson, B. W. Optics and Optical Instruments. New York: Dover Publications, Inc., n.d. (Paperback.)

Kingslake, Rudolph. Lenses in Photography. New York: Ziff-Davis Publishing Co., 1963.

Kissam, Philip. Optical Tooling for Precise Manufacture and Alignment. New York: McGraw-Hill Book Co., Inc., 1962.

Lengyel, Bela A. Lasers. New York: John Wiley & Sons, Inc., 1962. (Reference text.)

Martin, Louis C. Technical Optics (2 vols.). London: Sir Isaac Pitman & Sons, Ltd., 1948, 1961.

Mees, Charles E. Kenneth. Theory of the Photographic Process. New York: The Macmillan Co., 1954. (Reference text.)

Neblette, Carroll B. Photography: Its Materials and Processes. Princeton, N.J.: D. Van Nostrand Co., Inc., 1962.

Palmer, C. Harvey. Optics: Experiments and Demonstrations. Baltimore: Johns Hopkins Press, 1962. (Optics lab manual.)

Ruechardt, Eduard. Light: Visible and Invisible. Ann Arbor: University of Michigan Press, 1958. (Paperback.)

Sears, Francis W. Optics. Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1949.

Strong, John. Concepts of Classical Optics. San Francisco: W. H. Freeman & Co., Publishers, 1958.

Texercau, Jean. How To Make a Telescope. New York: Interscience Publishers, Inc., 1957.

Twyman, F. Prism and Lens Making. London: Hilger and Watts, Ltd., 1952. (Text for optical fabrication lab.)

U.S. Department of the Army. Elementary Optics and Applications to Fire Control Instruments (Tech. Man. TM 9-2601). Washington: Superintendent of Documents, 1945.

U.S. Department of the Army. Optical Labs Specialty (Tech. Manual TM 8-237). Washington: Superintendent of Documents, 1957. (Reference text.)

Walsh, John W. T. Photometry. New York: Dover Publications, Inc., 1958. (Paperback.)

Wood, Robert W. Physical Optics. New York: The Macmillan Co., 1934.

Zim, Herbert S., and R. Will Burnett. Photography (Golden Handbook Series). New York: Golden Press, Inc., 1956.

Periodicals

Industrial Photography (Published by Photography in Business, Inc., New York.)

Photo Methods for Industry (Published by Gilbert-Wolfman Publishing Corp., New York.)

Journal, Optical Society of America (Published by American Institute of Physics, New York.)

Journal of Applied Optics (Published by Optical Society of America, Washington, D.C.)

Photographic Science and Engineering (Published by Society of Photographic Scientists and Engineers, Washington, D.C.)

Sky and Telescope (Published by Sky Publishing Corp., Harvard College Observatory, Cambridge, Mass.)

Films

Optical Instrumentation at Vandenberg Air Force Base

20-min. sound color film showing how information not obtainable by telemetry is possible by optical instrumentation. Produced by 1369th Photo Squadron, APCS (MATS), Vandenberg Air Force Base.

High-Speed Studies of High-Explosive Phenomena

20-min. sound film showing versatility of high-speed camera (million frame per second). Produced by Stanford Research Institute, Poulter Laboratories, Menlo Park, Calif.

Scientific Photography at Edwards Air Force Base

18-min. color sound film showing use of scientific photography on X-15 and rocket-propelled sleds. Produced by Photography Branch, Edwards Air Force Base.

The Mystery of Time

41-min. color film using examples from astronomy and sequences of high-speed and time-lapsed photography to show that time and space are relative standards of reference. Produced by Moody Institute of Science, Los Angeles.

APPENDIX D

Job Description 1

PHOTO OPTICAL EQUIPMENT TECHNICIAN, GS-9
Point Mugu, California

1. INTRODUCTORY STATEMENT

The incumbent of this position is directly responsible to the Head of the Optical Mechanical Repair Section for the overhaul, modification, preventative maintenance, and incidental operation of all optical instrumentation lenses and telescopes being utilized in the Pacific Missile Range.

The incumbent reports directly to the Head of the Optical Mechanical Repair Section, Optical Instrumentation Branch, Field Instrumentation Division, Range Operations Department.

The incumbent of this position is responsible for the disassembly, cleaning, alignment, reassembly, and collimation of all optics used in the operation of optical data recording instrumentation.

The incumbent is responsible to the Section Head for the above mentioned functions as they relate to all PMR optical installations which are operated and maintained by civil service or contractor personnel.

2. MAJOR DUTIES AND RESPONSIBILITIES

A. The incumbent is responsible for the overhaul, modification, and preventative maintenance of optical prisms, lenses, and telescopes used on optical data recording systems of the PMR. Specifically, his major duties consist of the following: 50%

(1) Knowledge and ability to disassemble, repair, and assemble various types of lenses, tracking telescopes, and optical image transmission systems.

(2) Collimation of optical lenses to the instrument axis and to the azimuth and elevation tracking telescopes after installation of an optical tracking instrumentation site.

(3) Knowledge and ability to operate the various precision machines in the optical machine shop to fabricate precision lens and telescope parts.

(4) Knowledge and ability to optically center and re-cement various optical elements used in binoculars, lenses, and telescope.

(5) Knowledge and ability to use the various optical laboratory collimators to align the optical axis of the lenses and the instrument.

B. The incumbent is required to recalibrate, recollimate, and align the optical systems after installation in the field at local or remote locations in the Pacific Missile Range. He is required to use various precision tools, machines, and testing equipment to accomplish his daily tasks. 25%

C. The incumbent is required to operate the optical tracking devices after its installation in the field to determine its over-all accuracy. He is responsible for the precision alignment of the optical and mechanical axis of the system. He is required to operate the various optical data acquisition devices when operational work loads necessitate the use of the incumbent's optical instrumentation operating skills. 25%

3. POSITION CONTROLS

The incumbent's supervisor is Head of the Optical Mechanical Repair Section. His supervisor will inform him verbally and/or in writing of the desired technical projects currently to be advanced. He will work closely with his supervisor at all times, but will be expected to solve the major technical problems, especially those encountered in the field, with little or no guidance. He will consult his supervisor only when encountered by unusual or highly complex areas of his work and will be expected to provide his own answers to the normal technical problems that may arise.

During and after field assignments, the incumbent is required to report verbally and/or in writing on the assignment, as requested by his supervisor.

Job Description 2

PHOTOGRAPHER (SCIENTIFIC), GS-9

1. INTRODUCTION

The incumbent provides scientific photographic support for the assembly, test, and firing of surface launched missiles and their components at U.S. Naval Missile Facility, Point Arguello, Lompoc, California, and at Vandenberg Air Force Base; and other activities as required.

II. MAJOR DUTIES AND RESPONSIBILITIES

Operation of highly technical hand and electrically powered photographic tracking mounts and the photographic components thereof; installation, bore-sighting, test and operation of various photo-optical and electromechanical equipment used for recording scientific and engineering sequential data in support of missile-satellite and astronautics programs. 20%

Prior to a scheduled event the incumbent conducts a systematic checkout of tracking mounts and selects and tests the instrumentation and optical equipment required. A typical operation may require a 35mm high-speed "Mitchell" with an 80-inch lens, a 16mm high-speed "Mitchell" with a 40-inch lens, and 16mm, 35mm, and/or 70mm "Photo-Sonics" cameras with various combinations of lenses. These cameras will be utilized to record second and third stage ignition and separation of stages and payload.

Installation, boresighting, loading, check-out and tests of remotely controlled high-speed, normal-speed, and special-effects cameras on pads and instrumentation sites located within or adjacent to test or launch complexes. 70 %

A typical operation may require 16mm "Milliken" cameras operating at 400 frames per second (fps), 16mm and/or 35mm "Fastax" cameras operating at 2000 to 8000 fps, 16mm and/or 35mm "Mitchell" cameras operating at 24 to 128 fps, and "Flight Research Mod. IV-E" cameras operating as slowly as one frame per minute.

Care and maintenance of photographic, optical, and accessorial electrical-electronics equipment utilized, and maintenance of working spaces in accordance with Navy standards. 10%

Camera pads and instrumentation sites are exposed to the elements and all equipment is subjected to corrosion and damage from blowing sand, dust, and salt spray. A thorough cleaning, check-out, and operational test are required preceding and following each launch. All cameras must be cleaned and properly lubricated, electrical components cleaned, checked and tested, and worn or damaged parts repaired or replaced in order to assure trouble-free operation.

The incumbent relies upon his knowledge and experience in the field of scientific photography in solving his photographic engineering problems. Guides available include test scheduling requests, flight test programs and reports, and data derived from previous operations. These guides supply planning information only and will not provide "canned" solutions for specific problems. Literature on general photography is voluminous, but no known publication contains solutions to the multitudinous problems encountered in recording scientific data in connection with assembly, testing, and firing modern missiles.

III. POSITION CONTROLS

During the probationary period the incumbent will be closely supervised by his immediate superior and others in the chain of authority. After the probationary period, supervision will be general in nature and will consist mainly of assignment to specific programs which require photographic coverage. Subordinate civilian personnel will often be assigned to work under his supervision and military personnel may be assigned for training or operational purposes. The incumbent will be responsible for photography obtained at his direction.

IV. QUALIFICATIONS

The occupant of this position must thoroughly understand the operation of hand and power operated photographic tracking units, for he is often the only photographer at a particular instrumentation site. If a photographic tracking unit should fail during an operation,

no data would be obtained. 208-volt 3-phase, 100-volt AC, 12-volt DC, and 28-volt DC power may be used to operate the various cameras and tracking mounts. The incumbent must, therefore, possess a thorough practical and theoretical knowledge of electricity and the circuitry of the cameras and tracking units.

Proper selection of the power supply is mandatory, for improper selection would mean complete and irreplaceable loss of data as well as extensive damage to valuable equipment. Precise adjustments are required in order to achieve proper frame rates, exposure, and running time of the cameras used and to preclude damaging the equipment.

Job Description 3

PHOTOGRAPHIC INSTRUMENTATION TECHNOLOGIST
Lockheed Aircraft Corporation

OCCUPATIONAL SUMMARY

Assist in the development of the sequence of photographic systems required to record on film qualitative and quantitative engineering test data, utilizing metric photography and/or other accessory photographic instrumentation equipment.

WORK PERFORMED

Assist in the coordination, installation and operation of photographic systems involving the use of equipment in the fields of flight test evaluation, model performance evaluation, laboratory studies, testing, etc. Consider the limitations of photographic instrumentation equipment and modification required to operate within environmental conditions.

Assist in the design of fabrication and assembly of photographic instrumentation complexes used in development and/or qualification tests. Tests will require the use of specialized photographic equipment such as pulse data recorders, high-speed framing cameras, and high-speed X-ray systems, in coordination with other equipment, where a measure of system error must be made or feasibility of measuring techniques must be determined. Design modifications of instruments for special environmental conditions or adapt photographic instruments to test equipment.

Coordinate with suppliers, customers, and engineering personnel to establish camera requirements for specific tests. Schedule manpower and equipment so that maximum efficient use will be obtained. Direct other personnel as required.

KNOWLEDGE AND ABILITY REQUIRED

Normally requires a minimum of two years technical training beyond high school level and four years photographic experience in order to be familiar with micro- and macro-, shadowgraph, surveillance, high-speed, smear, and streak photographic techniques. Two years of additional experience may be substituted for only one year of technical training. Must possess a working knowledge of the mathematical and physical considerations involved in selecting precision cameras and site locations and for obtaining data and triangulation at the test sites and a knowledge of the advantages and disadvantages of equipment limitations.

PHOTOGRAPHIC INSTRUMENTATION TECHNICIAN
Lockheed Aircraft Corporation

OCCUPATIONAL SUMMARY

This occupation requires the development, overhaul, modification and testing of photographic instrumentation equipment and cameras, including the set up and operation of environmental tests, optical bench, and photographic instrumentation systems in the laboratory and field for obtaining engineering data.

WORK PERFORMED

In order to qualify for this classification, must regularly perform all of the following duties:

Working from authorized information such as sketches, blueprints, schematic wiring diagrams, etc., perform the necessary development, modification, repair, and maintenance of items such as:

All types of motion picture cameras including pin-registration cameras, rotating prism cameras, gun

cameras, streak cameras, and time lapse cameras, and still cameras such as 35mm, 70mm and press.

Photographic instrumentation equipment such as timing oscillators, camera control systems, synchronizing systems and power supplies.

Set up and operate the optical bench for evaluating optical performance using the nodal slide to determine flange focus distance, nodal points, and off-axis resolution characteristics of lenses.

Set up and operate G tables, hot and cold chambers to simulate actual flight environmental conditions on the above type cameras, and associated equipment such as mounts, lenses, timing devices, and power units.

Set up photographic instrumentation systems in the laboratory and in the field for evaluating flight tests to obtain engineering data. Analyze instrumentation film footage to determine if the film meets the required test specifications and the processing procedures were correct. Collect, tabulate, report, and participate in the evaluation of test results.

Perform the work of lower classifications such as Flight Test Shop Mechanic, Instrument Technician - Bench "A", and Photographic Specialists, as required. Use all the tools, materials, and equipment necessary to perform the job.

Job Description 5

PHOTO OPTICAL EQUIPMENT TECHNICIAN
Tracking Mount Section, Naval Ordnance Test Station
China Lake

I. INTRODUCTION

The incumbent is a member of the Tracking Mount Section, Optical Instrumentation Branch, Instrument Operation Division, Test Department. The Section has cognizance of the Radar Optical boresight systems and the M-45 type Optical Tracking Mount Systems and has the mission of obtaining data for determining attitude of

guided missiles and rockets in flight as well as engineering sequential and documentary coverage. The incumbent is involved in test planning, preparation, operations, maintenance, evaluations, and special projects involving technical competence.

II. MAJOR DUTIES AND RESPONSIBILITIES

1. Preparation and operation of optical data-gathering instruments — 40%

The incumbent is responsible for the preparation (mounting, aligning, calibrating and collimating the various optics, cameras, and electronic components) of his assigned tracking mount for the forthcoming tests. He directs or assists others (test range trackers, trainees, and borrowed personnel from other sections) in the field operation preparation.

He operates this equipment in the field as prescribed. He is also expected to understand the parameters of the test and to call to the attention of the responsible persons any inconsistencies, or errors, that may become apparent to him in the field. He is assigned complicated one-mount tests where the instrument array on the mount is complicated and/or direct liaison with the range or project engineer on site is necessary to refine the requested metric data needs.

2. Special projects — 40%

The incumbent assists in the evaluation of new equipment such as high speed cameras, long lenses, new films, tracking mount modifications etc. He will evaluate new or existing camera stations as to feasibility (proper line of sight, sun angle, tracking rate, accessibility, etc.) for new or unique metric coverage. He performs such duties as quality control of films produced by the Section and monitors the autocollimation focusing program of the long lenses used by the Section. He will also be assigned developmental projects which will expand both his and the Section's technical capabilities.

3. Test planning — 20%

The incumbent must have a technical understanding of the basic capabilities and limitations of the equipment and personnel assigned to the Section. He must be able to follow

the guide lines of his supervisor and, using his own ingenuity, interpret the data requests and create a proposed equipment and personnel test schedule for the forthcoming day. He will, as directed, contact people (Project Engineers, Range Engineers, Scheduling Office, and support codes, such as Timing or Communications) outside the Branch regarding logistics concerning forthcoming tests.

III. CONTROLS OVER THE POSITION

The incumbent is under the supervision of the Head, Tracking Mount Field Operation Unit, in all work relative to the field. On special assignments he is under the supervision of the Section Head or a Physicists, Mathematician, or higher-rated Photo-Optical Equipment Technician.

IV. QUALIFICATION REQUIREMENTS OF THE WORK

The incumbent is required to have a good background in the practical use of most optical data gathering instruments used by the Branch. Further, it is expected that he will expand his scientific and technical competence by working on a series of assigned development projects relative to data gathering equipment and techniques.

Job Description 6

PHOTO OPTICAL EQUIPMENT TECHNICIAN, GS-7
Optical Instrumentation Branch, Naval Ordnance Test Station
China Lake

I. INTRODUCTION

The incumbent is a member of the Special Applications Section, Optical Instrumentation Branch, Instrument Operations Division, Test Department. The Section has cognizance of approximately 30 different types of optical data and documentary gathering cameras (including Dynafax, Fastax, Milliken, Mitchell, Photo Sonic, etc.). The incumbent is involved in preparation, setup, and design modifications of instruments, and in special projects involving moderate technical competence.

II. MAJOR DUTIES AND RESPONSIBILITIES

1. Test preparation — 20%

The incumbent is involved in the physical positioning of the instruments for a test, checking that the instrument location is feasible (in the sense that the proper barricading is furnished, no obstacles in the field of view, proper electrical power for the instrumentation requirement, etc.), and the preparation of special equipment, as well as the scheduling of personnel and standard equipment.

2. Set-up, operation, and check-out of optical data and documentary gathering instrumentation — 30%

An important segment of the incumbent's duties lies in the field activities of the Section. He is expected to assist in the selection and preparation of special equipment, cameras, and types of films necessary to meet instrumentation requirements, to maintain good field data cards, as well as to assist in the check-out at the completion of the test. Therefore, it is necessary for him to understand the parameters of the tests and to recognize discrepancies of errors in data cards or instrument orientations and correct them. He will at times be in charge of less complicated tests. Accuracy in setting up of equipment, boresighting, focusing, and choosing exposure is of prime importance, as errors here could result in a complete loss of a record for that instrument.

3. Maintenance, design modification, and special projects — 50%

The accuracy of data and quality of documentary records is dependent upon the maintenance and care in handling and calibration of equipment. The increasing capability of the Section is dependent upon the design modifications of existing equipment as well as the purchase of newly developed equipment. The incumbent assists in performing minor maintenance, care, and calibration, and is expected to add ideas for the better utilization of equipment. He will be assigned developmental projects which will expand both his and the Section's technical capabilities.

III. CONTROLS OVER THE POSITION

The incumbent is under the general supervision of the Head, Special Applications Section, who schedules or approves his assignments. For specific projects he may be under the supervision of Mathematicians, Physicists, or higher-rated Photo-Optical Equipment Technicians.

IV. QUALIFICATION REQUIREMENTS OF THE WORK

The incumbent is required to have a good background in the practical use of most optical data gathering instruments used by the Branch. Further, it is expected that he will expand his scientific and technical competence by working on a series of assigned development projects relating to data gathering equipment and techniques.

Job Description 7

PHOTO OPTICS EQUIPMENT TECHNICIAN GS-10
Optical Instrumentation Branch, Naval Ordnance Test Station
China Lake

I. INTRODUCTION

This position is located in the Tracking Mount Section, Optical Instrumentation Branch, Instrument Operations Division, Test Department, the function of which is to obtain data for determining attitude of guided missiles and rockets in flight, obtaining documentary photographic coverage of the flight, and insuring that the radar optical boresight system and the M-45 type optical tracking mount systems are modified to improve or incorporate the latest developments in the state of the art.

The purpose of this position is to plan the day-to-day operations of the M-45 type optical tracking mount system; train crews in the use of this equipment; supervise the use of this equipment in the field; personally perform or supervise the performance of design, modification, fabrication, and evaluation of tracking mount hardware; and personally operate the above-described equipment in the field.

II. MAJOR DUTIES AND RESPONSIBILITIES

A. Planning

Plans the day-to-day operations of the M-45 type optical tracking mounts, including changing the Experiment Specifications on which the day-to-day plans of the unit are based. This involves changing site locations of the cameras; changing camera, frame rate, lens setting, make and type of film used, etc. These changes are made to provide optimum results. These changes are independently made by the incumbent when there is insufficient time to notify the project engineer. When sufficient time is available, the Project Engineer is notified of the change and told the reason for same.

The incumbent recommends or makes instrumentation array decisions necessitating changes in the range firing schedule based upon the incumbent's experience and knowledge of his unit's capabilities as far as personnel, equipment, and climatic conditions influence the type of coverage his unit can provide. Also effects change in the schedule when in his opinion the events are scheduled too close together to allow time to move and set up the equipment when different locations are involved. In determining the need for these changes, the incumbent must depend upon his own knowledge and experience, precedent actions in the past, a good understanding of the effect upon other activities, and the desired results the project engineer is attempting to accomplish through the test.

In effecting changes in both the scheduled firing or Experiment Specification, it is necessary for the incumbent to have coordinative contacts with the Scheduling Branch, project engineers, range engineers, and data assessment representatives.

B. Training duties

Trains lower-graded Photo-Optical Equipment Technicians, Test Range Trackers, contract personnel, and other personnel, including professional engineers, physists, and mathematicians, assigned to the unit for training purposes. This training consists of teaching others to perform the operation, modification and positioning of high speed motion picture and/or still cameras mounted on an M-45 type optical tracking mount. Since part of the training includes actual operation of the cameras in the field, the incumbent must make many of the operating determinations for the trainees. These determinations include such things as focal length of lenses, frame speed, type of camera to use, type of filter, exposures,

and sampling rates. When mechanical trouble develops, the incumbent informs the trainees by use of radio what to do to place the camera back in operation.

C. Evaluation

Evaluates experimental, prototype and/or unusual cameras, lenses and associated controls; electronic, electrical or mechanical mount drives; and other allied components as to their feasibility for use as a part of a camera tracking mount system. This involves evaluating the size, weight, ruggedness, dependability, accuracy, capacity, speed, ease of operation, etc. The evaluation of the above listed equipment is from a practical utilization standpoint as to how well the equipment performs under actual working conditions. Submits reports of evaluation either orally or in writing to his immediate supervisor.

D. Modification, design, and maintenance

Performs onsite observation and does research reading on the state-of-the-art of data gathering instrumentation. Based on this observation and research reading the incumbent identifies the need for improvement of the equipment and instrumentation used by his monitor and the need for obtaining new equipment or instrumentation to improve the data gathering capabilities of his unit. Recommends and/or performs modifications to existing conventional equipment which needs modification to meet specific test requirements or minor modifications which do not change the original purpose of the equipment but do improve its capabilities. This design and development is confined largely to conventional attachments, accessories, and mounts which are improved or relocated to accommodate the operating requirements of the equipment.

E. Supervision exercised

Exercise technical supervision over four full-time subordinates. The full-time employees consist of one Photo Optical Equipment Technician GS-7, two Test Range Trackers, and one contract employee. Assigns duties on the basis of their individual capabilities and knowledge of the equipment and cameras to be used and the difficulty of the test, modification, or maintenance work to be performed. Selects equipment and cameras to be used, and provides assistance and guidance during the more difficult portions of their duties. Provides subordinates with a written plan of each day's duties which specifies time, place, equipment to be used, etc.

Acts as Head, Tracking Mount Section, for approximately 20% of the time (during the absence of the incumbent's supervisor). This duty includes both administrative and technical supervision over both the M-45 system and the radar optical boresight system. Has full authority to commit the Section while performing this duty. While performing this duty, often represents the Branch at long-range scheduling and planning meetings. Coordinates the activities of the two units with range and project engineers, assessment representatives, and other Station personnel.

III. CONTROLS OVER THE POSITION

Receives supervision from Head, Tracking Mount Section, PD#28328. Receives written instructions on broad commitments involving his unit by means of the Experiment Specification, which the incumbent may change as described previously. Discusses the most difficult problems with his immediate supervisor, and they arrive at the mutual agreement concerning these problems.

Modifications which will require more than 16 hours or the use of a job order for other than overhead require the prior approval of the incumbent's immediate supervisor.

In modifying or designing equipment, the incumbent recognizes the need for the modification or design, identifies the problem, and provides the boundaries within which the problem has to be solved. Then the incumbent receives the advice and assistance of professional engineers, mathematicians, physicists, and design specialists in arriving at the final solution of the problem.

The incumbent cannot commit his unit to long-term plans without obtaining the previous consent of his supervisor. Refers to his supervisor before performing those duties which involve controversial problems or deviation from established policy.

Job Descriptions 8 through 11

Below are job descriptions which describe the kind of work the POIT may perform. (From: Dictionary of Occupational Titles, Addendum B, Additional Definitions and Codes, California State Department of Employment, January 1963)

PRECISION-LENS TECHNICIAN (optical goods) 5-08.075

Performs research and development in fabrication and testing of precision optical components, (made of such materials) as strontium titanate, rutile, and rock salt. Produces any required optical component to tolerance of plus or minus .005" in thickness, plus or minus 2" of arc in angular measurement. Selects component blank or glass, examines for internal strain, seed, or flaws and performs necessary mathematical calculations from specifications and blueprints. Sets up and operates a variety of optical equipment and machinery to produce precision lenses, prisms, and mirrors.

OPTICAL-INSTRUMENT INSPECTOR (inst. & app.) 5-08.062

Examines and tests assembled or partially assembled optical instruments, such as field glasses, telescopes, gun sights, compasses, military sighting equipment and fire-control instruments. Visually inspects optical glass elements and mountings. Examines mechanical adjustments to lens systems for proper action. Tests optical systems for watertightness by immersing or spraying with water. Tests optical systems for qualities, such as good definition of image and accuracy of calibration, using special laboratory tests and measurements.

INSTRUMENT INSPECTOR (air trans; aircraft mfg.) (inst. & app.) 5-08.064

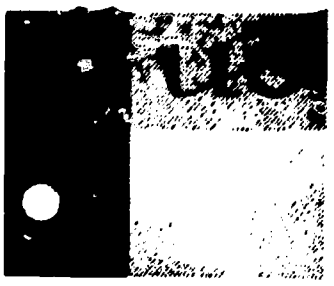
Inspects and tests sighting, range-finding, and other military instruments to check conformity to specifications. Visually examines mechanical elements and compares them with specifications. Operates moving parts by hand to check ease and freedom of movement. Verifies optical accuracy and calibration by installing instrument in test mounts or fixtures and taking trial observations. Compares indications of spirit-level attachments with laboratory standards. May inspect calibration dials and scales to check on accuracy of graduating and engraving, using gages and other measuring instruments.

INSTRUMENT MAKER (optical goods) 5-08.066

Instrument assembler; precision-lens mounter. Specializes in the assembly and mounting of optical elements, such as precision lenses, prisms, and mirrors, in the mechanical portion of optical instruments: Selects the proper optical element for the instrument being worked on and carefully mounts it, scraping, filing, and lapping the mount to align the parts correctly. Focuses instruments on standard targets and accurately adjusts optical elements, making the calibrations on the instruments read correctly.

APPENDIX E

U. C. L. A. Extension Service Course, 1959



UNIVERSITY EXTENSION
UNIVERSITY OF CALIFORNIA

ENGINEERING EXTENSION
UNIVERSITY OF CALIFORNIA
LOS ANGELES

in cooperation with

THE SOCIETY OF PHOTOGRAPHIC INSTRUMENTATION ENGINEERS

announces

PHOTOGRAPHIC INSTRUMENTATION FOR QUALITATIVE ENGINEERING ANALYSIS X 454ABC

Place . . . . . Room 2224 Chemistry Building, University of California

Date . . . . . February 12, 1959, for 18 weekly meetings

Time . . . . . Thursday evenings, 7:00 to 9:30 p.m.

Fee $45.00

Coordinator . . . . . A. J. Carr, Executive Secretary for Society of Photographic Instrumentation Engineers

LECTURES

February 12 — INTRODUCTION AND REVIEW OF FUNDAMENTALS
Nomenclature; documentation.

February 19 — FROZEN MOTION
Recording high-speed phenomena with electronic-flash and shadow-graphs.

February 26 — SEQUENCE RECORDING
Conventional still- and cine-cameras as data recorders; pulse-cameras for time minification.

March 5 — TIME MAGNIFICATION - 500:1
High-speed cine-cameras and transient phenomena; exposure calculation; programming.

March 12 — TIME MAGNIFICATION - 10,000:1
Application of the Batelle Isotran and similar devices to self-luminous phenomena.

March 19 — TIME MAGNIFICATION - 1,000,000:1
Displacement recording with Kerrcell and Faraday shutter; guided spark generators.

March 26 — TIME MAGNIFICATION - 100,000,000 PICTURES PER SECOND
Grid-framing cameras compared with Image Converters and "streak" cameras; the Sultanoff techniques.

April 2 — FLUID-FLOW RECORDING
Schlieren, shadow-graph and interferometer techniques for fluid-flow analysis.

CONSULTANTS AND INSTRUCTION STAFF (Continued)

Amron Katz, The RAND Corporation.
John P. Kiel, Photo-Sonics Corporation.
Wolfgang D. Klemperer, Douglas Aircraft Company, Inc.
Hollis W. Moyse, E. I. DuPont and Company.
George Silberberg, Naval Ordnance Test Station, China Lake.
Ernest Stern, The Ramo-Wooldridge Corporation.
Charles E. Taylor, Northrop Aircraft, Inc.
E. L. Taylor, USAF - ARDC.
Eugene K. Thorburn, Pacific Optical Corporation.
Donald Weber, The Ramo-Wooldridge Corporation.
R. C. Wheeler, Northrop Aircraft, Inc.
Robert L. Woltz, President, Society of Photographic Instrumentation Engineers.

REGISTRATION FORM

Mail to: University Extension, University of California, Los Angeles 24, California

Enclosed find $_____ to cover _____ registrations at $45.00 each (make checks and money orders payable to THE REGENTS OF THE UNIVERSITY OF CALIFORNIA) for Engineering X 454ABC Photographic Instrumentation for Qualitative Engineering Analysis.

NAME _____
(Please print)

ADDRESS _____

_____

AFFILIATION _____

Mail enrollment material will be available at the first meeting of the class if you do not wish to pre-enroll.

April 9 — COLOR SCHLIEREN
Color contrast as an aid in analysis; high-speed motion picture color schlieren technique.

April 18 — FIELD TRIP TO N.A.M.T.C., POINT MUGU - CINE-THEODOLITES
Optical tracking and recording instruments; correlation problems; data-processing; data reduction.

April 23 — PHOTO-SURVEILLANCE
Aerial-reconnaissance for military intelligence; reconnaissance data handling; industrial security applications; quality control in manufacturing.

April 30 — AIRCRAFT PHOTO-INSTRUMENTATION
Ballistics recording; scoring systems; aero-elasticity studies; attitude determination; photo-panels.

May 7 — SLED AND TRACK INSTRUMENTATION
High-speed cine, Bowen, streak and "metric" cameras; reliability of equipment under "G" loads.

May 16 — FIELD TRIP TO NAVAL ORDNANCE TEST STATION, CHINA LAKE
Special demonstration of ground-optics and range instrumentation; track instrumentation; ballistics techniques; research and development labs.

May 21 — HUMAN ENGINEERING STUDIES
Time-motion studies; conditioned-reflex response; environmental response; aero-medical applications.

May 28 — INTRODUCTION TO THE TECHNIQUES OF PHOTOGRAPHIC MEASUREMENT
The photographic image as a source of quantitative data; comparators; measuring microscopes, automated data-reduction equipment; establishment of error.

June 4 — PHOTO-SYSTEMS CALIBRATION
Aberrations and distortions of optical systems; camera-lens orientation; determination of the camera function and establishment of the origin of its coordinates.

June 11 — RECAPITULATION AND FINAL EXAMINATION

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CONSULTANTS AND INSTRUCTIONAL STAFF

Bernard Benson, Benson-Lehner Corporation.
A. F. Bernard, J. A. Maurer, Inc.
A. J. Carr, (Course Coordinator), Executive Secretary for Society of Photographic Instrumentation Engineers.
John Clemente, Naval Air Missile Test Center, Point Mugu.
William H. Cook, W. H. Cook and Associates.
Richard Councilman, Photo-instrumentation Consultant.
Carlos Elmer, Traid Corporation.
Raymond F. Grant, Eastman Kodak Company.
Stewart Hauser, Electro-Optical Systems Corporation.
Waldo S. Hunter, Ansco Corporation.

UNIVERSITY EXTENSION/UNIVERSITY OF CALIFORNIA/LOS ANGELES

ENGINEERING EXTENSION
UNIVERSITY OF CALIFORNIA
LOS ANGELES
in cooperation with
THE SOCIETY OF
PHOTOGRAPHIC INSTRUMENTATION ENGINEERS

announces

Engineering Applications of Photographic Instrumentation

X 454DEF

Place	Room 208, Mechanics Building, University of California, Los Angeles
Date	September 29, 1959, for 18 weekly meetings
Time	Tuesday evenings, 7:00 to 9:30 p.m.
Fee	$45.00
Coordinator	Robert L. Rodgers, Supervisor — Photographic Services, Aerojet-General Corporation, Downey

Course Description and Lectures

Development of the basic elements of optics, light sources, photosensitive materials, instrumsnt mechanisms, time correlation and electrical circuitry. Guest lecturers and laboratory sessions on applications of these principles to various items of equipment and use of this equipment in specific areas of engineering investigation. Enrollment limited to 40 persons.

September 29	OPTICS AND BASIC CAMERA COMPONENTS
October 6	LIGHT SOURCES
October 13	PHOTOSENSITIVE MATERIALS AND CHEMISTRY
October 20	INSTRUMENT MECHANISMS AND TIME CORRELATION
October 27	ELECTRICAL CIRCUITRY
November 3	STILLS, ELECTRONIC FLASH AND KERR CELL
November 10	TIME-LAPSE AND CONVENTIONAL CINE (to 400 fps.)
November 17	TIME MAGNIFICATION PRINCIPLES AND CINE (to 16,000 fps.)
November 24	STREAK CAMERAS AND CINE (to 4.3 million fps.)
December 1	ISO TRANSPORT CAMERA
December 8	SULTANOFF TECHNIQUES AND CURRENT RUSSIAN DEVELOPMENTS
December 15	SCHLIEREN AND SHADOWGRAPH TECHNIQUES
December 22	BALLISTIC-SYNCRO TECHNIQUES AND SLED TRACK INSTRUMENTATION
December 29	RANGE TRACKING INSTRUMENTATION
January 5, 1960	AIRCRAFT/MISSILE ON-BOARD AND WIND TUNNEL INSTRUMENTATION
January 12	RECONNAISSANCE/SURVEILLANCE APPLICATIONS
January 19	HUMAN ENGINEERING PROBLEMS
January 26	UNDERWATER APPLICATIONS

CONSULTANTS AND INSTRUCTIONAL STAFF

Stanley E. Baker, Society of Photographic Instrumentation Engineers
A. J. Carr, Executive Secretary, Society of Photographic Instrumentation Engineers
John Clements, Naval Air Missile Test Center, Point Mugu
Richard Councilman, Photo-Instrumentation Consultant
Carlos Elmer, Traid Corporation
Raymond F. Grant, Eastman Kodak Company
Waldo S. Hunter, Ansco Corporation
Dr. Irwin Moon, Moody Institute of Science
William T. Read, Battelle Memorial Institute
Robert L. Rodgers, Aerojet-General Corporation (Course Coordinator)
Glen Sanderson, Lockheed Aircraft Company
Morton H. Sultanoff, Ballistic Research Laboratories
Robert L. Woltz, Flight Research, Inc.

APPLICATION FOR ENROLLMENT

Mail to: **DEPARTMENT K, UNIVERSITY EXTENSION**
UNIVERSITY OF CALIFORNIA, LOS ANGELES 24,
CALIFORNIA

Please enroll me in the course, Engineering X 454DEF, ENGINEERING APPLICATIONS OF PHOTOGRAPHIC INSTRUMENTATION, to be held on the UCLA campus, Room 208, Mechanics Building. Enrollment fee is $45.00 for individual. Enclosed is check for the amount of $_____ to cover course fee, made payable to THE REGENTS OF THE UNIVERSITY OF CALIFORNIA.

NAME_____
Please Print

ADDRESS_____ CITY_____ ZONE_____

HOME TELEPHONE_____ BUSINESS TELEPHONE_____

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Westwood Campus • 10851 Le Conte Avenue, Los Angeles 24 • BRadshaw 2-6161 • GRanite 3-0971 extension 721
Downtown Los Angeles • 813 South Hill Street, Los Angeles 14 • MAdison 3-6423

The following information has been taken from A Directory of Occupation-Centered Curriculums in California Junior Colleges, published by the California State Department of Education in 1962.

PHOTOGRAPHY* (2.04)

Nature of work

The primary job of a photographer (D.O.T. 0-56) is to take pictures, and he is responsible for seeing that these pictures are properly composed and lighted. He may develop the exposed film, make the prints, do retouching, enlarging, etc., and prepare the chemicals and solutions used in the laboratory process. However, that portion of photography concerned with taking pictures as art is far overshadowed by newer uses in industry and research.

The photographic subjects are varied: people and places, objects and materials, plants and animals, atoms and viruses, action and processes. The photographer may use still and/or moving picture cameras, or specialized models of these. He may take pictures in black and white and/or color.

Photography is used extensively as a measuring device. It is essential in photo-instrumentation, in industrial research, in microphotography and macrophotography, and in aerial mosaics used for road building. High-speed cameras are used to disclose the exact motion of rapidly moving machine parts. Stress or incipient wear and tear can be detected, alignment can be analyzed and corrected, and unexpected behavior of machinery and parts can be detected through the medium of photography.

Pictures may be taken indoors or out-of-doors, in the air, on the ground, underground, or underwater, depending upon the area of specialization and assignment. The photographer is almost constantly dealing with people in one relationship or another, except during his laboratory activities.

Training and other qualifications

Training for photography can deal only with basic principles. The equipment used in industry is so expensive, highly scientific, and

*Material given here is adapted from Occupational Guide No. 51, "Photographer," California State Department of Employment (rev. ed.; Sacramento: 1961).

so rapidly replaced by newer and more advanced equipment, that training must be given with less complicated equipment using the same basic principles. With a knowledge of the fundamentals, a photographer is ready to move with changes.

In addition to photography, other allied areas should be studied. Art, chemistry, mathematics, psychology, salesmanship, and bookkeeping are important to this field. An artistic sense and a vivid imagination are assets.

Employment outlook

This is an occupation containing many partially qualified persons, but with a shortage of well-qualified applicants. Photography is a growing field. New uses for it are constantly being found in industry, science, commerce, government, and armed forces. New photographic techniques are being developed. The field is broad and varied and offers opportunities for persons with quite different characteristics and interests. Many segments of the field, however, are highly competitive, especially those which do not demand specialized training.

Other sources of information

Films and Filmstrips: "Photography."
Occupational Guide: No. 51, "Photographer," and No. 265, "Camera Repairman."
Occupational Outlook Handbook: "Lithographic Occupations."

Key to Charts: AA - Associate in Arts Degree
C of C - Certificate of Completion
C of A - Certificate of Attendance

COLLEGE OCCUPATIONAL CURRICULUM JOB TITLE	DAY	EVENING	MEN	WOMEN	AA	C OF C	SEMESTERS	UNITS IN MAJOR	ENROLL-MENT	PLACEMENT (PERCENT)
BAKERSFIELD COLLEGE Photography, Commercial Photo-lab technician, news photographer, sales person in camera store	X		X	X	X		4	21-30	Less than 20	20-39
COMPTON COLLEGE Photography News, general assignment photographer	X		X	X	X		4	11-20	20-29	
EAST LOS ANGELES Photography Commercial, self-employed photographer	X	X	X	X	X		4	11-20	50-75	Less than 20
GLENDALE COLLEGE Photography Photographer, laboratory technician	X	X	X	X	X		4	31-40	20-29	Less than 20
LOS ANGELES CITY Photography Commercial photographer	X		X	X	X		4	11-20	Less than 20	
L.A. TRADE TECHNICAL Professional (Vocational) Photographer *After 6 mon. of employment	X	X	X	X	X	X*	4	41-50	40-49	80-99
MODESTO JR. COLLEGE Photography Photographer		X	X	X	X	X	4	10 or less	30-39	Less than 20
OAKLAND C.C., LANEY Commercial Photography Photographer	X		X	X	X	X	4	41-50	20-29	40-59
PASADENA CITY COLLEGE Photography Photographer, photo-lab technician, camera store salesman	X		X	X	X		4	31-40	Less than 20	40-59

COLLEGE OCCUPATIONAL CURRICULUM JOB TITLE	DAY	EVENING	MEN	WOMEN	AA	C OF C	SEMESTERS	UNITS IN MAJOR	ENROLL-MENT	PLACEMENT (PERCENT)
SAN DIEGO CITY COLLEGE Photography Portrait, commercial, or science photographer; graphic arts processor	X		X	X	X	X	4	31-40	20-29	80-89
C.C. OF SAN FRANCISCO Photography Commercial, portrait, newspaper photographer; photographic research, laboratory technician; salesman, owner, operator of photo business	X		X	X	X	X	4	31-40	50-75	80-99
SANTA MONICA C.C. Photography Commercial photographer photo-lab assistant	X		X	X	X	X	4	31-40	50-75	60-79
SANTA ROSA JR. COLLEGE Photography Press, portrait, or commercial photographer		X	X	X	X		4	11-20	Less than 20	20-39
VALLEJO JR. COLLEGE Photography Photographer, photographer's helper or assistant	X		X	X	X		4	31-40	Less than 20	20-39

EVENING HIGH SCHOOLS OCCUPATIONAL CURRICULUM JOB TITLE	DAY	EVENING	MEN	WOMEN	C OF C	C OF A	SEMESTER PERIODS IN MAJOR	ENROLL-MENT	PLACEMENT (PERCENT)
BEVERLY HILLS Photography Photographer		X	X	X	X		10 or less	20-29	Less than 20
SANTA CRUZ Photography Photographer; photography technician, developer		X	X	X	X		21-30	20-29	Less than 20
WHITTIER UNION Photography Cameraman, darkroom technician		X	X	X	X		31-40	50-75	Less than 20

APPENDIX G
Survey Instrument

PHOTO-OPTICS INSTRUMENTATION TECHNICIAN SURVEY CONDUCTED FOR THE CALIFORNIA STATE DEPARTMENT OF EDUCATION AND DIABLO VALLEY COLLEGE, CONCORD, CALIFORNIA

GENERAL INFORMATION

a. Address of Firm:.

Date of Interview _____

Total employees, all catagories _____

Nature of business _____

b. Name of person completing questionnaire _____

_____

Title _____

Phone no. and ext. _____

c. What work relationship do you have with the photo-optics instrumentation technician?

( ) supervise his work
( ) perform liaison
( ) assign technician's work
( ) other, describe

d. Firm's occupational title for these technicians _____

_____

e. Firm's job description of these technicians:

( ) Job is not described
( ) No copy available
( ) Copy attached
( ) Other

f. Number of photo-optics instrumentation technicians presently employed _____
needed now _____
w/i next 5 years _____

g. In which of the following departments does this technician primarily work?

( ) Research, design development
( ) Technical sales and service
( ) Field installation and maintenance
( ) Measurements laboratory
( ) Quality Control
( ) Other

2

g. To what degree are knowledge and related skills in the following areas applied by photo-optics instrumentation technicians?

Scale: 0 - none
1 - little
2 - a fair amount
3 - a great deal
4 - thoroughly

MATHEMATICS

( ) algebra
( ) geometry
( ) trigonometry
( ) solid geometry
( ) other, describe

SCIENCE AND TECHNICAL

( ) blueprint reading and/ or drafting
( ) chemistry, basic
( ) electricity, basic
( ) electronics, fundamentals
( ) electronics, advanced
( ) heat
( ) light
( ) sound
( ) geometric optics
( ) physical optics
( ) optical tooling
( ) optical alignment
( ) optical instrumentation design layouts
( ) elementary lens computation
( ) optical lab testing or instrument evaluation
( ) optical ray tracing
( ) photographic processing
( ) color photography
( ) photometry
( ) sensitometry
( ) radiometry
( ) camera repair
( ) photogrammetry
( ) mechanics
( ) surveying
( ) astronomy
( ) metallurgy
( ) strength of materials
( ) shop tools
( ) tool design
( ) other, describe

h. What kinds of equipment would be necessary to offer a junior college program in this field? Cost?

i. Could you suggest textbooks, periodicals, teaching aids, or other published and filmed materials which are now available?

h. For the purposes of this survey, this person is being called a photo-optics instrumentation technician. Can you suggest a more appropriate name? _____

TRAINING PROGRAM

a. What are the vocational backgrounds of your photo-optics instrumentation technicians?

b. What training program is provided for photo-optics instrumentation technicians within your firm?

c. Could a photo-optics instrumentation technician's work be done equally as well by women as by men?

d. What would you estimate as the percent of time your engineers devote to work that a properly trained technician could perform?

e. Would you hire people to train and work as photo-optics instrumentation technicians with the following backgrounds? Rate your answers.

directly from high school
high school and 2 years experience
directly from junior college (science background--no photo optics)
directly from junior college (photo-optics major)
other, describe

f. Which type of training would be of more value to the photo-optics instrumentation technician?
( ) Specialists--in depth training in photo-optics
( ) Generalist--broad background training; electronics, photography, optics, math, etc. Not too much depth.

j. Would you participate in a cooperative work-study program for technicians which would include
( ) summer employment
( ) part-time work
( ) alternating full-time employment every other semester
Comments:

k. Other comments:

JOB DESCRIPTION AND WORK ACTIVITIES (Record general comments and describe)