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ABSTRACT

This curriculum guide, designed as an aid in planning and developing a 2-year post-secondary curriculum in scientific glass technology, provides guidelines for the use of administrators, supervisors, and teachers. Developed by a regional group of faculty and staff at a technical institute, this suggested curriculum outline would also be applicable for a part-time program for employed adults. A program rationale, resource lists, and descriptions of laboratory experiments are included. General program development considerations are detailed, emphasizing the role of library facilities and the use of equipment characteristic of scientific glassblowing technology. Course descriptions for four semesters of 15 class hours and 15 lab hours each are presented, grouped into the following categories: (1) technical courses, (2) mathematics and science courses, (3) auxiliary or supporting technical courses, and (4) general courses. Based upon the experience of educators and industrialists with experience in scientific glassblowing technology, this guide should prove valuable for developing similar programs to meet local and national manpower needs in this field. (AG)

MEMORANDUM Revised 5/69

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
1900 Kenny Road
Columbus, Ohio 43210

FROM: (Person) Benjamin Shapiro, Director (Agency) N.J. Voc-Tech Curriculum Lab.

(Address) Building 4103 - Kilmer Campus, New Brunswick, N.J. 08903

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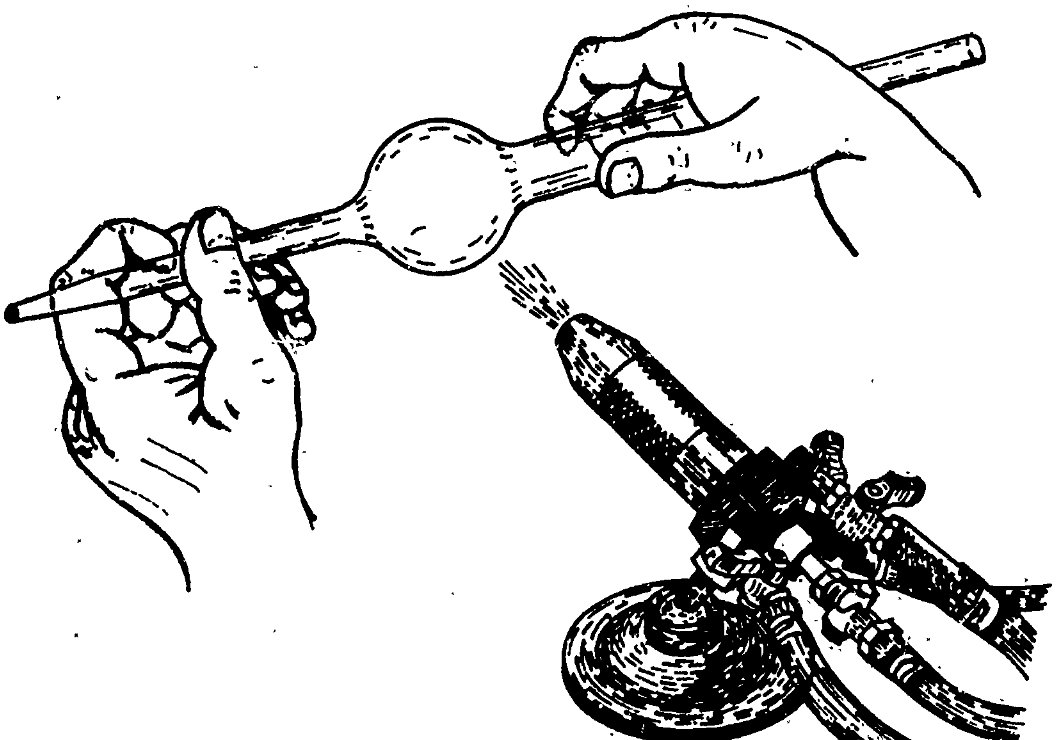
SCIENTIFIC GLASS TECHNOLOGY

A Suggested 2-Year Post High School Curriculum



State of New Jersey
Department of Education
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Curriculum Laboratory

State of New Jersey
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Division of Vocational Education

SCIENTIFIC GLASSBLOWING TECHNOLOGY
A SUGGESTED TWO-YEAR POST HIGH SCHOOL CURRICULUM

Prepared by
Faculty Members
Salem County Technical Institute
Penns Grove, New Jersey

Vocational-Technical
Curriculum Laboratory
Rutgers – The State University
Building 4103 – Kilmer Campus
New Brunswick, New Jersey

January 1972

DIVISION OF VOCATIONAL EDUCATION

STEPHEN POLIACIK, ASSISTANT COMMISSIONER (ACTING)

CURRICULUM LABORATORY

RUTGERS – THE STATE UNIVERSITY

BUILDING 4103 – KILMER CAMPUS

NEW BRUNSWICK, NEW JERSEY

FOREWORD

The technological revolution of our age is built upon thousands of hours of scientific research. Painstaking laboratory experimentation is the necessary prerequisite for every small step in the process of discovery.

Because of the unique properties of glass, most laboratory apparatus is constructed of this material. The scientific glassblowing technician is the man who designs and develops the laboratory glass apparatus essential to the work of experimentation. Consequently, he is a vital member of the research team. As we increase our scientific efforts to understand man and to place him in harmony with his environment, the role of the scientific glassblowing technician in modern research will grow to even greater stature.

This suggested curriculum guide was prepared to aid in planning and developing programs for educating highly skilled scientific glassblowing technicians. It is designed primarily as a two-year post high school program. However, the guidelines given would also be useful in planning a part-time educational program for employed adults.

The guide is intended for the use of school administrators, supervisors, and teachers in planning and promoting new programs in scientific glassblowing technology. It contains suggested curriculum, course outlines, lists of textbooks and references and laboratory recommendations. The courses are carefully inter-related and designed especially for this program. Particular attention is given to the supplies, tools, and equipment characteristic of scientific glassblowing technology. Library facilities, content, and use are stressed.

The curriculum guide was developed under the direction and supervision of Benjamin Shapiro, Curriculum Specialist of the New Jersey Department of Education, Division of Vocational Education. Preparation of all materials was under the sponsorship of the Vocational-Technical Curriculum Laboratory at Rutgers, New Brunswick, New Jersey.

The guide was prepared by faculty members of Salem County Technical Institute, Penns Grove, New Jersey, with the assistance of their scientific glass industrial advisory committee. The Institute has graduated scientific glassblowing technicians for more than 10 years. This experience was the foundation upon which these suggested guidelines were built. It is evident, however, that an institution planning any new program would do so only after careful evaluation of its own community's needs and resources and that its program would be carefully tailored.

This curriculum guide is based upon the efforts of educators and industrialists with successful experience in scientific glassblowing technology. As such, it should serve as a guide in developing similar programs to meet local as well as national research manpower needs.

Robert M. Worthington
Assistant Commissioner
for Vocational Education

Morton Margules
Associate State Director
for Vocational Education

July 1971

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ADMINSTRATION

Herbert C. Donaghay, Director
William G. Mark, Dean of Instruction
Lois G. Allen, Guidance Counselor
Margaret S. Henderson, Registrar-Business Manager

FACULTY

Robert N. Chambers, Drafting and Design
Harry Hunter, Jr., Scientific Glassblowing
Robert Koval, Electronics
Bernard F. Ostmeier, Mathematics
Victor C. Rogers, Chemistry
Samuel Tillis, Physics
James E. Valimont, Instrumentation

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ADVISORY COMMITTEE

CLYDE I. KRAMME, Chairman, Ace Glass Incorporated, Vineland, N.J.

JOHN J. GOTTKO, Laboratory Products, Technical Products Division, Corning Glass Works, Corning, N.Y.

JOHN HARKER, Bellco Glass, Incorporated, Vineland, New Jersey.

SAMUEL KNISELY, Mobil Oil Company, Paulsboro, New Jersey.

NONTAS KONTES, Kontes Glass Company, Incorporated, Spruce Street, Vineland, N.J.

DR. HOWARD MORRIS, JR., County Superintendent of Schools, 90 Market St., Salem, N.J.

DANIEL PEDRONI, Lab Glass, Northwest Boulevard and Oak Road, Vineland, N.J.

EDWARD WHEATON, Wheaton Glass Company, Millville, New Jersey.

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THE SCIENTIFIC GLASSBLOWING TECHNOLOGY PROGRAM

The age of technology is an age created by human ingenuity, creativity, and patient perseverance through research. The conveniencies of modern twentieth century living in the United States are the result of painstaking laboratory experiments..

Growth in research has multiplied to previously unheard of proportions during the past 10 years. In 1964 there were approximately 12,000 chemists and 40,000 physicists employed in the United States. Chemists are employed in industries producing chemicals, food, petroleum, electrical equipment, paper, and primary metals.

This nation owes a debt of gratitude to the researchers who have developed the technical inventions that have raised our standard of living. Thousands work each day to continue to improve and protect our way of life. The research of these scientists has been dependent on the men who work with glass. Without glass, our age of technology would have taken a very different course. The unique chemical and physical properties of glass make it a necessity in nearly all areas of experimentation. The simple and complex apparatus of the laboratory is made primarily of glass.

Whereever scientific research takes place, whether in the industrial, university or governmental setting, laboratory glass is used. In 1967, the chemical industry alone devoted $790 million to research activities. During 1969, more than $200 million dollars were allotted for research and development in the rubber industry. These statistics give some idea of the extraordinary level of present scientific research and of the continual development and use of scientific laboratory equipment.

The scientific glassblowing technician is responsible for the design. fabrication, and repair of laboratory glass apparatus. He is, therefore, an essential element in the scientific research team. Without condensers, multiple-necked flasks, elaborate extraction devices, high vacuum equipment, and other glass apparatus, experimenters would lack the equipment with which to test their ideas. Through close cooperation between the glassblowing technician and the researchers, large and complicated apparatus designed for the particular problem at hand can be built, assembled, and installed so that the research project can achieve its intended goals. The importance of and the demand for the scientific glassblowing technician is, therefore, in direct proportion to the level of our nation's scientific research.

GENERAL CONSIDERATIONS

The primary objective of the total curriculum recommended in this guide is the training of qualified scientific glassblowing technicians. As technicians they will work and communicate directly with scientists and other professional personnel. They will be expected to perform as successful employees and to grow into supervisory and administrative positions. In addition. as graduate technicians they will be expected to be well-informed, active, responsible members of society.

To accomplish these goals the curriculum must be carefully planned and implemented. In many ways, more is expected of the 2-year technical graduate than of the 4-year liberal arts graduate.

Consequently, curriculum and courses must be planned for maximum effect. Each course must be designed to develop its particular knowledge and skills and still be closely integrated into the whole curriculum. The sequence of courses is such that each is placed in the most strategic position for its correlation to other courses.

The curriculum's technical content is intended to give the student an understanding of scientific glass laboratory apparatus and an expertise in its design, fabrication, and repair. A parallel development takes place in the student's understanding of the apparatus and his skill in its fabrication. Courses in mathematics, science, and technical support areas focus their applications on understanding of the nature and function of glass laboratory apparatus. Since ability must be developed in manipulative skills, much time is devoted to laboratory scientific glassblowing experience. While it is true that the glass technician requires technical knowledge, it also is true that he will not be successful in employment unless he has adequate physical skills. This technology is one which is a technology but it is also true that it is probably more of an art than any other technology. An interested student of average coordination and dexterity will gradually become proficient, but this is accomplished normally only after many hours of laboratory experience.

Graduates of this curriculum can expect to find employment in laboratories where much apparatus is used. One or more scientific glassblowing technicians are needed on locations where research teams are engaged in experimentation. Among the industries in which graduates can be employed are: aerospace, food products, chemicals and allied products, rubber and plastics products, primary metals, petroleum, electronic equipment and components, and instruments and controls. Graduates are also employed in university science and research departments. Positions are available as sales representatives for manufacturers of scientific laboratory apparatus.

Examples of work titles available to graduates are:

1. Scientific glassblowing technician
2. Scientific glass designer
3. Chemical science assistant
4. Physical science assistant
5. Engineering aide
6. Research technician

Scientific glassblowing technicians must be capable of working closely with scientists and researchers and of supervising and coordinating the activities of skilled craftsmen and workmen. Graduates must be able to serve as the effective bridge between theoretical knowledge and practical execution. The graduate must be able to understand sufficiently the professional's scientific and mathematical expression of laboratory plans in order to present tentative and final designs and to fabricate effective apparatus. The student must be given special skills and a near-professional level of education, attitude, and competence.

ABILITIES AND ACTIVITIES REQUIRED OF TECHNICIANS

The following analysis of the special scientific technical abilities and work capabilities required of technicians in several related fields and specialized occupations will give some indication of the special nature of post-secondary, technician education programs.

Special abilities[1] required of technicians are as follows:

1. Proficiency in using scientific method to apply the basic principles, concepts, and laws of physics and chemistry, and/or the biological sciences, to the individual's field of technology.

2. Facility with mathematics: ability to use algebra and trigonometry as tools to develop, define, or to quantify scientific phenomena or principles; an understanding of, through not necessarily facility with, higher mathematics through analytic geometry, calculus, and differential equations, according to the requirements of technology.

3. A thorough understanding of the materials, processes, equipment, and techniques commonly used in the technology.

4. An extensive knowledge of a field of specialization, with an understanding of the underlying physical or biological sciences and their application to the engineering, health, agricultural or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish rapport with the scientists, managers, researchers, or engineers with whom he works, and to enable him to perform a variety of detailed scientific or technical work using general procedures or instructions but requiring individual judgement, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data.

5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas orally, graphically, and in writing with complete objectivity.

[1] Adapted from Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs, OE-80015 U.D., Department of Health, Education, and Welfare, Office of Education (Washington: U.S. Government Printing Office, 1962).

Work activities[2] required of technicians, some combinations of which any technician must be prepared to perform, are as follows:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to physical, chemical, or biological scientists, or engineers engaged in scientific research and experimentation.

2. Designs, develops, or plans modifications of new products and techniques or processes under the supervision of scientific or engineering personnel in applied research, design, and development.

3. Plans, supervises, or assists in installation, and inspects complex scientific apparatus, operation equipment and control systems.

4. Advises regarding the operation, maintenance, and repair of complex equipment with extensive control systems.

5. Plans production as member of the management unit responsible for efficient use of money, manpower, materials, and equipment in mass production or in routine technical services.

6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical equipment and/or products or services.

7. Assumes responsibility for performance of tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences; and/or for determinations, tests and/or analyses of substances in physical, chemical, biological, or medical or health-related sciences, and the preparation of appropriate technical reports covering the tests.

8. Prepares or interprets engineering drawings and sketches, or writes detailed scientific specifications or produces for work related to the physical, chemical or biological sciences.

9. Selects, compiles, and uses technical information from references such as engineering standards, handbooks, biological or chemical outlines, and technical digests of research findings.

10. Analyzes and interprets information obtained from precision measuring and recording instruments and/or from special procedures and techniques, and makes evaluations upon which technical decisions are based.

11. Analyzes and diagnoses technical problems that involve independent decisions. Judgment requires, in addition to technical know-how, substantive experience in the occupational field.

12. Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. This versatility is a characteristic that relates to breadth of understanding applied scientific and technical principles, the antithesis of narrow specialization.

[2] Ibid.

A 2-year curriculum must concentrate on primary or fundamental needs if it is to prepare individuals for responsible technical positions in modern industry. It must be realistic and practical in its approach. The suggested curriculum outlined in this bulletin is designed to provide maximum technical instruction in the time that is scheduled.

To those who are not familiar with this type of educational program, or with the goals and interests of students who elect it, a technical curriculum often seems to be inordinately rigid and restrictive. While modifications may be neces-ary to meet local needs or the objectives of certain institutions, the basic structure and content of this suggested curriculum should be maintained.

The specialized technical courses are laboratory-oriented. They p.ovide application of the scientific principles concurrently being learned in physics, mathematics, and chemistry. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by a concurrent scheduling of these courses during the first two semesters, a curriculum principle that will be illustrated at several points. General education courses constitute a relatively small part of the total curriculum. Experience shows that students who enter a technical program do so because of the depth of specialization that the program provides, and that many students who elect this type of program will bring to it a background of general study.

SPECIFIC ABILITIES OF SCIENTIFIC GLASSBLOWING TECHNICIANS

The following description[3] presents some of the activities which the graduate will be expected to perform:

Develops specifications for, and blows and shapes glass laboratory apparatus, such as test tubes, retorts, and flasks, and glass components for such apparatus as condensers, vacuum pumps, barometers, and thermometers: Develops customer's sketches into working plan. Correlates plan with knowledge of various factors, such as effects of heat, vacuum, and corrosive chemicals, to determine type of glass to be used. Heats glass tubing until pliable, using gas flame. Blows tubing into specified forms, using compressed air or own breath. Shapes, bends, or joins together sections of blown tubing, using flaring, pressing, and flattening tools, and stop cork. Measures products to verify dimensions, using micrometers, calipers, and rule. Fills tubes with mercury to form thermometers.

Joins and shapes glass or plastic tubing, according to blueprints and work orders, using glassblowing lathe. Selects, inserts, and clamps specified mandrels in head and tailstock of lathe, using wrenches. Turn knobs to adjust rotation speed. Inserts and clamps tube and other glass parts of various lenths, shapes, and diameters to be joined in

[3]Dictionary of Occupational Titles, U.S. Department of Labor, U. S. Government Printing Office, Washington, D. C., 1965, Volume 1, pg. 333.

chucks, using mallet and wrenches. Lights fixed jets and hand torches and turns gas valves to adjust height and color of flames to obtain specified temperature. Turns hand-wheels to move head and tailstock and bring workpieces in contact with flames. Blows through hose connected to center of chuck to shape glass or maintain air pressure within tube. Selects and manipulates spatula, hand torches and tips, and glass rods to shape, seal, splice, imbed, and weld rotating parts according to specifications. Uses hand torch and fixed jets to anneal joined or shaped areas. Turns handwheels to move head and tailstock and stretch or separate heated stock to specifications. May manually move glass tube over flame and blow it into specified shape.

FACULTY

The effectiveness of the scientific glassblowing technology program depends primarily upon the competence and the enthusiasm of the teaching staff. Glassblowing technology instructors must have special competencies which can be gained only through training, practice, and industrial experience in the technical subject matter. Instructors of supportive, related subjects should not only be competent in their specific subject areas, but also experienced or effectively oriented to the educational philosophy, goals, and requirements of technical education in general and scientific glassblowing education in particular.

The scientific glassblowing instructor is, of course, the central figure upon whom the program's success depends. Student interest, motivation, technical understandings and skills will be proportionate to that of the instructor. The student will sense his appreciation of the theoretical knowledge needed for a genuine technical understanding of the purpose, design, and function of the laboratory equipment which he fabricates. The major instructor's concern for precision in fabrication performance is matched by the constant realization that his graduates must communicate effectively about laboratory equipment with highly qualified chemists, physicists, and engineers. Consequently, continuing education is essential so that the scientific glassblowing instructor can keep abreast of developments and laboratory research procedures.

Cooperation between the major instructor and all other instructors in the program is essential. The glassblowing technology instructor must orient supportive instructors to the technology so that their presentations will be truly meaningful and relevant to glassblowing laboratory activities. All staff members should be able to make practical examples and applications of their subject matter so that it will be truly supportive to understanding glassblowing, laboratory glassblowing and its fabrication, and laboratory procedures. The principles taught in physics, mathematics, and chemistry to be emphasized are those relating to the scientific glassblowing technologist's work.

TEAM TEACHING

Teachers of specialized technical subjects must have advanced technical training. These teachers will often be drawn from the ranks of the engineering profession. Their combined background of industrial experience and technical education often makes them excellent teachers of specialized technical subjects. Consequently, they are more likely to understand the theoretical and practical objectives of the instructional program. They will understand the importance of a problem-oriented laboratory approach.

The glassblowing technology program must be presented as a series of well-integrated courses if the breadth and depth of training necessary is to be achieved. Therefore, every new concept and skill should be introduced at the proper level within each course and in relation to supportive courses. The teaching staff must constitute a highly organized and coordinated "team". Each member of the team must be integrated into the team so that his strongest knowledge and skills are utilized for the students' benefit. Lack of coordination between instructors will result in student discouragement through confusion, boredom, and lack of understanding. Closely coordinated courses will prevent overlapping, duplication, and unnecessary repetition of course materials. In this way, the student's time is used with maximum efficiency.

True team teaching and maximum curriculum coordination can only be accomplished by a constant flow of communication between staff members. A running dialogue is necessary across departmental lines. Instructors of the program must meet at least weekly to check with one another as to where they are and what they are doing at each step of their own part of the program. The official courses of study must be in continual review in order to measure their effectiveness for the particular group of students presently in attendance. Individual instructors must be adaptable and flexible enough to change procedures or the pre-set order of course content when such is most beneficial for overall program effectiveness. Adjustments should be made as quickly as possible to student problems of understanding.

Frequent staff meetings will also enable instructors to share their particular areas of expertise with one another. Instructors of technical subjects will give instructors of mathematics and science, ideas and examples of practical applications of theoretical knowledge. The glassblowing technology instructor will assist the technical instructors in organizing the most relevant classroom and laboratory experiences. The major instructor and the technical instructors will feed ideas to the "liberal arts" instructors so that their course will be of obvious practical value and truly integrated to the program's total purpose. Instructors will share with each other the scientific, technical, and industrial journals which will expand their ideas as to glassblowing technology, the industry, and improved methods of instruction.

PROFESSIONAL GROWTH

Instructors should be active members of professional and technical societies. Through these organizations and their meetings, they keep abreast of the latest ideas in their fields and maintain a closer liaison with the technology and with employers in the field. An in-grown system of education becomes near-sighted and ineffective. This is particularly true in employment-oriented education. Consequently, instructors should be encouraged and enabled to attend meetings of professional and technical societies and special teacher-training institutes. Frequent visits to representative industrial and university laboratories as well as scientific glassblowing production industries are essential so that all instructors will be as completely aware as possible of their graduates' employment environment and needs.

CLASS HOURS AND SIZE

In determining teaching loads for instructors of technical speciality courses, careful consideration should be given to the number of student-contact hours required in the schedule. To be fully effective, these instructors require more time in their schedules to develop courses and laboratory materials than do shop instructors or teachers of general education courses. Consequently, 15 to 20 student-contact hours per week usually constitute a full teaching load for instructors in the glassblowing technology program, permitting teachers sufficient time to assist students and to develop courses and effective laboratory experiments.

Since being able to give individual attention to students is a vital part of effective teaching, class size is of prime importance. This is particularly true in technical education. The maximum size of lecture classes should be considered to be 30 students. Active class participation is an essential sign and expression of student learning. Instructors of so-called "lecture" subjects should use as many varied techniques and audio-visual aids as possible in order to encourage student interest, motivation, and involvement. Laboratory classes should be limited to 20 students. The manipulative skills of the blassblowing technologist are developed through the student's patient, repetitive practice and the instructor's careful individualized instruction and observation. An overly large laboratory group creates a situation encouraging student frustration and the development of poor techniques.

STUDENT SELECTION AND SERVICES

Much emphasis has been placed upon faculty quality. However, since the program's ultimate objective is to produce high-quality graduates, it is essential that accepted students have certain capabilities. The program will not produce a scientific glassblowing technologist if the classes are composed of students whose intellectual or manipulative abilities are inadequate for the program's goals.

The scientific glassblowing technology program is a post-secondary, college-level program. A high school diploma is the minimal requirement for entrance. Ideally, students entering the program should have completed two years of high school mathematics, including algebra and geometry, and one year of chemistry. Some knowledge of physics is also desirable. Essential to the successful glassblowing technologist are visual and manipulative aptitudes. Scientific glassblowing requires the development of a high degree of proficiency in spatial perception, form perception, motor coordination, finger dexterity, and manual dexterity. Any applicant who is deficient in any one or combination of these aptitudes should be discouraged from entrance into the program. The student should also have the potential for developing ambidexterity. Certain types of color blindness may negate his effectiveness in working in the fabrication of laboratory glassblowing. It is highly recommended that all applicants be administered the Department of Labor's General Aptitude Test Battery (GATB). The GATB will include test results on all the physical aptitudes necessary other than that of color vision. In cases of doubt as to color vision, an individual test by the glassblowing technology instructor in the laboratory setting is suggested.

In a properly organized program with truly relevant and coordinated courses, the student with average scholastic potential and average dexterity can be successful. Therefore, many high school graduates who were not motivated to attempt or to successfully complete college preparatory mathematics and science courses at the secondary level, may be quite capable of becoming effective glassblowing technologists. If they are genuinely interested and properly motivated, they can achieve well in the educational program provided that they have the opportunity to upgrade their academic background beforehand. A six- to eight-weeks' preparatory summer program is recommended in these cases. In such a preparatory program, emphasis should be placed on mathematics and science with study skills stressed through the learning of these subjects.[4]

Effective guidance and counseling services are essential in the admissions process. The applicant should be counseled objectively in the selection of occupational objectives consistent with his interests and aptitudes. Standardized test results, the high school transcript, and personal interviews should be used collectively for effective student placement. In technical education, the new student should be observed with closeness and frequency so that he may be directed quickly to another program in the event of improper placement.

The new student's orientation will include a familiarization with all campus facilities, philosophy, and rules and procedures. A special introduction should be given on the resources and the use of the library. If possible, field trips should be arranged to employment settings so that new students might see glassblowing technologists at work. Through such visits the nature and purpose of the educational program can be better understood and student motivation be increased.

Individual and group counseling should have at the core of its purpose the development of successful employees. The courses in Human Relations and Industrial Organization provide ample opportunities for the discussion of successful human relations

[4]See publication *Pretechnical Post High School Programs,* A Suggested Guide, OE-80049. U.S. Department of Health, Education, and Welfare, Office of Education (Washington: U.S. Government Printing Office, 1967).

in general and work relations in particular. In individual conferences the counselor should allow the student to explore his attitudes and aptitudes with reference to the world of work. Successful employment is determined in large part by personality factors which scholastic grades cannot measure. Students must become aware of these factors and of their development within themselves. This is definitely a guidance function in technical education.

The observation of the technology of scientific glassblowing is a fascinating experience. Students should be encouraged to participate in demonstrations of their knowledge and skills. Such demonstrations will be welcome in schools, organizational meetings, and fairs. Demonstrations of the technology provide an educational service to the community and a public relations service for the glassblowing technology program.

The program is employment-oriented. Consequently, placement is a high-priority responsibility. Graduates should receive all the assistance possible from the placement personnel in finding suitable employment. Placement should be considered a 12-month activity. Employer contacts should be maintained continually through telephone, correspondence, and personal visits. Employer representatives and on-location supervisors should be supplied with copies of the curriculum, course descriptions, and, if desirable, course outlines. They should be invited to visit the facilities and to meet the instructors. The placement function is an extremely valuable service to the student, the employer, and the educational institution.

In addition to placement, the school should conduct annual follow-up studies of its graduates to evaluate their training and their progress. Follow-up is one of the most important tools in the continual study of the school program's relevancy and effectiveness.

TEXTBOOKS, REFERENCES, AND VISUAL AIDS

Textbooks, references, and visual aids for teaching any technology must be reviewed constantly and supplemented in light of (1) the rapid developments of new knowledge in the field, and (2) the results of research in methods of teaching and developing basic concepts in the physical sciences and mathematics. The impact of the newly developed areas of theoretical and applied scientific knowledge is demanding new textbooks and references, up-to-date information from scientific and technical journals, and new visual aids material.

New textbooks reflect recent methods of teaching scientific principles and their application as fast as the current research becomes applicable. Recent extensive research into the methods of teaching mathematics and physics certainly will affect teaching materials and methods. It is therefore mandatory that instructors review tests, references, and visual aid materials as they become available and adopt them when they are an improvement over those suggested here or those being used.

The suggested text and references listed in this guide have been carefully selected. There is a lack of good texts at the technician level in scientific glassblowing technology, but from the books listed herein department heads and teachers should be able to select suitable texts. However, it should not be assumed that other pertinent, but unlisted, books are not suitable—no doubt many are excellent.

Before undertaking a program in scientific glassblowing technology or any course in the curriculum, the department head or instructor is urged to become familiar with the texts and references listed in this guide and with other available literature. He will then be able to select the text and references that can best serve his particular needs and help him make an intelligible, high-level technical presentation to the students.

Visual aids can be of great help in many teaching programs, and the ones suggested in this guide have been selected from an extensive list and represent those considered most suitable at the time the curriculum was prepared. Many are not listed because the variety and extent of the materials would make an all-inclusive listing prohibitive. From among those listed and others that are available and pertinent, an instructor may select visual aids which meet his teaching objectives. These aids should always be viewed and studied prior to using them in a teaching program.

LABORATORY EQUIPMENT AND FACILITIES

Laboratories and equipment for teaching glassblowing technology must meet high standards of quality and variety, since the objectives and the strength of the program lie in providing valid laboratory experience, basic in nature, broad in variety, and intensive in practical experience. Well-equipped laboratories with sufficient facilities for all students to perform laboratory work are required for these courses. The training program should offer students an opportunity to work with a wide variety of glassblowing equipment. The glassblowing shop must have separate complete units where each individual student can produce quality glassware.

The variety and quality of the equipment and facilities are more important than quantity in the laboratory. Laboratory equipment and facilities are expensive, but are *essential* if training objectives are to be met.

Equipment must be of good quality if laboratory work is to offer the student opportunity for valid experience.

SCIENTIFIC AND TECHNICAL SOCIETIES

Scientific and technical societies[5] are important sources of information for both staff and students. The publications and the meetings of the societies are probably

[5]See publication *Scientific and Technical Societies Pertinent to the Education of Technicians*, OE-80037, United States Department of Health, Education, and Welfare, Office of Education (Washington: United States Government Printing Office, 1966).

the best means for keeping up-to-date in a particular phase of science or technology. Even new students can benefit from the exposure which broadens their technical vocabulary, their knowlwdge of equipment and supplies, and their awareness of new techniques in development. Teachers, through membership, obtain a continual source of instructional ideas and materials. Technical societies help the theorist to understand practical applications and encourage the technician to deepen his theoretical understandings. These societies can be expected to be the first to announce and describe significant research and innovations in the field.

All instructors in the glassblowing technology program should be encouraged to be active members of their respective societies. In this way, each member of the team will be sharing with the other instructors the new developments in his own field for possible application to glassblowing technology education. Consequently, the students will be at least aware, upon graduation, of the most recent developments in the field. Teacher membership in scientific and technical societies will set the stage for close liaison with employers and interested members of the community.

New students should be made aware of the literature and services of the scientific and technical societies related to the field of scientific glassblowing technology. They should be encouraged particularly to apply for student-affiliate membership in the

Scientific Glassblowers Society
309 Georgetown Avenue, Gwinhurst,
Wilmington, Delaware 19809

A description of the Society and its advantages should be given early in the student's career.

ADVISORY COMMITTEES AND SERVICES

Almost all successful technical education programs are assisted and benefited by advisory committees and special consultants. Most institutions have an advisory committee or committees to assist the administrators in planning and implementing programs to meet the objectives of the institution and the needs of those served. In addition, each specific technology program or other specialized occupational objective has a special curriculum advisory committee made up of representatives of employers, civic leaders, and representatives of public employment services, scientific or technical societies and associations in the field, and of specialists from the school's staff.

A curriculum advisory committee usually is appointed by the chief administrator or the dean of the institution when it becomes evident that a particular technology program should be considered, and perhaps offered by the institution. The advisory committee then assists in making a survey of employment requirements; employment opportunities; available student population; curriculum, faculty, laboratory facilities and equipment; and the cost of the program. These committees often provide the added support that school administrators need for requesting appropriations, raising public funds, and for obtaining State or Federal support for the program.

Sometimes results of studies made by the curriculum advisory committee demonstrate that a proposed program is not needed. But when they show that a program should be offered, the committee's support and assistance in planning and initiating the program is invaluable. When the program's graduates begin seeking employment, the committee assists in placing them in jobs and in evaluating their performance. These evaluations often lead to minor modifications in the program.

Committee members usually are appointed for a year to prevent the duties from becoming a burden to any one member and to give other qualified and interested people an opportunity to serve. The average committee usually consists of 12 members, but this number may vary from 6 to 20. Those selected to serve are busy people, and meetings should be called only when there are problems or tasks that demand committee action. The members serve without pay, participating as interested citizens and providing invaluable assistance whether serving formally or informally. The continuous support provided by an advisory committee has proved to be a source of strength for the program and the most reliable means of maintaining a successful, high-quality, and up-to-date program.

As stated in the Foreword, this guide is to be used for program planning and development in post-high school institutions. Modifications in the program are expected in order to make it suitable to local needs and/or various school situations. The assistance given by an advisory committee and special consultants, using a guide such as this and modifying it to meet local needs, has been found effective in initiating needed programs and developing them quickly to a high level of excellence. The courses have often been modified by school administrators and advisory committees to serve the needs of employed adults who need to update or upgrade their skills and technical capability.

SUGGESTED CONTINUING STUDY

A 2-year program must concentrate on providing the necessary science, mathematics, and related knowledge and skills in the technical speciality if it is to produce graduates who can qualify for employment.

. This type of program cannot cover in depth all of the subjects which are pertinent to the technology; other important related subjects may be introduced. In addition, the graduate may obtain work in a new area of the industry for which little or no related subject matter had been developed during his training period.

The program is not designed to produce an individual who is proficient in all of the duties he might be asked to perform. Proficiency in highly specialized work will come with practice and experience. It is impossible to forecast the exact requirements of the duties assigned to any individual, and it is almost impossible to predict accurately the direction or rate of change in various technologies. Employers generally recognize that recent graduate engineers may require a year or more to obtain the specific training needed and to become fully aware of their responsibilities and role in an organization. Similarly, employers must allow newly graduated scientific glassblowing technicians a 3- to 6-month orientation period to give them time to become familiar with the special procedures and problems related to the job. Furthermore, productive graduate technicians will continue to study throughout their careers in order to develop their capabilities to the maximum.

For these reasons, continuing study is necessary for graduates of technology programs. They can, however, keep abreast of technical developments by reading current literature related to the technology, by attending meetings of scientific and technical societies, and by studying on the job. These methods of study tend to build on the organized technological base of the 2-year curriculum. Continuing study in supplementary courses is the most efficient and practical way for the post-secondary graduate to acquire additional knowledge and skill that can broaden his initial education. Formal study offers the advantages of systematic arrangement of subject matter, disciplined and competent teaching, and class discussion. In addition, the courses studied may be scheduled for Saturday or after the technician's work hours.

THE CURRICULUM

CURRICULUM OUTLINE

	Hours per Week Class	Laboratory
FIRST SEMESTER		
Mathematical Analysis I	3	0
Communication Skills I	3	0
General Chemistry	3	3
Scientific Glassblowing I	3	12
Blueprint Reading and Sketching	3	0
	15	15
SECOND SEMESTER		
Mathematical Analysis II	3	0
Communication Skills II	3	0
Glass Chemistry	3	3
Scientific Glassblowing II	3	12
Human Relations	3	0
	15	15
THIRD SEMESTER		
Physics I	3	3
Economics	3	0
Scientific Glassblowing III	3	12
Industrial Electronics	3	0
Technical Writing I	3	0
	15	15
FOURTH SEMESTER		
Physics II	3	3
Scientific Glassblowing IV	3	9
Glass Drafting and Design	1	2
Industrial Instrumentation	3	0
Industrial Organization	3	0
Technical Writing II	3	0
	16	14

COURSE OUTLINES

Scientific Glassblowing I

Hours Per Week: Class, 3; Laboratory, 12

Course Description: An introductory study of the fundamental principles and practices of scientific glassblowing as applied to the fabrication and repair of laboratory research materials.

Applications are made to industrial production and laboratory settings. A careful orientation is given to the history of glass, the glass industry, and scientific glass. Emphasis is upon familiarization with the basic materials, tools, and equipment.

In order that the student can begin to develop the necessary manipulative skills and dexterity, much time is spent in the fabrication of simple laboratory glassware.

Major Divisions:
I. Orientation
II. Glassblowing Equipment
III. Glass Tubing
IV. Using the Lehr and Polariscope
V. Preliminary Operations
VI. Making Simple Glassware Items
VII. Fundamental Sealing

I. Orientation

A. Shop Rules and procedures
B. Shop Vocabulary
C. Safety
D. Employment
E. History of Scientific Glassblowing

II. Glassblowing Equipment

A. Gas and Oxygen Supply
B. Burners – Types, Parts, and Adjustments
C. Hand Tools and Bench Equipment
D. Power Tools and Laboratory Equipment
E. Valves – Types, How to Operate

II. Glass Tubing

A. Identification of Types of Glass Tubing – Sizes
B. Cleaning
C. Cutting

IV. Using the Lehr and Polariscope

A. The Lehring of Different Types of Glass
B. The Interpretation and Relieving of Strain Patterns as Revealed by the Polariscope

V. Preliminary Operations

A. Flaring and Fire Polishing
B. Beading
C. Pulling Points
D. Bottoming (round)
E. Bottoming (flat)
F. Making Constrictions
G. Straight Seals
H. T-Seals
I. Ring Seals
J. Blowing Bulbs
K. Sealing With Capillary Tubing
L. Bending

VI. Making Simple Glassware Items

A. Making a Test Tube
B. Making a Hose Connection
C. Making a Y-Hose Connection
D. Making a U-Hose Connection
E. Making a Thistle Tube Funnel
F. Making Small Chemical Funnels
G. Putting Hooks on Standard Wall Tubing
H. Putting Hooks on Capillary Tubing
J. Making a Straight Drying Tube

VII. Fundamental Sealing

A. T-Sealing of Tubes
B. Angle Sealing Other Than T
C. Ring Seal in Blind Tube
D. Insertion Ring Seal
E. Ring Seals, Dewar Type
F. Side Ring Seal
G. Closed Circuit Tubing Seals
H. Sealing Rods
I. Seal Capillary Tube
J. Hand Torch Sealing
K. Making Spirals

Texts and References for All Scientific Glassblowing Courses

American Ceramic Society, *Advances in Glass Technology,* Plenum Press, New York.

Barr, W.E., *Scientific and Industrial Glass Blowing and Laboratory Techniques,* Instruments Publishing Company, Pittsburgh, Penna.

Davis, Pearce, *The Development of the American Glass Industry,* Harvard University Press, Cambridge, Massachusetts.

Day, Ralph, *Glass Research Methods,* Industrial Publications, Chicago, Illinois.

Diamond, Freda, *The Story of Glass,* Harcourt Brace, New York.

Dickson, J., *Glass: A Handbook for Students and Technicians,* Chemical Publishing Company, New York.

Haggar, Reginald. *Glass and Glassmakers,* Roy Publishers, New York.

Hodges, Elizabeth, *The Story of Glass: Bottles and Containers through the Ages,* Sterling, New York.

Jones, G., *Glass,* Wiley, New York.

McKearin, Helen, *Two Hundred Years of American Blown Glass,* Crown, New York.

Parr, L., *Laboratory Glassblowing,* George Newnes Limited, London.

Phillips, Charles, *Glass: Its Industrial Applications,* Reinhold, New York.

Volf, M., *Technical Glasses,* Sir Isaac Pitman and Sons, London.

Weyl, Woldemar, *The Constitution of Glasses,* Wiley, New York.

Wheeler, E., *Scientific Glassblowing,* Interscience Publishers, Inc., New York.

Scientific Glassblowing II

Hours Per Week: Class, 3; Laboratory, 12

Course Description: A course designed to intensify the ability to fabricate and repair laboratory glass apparatus with the use of various types of gas and oxygen burners. Additional experience is given in the use of the lehr and of the polariscope. Students receive an introduction to the lathe and tooling operations. Fundamental sealing is applied to the fabrication of manometers, simple columns, and condensers. Emphasis is placed upon manipulative skill along with concern for precision by a careful application of mathematics, blueprint reading, and sketching to glass laboratory experiences.

Major Divisions:
I. Tooling
II. Lathe Operations
III. Making Apparatus: Adapters
IV. Making Apparatus: Traps
V. Making Apparatus: Manometers
VI. Making Apparatus: Simple Columns
VII. Making Apparatus: Condensers

I. Tooling

A. Adjusting Fires
B. Use of Rollers
C. Using the Forming Tool
D. Making Stop Cock Plugs
E. Making Barrels
F. Making Side Arms
G. Making Hose Connections

II. Lathe Operations

A. Making Round Bottoms
B. Blowing Bulbs
C. Making Straight Seals
D. Sealing Tubes of Different Diameters

III. Making Apparatus: Adapters

A. Aeration Tubes, Thermometer Wells and Holders
B. Sidearm and "U" Adapters
C. Tapered Point Adapters

IV. Making Apparatus: Traps

A. The Cold Trap
B. The Foam Trap
C. Dewar Traps

V. Making Apparatus: Manometers

A. Open End "U" Type
B. Closed End Manometers
C. Concentric Tube Closed End Type

VI. Making Apparatus: Simple Columns

A. The Vigreaux Column
B. The Hemple and Honeycomb Support Column
C. Distilling Column with Side Arm

VII. Making Apparatus: Condensers

A. The Liebig Condenser
B. The West Condenser
C. The Allihn Condenser
D. The Graham Condenser
E. The Spiral Condenser

Scientific Glassblowing III

Hours Per Week: Class, 3; Laboratory, 12

Course Description: A course designed to intrւduce the design, fabrication, and repair of more complicated scientific glass laboratory apparatus. Renewed emphasis is placed on sound safety regulations. Industrial production and laboratory expectancies in employment are stressed in the development of efficient, economical work techniques. Precision of design and execution is achieved in the fabrication of apparatus introduced in the previous semester. Silvering operations are introduced. Students are given extensive theory and practice in the fabrication of soxlet extractors, diffusion pumps, and dry ice traps.

Major Divisions:
I. Orientation
II. Review to Check on Student Improvement During Summer
III. Silvering Operations
IV. Making and Repair of Flask
V. Soxlet Extractor
VI. Two-Stage Mercury Diffusion Pump (Ruggles Pump)
VII. Dry Ice Traps

I. Orientation–Safety

A. Check All Equipment and Hoses for Leaks
B. Proper Handling of Oxygen Tanks and Correct Pressures
C. Review Safety Rules of Shop

II. Review to Check on Student Improvement During Summer

A. 10 Min. T-Tube
B. 10 Min. L-Bends
C. 10 Min. U-Gends
D. Make One Kjeldahl Bulb

1. Measure Sample and Sort Tubing
2. Only One Try

E. Make Distilling Head Containing Vigreaux Column, Condenser, and Vacuum Take Off

III. Silvering Operations

A. Mixing of Silvering Solution
B. Method of Speeding Silvering Operations

1. Warming of Solution
2. Using Aspirators and Stopcocks

C. Silvering Dewars and Columns

1. Cleaning with Acids and Distilled Water
2. Oven Cleaning by Annealing
3. Evacuation
4. Safety Measures

IV. Making and Repair of Flask

A. Off Hand Blowing of Small Flask

1. Round Bottom
2. Flat Bottom
3. Erlenmyer Flask
4. Suction Flask

B. Making S-3 Neck Flask

1. Types of Holders
2. Location of Necks
3. Importance of Not Distorting S-Joints
4. Cutting and Etching S-Joints

C. Repair of Boiling Flask

1. Repairing Side Neck
2. Healing Star Cracks

D. Removing Frozen S-Stoppers and Stopcocks

1. Ice Water and Boiling Water
2. Heating by Flame
3. By Solution
4. Oven Removal
5. Commercial Devices

V. Soxlet Extractor

A. Practice Blind Seal with Large and Small Tubing
B. Practice Closed Circuit Seals with 10 mm Tubing
C. Simulate Extractor Without Joints
D. Make Extractor with S-Joints

VI. Two-Stage Mercury Diffusion Pump (Ruggles Pump)

A. Make Parts for Pumping Stages
B. Make Boiler for Containing Mercury and Inserting Heater
C. Assemble Pump

VII. Dry Ice Traps

Outlet and Inlet Tubes Same Size as Pump Lead on Diffusion Pump

Scientific Glassblowing IV

Hours Per Week: Class, 3; Laboratory, 9

Course Description: A course designed to strengthen the understanding of the use and function of sophisticated scientific glass apparatus and to refine employment skills in its fabrication and repair. All of the student's previous courses should be brought to focus in this course to accomplish a true technical understanding and proficiency. The student progresses from the making of fundamental seals to glass-to-metal seals. Drafting skills are applied to the design and fabrication of high vacuum systems and pilot plant condensers. Skills are refined in the use of gas and oxygen burners, glass lathes, annealing ovens.

Major Divisions:
- I. Dewar Seals
- II. Magnetic Distilling Head
- III. Vacuum System
- IV. Pilot Plant Condenser
- V. Glass to Metal Sealing
- VI. Graded Seals

I. Dewar Seals

A. Dewar Seals by Hand
B. Dewar Seals on Lathe
C. Safety Precautions When Using Dewar Under High Vacuum

1. Plastic Evating
2. Asbestos Wrappings
3. Wire Shields

II. Magnetic Distilling Head

A. Making Parts for Head
B. Making Funnel with Soft Iron Balance
C. Making Condenser for Top of Distilling Head
D. Making Small Condenser for Take-Off
E. Assembling Distilling Head

III. Vacuum System

A. Sealing Dry Ice Trap to Mercury Diffusion Pump
B. Assemble System on Ring Stand; Include McCleod Gauge

IV. Pilot Plant Condenser

A. Wrapping Coil
B. Means of Supporting Coil
C. Means of Supporting Inner Tube
D. Condenser Assembly

V. Glass-to-Metal Sealing

A. Tungsten to Glass
B. Platinum to Glass
C. Kovar Seals

VI. Graded Seals

A. Commercial Seals
B. Grade Seals with Rod

Mathematics for Glass

Hours per week: Class, 3; Laboratory, 0

Course Description: This course, Mathematics for Glass, furnishes the mathematical foundation for students entering the glassblowing science technology.

In conducting this course following the outline, stress should be placed on understanding of basic principles, as well as knowledge of concepts and procedures. This course has been designed so that only an understanding of arithmetic is necessary as a prerequisite.

The slide rule is presented as a primary technician's tool and students should be required to use it when ever possible and become proficient in its use.

Fundamental algebraic operations are introduced for the solution of science problems essential to the understanding of the properties of glass and the function of scientific laboratory equipment. The arrangements of topics may be altered to suit particular class needs.

Major Divisions

I. The Slide Rule
II. Units of Measurements Applied to the Glass Technology
III. Arithmetic With Applications for the Glassblowing Technology
IV. Measurement and Scale Readings As Applied to Glass Laboratory Equipment
V. Fundamental Operations in Algebra With Applications Pertaining to the Glass Laboratory
VI. Equations and Formulas Applying to Glass Science
VII. Functions and Their Graphs

I. The Slide Rule

A. Description of the Slide Rule
B. Locating Numbers on the Slide Rule
C. Multiplication of Two or More Factors
D. Division of Two or More Factors
E. Findings Squares, Square Roots, Cubes, and Cube Roots of Numbers
F. The Use of the Slide Rule in Extended Computation

II. Fundamental Units of Measurement

A. The English System of Measurements

1. Length Measures: Inch, Foot, Yard
   –Measures of Tubing and Glassware
2. Area Measures: Square Inch, Square Foot, Square Yard
   –Measures of Circles, Ellipses
3. Volume Measures: Cubic Inch, Cubic Foot, Cubic Yard
   –Measures of Cylinders, Spheres, Spheroids, Cones
4. Weight Measures: Pounds, Ounces
5. Use of Tables

B. The Metric System of Measurements

1. Length Measures: Millimeter, Centimeter, Meter
   –Measures of Tubing and Glassware
2. Area Measures: Square Millimeters, Square Meters
   –Measures of Circles, Ellipses
3. Volume Measures: Liter, Milliliter, Cubic Centimeter
   –Measures of Cylinders, Flasks, Tubes, Bulbs
4. Weight Measures: Grams, Milligrams
5. Use of Tables
6. Simplicity of the System in Base 10

C. Changing English to Metric and Metric to English Systems

--Use of Different Measures in Blueprints

III. Arithmetic With Applications

A. Whole Numbers in the Decimal System
   –Tolerance
B. Common Fractions--Basic Operations
C. Decimal Fractions--Basic Operations
D. Fraction-Decimal Conversion
E. Square and Square Roots
F. Powers of Ten
   –Use With Coefficients of Expansion in Glass
G. Positive and Negative Numbers

1. Basic Operations
2. Use for Tolerance Measure (±)

H. Ratio, Proportion, and Percentage

1. Basic Operations
2. Proportions in Glass Composition
3. Proportions in Cleaning Solutions Used for Glassware
4. Use of Ratio
   a. Coefficient of Thermal Expansion
   b. Boyle's Law
   c. Density Measure
5. Rates of Change
   a. Degrees Per Minute
   b. Standard Taper in Glass

IV. Measurements and Scale Readings

A. Measurements of Time, Heat

1. Time
   –Units of Measure

2. Heat
    a. Units of Measure of Temperature
        (1) Centigrade
        (2) Kelvin
        (3) Fahrenheit
        (4) Rankine
    b. Converting Centigrade to Fahrenheit
    c. Measures of Heat
        (1) BTU
        (2) Calorie

B. Reading Linear Scales

C. Reading Angles

1. Tapers
    a. Glass
    b. Metal
2. Right angles
3. Use of 75° and 105° angles
4. Use of 58° and 60° angles in funnels

D. Reading Logarithmetic Scales
—McLeod Pressure-Gauge Readings

E. Calibrating Scales
——Use in Manometers, Pressure Gauges, Thermocouples

V. Fundamental Operations in Algebra

A. Addition and Subtraction of Algebraic Expressions
B. Laws Governing Use of Parenthesis (or Brackets)
C. Exponents and Radicals
D. Multiplication and Division of Algebraic Expressions

VI. Equations and Formulas

A. Rules and Procedures for Solving Equations and Formulas

1. Basic Operations and Procedures
2. Uses
    a. Hooke's Law of Elasticity
    b. Formulas for Bending
    c. Pressure Formulas
    d. Boyle's Law
    e. Archimedes Law

B. Simplification of Equations

VII. Functions and Their Graphs

A. Constants and Variables
B. Functions of Several Variables
—Use in Boyle's law

C. Graphs and Functions Given by Tables of Data
   —Rates of Change
D. Coordinate System
E. Graphs of Linear Equations
F. Slope of a Line
G. Interpreting Information from a Linear Graph

Texts and References

Andres and others, *Basic Mathematics for Engineers,* J. Wiley and Sons, Inc.

Rice and Knight, *Technical Mathematics With Calculus*, McGraw Hill Book Company.

GENERAL CHEMISTRY

Hours Required Per Week: Class,3: Laboratory,3

Course Description: This one-semester course is designed to prepare glass-blowing technology students for the subsequent course in Glass Chemistry. It provides an introduction to the language of chemistry and basic chemical principles which are operative in glass technology.

Experiments, which introduce laboratory techniques and equipment, deal primarily with the preparation and properties of glass-making materials. The experiments are also designed to reinforce the principles developed in class discussions.

Major Divisions

I. The Material World
II. The Physical Properties of Matter
III. The Nature of Chemistry
IV. The Language of Chemistry
V. Fundamental Particles
VI. Some Simple Chemical Reactions
VII. Oxidation and Reduction
VIII. Oxygen and Hydrogen
IX. Water—Its Chemistry and Uses
X. Acids, Bases and Salts
XI. The Nature of Solutions
XII. The Metals
XIII. The Non-Metals
XIV. Chemical Contributions Toward a Better Living

I. The Material World

1. Composition of the Earth's Crust
2. The Use of Natural Materials
3. Curiosity and Experiment Lead to New Materials

II. The Physical Properties of Matter

1. Useful Physical Properties
2. Changes in Physical Properties
3. Energy Changes and the Changes of Physical State
4. The Temperature, Pressure and Volume Relationships of the Gases

III. The Nature of Chemistry

1. Changes in Composition and Physical Properties
2. The Search for More Useful Materials
3. Trial and Error Experiment
4. The Scientific Method

IV. The Language of Chemistry

1. Symbols and Formulas
2. Atomic and Molecular Weights
3. Equations Quantitatively Record Chemical Changes
4. Ions and Radicals

V. Fundamental Particles

1. Atoms and Their Structure
2. Electrons and Energy Levels
3. Ions and Electrons

VI. Some Simple Chemical Reactions

1. Decomposition of Compounds
2. Combination of Atoms and Molecules
3. Reactions Involving Exchange of Ions and Radicles
4. Displacements of One Element by Another

VII. Oxidation and Reduction Reactions

1. Combining Power of the Elements—Valence
2. Elements With Variable Valences
3. Typical Oxidation-Reduction Reactions

VIII. Oxygen and Hydrogen

1. Preparation
2. Properties
3. Industrial Uses

IX. Water: Its Chemistry and Uses

1. Physical Properties
2. Chemical Properties
3. The Water Cycle
4. Water Purification

X Acids, Bases and Salts

1. Properties and Reactions
2. Oxides With Acidic and Basic Properties

XI. The Nature of Solutions

1. Solubility and Concentration
2. Physical Properties of Solutions
3. Crystallization from Solutions
4. Phase Equilibrium

XII. The Metals

1. Some Common Metals and Their Compounds
2. Structure and Reactions of the Metals
3. Metal Oxides
4. Metallurgy

XIII. The Non-metals

1. Carbon, Silicon, Phosphorous and Sulfur
2. Structure and Reactions of the Non-metals
3. Oxides of the Non-metals

XIV. Chemical Contributions Toward Better Living

1. Man's Needs and Desires
2. Synthetics and Substitutes
3. Resources, Products and Refuse
4. The Role of Glass the Economy

Texts and References

Boylan, P.J. and Weld, P.B., *Elements of Chemistry*, Allyn and Bacon, Boston, Mass.

Hogg, J.C. et al, *Chemistry: A Modern Approach*, D. Van Nostrand Company, Princeton, N.J.

Horrigan, P.A., *The Challenge of Chemistry,* McGraw-Hill Book Company, New York, N.Y.

Jones, W. Norton, *Text Book of General Chemistry*, The C.V. Mosby Company, St. Louis, Mo.

Sienko, M.J. and Plane, R.A., *Chemistry*, McGraw-Hill Book Company, New York, N.Y.

Williams, Arthur et al, *Introductory Chemistry*, Addison-Wesley, Reading, Mass.

Laboratory – 48 Hours

1. A Look at Some Common Materials. Minerals, Fuels and Fabricated Products.
2. Some Methods of Separation. Examination of a Raw-Material Glass Batch.
3. Determination of the Composition of a Hydrate. Preparation of 'Salt Cake' from Sodium Sulfate Hydrate.
4. Verification of the Constant Composition of a Compound. The Analysis of a Sample of Copper Oxide.
5. The Decomposition of Calcium Carbonate. The Examination of a Sample of Limestone.
6. Oxidation of a Metal. The Rusting of Iron and the Reduction of Iron Oxide.

7. Determination of the Percentage of Oxygen in Air. The Reaction of Phosphorous and Ox;·gen.

8. Solubility of Salts. The Purification of Potassium Dichromate.

9. Analysis of a Sample of Soda Ash. The Reaction of an Acid and a Base.

10. Conductivity of Solutions and Melts. Electrolytes and Non-electrolytes.

11. Measuring the Equivalent Weight of a Metal. Some Properties of Aluminum.

12. Electrolysis of Salt Solutions. Electroplating.

13. Properties of Metal Oxides and Non-Metal Oxides. Reaction of Acidic and Basic Oxides.

14. Preparation of Lucite, a Synthetic Substitute for Glass.

GLASS CHEMISTRY

Hours per Week: Class, 3; Laboratory, 3

Description: This is a course dealing with the properties of glass and the raw materials involved in its manufacture. The chemical reactions and physical changes involved in glass-making are discussed. The characteristics of the major commercial glasses and the methods of testing are reviewed. Laboratory exercises provide experience in use of laboratory glassware, measurement of physical properties of glass, and simple analysis of glass and its raw materials. The course is designed to give the students in glassblowing technology an understanding of the uses of the more common pieces of laboratory glassware. Through work with this equipment the student recognizes the limitations of glass and the necessity for acceptable design and workmanship. The course also provides the student with a broader picture of the industrial utilization of glass and variations in the properties of glass than normally encountered in bench operations.

Major Divisions:
I. The Glassy State
II. The Glass Making Oxides
III. Equilibrium Phase Diagrams
IV. Chemical Composition of Glasses
V. Raw Materials
VI. Batch Calculations
VII. Fuels and Combustion
VIII. Viscosity
IX. The Melting Process
X. Strain and Annealing
XI. Color
XII. Engineering Properties of Glass
XIII. Physical Properties of Glass
XIV. Evaluation of Finished Glass
XV. Glass-house Refractories

I. The Glassy State

A. Definition of Glass
B. Occurrence

II. The Glass-Making Oxides

A. Network Formers
B. Network Modifiers
C. Accessory Oxides

III. Equilibrium Phase Diagrams

A. Binary Phase Diagrams

—Quantitative Considerations

B. Ternary Phase Diagrams

1. Crystallization Paths
2. Quantitative Considerations

IV. Chemical Composition of Glasses

A. Commercial Glass

1. Window Glass
2. Containers
3. Thin-blown Ware
4. Table Ware

B. Technical Glass

1. Laboratory Ware
2. Thermometers
3. Glass Tubing

C. Fiber Glass
D. Optical Glass
E. Colored Glass
F. Structural Glass

V. Raw Materials

A. Sources
B. Purity
C. Composition

VI. Batch Calculations

A. Calculations of Composition From Batch
B. Calculations of Batch From Composition

VII. Fuels and Combustion – Quantitative Considerations

A. Electrical Heat
B. Combustion Heat
C. Heat Capacity and Specific Heat
D. Industrial and Glass-house Fuels
E. Flame and Stack Gases

VIII. Viscosity

A. Units of Viscosity
B. Variables Affecting Viscosity
C. Viscosity and Plasticity
D. Viscosity Curves–Characteristic Points

IX. The Melting Process

A. Temperatures for Glass Melting
B. Mechanism of Melting
C. Fining and Stokes Law

X. Strain and Annealing

A. Hookes' Law
B. Causes of Thermally Induced Stresses
C. Temporary and Permanent Strain
D. Detection of Strain
E. Quantitative Strain Measurement
F. Annealing Processes
G. The Lehr
H. Toughened Glass

XI. Color

A. The Spectrum
B. Selective Absorption
C. Colorants

1. Colorants in Solution
2. Colloidal Colorants

D. Decolorizing

1. Chemical Decolorizing
2. Physical Decolorizing

E. Opal and Alabaster Glasses
F. Photo-sensitive Glasses

XII. Engineering Properties of Glass

A. Modulus of Elasticity
B. Shear and Bulk Moduli
C. Poisson's Ratio
D. Transverse Rupture
E. Impact Testing
F. Hardness
G. Brittleness
H. Thermal Endurance
I. Photo-elastic Phenomena

XIII. Physical Properties of Glass

A. Review of Properties Covered Previously
B. Density
C. Conductivity
D. Surface Tension
E. Electrical Properties

XIV. Evaluation of Finished Glass

A. Chemical Analysis
B. Density Measurements

C. Softening Point
D. Thermal Expansion
E. Quantitative Estimation of Strain
F. Heat Shock Tests
G. Strength Tests
H. Color Tests

XV. Glass-house Refractories

A. Raw Materials
B. Alumina and Siliceous Materials
C. Pot Making Material and Considerations
D. Tank Blocks

Texts and References

Azaroff, L.V., *Introduction to Solids*, McGraw-Hill Book Company, New York, 1960.

Day, R.K., *Glass Research Methods*, Industrial Publications, Inc., Chicago, 1953.

Morey, G.W., *The Properties of Glass*, Reinhold Publishing Corp., New York, 1954.

Norton, F.H., *Elements of Ceramics*, Addison Wesley Publishing Company, 1952.

Norton, F.H., *Refractories*, McGraw-Hill Book Company, New York, 1949.

Phillips, C.J., *Glass–Its Industrial Applications*, Reinhold Publishing Corp., New York, 1960.

Scholes, S.R., *Modern Glass Practice*, Industrial Publications Inc., Chicago, 1951.

Stanworth, J.E., *Physical Properties of Glass*, Oxford University Press, London, 1953..

Tooley, F.V., *Handbook of Glass Manufacture*, Ogden Publishing Company, New York, 1961.

Volf, N.B., *Technical Glasses*, Plenum Press, Pitman & Sons, Inc., London, 1961.

American Society for Testing and Materials – *Book of Standards*.

Supplemental References

"Kimble Glasses – Technical Data", Owens-Illinois

"This is Glass" – Corning Glass Works

"Engineering With Glass" – Corning Glass Works

"Properties of Selected Commercial Glasses" – Corning Glass Works

"Electrical Properties of Glasses and Ceramics" – Corning Glass Works

"Glass" – Charles H. Greene, Scientific American, Jan. 1961

"Fifty Years of Glass Technology" – R.W. Douglas, Nature, November 19, 1966

"Of Romans, Glass and Microprobes" – Transcript 318 & 319, American Chemical Society News Service

"The Elements of Glass Technology" – Westerner, University of Sheffield

"Characteristics of Fused Quartz" – R. J. Sommer, American Scientific Glassblowers Society

"Blown Glass" – Lubrication, Texaco Inc., Sept. 1962

"Plate, Window and Safety Glass" – Lubrication, Texaco, Inc., Feb. 1960

Laboratory – 36 Hours

1. Calibration of Volumetric Vessels
2. Use of Flasks and Beakers as Reaction Vessels
3. Distillations
4. Separations and Extractions
5. Density Determinations of Glass Samples
6. Coefficient of Linear Expansion of Glass
7. Corrosion Resistance of Glass
8. Examination of Sand
9. Analysis of Limestone
10. Identification of Glass Colorants
11. Analysis of Glass

PHYSICS I

Hours Per Week: Class, 3; Laboratory, 3

Description: This course is designed for the exploration and demonstration of the basic principles of physics as applied to the fundamental concepts of matter including molecular and crystalline structure, states of matter and their properties. Emphasis is placed on the measurement of temperature and the effects of heat and the change of state process. Heat transfer problems in convection, radiation, and conduction are analyzed. All laboratory experiments are designed to apply an understanding of the properties of matter and the principles of heat directly to laboratory glass apparatus. All instruction and laboratory experiences are aimed at an understanding of the scientific glass apparatus design and fabrication problems such as thermal and tensile stress, heat transfer, specific heat, and change of state points.

Major Divisions

I. Introduction
II. Properties of Solids
III. Properties of Liquids
IV. Properties of Gases
V. Temperature and the Effects of Heat
VI. Heat and Change of State
VII. Heat Transfer

I. Introduction

  A. What is Physics?
  B. Matter

    1. Types
    2. Structure (Molecular)
    3. Structure (Crystalline)

  C. Energy

    1. Types
    2. Uses

  D. Measurement Systems and Units

II. Properties of Solids

  A. Density
  B. Elasticity

    1. Stress
    2. Strain

  C. Ductility, Malleability, Hardness

III. Properties of Liquids

   A. Pressure
   B. Specific Gravity (Archimedes Principle)
   C. Pascal's Principle
   D. Fluid Flow

IV. Properties of Gases

   A. Atmospheric
   B. Industrial
   C. Gas Laws

V. Temperature and the Effects of Heat

   A. Temperature

      1. Measuring Units
      2. Measuring Devices

   B. Linear Expansion
   C. Area Expansion
   D. Volumetric Expansion

VI. Heat and Change of State

   A. Heat Units

      1. Calorie
      2. BTU

   B. Thermal Capacity

      –Specific Heat

   C. Latent Heat

      1. Vaporization
      2. Fusion

VII. Heat Transfer

   A. Conduction
   B. Convection
   C. Radiation

Texts and References

Banner, Philip, *Principles of Physical Science*, Addison-Wesley Publishing Company, Reading, Mass.

Harris and Hemmerling, *Introductory Applied Physics*, McGraw-Hill Book Company, New York, N.Y.

Rusk, Second Edition, *Introduction to College Physics*, Appleton-Century-Crofts, Inc., New York, N.Y.

Smith, Cooper, *Elements of Physics*, McGraw-Hill Book Company, New York, N.Y.

White, Harry E., 5th Edition, *Modern College Physics*, Van Nostrand (Litton Educational Publishing Company), Cincinnati, Ohio.

White, Weber and Manning, *Basic Physics*, McGraw-Hill Book Company, New York, N.Y.

PHYSICAL SCIENCE I
LABORATORY EXPERIMENTS

I. Precision Measurement— This experiment is to be used to afford the glass technician the opportunity to use precision measuring instruments in the calibration of Laboratory Glass apparatus.

II. Elasticity and Tensile Strength—A study of the elastic limit and tensile strength of materials used in making laboratory glass apparatus—The polariscope will be used as an aid in the visualization of stress within glass apparatus.

III. Archimedes' Principle— Glass apparatus will be used in a demonstration of Archimedes principle of floatation and displacement.

IV. Density and Specific Gravity—Density and specific gravity of glass materials and laboratory liquids will be determined while using apparatus designed and built by the glass technician.

V. Boyle's Law — The pressure-volume relationship of gases will be demonstrated, using apparatus built by the glass technician.

VI. Study of a Thermocouple —The calibration use of thermocouples in laboratory apparatus will be studied, using a thermopile imbedded in the side of a glass container. This experiment will afford a practical application of glass-to-metal seals.

VII. Linear Expansion of a Material With Heat—This experiment will demonstrate the difference in expansion rates of several types of metals and several types of glass. Emphasis will be placed on the relationship of expansion rates and materials used in glass-to-metal seals.

VIII. Heating Value of Fuels— To demonstrate the heating ability of various fuels and the temperature zones of a flame to improve the glass technician's understanding of fuel economy and costs.

IX. Specific Heat of Liquids and Solids — The rate at which materials absorb heat will be demonstrated. Various types of metals and glass will be used in this experiment.

X. Latent Heat and Change of State—The change of state process of water will be studied in this experiment,using scientific glass apparatus.

XI. Heat Transfer by Conduction—The conductivity of aluminum and copper will be studied in this experiment. Glass-to-aluminum seals will be used in the apparatus for measuring the conductivity of aluminum.

PHYSICS II

Hours Per Week: Class, 3; Laboratory, 3

Description: This course is designed for the exploration and demonstration of the basic principles of physics as applied to sound, light, energy, and mechanics. Emphasis is placed on the generation, transmission, and change in direction of light. Light is studied as a tool for measuring the refractive index and degree of polarization and also as a means of correcting and expanding images. Laboratory experiments in mechanics use the change in the degree of polarization for the measurement of the mechanical stability of scientific glass apparatus and its internal stress due to tensile forces or thermal loads.

Major Divisions:
I. Sound – Principles and Applications
II. Light – Principles
III. Light Applications
IV. Force and Motion
V. Work, Energy, and Power
VI. Static Equilibrium and the Principles of Moments
VII. Machines

I. Sound – Principles and Applications

A. Wave Motion

1. Longitudinal
2. Transverse

B. Wave properties

1. Wavelength
2. Velocity
3. Frequency

C. Physical Properties

1. Intensity
2. Method of Generation
3. Mode of Transmission

D. Physiological Properties

1. Loudness
2. Pitch
3. Overtones

E. Measurement Application

1. Distance
2. Thickness
3. Resonance

II. Light – Principles

A. Electromagnetic Wave Properties

1. Velocity
2. Frequency
3. Wavelength

B. Physical Properties

1. Method of Generation
2. Mode of Transmission
3. Polarization

C. Physiological Properties

1. Visible Sensing
2. Color
3. Color and Intensity Perception

III. Light Applications

A. Mirrors

1. Plane
2. Spherical
3. Parabolic

B. Lenses

1. Concave, Convex
2. Images
3. Powers

C. Polarizers

1. Crystals
2. Thin films or Reflectors
3. Stress Relationship in Glass
4. Stress Measurement in Glass

IV. Force and Motion

A. Relationship of Force and Motion

1. Force – Definition
2. Motion – Definition

B. Displacement
C. Velocity
D. Acceleration
E. Gravity
F. Newton's Laws of Motion

1. Inertial Law
2. Relationship of Force, Mass, and Acceleration

V. Work, Energy, and Power

A. Work

1. English Measurement System
2. Metric Measurement

B. Energy

1. Potential Energy
2. Kinetic Energy
3. Conservation of Energy

C. Power

1. English System
2. Metric System
3. Efficiency

D. Momentum

VI. Static Equilibrium and the Principles of Moments

A. Vectors
B. Scalars
C. Vector Addition
D. Moments
E. Summation of Forces
F. Summation of Moments

VII. Machines

A. Basic Machines

1. Lever
2. Inclined Plane
3. Hydraulic Press

B. Simple Machines

1. Pulleys
2. Wheel and axle

Texts and References

Banner, Philip, *Principles of Physical Science*, Addison-Wesley Publishing Company, Reading, Mass.

Harris and Hemmerling, *Introductory Applied Physics*, McGraw-Hill Book Company, New York, N.Y.

Rusk, Second Edition, *Introduction to College Physics*, Appleton-Century-Crofts, Inc., New York, N. Y.

Smith, Cooper, *Elements of Physics*, McGraw-Hill Book Company, New York, N.Y.

White, Harry E., 5th Edition, *Modern College Physics*, Van Nostrand (Litton Educational Publishing Company.), Cincinnati, Ohio.

White, Weber and Manning, *Basic Physics*, McGraw-Hill Book Company, New York, N.Y.

Physical Science II
Laboratory

I. Velocity of Sound by Resonance Methods

This experiment uses water-filled glass tube and air-filled tube as the resonating column.

II. Photometry and Illumination

Study of candle power rating and light distribution of various types of glass-enclosed light sources.

III. Spherical Mirrors

Study of reflection from curved surfaces with emphasis on glass surfaces.

IV. Index of Refraction

Study of index of refraction of different types of glass.

V. Image Formation by a Thin Lens

Study of the optical properties of glass.

VI. Polarized Light

Study of polarization and its use in the glassblowing trade.

VII. Concurrent Forces

Stress and strains in glass due to the action of concurrent forces.

VIII. Equilibrium of Forces

A study of glass in the static condition under the influence of external forces.

IX. Principle of Moments

A study of the action of torques and torsion on glass equipment.

X. Simple Machines

Application and principles of simple machines in their relationship to glass technology.

BLUEPRINT READING AND SKETCHING

Hours Per Week: Class, 1; Laboratory, 2

Description: This is a beginning course for the glass student who has had little or no previous experience in the reading or interpretation of mechanical and glass blueprints and sketches.

Blueprints are the benchmarks of industry, and by their use, both simple and complex parts of the Glass Industry can be described graphically with such completeness that one part or many may be manufactured to the specified size and shape with a good degree of accuracy.

The principal objectives of the glass blueprint reading and sketching course are: basic understanding of applied geometry and geometric construction, orthographic projection, a skill in orthographic, isometric, oblique sketching and drawing, glass trade terminology and shop practices that will test the student's ability to read and understand glass shop drawings.

Major Divisions:

I. Orientation
II. Fundamentals of Sketching
III. Applied Geometry and Geometric Construction
IV. Industrial Standards – Holes, Threads, Finishes – Pertaining to Glass Industry
V. Dimensioning
VI. Sketching Curved Lines – Circles – Irregular Shapes
VII. Orthographic Sketching
VIII. Oblique Sketching
IX. Isometric Sketching
X. Perspective Sketching
XI. Principles of Blueprint Reading
XII. Graphic Representation of Scientific Glass Apparatus

I. Orientation

A. The First Glassmaker

–General Types of Glass

B. Types of Duplicated Drawings

1. The Blueprint
2. Ammonia Process Prints
3. Photostat Prints

II. Fundamentals of Sketching

A. Universal Language

1. Hieroglyphics of Ancient Egypt
2. Cave Drawings of Primitive Man

B. Sketching Materials

1. Pencils
2. Pointers and Sharpeners
3. Erasers

C. Lines

1. Outline or Visible Lines
2. Hidden Lines
3. Center Lines
4. Extension Lines
5. Dimension Lines
6. Leader Lines
7. Break Lines
8. Section Lines
9. Cutting Plane Lines

D. Basic Lettering

III. Sketching Techniques and Geometric Form

A. Sketching Techniques

1. Proportioning
2. Blocking in
3. Grid System

B. Geometric form

1. Basic Description
2. Center Line Application
3. Arcs and Points of Tangency
4. Drawing a Perpendicular to a Line
5. Bisecting an Angle

IV. Industrial Standards – Holes, Threads, Finishes – Pertaining to the Glass Industry

A. Types of Holes (Drilled, Counterbored, Countersunk, Reamed, Ground)

B. Threads (Nomenclature, Type, and Methods of Representation)

C. Surface Finishes, Finish Marks

V. Dimensioning

A. Historical Measurement

B. Size and Location Dimensions

C. Dimensions

1. Continuous Lines
2. Base Line
3. Reference
4. Cumulative
5. Center Line
6. Arcs and Angles

D. Metrics

VI. Orthographic Sketching

A. Six Views

B. Choice of Views

C. Positon of Views

D. One-View Sketching

VII. Oblique Sketching

A. Oblique Projection

B. Cavalier and Cabinet Sketch

C. Circles in Oblique

VIII. Isometric Sketching

A. Isometric Axes

B. Sketching on Isometric Paper

C. Isometric Ellipses

IX. Perspective Sketching

A. One-point Perspective

B. Two-point Perspective

C. Circles and Arcs in Perspective

X. Principles of Blueprint Reading

A. Detail Print

B. Subassembly Print

C. Assembly Print

XI. Graphic Representation of Scientific Glass Apparatus

A. Stopcocks

B. Tubing

C. Elbows, Tees, Crosses, and Joints

D. Manometers, Gauges, and Pumps

E. Laboratory Glass System

Texts and References

Coover, Shiver L., *Drawing and Blueprint Reading*. New York: McGraw-Hill Book Company, Inc.

Fleming, Joseph W., *Applied Drawing and Sketching*. Chicago: American Technical Society.

Giesecke, Frederick E., Michell, Alva and Spencer, Henry C., *Technical Drawing*. New York: The Macmillan Company, Inc.

Oberg, Erik and Jones, F. D., *Machinery's Handbook*. New York: The Industrial Press.

Olivo, Thomas C., and Payne, Albert V., *Basic Blueprint Reading and Sketching*. New York: Delmar Publishers, Inc.

GLASS DRAFTING AND DESIGN

Hours Per Week: Class, 1; Laboratory, 2

Description: This course will provide the glass student with additional drafting and design fundamentals that are so essential to the glass technician in the fabrication of glassware.

Frequently it is necessary to prepare drawings that can be easily understood by persons without technical training. This type of drawing is called pictorial drawing, and is used extensively in glass catalogs and general sales literature. To help the student in object representation, air brush rendering is taught as a supplement to the pictorial drawings.

Principal objectives of this course are: to help the glass student develop the capability to apply his knowledge of drafting and the physical sciences in solving practical problems. The student will make this analysis from his own collection of field data and available technical information.

The work consists of basic drafting practices, and the designing and laying out of simple gauges, jigs, fixtures, forming tools, pictorial drawings pertaining to the glass field, and the silk screen process used in glassware printing and marking.

Major Divisions:
I. Fundamentals of Instrument Drawing
II. Orthographic Projection
III. Working Drawings
IV. Assembly Drawings
V. Pictorial Drawings
VI. Air Brush Rendering
VII. Complex Glass Apparatus
VIII. Glass Jigs and Fixtures
IX. Silk Screen Process

I. Fundamentals of Instrument Drawing

A. Working tools (pencils, papers, triangles, mechanics, architects scale, and drafting instruments)

B. Classification of lines (visible, hidden, center, dimension, extension, break and cutting, plane lines)

C. Formation of lettering, numerals, and proper spacing

D. Decimal, metric, and English measurements

E. Use of inking devices

II. Orthographic Projection

A. Position of Views
B. Selection of Views
C. Methods of Projection
D. Auxiliary Views and Inclined Surfaces
E. Dimensioning Practices

III. Working Drawings

A. Detail Drawings
B. Title and Record Strips
C. Drawing Numbers
D. Parts Lists
E. Drawing Revisions
F. Checking

IV. Assembly Drawings

A. Design Layout
B. Working Drawing Assembly
C. Sub-assembly
D. Assembly

V. Pictorial Drawings

A. Isometric Drawing
   1. Position of Axes
   2. Non-isometric Lines
   3. Steps in Construction
   4. Method of Constructing Ellipses

B. Oblique Drawing

   1. Choice of Position of Axes
   2. Steps in Construction
   3. Advantages and Disadvantages

C. Perspective

   1. General Principles
   2. One-point
   3. Two-point

VI. Air Brush Rendering

A. Equipment and Materials
B. Preparation of Projects
C. Process
D. Cleaning and Maintenance
E. Errors: Causes and Remedies
F. Rendering

VII. Complex Glass Apparatus

A. Layout and Completion of Glass Apparatus Drawings
B. Use of Glass Container Manufacturers Institute Standards
C. Use of Commercial Standards from U.S. Department of Commerce

VIII. Glass Jigs and Fixtures

A. Production Cost
B. The Jig Body
C. Binding and Clamping Devices
D. Make Jig "Fool-proof"
E. Practical Fixtures
F. Basic Forming Tools

IX. Silk Screen Process

A. Preparation of the Art Work
B. The Silk Screen
C. Stencil Cutting
D. Stencil Adhering and Blocking
E. Printing Operation

Texts and References

Calvin, F. H. and Haas, L. L. *Jigs and Fixtures*, New York, McGraw-Hill Book Company, Inc.

French, Thomas E. and Vierck, Charles J., *Engineering Drawing*, New York, McGraw-Hill Book Company, Inc.

Giachino, J. and Beukema, Henry, *Engineering: Technical Drafting and Graphics*, Chicago, American Technical Society.

Oberg, Erik, and Jones, F.D., *Machinery's Handbook*, New York, The Industrial Press.

Rusinoff, Samuel E., *Tool Engineering*, Chicago, American Technical Society.

U. S. Department of Labor, *Testing of Glass Volumetric Apparatus*, Washington, U.S. Government Printing Office.

U. S. Department of Labor, *Interchangeable Taper-Ground Joints, Stopcocks, Stoppers, and Spherical-Ground Joints*, Washington, U.S. Government Printing Office.

INDUSTRIAL ELECTRONICS

Hours Per Week: Class, 3; Laboratory, 3

Description: The glassblowing technician will be called upon to work with apparatus made of electronic as well as glass components. He may be asked to build, repair, or even to design such apparatus. This course gives an orientation to basic electricity and electronics. Topics are selected which give combined background for understanding of industrial electronics in general, and glass industrial and laboratory electronics in particular. Emphasis is placed on fundamental theories applicable regardless ofchanges in the technology or in circuit concepts.

Major Divisions:
- I. Electricity
- II. Resistors
- III. Ohm's Law
- IV. Series Circuits
- V. Parallel Circuits
- VI. Combination Series–Parallel Circuits
- VII. Direct Current Meters
- VIII. Alternating Current and Voltage
- IX. Inductive Reactance
- X. Capacitive Reactance
- XI. Resonance
- XII. A. C. Power
- XIII. Pollution from Power Production
- XIV. Electron Tubes
- XV. Transistors

I. Electricity

- A. Negative and Positive Charges
- B. Polarities
- C. The Volt
- D. The Ampere

II. Resistance

- A. The Ohm
- B. Conductance

III. Ohm's Law

- A. Ohm's Law is a mathematical statement of the relationship shared by voltage, current, and resistance.
- B. Practical Units
- C. Power
- D. Electric Shock

IV. Series Circuits

A. Current has the same value in all parts of a series circuit.

B. The total resistance of a series circuit is equal to the sum of the individual resistances.

C. The sum of the voltage drops on all of the resistors in a series circuit is equivalent to the source voltage.

D. The total power dissipated by a series circuit is equivalent to the sum of the individual power-dissipating resistances.

E. An electrical "open" in any part of a series circuit prevents electron-flow in the entire circuit.

V. Parallel Circuits

A. In a parallel circuit the voltage is the same across all parallel branches.

B. Each branch current is equal to E/R.

C. The line current, I_t, is the sum of the branch currents.

D. Resistances in parallel add up according to this equation:

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_n}$$

E. Conductances in parallel add up according to this equation:

$$G_t = G_1 + G_2 + G_n$$

F. The total circuit power dissipation is equal to the sum of the individual branch powers.

VI. Combination Series-Parallel Circuits

A. Resistance Banks and Strings in Series-Parallel

B. Series Voltage Divider to Specified Loads

C. Mathematical Relationship Among the Components in a Wheatstone Bridge Configuration

VII. Direct Current Meters

A. Moving Coil Meters
B. Measuring Current
C. Current Meters Have Low Internal Resistance

D. Meter Shunts
E. Voltmeters
F. Ohmmeters
G. Multimeters

VIII. Alternating Current and Voltage

A. The Sine Wave
B. Frequency, Period, Wavelength
C. Ohm's Law for a.c.

IX. Inductive Reactance

A. Inductive Reactance Reduces Current in an A.C. Circuit
B. Basic Equation
C. Series and Parallel Inductive Reactances
D. Current Lags Voltage by 90 Degrees
E. Inductive Reactance and Resistance in Series
F. Inductive Reactance and Resistance in Parallel
G. Power Dissipation in Inductive Circuits
H. Coil Q
I. Skin Effect
J. A.C. Effective Resistance
K. The L/R Time Constant
L. Inductive Kick-back by Opening the RL Circuit

X. Capacitive Reactance

A. Capacitance stores charge in the dielectric between two conductors
B. Electric field between the charges
C. The Farad Unit of Capacitors
D. Typical Capacitors
E. Color Coding
F. Parallel Capacitances
G. Series Capacitances
H. Stray Capacitive and Inductive Effects
I. Testing Capacitors with an Ohmmeter
J. Alternating voltage produces alternating current in a capacitive circuit
K. Capacitive Reactance
L. Series or Parallel Capacitive Reactances
M. Capacitor Voltage Lags Capacitor Current by 90 Degrees
N. Capacitive Reactance and Resistance in Series
O. Capacitive Reactance and Resistance in Parallel
P. Capacitive Voltage Divider
Q. RC Time Constant
R. Energy in the Electrostatic Field

XI. Resonance

A. The Resonance Effect
B. Series Resonance
C. Parallel Resonance

D. Calculation of Resonant Frequency
E. The Q Magnification of the Resonant Circuit
F. Bandwidth of Resonant Circuits

XII. A.C. Power

A. Basic Equations
B. Electrical Power Related to Mechanical Power
C. Power Factor
D. The Kilowatt-hour Unit

XIII. Pollution from Power Production

A. Hydro-electric plants
B. Steam Plants
C. Photo-electric Possibilities
D. Specific Problems

XIV. Electron Tubes

A. Construction
B. Diodes
C. Triodes
D. Pentodes
E. Characteristics
F. Amplification and Rectification
G. Cathode Ray Tubes
H. Photo-tubes
I. Gas Tubes

XV. Transistors

A. Advantages Over Tubes
B. Semiconductors
C. Atomic Structure
D. The PN Junction
E. Bias
F. Transistor Action
G. Circuit Arrangements
H. Characteristics
I. Types of Transistors

Example of an Electronics Laboratory Experiment

Project: Determining the dielectric constant of glass used in forming a capacitor.

Texts and References

Gerrish, H. H.. *Electricity and Electronics,* The Goodheart-Wilcox Co., Inc., Homewood. Ill.

Hickey, H.V., *Elements of Electronics,* McGraw-Hill Book Co., Inc., New York N. Y.

Nokes, M. C., *Modern Glass Working and Laboratory Technique,* Chemical Publishing Co., Inc., New York, N. Y.

Parr, L. M. and Hendley, C. A. *Laboratory Glassblowing,* George Newsomes Limited, London.

Phillips, Charles J. P., *Glass, Its Industrial Applications,* Reinhold Publishing Corp., New York, N. Y.

Shand, E. B., *Glass Engineering Handbook,* McGraw-Hill Book Co., Inc., New York, N. Y.

Wheeler, E. I., *Scientific Glassblowing,* Interscience Publisher, Inc., 250 Fifth Avenue, New York, N. Y.

White, Harvey E., *Modern College Physics,* D. Van Nostrand Co., Inc., New York, N. Y.

INDUSTRIAL INSTRUMENTATION

Hours Per Week: Class, 2; Laboratory, 4

Description: An introduction to the various types of instruments that are employed in the industrial and scientific fields. Particular emphasis is placed on those instruments which are used in the manufacturing and heat-treating of glass. The basic principles involving the measurement of temperature, pressure, level, flow, viscosity, and humidity are presented. The purpose of the instrument in a control system is closely examined and the problems associated with instrument performance in industrial processes are explained.

The laboratory periods are structured to provide the glass student with an opportunity to examine, service, and calibrate various instruments. By this method, a greater comprehension of the instrument's operation is acquired. The course concludes with a project assignment in which the student is required to design and fabricate a measuring instrument from glass.

Major Divisions:
I. General Characteristics of Instruments
II. Temperature Measuring Instruments
III. Pressure Measuring Devices
IV. The Measurement of Level
V. Flow Metering Instruments
VI. Viscosity Measurements
VII. Methods of Humidity Measurements
VIII. Voltmeters, Ammeters, Ohmmeters and Wattmeters
IX. Instruments In the Control System
X. Problems in Process Control
XI. Portable Instruments
XII. Glass Instrumentation Project

I. General Characteristics of Instruments

A. Recorders and Monitors
B. Instrument Panelboards
C. Static Characteristics
D. Dynamic Characteristics

II. Temperature Measuring Instruments

A. Methods of Heat Transfer
B. Thermometers nd Temperature Scales
C. The Thermocouple
D. Pyrometers

III. Pressure Measuring Devices

A. Differential Pressure

1. Gauge Pressure
2. Negative Gauge Pressure

B. Types of Manometers

C. Elastic Deformation Elements

1. Bourdon Tube
2. Bellows
3. Capsule and Diaphragm

IV. The Measurement of Level

A. Direct Level Measurements
B. Indirect Level Measurements
C. Radioactive and Sonic Level Instruments
D. The Strain Gauge

V. Flow-Metering Instruments

A. Rate of Flow Meters

1. Differential Pressure Meters
2. Variable Area Meters
3. Electromagnetic Flow Meters
4. Orifice Plates and Reynolds Number

B. Total Flow Meters

1. Positive Displacement Meters
2. Impact and Velocity Meters
3. Mass Flow Meters

C. Integrators

D. Flow Calculations

VI. Viscosity Measurements

A. Effects of Temperature
B. Newtonion and non-Newtonion Fluids
C. Centipoise and Centistokes
D. Types of Viscometers

VII. Methods of Humidity Measurements

A. Absolute Humidity
B. Relative Humidity

C. Psychrometers and Hygrometers
D. Moisture Content in Materials

VIII. Voltmeters, Ammeters, Ohmmeters, and Wattmeters

A. Applications in Instrument Service
B. Units of Measurement
C. Methods of Conversion

IX. Instruments in the Control System

A. The Primary Element
B. Transducers and Measuring Elements
C. Controllers

1. On-Off
2. Proportional
3. Proportional Plus Reset
4. Proportional Plus Reset Plus Rate

D. Final Control Devices

X. Problems in Process Control

A. Energy Transfer Characteristics

1. System Capacitance
2. System Resistance
3. System Response

B. The Closed Loop
C. Droop and Transfer Lag
D. Cycling and Overshoot
E. The Step Function

XI. Portable Instruments

A. The Wheatstone Bridge
B. Potentiometric Circuits Calibrators
C. The Galvanometer

XII. Glass Instrumentation Project

A. Design Seminar
B. Instrument Fabrication
C. Instrument Calibration

Typical Instrumentation Laboratory Experiment

Project: Establishing temperature gradients and consequent internal stresses in a glass rod, recording the results, plotting a graph showing rod temperature versus distance from the heated end.

Equipment: Bunsen burner and thermocouples

Texts and References

Carrol, Grady C., *Industrial Process Measuring Instruments*, McGraw-Hill Book Company, New York.

Eckman, Donald P., *Industrial Instrumentation*, John Wiley and Sons, New York.

Holzbock, Werner G., *Instruments for Measurement and Control*, Reinhold Publishing Company, New York.

Kirk and Rimboi, *Instrumentation*, American Technical Society, Chicago, Illinois.

O'Higgins, Patrick J., *Basic Instrumentation*, McGraw-Hill Book Company, New York.

Rhodes, Thomas J., *Industrial Instruments for Measurement and Control*, McGraw-Hill Book Company, New York.

Visual Aids

Instrument Society of America, Penn-Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pennsylvania. AUTOMATIC PROCESS CONTROL. 33 mins, 16mm, color, sound.

Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California. DEEP SPACE INSTRUMENTATION FACILITY. 19 mins., 16 mm, color, sound.

International Business Machines Corporation, Department of Information, 590 Madison Avenue, New York 22, New York, INTRODUCTION TO FEEDBACK. 11½ mins., 16mm, color, sound.

United States Steel Corporation, Film Distribution Center, 525 William Penn Place, Pittsburgh, Pennsylvania. CHEMISTRY OF IRON AND STEEL. 14 mins, 16mm, color, sound. THE ELECTRIC ARC FURNACE. 7 mins, 16mm, color, sound. THE OPEN HEARTH FURNACE. 7 mins., 16mm, color, sound. THE MAKING, SHAPING, AND TREATING OF STEEL. 7½ mins., 16mm, color, sound.

Minneapolis-Honeywell Regulator Company, Educational Assistance Group, Station 213, Industrial Division, Wayne and Windrim Avenues, Philadelphia, Pennsylvania. Film strip series–BASIC AUTOMATIC CONTROL, RADIATION PYROMETERS, PRESSURE AND VACUUM GAUGES, PRESSURE TYPE THERMOMETERS, ELECTRICAL TEMPERATURE MEASUREMENTS, FLOWMETERS, ELECTRONIC POTENTIOMETERS. 30-45 mins., 35mm, black and white.

COMMUNICATION SKILLS I

Hours per Week: Class, 3; Laboratory, 0

Description: This course is designed to develop or strengthen the use of correct English in writing skills and to help the student to become more proficient in oral expression. Emphasis is placed on student activity in written exercises, oral communication, and listening. It is recommended that written and oral assignments be related to scientific glass technology, to develop effectiveness in technical expression. Assignments should be closely correlated to the students' progress in Scientific Glassblowing I. Grammar should be integrated throughout as dictated by individual and group student need; it is not recommended that grammar be taught in large blocks of time and in the traditional sequence. It is intended that the lessons presented by the instructor be a gradual natural outgrowth of student activity and need.

Major Divisions:
- I. Communications and the Technologist
- II. Sentence Structure
- III. Individual Paragraph Structure
- IV. Kinds of Paragraphs
- V. Methods of Clarifying Ideas

I. Communications and the Technologist

- A. Need for Proficiency in Oral Expression
  1. Person-to-person Communication
  2. Verbal Reporting
- B. Need for Effective Listening
- C. Need for Writing Skills
  1. Statement of Facts
  2. Expression of Ideas
  3. Technical Reporting
     - a. Formal
     - b. Informal

II. Sentence Structure

- A. Laboratory Assignments in Writing Sentences
- B. The Complete Sentence
- C. The Use and Position of Modifiers
- D. Conciseness and Clarity
- E. Subject-Verb Agreement

III. Individual Paragraph Structure

A. Laboratory Assignments in Writing Paragraphs
B. The Paragraph

1. Development
2. Topic Sentence
3. Coherence
4. Pronouns

IV. Kinds of Paragraphs

A. Laboratory Assignments in Sequential Paragraphs
B. Descriptive Paragraph
C. Explanatory Paragraph
D. Narrative Paragraph
E. Problems of Mood

V. Methods of Clarifying Ideas

A. Laboratory Assignments in Written and Oral Idea Clarification
B. Unity and Logical Thinking

1. Unrelated Ideas
2. Excessive Detail
3. Obscure or Illogical Constructions

C. Subordination
D. Coherence
E. Emphasis
F. Variety

Texts and References

Carlin, Jerome & Christ, *English on the Job*, Globe, New York.

Hodges, John C., *Harbrace Handbook of English*, Harcourt, Brace and Company, New York.

Kierzek, John M., Gibson, Walker, *The Macmillan Handbook of English*, Fifth Ed., New York: The Macmillan Company.

Leggett, Glenn, *Handbook for Writers*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Pollock, Thomas C., *Language Arts and Skills*, The Macmillan Company, New York.

Rowland, Dudley H., *Handbook of Better Technical Writing*,, Business Reports, Larchmont, New York.

Shaffer, Virginia, *Handbook of English*, McGraw-Hill Book Company, Inc., New York.

Shefter, *Shefter's Guide to Better Composition*, Washington Square Press, New York.

Thompson, *Fundamentals of Communication*, McGraw-Hill Book Company, Inc., New York.

Turner, Rufus, P., *Grammar Review for Technical Writers*, Holt, Rinehart and Winston, New York.

Warriner, John E., *Handbook of English*, Harcourt, Brace and Company, New York.

Warriner, John E., *Advanced Composition: A Book of Models for Writing*, Harcourt, Brace and Company, New York.

COMMUNICATION SKILLS II

Hours Per Week: Class, 3; Laboratory, 0

Description: This course is designed to develop skills in oral and written expression based upon research. Students should be actively engaged throughout in the process of researching and writing at least two papers of greater length and depth than were done in Communications I. Emphasis is placed on subject selection, the development of the outline, and the taking of notes. An orientation to the use of the library, particularly in its value to the technical researcher, is essential. Individual and panel oral presentations are given in class of written research. The rules of effective speaking are elicited from peer group reactions. The basic rules of grammar and punctuation are presented in accordance with individual and group student need. Written and oral assignments are intended to draw upon blowing technology and be closely coordinated with Scientific Glassblowing II.

Major Divisions:
I. Using Resource Materials
II. Planning the Paper
III. Writing the Paper
IV. Speaking and Listening
V. Mechanics of the Technical Paper

I. Using Resource Materials

A. Laboratory Exercises in Finding Technical Information
B. The Library

1. Card Catalogue
2. Reference Works

a. Encyclopedias
b. Indexes to Periodicals
c. Bibliographies
d. Technical Journals

II. Planning the Paper

A. Laboratory Exercises in the Planning of a Specific Paper
B. Selecting the Subject
C. Limiting the Subject
D. The Preliminary Bibliography
E. Outlining
F. Note-taking

III. Writing the Paper

A. Classroom and Library Activity in Writing the Paper
B. Evaluating and Analyzing the Data
C. Improving Sentence Structure
D. Periods, Commas, and semicolons

IV. Speaking and Listening

A. Individual and Group Oral Classroom Presentations of Written Projects
B.. Planning and Outlining
C. Directness in Speaking
D. Visual Aids
E. Effective Listening
F. Taking Lecture Notes

V. Mechanics of the Technical Paper

A. Library and Classroom Activity in Writing and Typing a Paper
B. Manuscript Form
C. Technical Style
D. Hyphenation
E. Documentation

Texts and References

Carlin, Jerome & Christ, *English on the Job*, Globe, New York.

Hodges, John C., *Harbrace Handbook of English*, Harcourt, Brace and Company, New York.

Kierzek, John M., Gibson, Walker, *The Macmillan Handbook of English*, Fifth Ed., New York: The Macmillan Company.

Leggett, Glenn, *Handbook for Writers*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Pollock, Thomas C., *Language Arts and Skills*, The Macmillan Company, New York.

Rowland, Dudley H., *Handbook of Better Technical Writing*,, Business Reports, Larchmont, New York.

Shaffer, Virginia, *Handbook of English*, McGraw-Hill Book Company, Inc., New York.

Shefter, *Shefter's Guide to Better Composition*, Washington Square Press, New York.

Thompson, *Fundamentals of Communication*, McGraw-Hill Book Company, Inc., New York.

Turner, Rufus, P., *Grammar Review for Technical Writers*, Holt, Rinehart and Winston, New York.

Warriner, John E., *Handbook of English*, Harcourt, Brace and Company, New York.

Warriner, John E., *Advanced Composition: A Book of Models for Writing*, Harcourt, Brace and Company, New York.

ECONOMICS

Hours Per Week: Class, 3; Laboratory, 0

Description: A course designed to develop an understanding of basic economic concepts, principles, and practices. Care has been taken to correlate content areas closely to prevent overlapping with Industrial Organization, for which it is a prerequisite. Students are introduced to the basic concepts and principles of consumption, production, exchange, and money. Emphasis is placed on an understanding of the distribution and planning of personal income. Government's role is examined in its impact on the national and international economics. The history and development of labor-management relations are explored. The course concludes with a study of recent economic trends.

Major Divisions:
- I. Introduction
- II. Consumption
- III. Production
- IV. Exchange
- V. Money, Credit, and Banking
- VI. Distribution of Personal Income
- VII. Government and the Economy
- VIII. International Trade
- IX. Major Economic Problems
- X. Personal Economics
- XI. Recent Economic Trends

I. Introduction

- A. Definition of Economics
- B. A Background for Understanding Industry

II. Consumption

- A. Kinds of Goods
- B. Kinds of Utility
- C. Kinds of Wants
- D. Consumer Demand
- E. Influencing Consumer Demand

III. Production

- A. The Production Process
- B. Natural Resources
- C. The Role of Labor
- D. The Role of Capital
- E. The Role of Management
- F. Forms of Business Organization
- G. An Overview of U.S. Production

IV. Exchange

- A. Balancing Supply and Demand
- B. Determination of Demand
- C. Determination of Supply
- D. Forms of Competition
- E. Regulation of Monopoly
- F. Stock Market

V. Money, Credit, and Banking

A. The Role of Money in Our Economy
B. The Importance of Credit
C. Banks and Their Services
D. The Federal Reserve System
E. Inflation and Deflation

VI. Distribution of Personal Income

A. Rent
B. Wages
C. Interest
D. Profits

VII. Government and the Economy

A. Economic Activities of Government
B. The Tax System

VIII. International Trade

A. Importance to the U.S.
B. Export and Import
C. The Tariff

IX. Major Economic Problems

A. Economic Insecurity
B. Maintaining Prosperity
C. Agricultural Revolution
D. Urban Decay
E. Labor-Management Relations
F. Measuring the National Income
G. Other Economic Systems

X Personal Economics

A. Managing Money
B. Planning for Economic Security

XI. Recent Trends in Economics

A. Domestic
B. International

Texts and References:

Lynn, Robert A., *Basic Economics Principles*, McGraw-Hill Book Company, Inc., New York.

Pond, Smith A., *Essential Economics*, Harcourt, Brace and Company, New York.

Smith, Adam, *The Wealth of Nations*, Modern Library Inc., New York.

Smith, A. H., *Economics for Our Times*, McGraw-Hill Book Company, Inc., New York.

HUMAN RELATIONS

Hours Per Week: Class, 3; Laboratory, 0

Description: This is a basic course which has been organized for the development of a better understanding of the human mechanism, its motivation and learning as related to interpersonal relationships. Intelligence and aptitude test, supervision, and job satisfaction are considered. Attention is also given to personal and group dynamics so that the student may learn to apply the principles of mental hygiene to his adjustment problems as a worker and a member of society. Instruction is focused upon the practical applications of the principles guiding human behavior rather than their physiological origin or historical significance. Special consideration is given to the unique situation in which the glassblowing technician is likely to be employed.

Major Divisions:
- I. Science of Psychology
- II. Methods of Psychological Investigation
- III. Personnel Testing and Measurement
- IV. Motivation and Morale
- V. Automation and Human Relations
- VI. Incentives
- VII. The Individual Worker
- VIII. Individual Mobility
- IX. Work Groups and Work
- X. Discontent and Grievances
- XI. Leadership
- XII. Interviewing Techniques

I. Science of Psychology – Orientation to Psychology and Knowledge of Scientific Method

A. Verification in Relation to Experience
B. Reliability
C. Psychological Laws, S-R Method

1. Principle of Association
2. Generalization
3. Discrimination
4. Reinforcement

D. Variables

1. Independent
2. Dependent
3. Intervening

II. Methods of Psychological Investigation

   A. Experimentation
   B. Naturalistic Observation
   C. Manipulation of Variables
   D. Graphic Relationships
   E. Correlation Methods
   F. Follow-up

III. Personnel Testing and Measurement

   A. Intelligence

      1. Group Testing
      2. Individual Testing

   B. Aptitude

      –Relationship to Occupational Success

   C. Personality

      1. Objective
      2. Projective

IV. Motivation and Morale

   A. Instrument Behavior
   B. Substitute Behavior
   C. Acquired Motives
   D. Motivation in the Frustration-Aggression Syndrome

      –Defense Mechanisms

V. Automation and Human Relations

   A. Greater Specialization
   B. New Technological Elements
   C. Automation of the Labor Force
   D. Consequences

VI. Incentives
   A. Financial
   B. Nonfinancial

VII. The Individual Worker

   A. Occupational Career
   B. Occupational Choices
   C. Type of Worker

VIII. Individual Mobility

A. Occupational Mobility
B. Specialization and Careers
C. Promotions Vs. Cutbacks
D. Occupational Stability
E. Career and Ambition

IX. Work Groups and Work

A. Function
B. Casual Associations
C. Organized Groups

1. Structure
2. Standards
3. Negotiations

D. Voluntary Groups

1. Personality
2. Standards
3. Effect on Morale

X. Discontent and Grievances

A. Specific Areas
B. Grievance Procedures
C. Personal vs. Group Unhappiness

XI. Leadership

A. Democratic
B. Authoritarian
C. Laissez-faire
D. Compelling Leadership
E. Impelling Leadership
F. Leadership and Morale
G. Leadership Theories

XII. Interviewing Techniques

A. Interviewer

1. Prejudices
2. Concerns
3. Objectivity vs. Subjectivity

B. Interviewee
1. Appearance
2. Concerns
3. Presentation

C. Interviewing Techniques

1. Objective Ratings
2. Subjective Ratings
3. Use of References

    a. Validity
    b. Invalidity

Texts and References

Atkinson, Richard C., *Introduction to Psychology*, Harcourt, Brace and World, Inc., New York.

Berrien, F. K., *Practical Psychology*, The Macmillan Company, New York.

Cole, Lawrence, *Human Behavior*, World Book Company, New York.

Dubin, Robert, *The World of Work*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Engle, T. L., *Psychology, Its Principles and Applications*, Harcourt, Brace and World, Inc., New York.

Foster, Charles R., *Psychology for Life Today*, American Technical Society, Chicago, Illinois.

Harnell, Thomas, and Rusmore, Jay T., *A Casebook in Industrial and Personnel Psychology*, Rinehart and Company, Inc., New York.

Kimble, Gregory A., and Garmezy, Norman, *Principles of General Psychology*, The Ronald Press Company, New York.

Laird, Donald and Laird, Eleanor, *Practical Business Psychology*, McGraw-Hill Book Company, Inc., New York.

Philips, E. Lakin and Gibson, James F., *Psychology and Personality*, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Smith, Karl U. and Smith, William M., *The Behavior of Man, Introduction to Psychology*, Henry Holt and Company, Inc.

Ruch, Floyd L., *Psychology and Life*, Scott, Foresman and Company, New York.

Wickens, Delos D. and Meyer, Donald R., *Psychology*, Holt, Reinhart, and Winston.

INDUSTRIAL ORGANIZATION

Hours Per Week: Class, 3; Laboratory, 3

Description: The course is an overview of the operations of an industrial organization, the interrelationship of functions, and the fundamental principles of management which lead toward effective coordination and control. The future technician studies the demands made on the major levels of administrative and technical responsibility. He achieves an appreciation and a general understanding of the interrelationships between the essential activities of a successful industry. These include the areas of research, engineering, plant engineering, quality control, production control, methods, and industrial relations. Among recent developments discussed are: innovations in research; improved methods of developing managerial and supervisory personnel; the latest equipment and procedures for the accumulation, analysis, and interpretation of data pertinent to more effective management. However, major emphasis throughout is placed on the understanding of in-plant operations, procedures, and interrelationships.

Major Divisions:

- I. Fundamental Concepts of American Industry
- II. The Internal Organization
- III. Managerial Controls
- IV. Industrial Risk and Forecasting
- V. Product Research and Development
- VI. Physical Facilities: Plant Location and Buildings
- VII. Physical Facilities: Plant Equipment, Layout, and Automation
- VIII. Production Control: Routing and Scheduling
- IX. Production Control: Dispatching and Follow-up
- X. Materials Control: Procurement and External Transportation
- XI. Quality Control
- XII. Plant Engineering
- XIII. Methods Improvement
- XIV. Personnel Management
- XV. Industrial Training
- XVI. Morale and Motivation in Employee Relations

I. Fundamental Concepts of American Industry

- A. Major Stages of Economic Growth
- B. Ownership and Structure of Industrial Enterprises
- C. Controls in a Mixed Economy
- D. Dynamic Change and Built-in Stabilizers

II. The Internal Organization

- A. Major Functions of the Industrial Enterprise
- B. The Organization Structure
  1. Responsibility and Authority
  2. Lines of Coordination and Facilitation

III. Managerial Controls

A. Elements of Coordination
B. Information for Control
C. Management Engineering
D. Sources of Control Information

IV. Industrial Risk and Forecasting

A. Product Risks and Problems
B. Relating Product to Enterprise
C. Relating Enterprise to Economy

V. Product Research and Development

A. Types of Research Organizations
B. Applied Research
C. Considerations in Product Development
D. Industrial Research Development

VI. Plant Location and Buildings

A. Location
B. Buildings

VII. Plant Equipment, Layout, and Automation

A. Selection of the Productive Equipment
B. Preparation of the Plant Layout
C. Automation

VIII. Routing and Scheduling

A. The Production-Control Function
B. Routing
C. Scheduling

IX. Dispatching and Follow-Up

A. Dispatching
B. Follow-up

X. Materials Control

A. Materials Management
B. Procurement
C. External Transportation

XI. Quality Control

A. Quality in Manufacturing
B. Standards and Specifications
C. Inspection
D. Statistical-Techniques
E. Measuring Instruments

XII. Plant Engineering

A. Plant and Equipment Maintenance
B. Plant and Equipment Replacement
C. Safety in the Plant
D. Waste Control

XIII. Methods Improvement

A. The Search for Improved Methods
B. Organization for Methods Improvement

XIV. Personnel Management

A. Employment–Office Functions
B. Maintaining the Labor Force

XV. Industrial Training

A. Training Techniques
B. Foremen Training
C. Management Development

XVI. Morale and Motivation

A. Job Satisfaction
B. Theory X – Theory Y
C. Company Services

Texts and References

Bethel, Lawrence L. et al, *Industrial Organization and Management*, McGraw-Hill Book Company, Inc., New York.

Reynolds, Lloyd G., *Labor Economics and Labor Relations*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Wilcox, Clair, *Public Policies Toward Business*, Richard D. Irwin, Inc., Homewood, Illinois.

Yoder, Dale, Herman and Herbert G., Jr., *Labor Economics and Industrial Relations*, South Western Publishing Company, Cincinnati, Ohio.

TECHNICAL WRITING I

Hours Per Week: Class, 3; Laboratory, 0

Description: This course is designed to develop skill in technical report writing. Students should be actively engaged throughout the course in the process of researching and writing at least two technical papers of considerable length and depth. Emphasis will be placed on the use of sources in gathering and recording data, the criteria for the evaluation and analysis of data, and the technical paper's plans and format. Students should be permitted to spend as much time as possible in gathering data and in writing technical reports. If time permits, an oral presentation in the form of a speech or panel leadership should be presented by each student on one of his research areas. Research papers should draw upon the student's learning in Scientific Glassblowing I, II, III, and in Physics and in Glass Chemistry.

Major Divisions:
- I. Introduction
- II. Designing the Report for a Specific Purpose
- III. Gathering and Recording Data
- IV. Evaluating and Analyzing Data
- V. Planning and Format
- VI. Writing the Rough Draft
- VII. Editing the Final Document

I. Introduction

A. Technical Reporting and Non-Technical Compositions
B. The Increased Need for Reports
C. Reporting Demands of Modern Industry
D. Steps in Technical Reporting

II. Designing the Report for a Specific Purpose

A. Classroom and Library Activity in Planning a Specific Paper
B. Tailoring to the Reader
C. Limitations on the Author
D. A Working Hypothesis
E. Frequently Misused Technical Vocabulary

III. Gathering and Recording Data

A. Classroom and Library Activity in Writing a Specific Paper
B. Data as Bases for Reports
C. Sources of Data
D. Principles and Systems of Recording Data
E. Rules of capitalization

IV. Evaluating and Analyzing Data

A. Classroom and Library Activity in Writing a Specific Paper
B. Criteria for Evaluation and Interpretation
C. Criteria for Analysis
D. Principles of Punctuation

V. Planning and Format

A. Classroom and Library Activity in Writing a Second Paper
B. Types of Outlines
C. Checklist for Planning
D. Selecting a Format
E. Developing Headings
F. Numbering and Footnotes
G. Clarity Through Simple Grammar Rules

VI. Writing the Rough Draft

A. Classroom and Library Activity in Writing a Second Paper
B. Getting Words on Paper
C. Characteristics of Technical Style
D. Legal Precautions
E. Rules of Abbreviations

VII. Editing the Final Document

A. Classroom and Library Activity in Writing a Second Paper
B. Checking for Factual Errors
C. Editing for Conciseness
D. Using Conventional Voc-bulary and Grammar

Texts and References

Estin, Herman, *Technical and Professional Writing,* Harcourt, Brace and Company, New York.

Glidden, H. *Reports, Technical W ·ing and Specifications,* McGraw-Hill Book Company, Inc., Ne· York.

Hays, Robert, *Principles of Technical Writing,*Addison-Wesley, Reading, Massachusetts.

Hicks, Tyler, *Successful Technical Writing,* McGraw-Hill Book Company, Inc., New York.

Levine, Stuart, *Materials for Technical Writing,* Allyn and Bacon, Boston, Massachusetts.

Menzel, Donald, *Writing .! Technical Paper,* McGraw-Hill Book Company, Inc., New York.

Nelson, J. Raleigh, *Writi·ıg the Technical Report,* McGraw-Hill Book Company, Inc., New York.

Rowland, Dudley, *Handbook of Better Technical Writing,* Business Reports, Larchmont, New York.

Van Hagan, Charles, *Report Writers Handbook,* Prentice Hall, Englewood Cliffs, New Jersey.

TECHNICAL WRITING II

Hours Required: Class, 3; Laboratory, 0

Description: This course is designed to be the culmination of all previous courses in Communications, Technical Writing, Scientific Glass Technology, and other supportive subjects. Students will prepare a highly detailed, technical paper on the formation and the function of a sophisticated piece of scientific laboratory glass to be constructed in their technology class by them. Drawings, graphs, and charts should be included among the descriptive materials. Photographs of the formation and operation of the apparatus will be essential to a clear, professional presentation. The course should incorporate the basic theory and some practical experience in typing and photography. As in the previous courses in Communications and Technical Writing, formal instruction to the group should be minimal, designed to get the students started on their projects. Follow-up assistance as to the rules of grammar, of technical writing, of report formats should be given according to individual and group needs.

Major Divisions: I. Format of Formal Reports
II. Duplication Methods, Format Selection, and Physical Makeup
III. Illustrating the Report
IV. Typing the Report
V. Before Final Submission
VI. Submitting the Final Report

I. Format of Formal Reports

A. Front Matter

1. Title
2. Cover
3. Title Page
4. Letter of Transmittal
5. Approvals
6. Distribution List
7. Preface
8. Acknowledgments or Credits
9. Table of Contents
10. List of Illustrations
11. Abstract or Summary

B. Main Text

1. Introduction
2. Discussion
3. Conclusions
4. Recommendations

C. Back Matter

1. Appendixes
2. Glossary
3. Bibliography or List of References
4. Index

II. Duplication Methods, Format Selection, and Physical Makeup

A. Selecting a Duplicating Method
B. Selecting a Format
C. Developing Headings
D. Insertion of Mechanical Aids
E. Numbering Pages, Headings, and Illustrations
F. Footnotes
G. Selecting a Binder or Cover
H. Special Effects

III. Illustrating the Text

A. General Principles of Visual Aids
B. Selecting Visual Aids
C. Engineering Drawings and Plates
D. Technical Illustrations
E. Graphs, Charts, and Diagrams
F. Photographs and Reproductions of Photographs

IV. Typing the Text

A. Introduction to the Typewriter
B. T ing Technical Material
C. Justification of Typed Lines
D. Ruled Tables
E. Table Headings

V. Before Final Submission of the Report

A. Checking the Final Draft
B. Checkpoints in Proofreading
C. Checking the Submission Copy
D. Correcting Errors

VI. Submitting the Final Report

A. The Master File Copy
B. Classified and Confidential Material
C. The Distribution List
D. Distribution of Copies
E. Maintaining Documents
F. Timing of Distribution

Texts and References

Estin, Herman, *Technical and Professional Writing*, Harcourt, Brace and Company, New York.

Glidden, H. *Reports, Technical Writing and Specifications*, McGraw-Hill Book Company, Inc., New York.

Hays, Robert, *Principles of Technical Writing*, Addison-Wesley, Reading, Massachusetts.

Hicks, Tyler, *Successful Technical Writing*, McGraw-Hill Book Company, Inc., New York.

Levine, Stuart, *Materials for Technical Writing*, Allyn and Bacon, Boston, Massachusetts.

Menzel, Donald, *Writing A Technical Paper*, McGraw-Hill Book Company, Inc., New York.

Nelson, J. Raleigh, *Writing the Technical Report*, McGraw-Hill Book Company, Inc., New York.

Rowland, Dudley, *Handbook of Better Technical Writing*, Business Reports, Larchmont, New York.

Van Hagan. Charles. *Report Writers Handbook*, Prentice Hall, Englewood Cliffs, New Jersey.

LIBRARY FACILITIES AND CONTENTS

A successful technology program requires an adequately supplied, staffed, and organized library. The library program must be closely correlated with the needs of the scientific glassblowing technician.

The fast development of technological theory and practice requires that the students use a library whose magazines, reference works, manuals and books reflect the latest ideas and changes.

The library staff ideally should be one with education and experience in technical and scientific fields. If such professionals are not available, a "general" librarian can be successful if truly integrated into the team approach. Technical instructors must assume a serious, constant responsibility in recommending materials for ordering. Only in this way will the library begin to be the true learning center of the scientific glassblowing technology program.

Instruction in all subject areas should be focused toward the library so that students will use it as a source of information related to glassblowing technology. As a result, the students will gradually develop in their ability at research and in their realization of its importance in continued technical and professional development. The library should be open for student use during as many evening and weekend hours as possible. Instructors should cooperate with the library staff in keeping students aware of the materials available as related to the curriculum. In conjunction with instructors of Communication Skills and Technical Writing, study and writing projects should be assigned which demand full use of all the library's resource materials. Some of these classes should be conducted in the library itself so that instructors can supervise and assist students in the development of thorough and efficient research habits.

LIBRARY STAFF AND BUDGET

American Library Association standards indicate that "two professional librarians are the minimum number required for effective service in any junior college with an enrollment up to 500 students (full-time equivalent). In addition, there should be at least one nonprofessional staff member. The larger the institution, the more appropriate it will be to employ a higher proportion of nonprofessional staff members. Great care should be taken that professional staff members do not spend their time doing work that is essentially clerical, because this is not only wasteful but demoralizing."

According to the American Library Association, the library budget should be determined in relation to the institution's total budget for educational and general purposes, but the amount allocated to the library should be sufficient for operating a library program which supports the school's goals. The operation of the library program, as outlined in the Association's standards, normally requires a minimum of 5 percent of the total budget for educational and general purposes. This minimum allows for establishing a well-organized library, with the required staff and an adequate reference collection. The minimum would have to be augmented if there is a rapid increase in enrollment or course offerings, and again if the library is responsible for an audio-visual program. The library budget for a newly organized institution should be considerably higher than 5 percent.

Another criterion for the library budget, approved by the American Library Association, is that the funds allotted for new library materials should equal or exceed the cost of the total library staff. This applies to established libraries, but expenditures for materials should be substantially greater for new libraries, or if major additions to curriculum have been made.

LIBRARY CONTENT

The library must include adequate literature which pertains to all the subjects in a curriculum and extends beyond the learning activities of the classroom.

The library should serve the needs of full-time students and part-time students. In addition, its content should complement the teachers' need to keep up with new developments in their special fields.

Because of the highly specialized nature of reference material related to scientific glassblowing technology, the department head or chief instructor of the technology should be a member of the library committee and responsible for final approval of all materials selected for the technology and related courses. The librarian, as chairman of the committee, should assist the head of the scientific glassblowing technology department by keeping him informed of new literature and materials which become available. The librarian should consult with the department head to insure that the required materials will be purchased.

Library content may be classified into basic encyclopedic and reference index material, reference books pertinent to the technology, periodicals and journals, and visual aids.

ENCYCLOPEDIC AND REFERENCE INDEX MATERIAL

This category is basic in that it contains the broadly classified and organized cataloging of all available knowledge pertinent to the objectives of the library and the program it serves.

The following list is an example of the type of general reference material found in a publicly controlled technical institute. Though many are general references, all have some bearing on scientific glassblowing technology. Therefore, some or all of these are appropriate for a library which supports a scientific glassblowing technology program. When ordering any of the following references for a library collection, the latest edition should be requested.

American College Dictionary: Random House, Inc., 457 Madison Avenue, New York, New York 10022.

Applied Science & Technology Index: H. W. Wilson Co., 950 University Avenue, Bronx. New York 10452.

Astim Standards: American Society for Testing Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Bibliography Index, The: H. W. Wilson Co., 950 University Avenue, Bronx, New York 10452.

Business Periodicals Index: H. W. Wilson Co., 950 University Avenue, Bronx, New York 10452.

Chemical Abstracts: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

Chemical Industry Facts Book, The: Manufacturing Chemists Association, Inc., 1825 Connecticut Avenue NW., Washington, D.C. 20009.

Collier's Encyclopedia: Collier-Macmillan Library Service Division, 60 Fifth Avenue, New York, New York 10011.

Commercial Atlas and Mailing Guide: Rand McNally & Co., Box 7600, Chicago, Illinois 60680.

Cumulative Book Index: H. W. Wilson Co., 950 University Avenue, Bronx, New York 10452.

Dictionary of Applied Chemistry: J. Thorpe, John Wiley & Sons., Inc., 605 3rd Avenue, New York, New York 10016.

Encyclopedia Americana, The: Americana Corporation, 575 Lexington Avenue, New York, New York 10022.

Encyclopedia Britannica: Encyclopedia Britannica, Inc. 425 North Michigan Avenue, Chicago, Illinois 60611.

Encyclopedia of Chemical Reactions: C. A. Jacobson and Clifford A. Hampel, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, New York 10022.

Encyclopedia of Chemistry, The: Clark and Hawley, Reinhold Publishing Corp, Book Division, 430 Park Avenue, New York, New York 10022.

Encyclopedia of the Social Sciences: The Macmillan Co., 60 5th Avenue, New York, New York 10003.

Encyclopedic Dictionary of Physics: J. Thewiis, Pergamon Press, 44-91 21st Street, Long Island City, New York 11101.

Engineering Index: Engineering Index, Inc., 29 West 39th Street, New York 10013.

Engineering Materials Handbook: Charles L. Mantell, McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, New York 10036.

Handbook of Chemistry and Physics: Chemical Rubber Publishing Co., 2310 Superior Avenue, NE., Cleveland, Ohio 44114.

International Critical Tables: McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, New York 10036.

International Dictionary of Physics and Electronics: D. Van Nostrand Co., Inc., Princeton, New Jersey 08540.

Labor Policy and Practice: Bureau of National Affairs, Inc., 1231 24th Street, Washington, D.C. 20037.

Library of Congress Catalog: U. S. Library of Congress, Washington, D. C. 20540.

Manual for Process Engineering Calculations: McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, New York 10036

McGraw-Hill Encyclopedia of Science and Technology: McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, New York 10036.

Metals Handbook: American Society for Metals, Technical Book Dept., Novelty, Ohio 44073.

Moody's Industrial Manual: Moody's Investor's Service, 65 Broadway, New York, New York 10004.

Nuclear Science Abstracts: U. S. Atomic Energy Commission, Washington, D. C. 20545.

Oxford English Dictionary: Oxford University Press, Inc., 417 5th Avenue, New York, New York 10016.

Poor's Register of Corporations, Directors, and Executives: Standard and Poor's Corp., 345 Hudson Street, New York, New York 10014

Reader's Guide to Periodical Literature, The: H. W. Wilson Co., 950 University Avenue, Bronx, New York 10452.

Research and Development Abstracts: U. S. Atomic Energy Commission, Washington, D. C. 20545.

Scientific and Technical Societies of the United States and Canada: National Academy of Sciences, National Research Council, 2101 Constitution Avenue, NW., Washington, D. C. 20037.

Statistical Abstract of the United States: U. S. Department of Commerce, Washington, D. C. 20230.

Sweet's Industrial Construction File: Sweet's Catalog Service, F. W. Dodge Corp., 119 W. 40th Street, New York, New York 10014.

Temperature-Its Measurement and Control in Science and Industry: American Institute of Physics, 335 East 45th Street, New York, New York 10017.

Thomas Register: Thomas Publishing Co., 461 Eighth Avenue, New York, New York 10001.

Van Nostrand's Scientific Encyclopedia: D. Van Nostrand Co., Inc., Princeton, New Jersey 08540.

Webster's International Dictionary: G. & C. Merriam Co., 47 Federal Street, Springfield, Massachusetts 01105.

Welding Handbook: American Welding Society, 345 East 47th Street, New York, New York 10017.

TECHNICAL JOURNALS, PERIODICALS, AND TRADE MAGAZINES

These authoritative publications present the most recent and complete information about a specific area of applied science. It is therefore essential that both instructors and students make frequent and systematic use of these publications.

Selectivity should be exercised in determining which periodicals should be bound or microfilmed as reference material. Some, especially the trade journals, should not be bound and retained as permanent reference material because any important information which they contain is usually incorporated into a handbook or textbook, or a condensed version is presented for use within a few years.

The following list gives examples of the technical journals, periodicals, and trade magazines which should be in the library, as well as suggesting publications to be considered by those concerned with libraries serving scientific glassblowing technology programs.

Aerospace Management: Clinton Co., Chestnut and 56th Street, Philadelphia, Pennsylvania 19106.

American Ceramic Society Bulletin: American Ceramic Society, Inc., 4055 North High Street, Columbus, Ohio 43214.

American Laboratory: International Scientific Communications, Inc., Green Farms, Connecticut 06436.

Analytical Chemistry: American Chemical Society, 1155 16th Street, NW., Washington, D. C. 20036.

Battelle Technical Review: Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201.

Bell Laboratories Record: Bell Telephone Laboratories, Inc., 463 West Street, New York, New York 10014.

Chemical and Engineering News: American Chemical Society, 1155 16th Street, NW., Washington, D. C. 20036.

Chemical Engineering: McGraw-Hill Publishing Co., 330 West 42nd Street, New York, New York 10036.

Chemical Engineering Progress: American Institute of Chemical Engineers, 345 East 47th Street, New York, New York 10017.

Chemical Week: McGraw-Hill Publishing Co., 330 West 42nd Street, New York, New York 10036.

Chemistry: American Chemical Society, 1155 16th Street, NW., Washington, D. C. 20036.

Clinical Chemistry: (American Association of Clinical Chemicals, Inc.), Paul B. Hoeber, Inc., 49 East 33rd Street, New York, New York 10016.

Fusion: The American Scientific Glassblowers Society, Gwinhurst, Wilimgton, Delaware 19809.

Glass Industry: The Glass Publishing Co., Inc., 660 Madison Avenue, New York, New York 10021.

Hydrocarbon Processing & Petroleum Refiner: Gulf Publishing Co., Box 2608, Houston, Texas 77001.

Industrial and Engineering Chemistry: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

Industrial Bulletin: Industrial Bulletin, Inc., 450 East Ohio Street, Chicago, Illinois 60611.

Industrial Equipment News: Thomas Publishing Co., 461 Eighth Avenue, New York, New York 10001.

Instrumentation: Honeywell Industrial Products Group, Wayne and Windrim Avenues, Philadelphia, Pennsylvania 19140.

Journal of the American Ceramic Society: American Ceramic Society, Inc., 4055 North High Street, Columbus, Ohio 43214.

Journal of American Chemical Society: American Chemical Society, 1155 16th Street, NW., Washington, D. C. 20036.

Journal of Applied Physics: American Institute of Physics, 335 East 45th Street, New York, New York 10017.

Journal of Chemical Education: Division of Chemical Education of American Chemical Society, 500 Fifth Avenue, New York, New York 10036.

Journal of Research (National Bureau of Standards), Part A, Physics and Chemistry: U. S. Government Printing Office, Washington, D. C. 20402.

Lubrication: Texaco, Inc., 135 East 42nd Street, New York, New York 10017.

Materials in Design Engineering: Reinhold Publishing Corp., 430 Park Avenue, New York, New York 10022.

Materials Research and Standards: American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Missiles and Rockets: American Aviation Publications, 1001 Vermont Avenue, NW., Washington, D. C. 20005.

Modern Plastics: Modern Plastics, Inc., 575 Madison Avenue, New York, New York 10022.

Physics Today: American Institute of Physics, 335 East 45th Street, New York, New York 10017.

Plastics Technology: Bill Brothers Publishing Corp., 630 Third Avenue, New York, New York 10017.

Popular Science Monthly: Popular Science Publishing Co., Inc., 355 Lexington Avenue, New York, New York 10017.

Product Engineering: McGraw-Hill Publishing Co., 330 West 42nd Street, New York, New York 10036.

Production: Bramson Publishing Co., Box 1, Birmingham, Michigan 48012.

Review of Scientific Instruments: American Institute of Physics, 335 East 45th Street, New York, New York 10017.

Science News Letter: Science Service, Inc., 1719 N Street, NW., Washington, D. C. 20036.

Scientific American: Scientific American, Inc., 415 Madison Avenue, New York, New York 10017.

Society of Plastics Engineers Journal: Society of Plastics Engineers, Inc., 65 Prospect Street, Stamford, Connecticut 06902.

Technical Education News: McGraw-Hill Book Company, 330 West 42nd Street, New York, New York 10036.

Technology Review: Alumni Association of Massachusetts Institute of Technology, Room 1-281, Cambridge, Massachusetts 02139.

THE BOOK COLLECTION

According to the American Library Association, "a 2-year institution of up to 1,000 students (full-time equivalent) cannot discharge its mission without a carefully selected collection of at least 20,000 volumes, exclusive of duplicates and textbooks. Institutions with broad curriculum offerings will tend to have larger collections; an institution with a multiplicity of programs may need a minimum collection of 2 or 3 times the basic figure of 20,000 volumes. The book holdings should be increased as the enrollment grows and the complexity and depths of course offerings expand. Consultation with many junior college librarians indicates that for most, a convenient yardstick would be the following: The bookstock should be enlarged by 5,000 volumes for every 500 students (full-time equivalent) beyond 1,000."

At the initiation of a scientific glassblowing technology program, the department head and the librarian should review current reference books and select references for the library. A recommended policy is to exclude those books which are used as texts for the various courses.

At the beginning of the program, the library should have from 200 to 300 reference books on the technology and its related fields. Then, from year to year, additional references should be acquired regularly and systematically, eventually weeding out obsolete references.

VISUAL AIDS

The librarian and the department head should review and evaluate visual aids as they become available; and those selected should either be borrowed for special use, or purchased for regular use if the library is responsible for an audio-visual program. Because of current research into methods of teaching scientific principles, many new visual aid materials will become available in the future.

FACILITIES, EQUIPMENT, AND COSTS

PERMANENT EQUIPMENT

Much of the equipment needed for scientific glassblowing technology is made commercially and available at scientific supply houses. Equipment includes many types of burners, rollers, supports, flask holders, shaping tools, and polariscopes. Equipment described in this text is a partial listing of that given in Appendix A. Further reference should be made to the classic texts of Barr and Wheeler. Appendix B gives a list of some of the suppliers.

The glassblowing bench should be arranged so that the student has adequate room at each end for handling long pieces of tubing. It is not necessary that the room be air-conditioned, but it should be free from drafts. A convenient bench is 36 inches wide by 60 inches long, with slots cut in the top for two sets of cross fires. The scientific glassblowing technician works in a seated position, a position that allows him to rest his elbows on the table so as to steady the glass when in the flame. Comfort and stability are especially important for the beginning student to prevent physical strain and frustration in his work. Thirty-one inches is an acceptable height for the bench. The top of the bench should be covered, preferably with 3/8 inch asbestos–cement board. Gas, air, and oxygen are piped to the bench into a manifold and to valves located at the front of the bench. The valves are within easy reach of the worker, preferably to the right of each pair of burners.

A pressure regulator for the oxygen tank is necessary so that students can regulate their burners by the valves on the bench. A pressure of 8 to 12 pounds is adequate. If the oxygen is piped into the room from another location, a regulator is advisable at the bench in addition to the one on the oxygen tank. In such cases the oxygen is brought into the laboratory under higher (50 pounds) pressure and reduced to 8 to 12 pounds at the bench. Each student station should have separate secondary regulators.

A cabinet is needed for storing the glass tubing. The cabinet should be enclosed to protect the tubing from dust. To accommodate the beginning and the experienced student, a wide variety of tubing sizes should be stored.

Goggles are needed to protect the eyes from the intense sodium glare of the heated glass. Corning Glass Company supplies such goggles made from didymium glass. These goggles absorb the light in the region of sodium D line. This absorption makes the heated glass clearly visible through the flame. A lens 3½ mm. thick gives adequate protection and is reasonably comfortable to wear. Very dark glasses should be worn in blowing quartz because of the intense light given off by quartz heated to the softening point. Welder's goggles may be used, and a pair with dark lenses should be chosen.

A grease pencil that writes easily on glass is necessary. It must mark the glass enough to remain when heated, yet not burn into the glass. A Scripto pencil with China Marking lead G-920 is satisfactory. A diamond pencil is also useful.

A polariscope is needed so that the students may really understand the strength of the materials with which they are working. The polariscope is adjusted with the two pieces of polarized glass set at 90° to each other, thus cutting out the light. In viewing glass, any strain shows as a light spot, and its location, size, and intensity are determined.

The glassblowing bench requires a pair of rollers or glass supports. It is preferable to have one pair of rollers for each set of burners. One roller is sufficient for work with small-diameter tubing, but two rollers are necessary for larger tubing. When four rollers are lined up, two on each side of the burner, long lengths of tubing may be sealed together with more ease than when the tubing is supported in the hands alone.

GLASSBLOWING BURNERS AND FLAMES

The Bunsen burner is the most common laboratory burner. This burner is quite satisfactory for simple glassblowing with soft glass. In working with Pyrex glass, a Bunsen burner is used primarily for preheating the glass in preparation for the actual glass seal and for keeping the glass hot while work is in progress. It is practical to modify the Bunsen burner so that it can be tilted and focused at the work from many angles.

A hand torch is valuable for small work and for work on vacuum equipment built in place. This burner is equipped with an oxygen tip, and two gas-air tips that can be used for annealing small pieces of glass.

POWER TOOLS

Several sizes of grinding and polishing wheels are made by Sommer and Macca. With a grinder many operations can be performed. Bottles and squares can be cut and ground. Pieces of flat glass can have the edges ground square or beveled. Glass tubing can have the ends ground square with the sides of the tubing or at an angle.

An annealing oven is an essential piece of equipment for the scientific glassblowing technician. The time necessary to flame-anneal a finished piece of glass laboratory apparatus is about the same as that spent in fabrication of the piece. An annealing oven will reduce considerably and in some cases, eliminate entirely the time spent in flame annealing. The annealing oven should be controlled so that it will heat to annealing temperature, hold that temperature for a predetermined time, and then shut off automatically.

A glassblowing lathe can save considerable time and is a piece of equipment with which the students should become familiar. It should be selected to fit the glass instructor's intended program and the school's financial potential.

A bench grinder should be included as a means of grinding new surfaces on the glass cutting files, as well as of sharpening the various tools used in the laboratory.

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APPENDIX A

Equipment Lists and Estimated Costs of Scientific Glassblowing Laboratory

STUDENT STATION

Burner	$150.00
Vertical Rollers	10.00
Oxygen Gauge	30.00
Gas Regulator	100.00
Bench (3' x 5') and Chair	150.00
Transite Table Top	85.00
Individual Tools	450.00

a. Bethlehem Glassblowing Kit $425.00

Hot Glass Rest	Twin Tubing
Sharp Flame Hand Torch	Didymium Goggles
Torch Stand	Vernier Calipers
Blowhose	Tungsten Carbide Knife
Spandle	Graphite Hex
Graphite Flat	Rollers
Assorted Corks	Brass Shaper
Asbestos Paper	Beeswax
Graphite Rods	Tungsten Tool
Wire Screen	Sodium Nitrate
Tweezers	Plurostopper
Ribbon Fire	Metal Kit Box
Ruler	

b. Reamers, Forceps Kit $20.00

c. Swivel Blowhose 4,00

d. Spark Coil 1.00

Estimated Cost Per Student $1000.00

SHOP EQUIPMENT AND SUPPLIES

Wet Wheel for Cutting Glass (Bench Model)	$200.00
Wet Wheel for Cutting Glass (Floor Model	500.00
Carborundum Wheel for Wet Wheel	2.50 each
Electric Rollers	90.00
Spark Coil	1.00
Glass Lathe	3800.00
Instructor's Bench and Chair	250.00
Bunsen Burner for Instructor	150.00
Oxygen Gauge for Instructor	30.00
Gas Pressure Regulator for Instructor	100.00
Set of Individual Tools (above)	450.00

Annealing Oven	2300.00
Cleaning Trough	25.00
Glass Rack	75.00
Book Case	25.00
Storage Cabinets	20.00 each
Mandrel for Winding Coils	10.00 each
Polariscope	100.00
Glass Grinding Machine	225.00
Coolant Tank	175.00
Flask Holders	$65.00 set
Asbestos Tape	$1 - $5 per ft.
Asbestos Cloth	12.00 per yd.
Asbestos Gloves	8.00 pair
Grinding Compounds	5.00 per lb.
Aquadag (graphite)	8.50 per qt.
Glass Forming Tools	150.00
Stopcock Barrel Tool	70.00
Side Arm Tool	25.00
Hose Connection Tool	30.00
Standard Taper Tools	20.00 each
Standard Taper Reamers	50.00
Oxygen per semester	1000.00
Natural or Manufactured Gas per semester	60.00
Supply of Glass Tubing (borosilica, flint, rods)	800.00
Ribbon Burner	300.00
Reagents (acids, borax, cleaning solutions)	50.00
Grinding and Drilling Machine	575.00
Tooling Bench	
Bench, Chair and Transite Top	250.00
Set of Crossfires	40.00
Rollers Adapted for Tooling	50.00
Container for Aquadag	5.00
Kick-off	65.00
Corks (approx. 750 corks of various sizes)	7.50
Oxygen Gauge	30.00
Pressure Regulator	100.00
Estimated Cost for Basic Shop Equipment	$12,000.00

RECOMMENDED FOR AUDIO-VISUAL USE —Five 16 mm. Sound and Color Films

Creative Glass Blowing by Willard Pictures, Inc. from
W.H. Freeman & Co., San Francisco $475.00

APPENDIX B

List of Suppliers and Addresses

Air Reduction Company
New York, N. Y.

American Instrument Company
Silver Springs, Md.

Bethlehem Apparatus Company
Hellertown, Pa.

Biddle Company, James G.
Philadelphia, Pa.

Braun Corporation
Los Angeles, Calif.

Callite Tungsten Corporation
Union City, N. J.

Carlisle Gas Burner Equipment
Millville, N. J.

Central Scientific Company
Chicago, Ill.

Consolidated Vacuum Corporation
Rochester, N. Y.

Eisler Company, Chas.
Newark, N. J.

Gordon Duff & Company
West Los Angeles, Calif.

Leiman Brothers Incorporated
Newark, N. J.

Lepel High Frequency Lab.
Woodside, N. Y.

Litton Industries
Grass Valley, Calif.

Lydon Brothers
Hackensack, N. J.

Manville, Johns
Los Angeles, Calif.

Norton Company
Worcester, Mass.

Optical Equipment Company
Los Angeles, Calif.

Polaroid Corporation
Cambridge, Mass.

Precision Distillation Apparatus Company,
Santa Monica, Calif.

Raytheon Manufacturing Company
Waltham, Mass.

Research Vacuum Supply Company
Chicago, Ill.

Sargent, E. H. & Company
Chicago, Ill.

Schaar & Company
Chicago, Ill.

Scientific Glass Apparatus
Bloomfield, N. J.

Sheffield Bronze Paint Company
Cleveland, Ohio

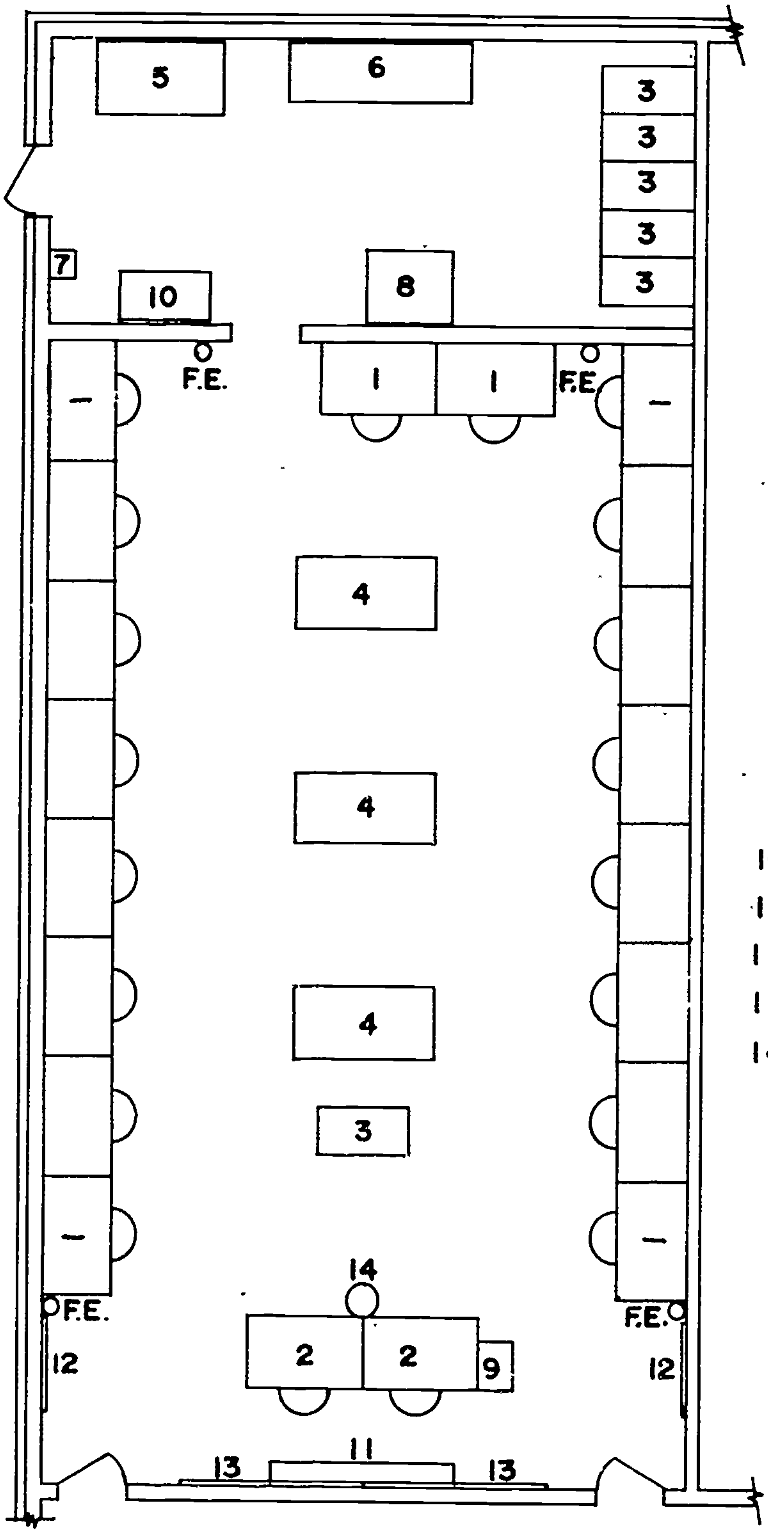
Sommer & Maca
Chicago, Ill.

Stupakoff Ceramic Manufacturing
Company, Latrobe, Pa.

Western Scientific Company
Berkeley, Calif.

APPENDIX C

Suggested Glass Laboratory



LEGEND:

1. WORK BENCH
2. INSTRUCTOR'S DESK & WORK BENCH
3. GLASS RACK
4. GLASSBLOWING LATHE
5. WET WHEEL GLASS CUTTER
6. WATER TROUGH
7. STEEL BLADE GLASS CUTTER
8. ANNEALING FURNACE
9. FILE CABINET
10. STORAGE CABINET
11. BOOKCASE
12. BULLETIN BOARD
13. CHALK BOARD
14. POLARISCOPE

GLASSBLOWING LABORATORY (CAPACITY 18 STUDENTS)	SCALE 1/8" = 1'-0" DATE 5-6-71