8-1965

THE POINT OF VIEW OF INDUSTRY ON THE MODERNIZATION OF CONTENT AND THE UPGRADING OF TECHNICAL DRAFTING INSTRUCTION

Daniel R. Oliver
Kansas State College of Pittsburg

THE POINT OF VIEW OF INDUSTRY ON THE MODERNIZATION OF CONTENT AND THE UPGRADING OF TECHNICAL DRAFTING INSTRUCTION

A Thesis Submitted to the Graduate Division in Partial Fulfillment of the Requirements for the Degree of Educational Specialist

By

Daniel R. Oliver

KANSAS STATE COLLEGE OF PITTSBURG

Pittsburg, Kansas

August, 1965

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Dr. J. V. Melton, who served as major advisor, and to committee members Dr. Forest Penny and Dr. J. H. Timmons. Their positive criticisms and guiding counsel was most helpful in the preparation of this study.

A sincere token of thanks is expressed to the industries of Arizona that participated in the study and the Employment Security Commission Offices that supplied the lists of industries that employed draftsmen. A particular token of thanks to Mr. Dean Frey, State Supervisor of Technical Education in Arizona, who gave freely of his time and efforts in helping make the study possible.

TABLE OF CONTENTS

ABSTRACT

Modern society relies heavily on the achievement of science and technology while the need for well prepared industrial technicians continues to grow. During the past decade or so, technological change has progressed at an unprecedented rate, and technical training programs must meet changing conditions.

This study was developed on the premise that technical drafting instructors should focus their attentions on the view of industry concerning the past and future training of technical draftsmen. An attempt was made to encourage drafting supervisors of Arizona's industries to point out areas in which beginning draftsmen were weak and in need of improved instruction. These supervisors were also encouraged to express their views on possible methods for correcting these weaknesses that might exist.

Sixty-eight firms participated in the study and indicated the following types of drafting are most often used in Arizona.

A. Architectural
B. Civil
C. Construction
D. Electrical
E. Electronic
F. Illustrative
G. Machine and Mechanical
H. Map and Topographic
I. Structural
J. Tool and Die Design

The sixty-eight firms employed a total of 993 draftsmen and the majority of these firms made it a practice to employ from one to ten draftsmen. Over fifty per cent of these firms hire beginning draftsmen.

The study revealed a need for improvement in most of the areas of basic drafting practices. The need for this improvement was based on the past experiences of drafting supervisors in industry. These supervisors further pointed out that existing weaknesses could be improved and most respondents were willing to work with educational institutions in this

effort.

The best method recommended by these firms for keeping drafting instructors up-to-date and in line with industry was through summer workshops of one or two weeks in length carried out in various industrial firms. Other methods leading to this improvement are also pointed out in the study as being necessary and helpful.

LIST OF TABLES

CHAPTER I

INTRODUCTION

The United States has experienced significant changes in the occupational patterns of industry in the past two decades. These rapid industrial changes, involving new materials, improved techniques of measurement, new processes, and new equipment automation have combined to increase the need for technically competent persons in the field of drafting. Drafting technicians are needed to support and supplement the efforts of engineers and scientists. The need for technically competent persons is being partially met by expanded educational services. As these educational services expand, the drafting curriculums should be upgraded, expanded, developed or modified to meet the demands of modern industrial technology.

Statement of the Problem

The study is an attempt to present the point of view of industry concerning the training of technical draftsmen. An effort was made to encourage drafting supervisors in the industries of Arizona to point out areas in which beginning draftsmen were weak and in need of improved instruction. A second attempt was made to determine, according to the drafting supervisors, how these weaknesses might be corrected in the future instruction of students in technical drafting.

The research described in this report was conducted in an effort to answer the following questions:

1. How can drafting instructors be upgraded?

2. How can the curricula of technical drafting be improved?
3. What industries indicated a desire to participate in upgrading technical drafting instruction and curricula?
4. Where should training sessions for upgrading drafting curricula and instruction be conducted?
5. In what way do textbooks need additional supplementation?
6. What industrial firms and other agencies hire inexperienced draftsmen?
7. What specific drafting practices have changed in the past few years?
8. How many of the latest drafting changes can be taught to students, providing the instructors are informed and upgraded in this direction?
9. What related areas of instruction are necessary for draftsmen?

The Technical Draftsman Concept

Although some concern has been voiced over the term, "technician," the name "Technical Draftsman" used throughout the remainder of this study will be based on the following concept:

A Technical Draftsman is a person capable of preparing usable working plans, illustrations, sketches and detail drawings, for products that are to be manufactured or documented for later use or revision. He must possess the knowledge and skill that enables him to bridge the gap between the engineer and the skill of the craftsman. He has a broad related background of mathematics, science and manufacturing processes, that enables him to prepare a set of plans from the designer's ideas that

are capable of being transformed into a usable product by the skill of the craftsman with a minimum of wasted effort. He is skilled in the use of up-to-date methods, materials, processes and tools of the drafting industry.

Need for the Study

The need for upgrading technical drafting programs becomes apparent when one considers that new drafting processes, materials, instruments and methods are being developed at a rapid pace, a pace that enables the draftsmen to improve on both the quality and time necessary for the preparation of a drawing. The need for continued improvement of technical drafting instructors is pointed out by Henniger. "To have had industrial experience in the past will not suffice, for technical instructors. He must keep abreast of new developments of equipment, materials and procedures in his chosen technologies."[1] There is reason to believe that technical drafting instructors need recent industrial experience if they are to keep up-to-date with the practices being used in industry.

There exists an increasing demand by industry for courses of a technical nature to be more closely correlated with the current practices in use by industry. Drafting and other areas of technical instruction in educational institutions need to establish a closer working relationship with industry. If institutions are to train technically competent workers for occupations in industry it is then necessary that these institutions first and foremost establish the basic needs that are desired by

---

[1]G. Ross Henninger, The Technical Institute in America, (New York: McGraw Hill Book Company, 1959) p. 126.

industry in a program of instruction. Once these needs are established they should be kept up-to-date by periodic surveys through the joint efforts of industry and education. The need for studies for this purpose, and the importance of technically competent draftsmen, cannot be over-emphasized.

Mr. Art Davis, Staff Engineer for Motorola Inc., Phoenix, Arizona, has this to say:

> Since the day of the Sputnik, many articles and papers have been written and seminars conducted on the subject of educating draftsmen and engineers for industry. (Reference Graphic Science and previous articles published.) Drafting courses are being reduced in scope or de-emphasized in colleges and universities teaching engineering; more theory is the trend. This is all well and good as long as we also get properly trained draftsmen. We need theoretically-minded engineers and, of course, must have space-age thinking to keep pace with the fast moving state of the art, especially in military electronics. Engineers on the average, however, are coming from colleges not very well prepared to understand easily the practical aspects of what it takes to make drawings or appreciate the role of draftsmen. That is all the more reason why we need practical-minded draftsmen to bridge the gap between the engineer/designer and the fabricator of the part or equipment that the engineer or designer has conceived.
>
> Industry must work together with educators to help them set up a compatable system, not only to bring the drafting teaching methods and materials up to date, but to keep up with the changing state of the art.[2]

Industry in Arizona is growing at a rapid rate. There are three hundred and twenty thousand workers now employed in the industries of the state with a projected working force of seven hundred thousand by 1970. The need for surveys of programs such as drafting and other areas of technology are necessary as determined by the Governor of Arizona, Paul Fannin who writes:

---

[2]Art Davis, "Vocational Training of Draftsmen Industry's Point of View" (paper presented at meeting between Educators and Motorola Supervisors, Phoenix, Arizona, May 24, 1963).

> The importance of vocational and technical education to our youth seeking employment and to industry seeking skilled employees is becoming greater each year. Much has been done in these areas in years past but automation and technological changes are constantly adding new demands for additional training in a variety of skills. I believe it is vitally necessary that existing programs and facilities in our school be brought up to date wherever necessary and maintained on a continuing basis consistent with our population needs and the changing economy.[3]

This study was an attempt to determine where current drafting programs needed to be upgraded and how they might be maintained according to the views of industrial drafting supervisors.

Sources of Data and Method of Study

The names and addresses of firms and offices that employ draftsmen in Arizona were obtained through the Arizona State Employment Services in Arizona and from salesmen who call on the various firms that use drafting supplies; further addresses were obtained from phone directories, the State Supervisors Office of Technical Education and two manufacturing directories for the industries of Arizona.[4] The compiled list totaled one hundred and six firms.

After a careful study of technical education and available information gathered in over two years of preparation for this study, a survey in the form of a questionnaire,[5] was constructed and sent to the chief

---

[3]Letter from Governor Paul Fannin to Marshall Humphrey, June 12, 1962, Education for a Changing World of Work, (Summary Report of the Governor's Committee on Technical Vocational Education, Governor Office, Phoenix, Arizona) Paul Fannin was elected to U.S. Senate in 1964 election.

[4]Bruce Parkinson, Arizona Directory of Manufacturers, Employment Security Commission of Arizona, Phoenix, Arizona: The Palmer Printing Company, 1962.

Phoenix Chamber of Commerce, Directory of Manufacturers in the Phoenix Area.

[5]See Appendix, pp. 106-109.

draftsman of each firm. The questionnaire, was designed to provide information concerning the basic drafting practice being used and the extent to which these chief draftsmen think that there is a need for improvement or revision of these practices. Of the one hundred and six questionnaires that were mailed, four were returned unopened and stamped unclamed because the firm had moved and left no forwarding address. For the remaining one hundred and two questionnaires, there were forty-six replies for a return of 46 per cent. A second questionnaire was sent to those firms not replying and resulted in thirteen additional returns. A third questionnaire sent to the remaining firms that had not replied resulted in nine more returns, making a total of sixty-eight or 66.6 per cent replies.

Additional data for the study were obtained from related studies, bulletins, pamphlets, books, correspondence with draftsmen and two personal experiences in drafting workshops held in industrial firms in Arizona. State Supervisor of Technical Education, Mr. Dean Frey, provided important information relative to the location of firms that employed draftsmen.

Limitations

The study was delimited to industries in the state of Arizona and the city and county government bodies that employ draftsmen. Federal installiations through-out the state were omitted due to security reasons.

The study was further limited to industrial type drafting with no direct attention given to the drawings or freehand sketches handed down by engineers for further development by drafting departments. The survey was designed to bring out problems dealing with basic drafting practices that apply to industrial type drawings prepared by draftsmen.

The number of firms that participated in the study was limited, since Arizona is not heavily populated with manufacturing firms. A survey[6] of manufacturing firms revealed that in 1962 there were only fifty-one firms in the state that employed 1,000 or more persons. Further research indicated that the drafting work needed by some of the smaller firms was contracted to the larger companies. This practice was preferable to the employment of a full time draftsman.

Related Studies

A search of literature revealed that no studies of this nature have been carried out in the state of Arizona. The State Supervisor of Technical Education was helpful in providing some fragmented studies of drafting made by industries in Arizona.[7]

One drafting survey[8] was located which was carried out in 1964 by Carl Squires, a drafting instructor, at Phoenix Union High School. This survey was limited to companies located in the Phoenix area and provided a source of information concerning the twenty firms that were surveyed. The information gathered from these sources was used mainly for their value preliminary to the study.

---

[6]Bureau of Census, 1962 Annual Survey of Manufacturers, The World Almanac and Book of Facts (New York: World-Telegram and the Sun, 1965) p. 711.

[7]Art Davis, "Vocational Training of Draftsmen Industry's Point of View" (paper presented at meeting between Educators and Motorola Supervisors, Phoenix, Arizona, May 24, 1963).

"Motorola's Drafting Organization Procedures and Educational Training Program" (Article presented to drafting instructors at a workshop, Phoenix, Arizona, June, 1964).

[8]See Appendix p. 110.

CHAPTER II

HISTORY AND DEVELOPMENT OF DRAFTING AS A TECHNICAL SUBJECT

The history of drafting is an important section of the study for its value in revealing the evolution of drafting as a technical subject. Research points out that most early contributions of drawing were made by educators or teachers who realized the significance of this subject. History discloses a record of changes in drafting that have taken place due to the technological developments of industry. Another eminent value reveals how educational institutions can develop a subject, then revise it to fit industries needs through a joint cooperation of ideas.

The rapid pace of technical development as concerned with drafting is difficult to understand without a review of past history as it relates to the study. New ideas, techniques, machines and methods of drafting have come about through the experiences of the past. Machines of today are capable of producing in minutes, line drawings of objects that only a few years ago required experienced draftsmen hours to complete. Modern methods of achievement are better understood and appreciated when the nature of their origin is examined.

Communication of thoughts from one person to another has never been universal through a world language of words and sentences. However, there has been a universal language in use since the earliest times, the graphic language. Communication by means of pictures occurred among the earliest cave dwellers. Examples of this type of communication are still in existence today. These pictures or forms of drawings were used to

record and communicate ideas.

Man has developed drawing along two different lines, each serving its own purpose either artistically or technically. Since the time of recorded history man has used drawing to represent objects to be built or constructed. Of these earliest drawings no trace remains today; but we definitely know that drawings were used, for man could not have built as he did without using fairly accurate drawings. In the Bible the statement is made that Solomon's Temple was "built of stone made ready before it was brought thither." Each stone and timber was carved or hewn into shape, brought to the site, and fitted together. It is evident that accurate drawings must have been used, showing the exact shapes and sizes of the component parts.[1]

The earliest known technical drawing in existence is a plan view of a fortress drawn on a stone tablet. This tablet is a part of a statue in Louvre, France and dates back to the earliest period of Chaldean Art around the year 4000 B.C. This plan is similar to those made by architects today, yet it was drawn several thousand years before paper was invented.[2]

There is written evidence of the use of technical drawings as early as 30 B.C. when the Roman architect Vitruvius wrote, "The architect must be skillful with the pencil and have a knowledge of drawing so that he readily can make drawings required to show the appearance of the work he proposes to construct." He also wrote concerning the use of the rule and compasses in geometric construction and about plan and elevation views of

---

[1]Frederick E. Giesecke, Alva Mitchell and Henry Cecil Spencer, Technical Drawing (New York: The Macmillan Company, 1964), pp. 2-3.

[2]Ibid., p. 3.

a building as well as drawing in perspective.[3]

Very little was done to encourage the idea of teaching drawing as a subject until the middle of the 16th century. Richard Mulcaster, a famous English schoolmaster, has been given the credit for being the first to make drawing, one of the fundamental studies of the school. Mulcaster, headmaster of Merchant Taylors School in England from 1561 to 1586, expressed his point of view, concerning drawing, by the following:

> For penne and penknife, icke and paper, compasse and ruler, deske and dustboxe will set them both vp, and in these young years, while the finger is flexible, and the hand fit frame, will be fashioned easely. And commonly they that have any naturall towardnesse to write well, have a knacke of drawing to, and declare some euident conceit in nature bending that waye. And as iugement by vnderstanding is a rule to the minde to discern what is honest, weemly, and sutable in matters of the minds, and such argumentes as fall within compasse of generall readon exempt from sense; so this qualitie by the proportion and seemelines of all aspectable thinges. As he that knoweth best, how to kepe that himselfe, which is comely in fashion, can also best iudge when complinesse of fashion is kept by any other. And why is it not good to have euery parte of the body: and euery power of the soule to be fined to his best?[4]

The importance of drawing was evident as it related to the educational aspect of cultivating an appreciation of lines, tint and space division for practical use and for pleasure. This idea was given further support in a pamphlet written by Sir William Petty in 1647, in which he proposed reforms for education. Paragraph five of these reforms, as indicated by Petty, stated:

> "That in no case the art of drawing and designing be omitted, to what course of life soever those children are to be applied, since the use thereof for ferior to that of writing, and in many cases performeth what by words is impossible."[5]

---

[3]Ibid.

[4]Charles Alpheus Bennett, History of Manual and Industrial Education Up to 1870 (Peoria, Illinois: The Manual Arts Press, 1926), p. 34.

[5]Ibid., p. 45.

Sir William Petty advocated the value of drawing as a means of expression and as a language. He considered it, in some cases, to be superior to the written language. The value of drawing, as it related to education took on a realistic approach between the years 1804 and 1824 in Yverdun, Switzerland in a school of John Henry Pestalozzi and one of his teachers, Johannes Buss. Pestalozzi, often referred to as the "father of manual training", realized that in considering what any object looked like, one should consider how many there were, the description of the form and the outline of the object. He gave considerable attention to the subject of drawing and with the aid of Buss, developed an alphabet of form as a means of measuring and finding proportions for various geometric forms. If Pestalozzi had applied this alphabet to his teaching of manual arts he might have developed a system of tool instruction. However, this was not the case and Pestalozzi remained content to use the alphabet for form study and drawing. He never reached the point of letting the alphabet apply to manual arts. Although Buss never fully understood Pestalozzi's ideas concerning drawing, he was convinced that through this alphabet of form, a technical language was being created.[6]

Pestalozzi had many followers and his practice of teaching soon spread to America. Robert Owen who had been successful as the founder of a school in England, came to America in 1825 and established a settlement called "New Harmony," at Harmonie, Indiana, with the idea of starting a new moral world. The educational director of New Harmony, William Maclure, was also a follower of Pestalozzi. Maclure and Owen established

---

[6]Ibid., pp. 120-23.

a higher school for pupils over twelve years of age spoken of as the "school for adults".

Maclure's aim was to make New Harmony the educational center of America through the Pestalozzian system of instruction. In an outline of his course of study, Maclure indicated that drawing would be an essential part of the student's curriculum in the higher school. In this outline he stated that mechanism would be taught by the study of machines or exact models of them; natural history was to be taught by examining the objects or accurate drawings of them; geography was to be studied by globes and maps from the students own construction. Drawing was pointed out to be one of the courses in which students were to receive manual training and was a type of drawing executed for the purpose of study and learning to draw in an accurate manner.[7]

References to drawing as a subject in some of the schools of the early 1800's did not make any definite distinction or division between drawing for the art of self-expression and drawing of accurate material objects for construction or documentation. For these reasons, drawing served these schools as a method of instruction, a means of self-expression and as a method of description and documentation of material objects as related to the teaching of the skills.

Other nations instrumental in the development of drawing as a technical subject were France and Germany. Both of these countries used educational drawing practices in their trade and technical schools that were later practiced in the United States.

France for a long time was recognized as a leader among nations in

---

[7] Ibid., pp. 174-8.

the practice of engineering. In the late 18th and early 19th centuries, a great number of technical schools were developed in France while Napoleon Bonaparte was still in power. Under his leadership a great movement was started in France in the early 1800's which placed an increased emphasis on the importance of drawing. Gaspard Monge, a professor at the Polytechnic School in France, developed the principles of projection which are today the basis of our technical drawing. Monge, sometimes considered the inventor of descriptive geometry, had for sometime worked with drawing problems involved with building construction and fortification. These principles of descriptive geometry were soon recognized to be of such military importance that Monge was compelled to keep his discovery a secret until 1795. His drawing practices later became an important part of technical education in France and Germany and later in the United States. A book by Monge, La Geometric Descriptive, is regarded as the first text to express the basic principles of projection drawing. Monge's principles were brought to the United States from France by Claude Crozet, a professor at the United States Military Academy. Crozet published the first text on the subject of descriptive geometry in the English language in 1821. Shortly following this publication these principles became a regular part of early engineering courses at such schools as Rensselaer Polytechnic Institute, Harvard, Yale and other schools. The principles of projection also applied to the firearms industries as an aid in the development of interchangeable parts.[8] Napoleon Bonaparte was instrumental again in the early improvement of drafting when he visited schools in the northern cities of France

---

[8]Giesecke, op. cit., p. 5.

and made the following statement:

> "I have found everywhere workmen distinguished in their craft, having great dexterity in execution, but hardly one who can make a drawing of the simplest type of machine or could express his ideas by a sketch or by a memorandum. It is a gap in French industry; I will fill it up. No more Latin (that will be taught in the lyc'ees which are going to be organized), but trades with the theory necessary for their progress. Here excellent foremen for our manufactories will be trained."[9]

Bonaparte increased his efforts toward improvement of technical schools for the purpose of providing superior workmen who knew enough mathematics, science and drawing to allow them to take positions as foremen, superintendents and draftsmen. Bonaparte's influence concerning the importance of drafting was seen again when he ordered publication of a drawing book for the national schools of France. This book titled, L'enseignement du dessin line'aire, was written by Louis Benjamin Francouer and published in France in 1827.

Francouer's work was essentially a book to teach geometric construction of figures and solids, architectural elements and other objects such as urns, bowls and pitchers in profile. The book was designed to teach drawing by working problems arranged in difficulty from simple to complex, and confined the exercises to line drawings only, with no emphasis on shading. Francouers book became a major step in the advancement of drafting as a special subject.

William Bently Fowle, master of a boy's school in Boston, obtained a copy of Francouers book and translated it for publication. Fowle titled the book, The Eye and Hand, and used it for instruction. The publication of the book created by Fowles increased interest in the subject of

---

[9]Bennett, op. cit., pp. 275-6.

drawing in the schools of America, and drawing was made a permissive study in the English High School in Boston in 1827.[10]

The subject of drawing was slow in being accepted in American schools; however, the countries of France and Germany continued to stress the importance of drawing as it related to instruction in the manual arts. Germany by the 1830's had taken steps to establish drawing as a major field of study in the manual arts. By 1837 they had established a course in industrial drawing known as the "Schmidt's Method". This course was developed by P. Schmidt, a teacher in the Royal Realschule in Berlin. The school had two forms of manual arts instruction; one was drawing especially for the boys, the other was needlework for the girls. The school was six years in length and boys participating in drawing were required to spend one hour a week the first year, two hours a week the second year, three hours a week the third and fourth years and four hours a week the last two years, learning to draw. The course was designed to include preparatory exercises, bodies in elevation, and solids bounded by plane figures, straight lines, shadows and curved surfaces. Schmidt's method of teaching drafting resembles the course pattern that was followed later by other educators of the manual arts and industrial education.[11] The transfer of drawing from foreign countries to American schools, came about through individuals who visited and studied these foreign schools in search of improved instructional methods.

Calvin E. Stowe of Cincinnati made a study of public instruction of Eouropean schools in 1839 and gave this report concerning a two-year

---

[10] Ibid., p. 416.
[11] Ibid., pp. 240-41.

course in drawing for students ranging from twelve to fourteen years of age:

> Elements of drawing: For this the pupils have already been prepared by the exercises in ornamental writing in the previous part of the course. They have already acquired that accuracy of sight and steadiness of hand which are among the most essential requisities in drawing well. The first exercises are in drawing lines, and the most simple mathematical figures, such as the square, the cube, the triangle, the parallelogram; generally from wooden models, placed at some little distance on a shelf, before the class. From this they proceed to architectural figures, such as doors, windows, columns, facades. Then the figures of animals, such as a horse, a cow, an elephant; first from other pictures, and then from Nature. A plant, a rose, or some flower is placed upon a shelf, and the class makes a picture of it. From this they proceed to landscape painting, historical painting, and the higher branches of the art, according to their time and capacity. All learn enough of drawing to use it in the common business of life, such as plotting a field, laying out a canal, or drawing the plan of a building; and many attain a high degree of excellence.[12]

Stowe's study, when properly analyzed, bears out the importance of drawing as it relates to industrial and business development of various technologies.

The development of drawing expanded rapidly in America, starting in the late 1850's. However, until this time it was a difficult task to convince school personnel of the importance of drawing as a special subject taught from a textbook. In the winter of 1839, Elizabeth Palmer Peabody, an instructor at Franklin School in Boston, gave drawing instruction to a class of fifty children. Miss Peabody put her methods for teaching drawing into a book called, A Method of Teaching Linear Drawing. Further interest in the subject was promoted by Miss Peabody when she instructed a course in drawing for teachers in the primary schools to prepare them as instructors of drawing. The course proved very successful

---

[12] Ibid., pp. 241-42.

with nearly 100 persons enrolled in the class in 1842.[13] Further emphasis that came about during this period of time pointed to an increased effort to include drawing in the curriculum of other schools in America. Drawing practices during this time were broad in scope and still used as a subject for the art of self-expression. There was, however, some emphasis placed on the use of drawing for the construction of material objects, maps and architecture. In 1842, Josiah Horbrook, one of the leaders of the Lyceum Movement, prepared a series of thirty-six drawing cards to assist teachers in giving instruction in drawing. This was a step in the right direction, although, many of the schools at this time were not ready to accept drawing as a special subject to be taught by special teachers. There were at this time a few teachers assigned as special instructors of drawing in some of the schools. One of these men, William Newton Bartholomew, an instructor in Boston, Massachusetts, had worked out a series of drawing lessons for use in the primary grades. He developed a drawing book that covered freehand instruction in outline, geometric drawing, model and object drawing and perspective. His aim was to help pupils gain a practical knowledge and skill in the art of presentation. Bartholomew's type of drawing was important and meaningful but it did not satisfy the demands of this time for drawings that would have immediate effect upon the industries of the state of Massachusetts.

Massachusetts was rapidly developing as an industrial center and the manufactureres were asking the schools to do more in helping to train industrial workers. More technical education was demanded, but the

---

[13] Ibid., pp. 419.

teaching of mechanical crafts and trades in public schools was not practicable at this time. However, the concept of teaching industrial drawing in the public schools was practical. This led to an act by the legislature of Massachusetts to make drawing a branch of the curriculum to be taught in the public schools.[14] Boston became a leader in instituting industrial drafting as a separate course of instruction. The following account of this success was evident in an evening school for drawing that was opened in November of 1870, in one of the large drawing rooms of the Massachusetts Institute of Technology.

> Nearly 1,000 applicants, male and female, entered their names upon the register; upwards of 500 pupils received instruction for a longer or shorter period, not more than 225 being accommodated in the rooms at one time; the school was open four nights a week, the pupils divided into two sets, attending in turn two nights a week . . . Ten different instructors were employed, most of whom were connected with the Institute of Technology, either as teachers or pupils. Instruction was given in general freehand drawing, in freehand drawing of machines from solid models, in mechanical drawing and architectural drawing, and in ship-drafting.
>
> The school was altogether a success. The pupils, a majority of whom were young mechanics, found they were getting what would be of the greatest use to them, and so they attended punctually and worked with a will.[15]

Massachusetts was one of the first states to realize the importance of drawing as it applied to the advancement of the industrial technologies. Other states such as Ohio, Pennsylvania and Maryland were also instrumental in the development of drafting programs in the United States.

A system of instruction in drawing developed by Rembrandt Peale of Philadelphia, became very successful and was approved, as a method for

---

[14] Ibid., pp. 421-30.

[15] Ibid., p. 431.

teaching drawing, by a committee made up of manufacturers, engineers, artists and educators. This system had two important features that required students to first work from a copy, then to draw from nature. The second feature pointed out that students were to learn freehand drawing before mechanical drawing. Peale believed that the early training of the eye and hand was of great value in the preparation for any mechanical pursuit and he placed a special emphasis on pencil drawings.[16]

The public school commissioners in Baltimore, Maryland, in 1845, introduced drawing as a branch of study in their high schools. It was the feeling of these commissioners that a knowledge of drawing was important to persons of almost every situation in life. Mr. William Minifie was hired by this committee to give lessons in drawing. Minifie, an acknowledged architect, became the author of a book on drafting, A Textbook of Geometrical Drawing. This book, being very comprehensive, was for many years the standard American textbook on the subject of drawing and was perhaps the first technical drawing book in this country. The book included fifty-six full page steel engravings, a section on definitions, geometric problems, sections on solids and several plates of developments. There were additional sections showing the designs of arches, a cottage, drawings of gear wheels and the cylinder of a locomotive. The final sections included isometric drawings, mechanical perspective, shades and shadows and coloring.[17]

In addition to Maryland, Pennsylvania and Massachusetts, the state of Ohio made great strides in promoting drawing as a special school

---

[16] Ibid., pp. 431-32.

[17] Giesecke, op. cit., p. 6.

subject. It is said that only the state of Massachusetts was in advance of Ohio in making drawing an integral part of school instruction. Calvin Stowe's report to the Ohio Legislature, mentioned earlier, gave prominence to instruction in drawing. For this reason, and the fact that southern Ohio was an industrial center that employed many skilled craftsmen, Cincinnati became one of the leaders in making drawing a specific subject of instruction.

In 1846, J. W. Bowers, was appointed to give instruction in drawing in the Cincinnati public school. Listed in Bowers' subjects, by 1847, were drawings from patterns, solid objects, linear perspective and shades and shadows. In addition to Bower's work, Cincinnati developed the first use of the title, "Drawing Department", in Central School under W. B. Shattuck, teacher in charge.

In 1868, drawing became a required subject in Cincinnati with a special supervisor appointed to organize this department of instruction. Ohio was given credit for being the first state to provide special teachers and a paid supervisor for drawing subjects.[18]

The industrial development as seen in Massachusetts, Ohio and other states, brought about some important changes in schools, not only in drawing but in the other craft trades as well. Other influencing factors with a direct bearing on the courses of American schools, were the technical institutions being developed in Russia which provided new scientific methods for teaching the mechanical arts.

Russia displayed their system of teaching in 1876, at the Centennial Exposition in Philadelphia. As a direct result of this exposition, a

---

[18]Bennett, op. cit., pp. 433-36.

school of Mechanic Arts was opened in Boston, in connection with the Massachusetts Institute of Technology. In addition, the principles of the Russian system for teaching the mechanic arts was applied in the St. Louis Manual Training School of Washington University. The school in St. Louis, established in 1880, was the first true "Manual Training" school to be developed in the United States with the main objective to teach the manual skills of this time. The five fundamental courses of study carried on in this school were mathematics, science, language, drawing and shopwork.[19] Drawing was one of the fundamental courses of the curricula determined as necessary in the training of manual arts students. Drawing was soon to be included as a part of other manual arts programs that were being developed in the United States.

The opening of the evening school in 1870 for drawing classes in the Massachusetts Institute of Technology was one of the first major efforts for training of industrial draftsmen. In this class, no emphasis was placed on drawing as an art of self-expression. This class was especially designed for teaching an industrial type drafting as a separate part of the curriculum and marked the beginning of a trend that was followed by the establishment of other drafting programs as they related to industrial technology.

The history of drafting would seem somewhat incomplete without a mention of the development of tools and materials used for drawing. The origin of drawing instruments date back to the dawn of recorded history when the Egyptians were using drawing instruments to plan their cities.

---

[19]Charles Alpheus Bennett, History of Manual and Industrial Education 1870 to 1917 (Peoria, Illinois: The Manual Arts Press, 1937), pp. 347-53.

Among the tools used by the Egyptians were a bronze point, string and reed pen. The bronze point and string were combined for drawing circles on such materials as stone, wood or papyrus. After the lines were drawn on the material they were retraced with the same type pen that was used for writing.

Instruments used by the Roman Architects, at about the time of Christ, are to be found in some of today's museums. Their instruments consisted of the compass, pen, ruler and stylus. The compass was about six inches in length, made of bronze with the legs held together sufficiently tight by a bronze rivet to keep them at any particular setting. The materials on which the Romans made their preliminary drawings were tablets made of wood coated with wax. More permanent drawings were constructed on papyrus imported from Egypt or upon the skins of animals, usually sheep or goat.[20]

The methods of drawing practiced by the Romans continued in general use for over fifteen hundred years. However, a great improvement was made in the type of material upon which the drawings were placed. These important changes that came about during the seventh century were the use of pens made from the quills of birds and improvements in the ink used for drawings.

During the renaissance period with the general use of paper, the silver point method of marking was developed. This process was carried out by applying a wash, consisting of finely ground pumice suspended in

---

[20] V. and E. Manufacturing Co., Historical Note on Drawing Instruments. A booklet prepared by the Vemco Drafting Company. Pasadena, California, 1950, p. 2.

a very dilute solution of glue or flour paste and letting it dry. A silver point drawn across this paper would leave a line of finely divided metallic silver. The density could be varied by pressure from a light grey to a good black. The silver point had many advantages; but it never fully replaced the old Roman method of first marking with a plain point, then drawing with pen and ink.[21]

Drafting practices greatly improved with the invention of the lead pencil. Early pencils were made from cores of graphite encased in wooden holders but were found to have the disadvantage of smearing rather badly. The graphite cores, cut from blocks of graphite, produced a great amount of scrap material left over after the cutting. Experiments were made with various waxes and gums in an attempt to bond the salvage material together and to produce a harder graphite core. In 1795, it was found that certain mixtures of graphite and clay produced the desired results which led to the many and varied degrees of hardness in drafting pencils we have today.

The industrial revolution brought about a demand for considerable improvement of drafting practices and instruments. During this time a great many new instruments were put into use by draftsmen such as bow pens, dividers, the beam compasses and other instruments of less importance.[22]

During the same period of time, the first drawing instrument manufacturing company was established in the United States. This company was organized by Theo. Alteneder and Sons in Philadelphia, Pennsylvania

---

[21] Ibid., pp. 3-4.
[22] Ibid., p. 8.

in 1850. Up to this time drafting instruments had been imported.

The graphic language up to 1876 was more or less an "art" characterized by fine line drawings. This period of time brought on a great change in the drafting industry with the introduction of the blueprint process. This was the beginning of modern technical drawing. The graphic language now became a relatively exact method of representation.[23] From this time forward the reproduction of drawings continued to improve. The blueprinting process was, for some time, rather slow and difficult to control. However, these methods improved and expanded to a great extent in the years to follow. In addition there have been other developments that provided great expansion in the reproduction and documentation of drawings. New diazo printers were introduced that provide a dry copy of drawings which is quicker and has some advantages over the wet process of blueprinting. Another reproduction method in use by some companies is the microfilming of drawings by a photographic process. Microfilming brought about a completely new approach to drafting practices. A picture of a drawing can now be taken that produces a negative small enough to be inserted on a 3 x 5 automatic index card. This card has many advantages in the storage, filing and locating of drawings. Special machines for automatic indexing will sort out a particular drawing by a number punch, on the card and automatically carries it to a reproduction processor which makes a photo copy of the drawing to its original size.

A new process in microfilm filing, not yet on the market, has been developed that provides random storing of drawings. Up to this time it has been necessary to store microfilm drawings on index cards

---

[23]Giesecke, op. cit., p. 6.

alphabetically or numerically and sort through groups of cards to locate a drawing by punch card machines. The new system called, "Access," permits drawings on various size index cards to be placed in a special tray and an operator of the machine can punch the drawing number or letter sequence and locate any drawing in less than ten seconds. The drawing index card can be returned anywhere in the tray and still be located in the manner mentioned above.[24]

Changing technology, including automation, affects job training and employment skills. Within modern plants and industries, technological changes are now being introduced that will alter the job skills and knowledge, create new job classifications or make some jobs obsolete. Many new and different techniques have taken place in the tools, materials and methods of drafting. There is some evidence to support the development of automatic drafting machines that could have a great affect on the some 500,000 people who work primarily at drafting boards. Two distinctly different automatic drafting machine concepts are under development and in limited use today. One based on electronic computer processing and one on a photographic - electro-mechanical relationship. Both have the potential of producing significant cost and time reductions. The automatic drafting machines designed thus far have limited capabilities and are made with a special purpose in mind. In order to make an automatic drafting machine capable or replacing the many draftsmen now employed, it must be developed to the extent that it can manipulate and

---

[24]Text of statement by Mr. Harold W. McCrath, Representative of Microfilm Systems, Recordak Corporation, Phoenix, Arizona, May 17, 1965.

revise graphic information.[25]

The technical advances in drafting are being developed at a rapid pace and have brought about many changes in the methods of rendering drawings. From the time of the earliest technical drawing on a stone tablet 4000 B.C., man has continued to improve and develop the drawing as a science, an art and means of communication. Technical drafting of today, as in time of the Romans, continues to be the universal language.

In summary the evolution of drafting as a school subject started with Pestalozzi, Buss and many others. Through their efforts and the contributions of industry the development of drafting has made great progress. This progress will continue as long as educational institutions and the industrial societies combine their joint efforts in such an endeavor.

---

[25]Article obtained at Motorola Workshop for Technical Drafting Instructors, "Thinking Out Loud," by Thurber J. Moffett, Publisher unknown.

CHAPTER III

INDUSTRIAL FIRMS IN ARIZONA EMPLOYING DRAFTSMEN

Employment and Plant Operations

Manufacturing employment in Arizona has more than tripled in the past decade.[1] The rapid growth in this area has brought about an increased demand on the educational institutions of this state to provide industry with a larger number of adequately trained technicians. The rapid industrial changes have brought about an increased emphasis on the technician and his job of bridging the gap between the skilled worker and the engineer. The training of technically competent draftsmen is a key role in this respect because many of the engineer's ideas and designs are put into final form by the draftsman, before being passed on to the skilled worker for manufacturing or further development.

In order to upgrade and improve the instruction of drafting in this state, institutions should have a definite knowledge of the types of drafting that the firms are using in their work. A particular section was included in the questionnaire[2] to determine the types of drafting most often used in firms that participated in the study.

The introduction to the questionnaire asked the individual completing the form to indicate the types of drafting being used in his firm of employment. Eight types of drafting were listed to be answered by a

---

[1]Bruce Parkinson, Arizona Directory of Manufacturers, Employment Security Commission of Arizona, Phoenix, Arizona: The Palmer Printing Company, 1962, p. 1.

[2]See Appendix p. 106.

check mark; additional space was provided to indicate other types of drafting that was practiced if it was not included in the list. The results for this section of the study is listed in the following chart. The first group in the chart lists eight types of drawings that were printed on the questionnaire; the second group lists the types of drawings not printed on the questionnaire but were being practiced in the firm and were so indicated by writing the type of drawing in the space provided.

TABLE I

TYPES OF DRAFTING CARRIED OUT IN THE INDUSTRIES OF ARIZONA

Types of Drafting	Number of firms Checking	Percentage of sixty-eight replies
Architectural	25	36.7
Construction	25	36.7
Electrical	17	25.0
Electronics	15	22.0
Illustrative	16	23.5
Map and Topographic	27	39.7
Structural	25	36.7
Tool and Die Design	13	19.1
*		
Ballistic	1	1.4
Civil	9	13.2
Fixture layout	1	1.4
Highway	3	4.4
Interior Design	2	2.9
Layout	2	2.9
Machine or Mechanical	22	32.3
Millwork Details	2	2.9
Pipe line	1	1.4
Stamping	1	1.4

Read thus: There are 25 firms or 36.7 per cent of the sixty-eight replies that render architectural type drawings in their work.
*Additional types of drafting written in on the questionnaire.

The information from the introduction section of the questionnaire, revealed the ten types of drawing most often used in Arizona's firms. Of these ten, map and topographic drafting was checked most frequently with twenty-seven firms indicating they used this type of drafting. Architectural, construction and structural drafting were each checked a total of twenty-five times, with machine or mechanical being checked twenty-two times. Other types of drafting checked at least fifteen times but less than eighteen times were electrical, electronic and illustrative. There were thirteen firms checking tool and die design and nine indications for civil. Eight other specific types of drafting were listed from one to three times, however, the firms indicating other types had also checked one of the other ten types of drafting most often checked.

The first part of the questionnaire, listed under section one of the survey, dealt with the employment and training of draftsmen as indicated by the participating firms. Particular questions were included that concerned the number of draftsmen each firm employed. Table II gives this response. Other questions were used to indicate the firms that did or did not employ beginning draftsmen; additional questions were used to determine how well beginning draftsmen had been trained and any further training that was given to these beginning draftsmen by the firms replying.

The number of replies received from chief draftsmen indicated that over fifty per cent of the firms replying employed from one to ten draftsmen. The number of draftsmen employed in these firms were important to the survey as it related to particular questions being dealt with later

in the study.[3] This information should be of further value to instructors and guidance personnel for the counseling values as concerned with this state in revealing to drafting majors possible employment opportunities.

TABLE II

NUMBER OF DRAFTSMEN EMPLOYED BY THE FIRMS REPLYING TO THE SURVEY

Number of Draftsmen Employed	Number of Firms Checking	Percentage of sixty-eight replies
0 - 10	46	67.2
11 - 20	12	17.6
21 - 30	2	2.9
31 - 40	3	4.4
41 - 50	0	0
51 - 60	0	0
61 - 70	2	2.9
71 - 80	0	0
81 - 90	0	0
91 - 100 or more	3	4.4

Read thus: There were forty-six or 67.2 per cent of the firms replying that employ from one to ten draftsmen.

A follow-up question was used to determine the number of firms that made it a practice to hire beginning draftsmen. This question revealed

---

[3]See Appendix, p. 106.

that of the sixty-eight replies, there were thirty-nine firms that employed beginning draftsmen while twenty-nine firms indicated that they did not employ beginning draftsmen. Of the twenty-nine firms not hiring beginning draftsmen, there were three replies with additional comments stating that these firms had hired beginning draftsmen in the past. One firm indicated they had tried several beginning draftsmen and found they were unable to handle the work, due to a lack of experience.

Of the thirty-nine firms hiring beginning draftsmen, there were two indicating that all beginning draftsmen were receiving adequate training in basic drafting practices. Twenty-nine firms replied some beginning draftsmen were adequately trained while five firms replied that none of these draftsmen had been sufficiently trained. The need for improved instruction in drafting basics is pointed out by the fact, that in the majority of replies, only some of these beginning draftsmen are adequately trained in these basics. Some of these weaknesses in drafting practices are pointed out in the following chapters. Beginning workers in most any firm experience a certain amount of difficulty in adjusting to a new position. To help solve this problem some firms have set up in-plant training for new employees that will acquaint them with the standards and practices used in their firm.

There was a desire to try and determine in this study the firms that found it necessary to give beginning draftsmen further training. Of these thirty-nine firms hiring beginning draftsmen there were seventeen administering some type of further training before these persons were put on usable drawings. The respondents were also asked to indicate the length and nature of this training. The data resulting from this question pointed out that training periods varied from three days to two years;

further information valuable to the study consisted of the comments on the nature of this training.

The following comments were made by supervisors indicating a definite training period for beginning draftsmen:

"Giving a person progressively more difficult and responsible work; length depends on individual."

"Three days maximum"

"No specific program - Training time varies with individual and according to division to which draftsmen is assigned."

"Five month program to supplement areas such as lettering, legibility and tolerancing."

"Work under experienced draftsmen."

"Beginning draftsmen run prints, do layout sheets for electrical, plumbing and mechanical, lettering title sheets and other misc. work."

"Lectures and class sessions on office standards and procedures; on the job training."

"On-the-job training for one year. Informal instruction in drafting practices and procedures for our firm."

"Beginning draftsmen work on projects of a simple nature."

"Two to three weeks - practice planning from original field notes - reproduce difficult drawings."

"Several months, under close supervision, on preliminary drawings - as time permits."

"Short practice, drafting studies of details and requirements to our office. (Ex. lettering, architectural details etc.)."

"One to six (6) months drawing revisions and detailing."

"Two weeks for simple tracing, and continued training in advanced phases of our work. Each man must also develop a competence in all computations and reduction of field survey notes."

"Work on simple plans."

"480 hours of training spread over a five month period. Training in good basic drafting practices for our firm."

In certain cases some firms indicated that they did not give any specific type of training to beginning draftsmen, however, they made the following comments concerning the practices they did use in helping these draftsmen adjust to their new employment:

"Teach them how to letter neatly, and how to layout a drawing."

"One is always training-working toward as little supervision as possible to get work done."

"Six months to one year under a senior draftsman."

"Informal, varies with the individual."

"On the job-as requires."

The above statements provide valuable information as it relates to a beginning draftsman and what he may expect in the way of further training upon entering employment as a technician in this area. Further value of these comments was evident as it related to the basics of drafting in which some firms feel these beginners need further instruction and assistance. The importance of providing complete and detailed instruction in the basic fundamentals of drafting is of utmost importance. However, students of drafting must be made to realize that upon entering employment they must maintain a certain amount of flexibility which will allow them to apply basic practices to the standards of the particular firm in which they gain employment. The largest percentage of firms replying to the survey do hire beginning draftsmen, with many of these firms providing some type of additional training for these persons before they go to work on usable drawings.

CHAPTER IV

RELATED AREAS OF DRAFTING PROGRAMS

Mathematics and Science

In order for a draftsman to complete a drawing or set of plans he should have a basic knowledge of the information that must accompany most drawings. The ideal method of learning the shop processes, field knowledge or related information as concerned with drawings is to acquire some actual work experience in these fields that are closely related to drafting. Most technical drafting students have had very little time to pursue such activities. If they are to gain these experiences, in an effort to broaden their background, they will most likely have to take additional course work related to the type or types of drafting they have chosen to pursue. Such related courses might be in the areas of electronics, mathematics, metal, science, surveying or other such subjects pertaining to the area of drafting.

The technological changes that are taking place in our society today are becoming more complex and for the most part center around more accurate specifications with less tolerance being the rule. It is very difficult for today's technical draftsman to achieve much success in the area of drafting without a basic background in mathematics.

Included in the first part of the questionnaire, were five mathematics courses for respondents to check if they believed these courses should be required for drafting majors. The results of these findings are listed in Table III.

TABLE III

MATHEMATICS COURSES OF COLLEGE LEVEL CHECKED AS BEING REQUIRED FOR DRAFTING MAJORS

Mathematics Courses	Number of Firms Checking	Percentage of sixty-eight Firms Checking	Not Checking
General Mathematics	47	69.2	30.8
Algebra	39	57.3	42.6
Trigonometry	48	70.5	29.4
Calculus	5	7.3	92.6
Technical Mathematics	37	54.4	45.5

Read thus: There were 47 or 69.2 per cent of the sixty-eight firms replying to the questionnaire that felt General Mathematics should be required of technical students who were majoring in drafting.

In general, with no specific attention given to the type of drafting carried out by the sixty-eight firms responding, college courses in general mathematics was checked forty-seven times, algebra thirty-nine, trigonometry forty-eight, calculus five and technical mathematics thirty-seven times. For each mathematics course listed in the survey, with the exception of calculus, over fifty per cent of the replies indicated these particular courses should be required. One hundred per cent of the firms checked the question as to whether college mathematics courses beyond the level of general college mathematics should be required. A combination of various types of mathematics to be required was listed by twenty firms as including general mathematics, algebra and trigonometry. Eleven firms checked technical mathematics as the only requirement while five firms

listed a combination of general mathematics, algebra, trigonometry and technical mathematics as being required in the student's program, while there were only three firms checking that all the courses listed should be required.

These combinations included a total of seventy-five per cent of the sixty-eight replies; the remaining twenty-five per cent of the returns checked the mathematics courses with no particular sequence or pattern being evident. Courses listed, other than the ones printed on the form, included slide rule, checked once, and analytic geometry which was checked twice.

Since the day of Sputnik, with an increased emphasis placed on the importance of science and mathematics, a follow-up question was included to determine what science courses, if any, should be recommended for technical drafting students. Table IV gives the responses to this question.

The three courses in science most often checked as being recommended, according to the survey, were Introduction to Physical Science, General Science and Technical Physics in that order. Over fifty per cent of the firms that replied felt the three courses mentioned above should be recommended for technical drafting majors. An introduction course in chemistry was checked nineteen times while technical chemistry was only checked nine times. No specific group of science courses could be determined as holding any significant relationship in the data. The largest number of firms checking any specific group of science courses to be required included the introduction course in Physical Science, Technical Physics and General Science. Ten firms checked these three courses while

the remaining fifty-eight firms rendered a scattered response by checking the different courses listed on the question. Three additional courses were written in as being necessary for drafting majors including, Geology and Strength of Materials, each receiving three checks, and Materials and Methods listed as being recommended.

TABLE IV

SCIENCE COURSES OF COLLEGE LEVEL RECOMMENDED FOR DRAFTING MAJORS

Science Courses	Number of Firms Checking	Percentage of Firms Checking	Not Checking
Introduction course in Physical Science	46	67.6	32.3
Introduction course in Chemistry	19	27.9	72.0
Technical Physics	36	52.9	47.0
Technical Chemistry	9	13.2	86.7
General Science	38	55.8	44.1

Other Related Courses

At this point it seems advisable to include other related courses that should become a part of a future draftsman's curriculum. Various types of drafting may call for courses of instruction valuable to only one or two types of drafting, such as a course in metal working as it relates to machine drawing, or surveying as it would relate to map drafting. However, the purpose intended by this study in conjunction with

drafting and the related areas on instruction, was to try to determine what courses would be most valuable in training technical draftsmen.

A group of ten courses were listed in the questionnaire to be checked as either, "necessary", "helpful" or "of no value" to a student preparing himself as a draftsman. The majority of the courses listed, were determined as "necessary" or at least "helpful" in the training of draftsmen. Table V gives the responses to this question.

TABLE V

THE VALUE OF RELATED COURSES IN THE TRAINING OF TECHNICAL DRAFTING STUDENTS

Related Courses	Number of Firms Checking	Percentage of firms Checking as: Necessary	Helpful	Of no Value	Percentage of Firms not Checking
General Metals	55	26.4	44.1	10.2	19.1
Machine Shop	57	27.9	38.2	17.6	16.1
Electricity	53	14.7	51.4	11.7	22.0
Photography	53	8.8	35.2	33.8	22.0
Electronics	51	8.8	44.1	22.0	25.0
Mechanics	60	36.7	42.6	8.8	11.7
Surveying	59	29.4	42.6	14.7	13.2
Metallurgy	47	5.8	30.9	32.3	30.8
Wood Construction	55	22.0	38.2	20.5	19.1
Design	58	57.3	25.0	2.9	14.7

Mechanics was checked the largest number of times and was regarded by thirty-six per cent of the respondents as being necessary for beginning draftsmen. This course was also listed as being helpful to students of drafting by forty-two per cent of the respondents. Eight per cent of the firms felt the course in mechanics was of no value as related to drafting. The course in design was rated the highest with fifty-seven per cent of the firms indicating this course was "necessary", twenty per cent checked the course as "helpful", while only two per cent found it "of no value" and fourteen per cent did not check the reply. Other courses checked as being of definite value to drafting were general metals, surveying, machine shop, electricity and wood construction. An indication of the importance of these courses to drafting students can be assessed by adding the percentages of replies that listed these courses as "necessary" or "helpful". In this figure, surveying had a combined total of seventy-two per cent, general metals had a combined total of seventy per cent, electricity and machine shop each had a combined total of sixty-six per cent with wood construction combining the "necessary" and "helpful" columns for a total of sixty per cent. The three courses receiving the least percentages of being "necessary" or "helpful" were metallurgy, photography and electronics in that order with metallurgy being the lowest in value to drafting majors.

Other courses written in on the replies as being "necessary" by two different firms were structural detailing, building specifications, photogrametry and cartography; construction principles, foundry and patternmaking were each listed one time in the space provided. In addition the course in structural detailing was listed as being "helpful"

in two replies and the course in construction was listed by one other reply as being "helpful".

The necessity of related courses that will supplement drafting or at least be helpful to students in this area are well established by the results of the survey. A student in drafting, for instance, when working on a set of plans for an electrical circuit or machine part, will be much better qualified to handle this responsiblity if he has taken at least a basic course in electronics or machine shop. Related courses or experience in the fields associated with drafting can be a valuable asset to a draftsman in helping him to gain a first hand knowledge of the complexities most often included in a set of plans. To become successful in any type of drafting, a knowledge of the processes,materials, methods, procedures, terminology and other related practices must be mastered in the chosen area of drafting. The technical draftsman of today can no longer be content to confine his skills to work on the boards; he must be trained to such an extent that he can become a technician capable of bridging the gap between the engineer and the skill of the craftsman.

CHAPTER V

DRAFTING PRACTICES

Drafting is a key function in almost any of the engineering, civil, military or production firms. Draftsmen may have to be prepared to make drawings for shop production, electrical layouts, maps and other types of technical plans that are completely legible and comprehensive so any firm or organization, when necessary, can work from these plans. The requirements of legiblity will continue to become more demanding with the technical advances of drawing reproduction, particularly with the increased emphasis on microfilming and other methods and materials now being used to copy drawings. A great deal of the practices that are common to successful drawing reproduction can be directly linked to the basic fundamentals of drafting such as lettering, neatness, clean sharp linework and dimensioning practices.

The advent of the space age has brought about a tremendous impact on drawing and the firms that must perform much of this type of production. For the most part, the space program is associated with our government which requires the firms doing any work for this program to follow military or federal specifications. Here again, the basic drafting practices play an important role in drawings either being accepted or rejected by the drafting checkers employed by the government. Drawings that are rejected may have to be completely redrawn or might require only a revision or two. This practice often holds true for a drawing in any firm, whether it is government or an individual contractor. The importance of the basic practices mentioned above and other basic practices of

equal importance should be included as a fundamental portion in the training of technical draftsmen. Although a large number of high schools in Arizona stress the importance of these basic principles in their drafting classes, the need for applying these principles in advanced training is also of considerable importance.

An article written by a drafting supervisor in one of Arizona's largest electronics firms, concerning the training of draftsmen in educational institutions, pointed out the following as being the five main weakness of their training.

1. Proficiency in hand printing.
2. Good clean, sharp and dense linework.
3. Proper drawing layout and reasoning ability. More logic needs to be explained to students here. Usually they are given such instructions as, "put views in center of the paper, space them 1" to 2" apart," etc.
4. Pride in their craftsmanship.
5. Knowledge of electrical symbols and electrical diagrams. (for electrical draftsmen).[1]

Articles such as the above and conferences with other drafting supervisors were valuable in helping to design the section of the questionnaire concerning drafting practices.

A question was constructed in an effort to determine what practices were being employed, concerning line construction that is being used in the firms replying to the survey. Supervisors were asked to check ten of the major lines in the line alphabet according to the darkness and width of these lines. The only significant implication in line work according to data received was an increased emphasis on the darkness of

---

[1]Art Davis, "Motorola's Drafting Organization Procedures and Educational Training Program" (Article presented to drafting instructors at a workshop, Phoenix, Arizona, June, 1964). p. 3.

lines. There were thirteen replies that indicated they used only dark lines in their drawings; a further study of these thirteen replies revealed that contrast was gained by the thickness of lines.

A follow-up question was included that asked if instructors had placed too much emphasis on the different width and darkness of lines. Of the sixty-eight replies, fifty-seven respondents checked this question; forty-one replied that instructors had not placed too much emphasis on the practice, while sixteen indicated that emphasis in this respect had been too great.

A study of industrial magazines and classes attended in the past indicated that some effort had been made to discontinue the use of arrowheads for terminating dimension lines. A question to this effect was designed and included in the survey asking if arrowheads, dots or other methods were being used for this practice. The results of this question are shown in Table VI.

TABLE VI

METHODS FOR TERMINATING DIMENSION LINES

Method Practiced	Number of firms Checking
Arrowheads	54
Dots	2
Combination of Arrowheads and Dots	5

The replies indicated that fifty-four firms used arrowheads, five used a

combination of both arrowheads and dots, two firms make it a practice to use only dots, two firms did not use anything to terminate these lines while three firms made use of a slash mark. A comment by two firms not using arrowheads gave the reason that arrowheads were too time-consuming to construct.

One of the frequent criticisms often heard in the circles of drafting personnel is the quality of lettering that is often exhibited by beginning draftsmen. In order to establish how well a beginning draftsmen had been trained in lettering prior to employment, a question was included in the survey asking the supervisors if beginning draftsmen had received adequate training in lettering. The question listed three possible selections to check to determine if most, some, or a few workers had received adequate training in lettering. Table VII describes the results of the replies.

TABLE VII

THE TRAINING OF BEGINNING DRAFTSMEN IN ADEQUATE LETTERING PRACTICE

Have beginning draftsmen received adequate training in lettering?	Number of firms checking
Most	8
Some	15
Few	42
Not checking	3

There were sixty-five of the sixty-eight replies answering this particular question. Of the sixty-five replies, eight firms indicated "most" draftsmen had received adequate training in lettering; fifteen indicated "some" beginners had been adequately trained, while forty-two replied that "few" of these beginning personnel had been adequately trained. No space was provided on the questionnaire for comments to this particular question, however some comments were written in stating that none of the beginners had been adequately trained in this respect.

A follow-up question concerning lettering was included in an effort to determine the standards that were being followed by draftsmen for placing the lettering on the drawing. The results on this question are given in Table VIII.

TABLE VIII

THE STANDARDS OF LETTERING

Standards Used	Number of firms Checking
Draftsmen follow standards set up by our company	29
Drafting standards are followed with some modifications	9
Military specifications are followed	13
Draftsmen select their own style	24

The largest number of replies indicated that draftsmen follow the standards set up by the individual firms with twenty-nine checking this procedure. In twenty-four firms draftsmen were at liberty to select

their own style; thirteen firms indicated military specifications were followed; the other nine replies checked that department standards were followed with some modifications. The most popular style of lettering practiced in these firms was vertical capital lettering which was checked as being used by forty-five firms while the inclined capital

TABLE IX

TYE STYLE OF LETTERING USED BY REPLYING FIRMS

Style of Lettering	Number of firms Checking
Capital	
Vertical	45
Inclined	13
Both vertical and inclined	10
Lower case	
Vertical	12
Inclined	10
Both vertical and inclined	5
Not checking	41

letter was in use by only thirteen firms and ten firms made it a practice to use both styles. Lower case lettering, in the vertical style, was used by twelve firms and the lower case inclined was used on drawings by ten firms. A total of forty-one replies indicated that capital and lower case letters were not used on the same drawing. Twenty firms stated they did use the upper and lower case letters on the same drawing.

Table IX gives the responses concerning the style of lettering practiced by replying firms.

Since drawing is a graphic language, many line symbols have been developed to represent particular features that are used repeatedly on certain drawings. These symbols are economical in producing a drawing, and for this reason there have been many templates designed to aid in a quick accurate rendering of these symbols. Templates and symbols have become a part of the standard tools used by almost all drafting departments.

The question pertaining to beginning draftsmen and their knowledge in the proper use of templates revealed that of the sixty-eight replies, thirty-six of the firms felt "some" of these beginners were adequately trained; sixteen replied "few" were adequately trained; while twelve firms indicated that "most" beginning draftsmen were trained in the proper use of templates.

TABLE X

KNOWLEDGE OF BEGINNING DRAFTSMEN IN THE PROPER USE OF TEMPLATES

Are beginning draftsmen receiving adequate training in the use of templates?	Number of firms Checking
Most	12
Some	36
Few	16
Not checking	4

Of the sixty-eight replies there were four of the firms that did not answer this particular question. The tabulated responses to this question appear in Table X.

In almost any type of drafting, there are certain symbols often used to speed up the work and aid in reading the drawing. In view of past experiences and a study of industrial drafting practices concerning the use of symbols, a question was included in the survey to determine how well beginning draftsmen had been trained in their use. The results of this question can be seen in Table XI.

TABLE XI

KNOWLEDGE OF BEGINNING DRAFTSMEN IN THE PROPER USE OF SYMBOLS

Have beginning draftsmen received adequate knowledge and training in the use of symbols?	Number of firms Checking
Most	3
Some	25
Few	37
Not checking	3

Of the firms replying to the survey, thirty-seven indicated "few" beginning draftsmen had been adequately trained in this respect; twenty-five firms replied "some" draftsmen had been adequately trained, while only three were found to reply that "most" beginning draftsmen had been adequately trained in this respect. There were three of sixty-eight firms

not answering this question. Many practices have been developed that improve drafting procedures, but one practice that has always been a problem to draftsmen is the number of revisions that must often be applied to a drawing or set of plans.

Changes on drawings are necessitated by changes in design, tools, desires of customers, and by errors in production or errors made by the draftsmen. In some cases changes might require the complete drawing to be made over; however, in most cases, revisions are made by erasures directly on the drawing. Revisions are a common practice in most firms and are handled in a variety of ways. It was on this basis that a portion of this section of the questionnaire was devoted to the revision of drawings.

TABLE XII

AWARENESS OF BEGINNING DRAFTSMEN CONCERNING THE USE OF DRAWING REVISIONS

Are beginning draftsmen aware of the fact that revisions are a necessary part of drafting practices?	Number of firms Checking
Most	3
Some	24
Few	39
Not checking	2

A particular question was designed to determine how well beginning draftsmen had been trained in this respect and if they were fully aware of the

fact that revisions are necessary for some drawings. To view the results of this question see Table XII. A follow-up question was included in an effort to determine how revisions were being carried out by the firms answering the questionnaire. The tablulated responses to this question appear in Table XIII.

TABLE XIII

METHODS OF REVISING DRAWINGS

Method	Number of firms Checking
Draftsmen make their own revisions	50
Special draftsmen are employed for revision work	0
Both of the above practices are used	11
Firms not checking	7

There were thirty-nine firms replying that beginning draftsmen were not fully aware of the fact that revisions were a necessary part of drafting practices. Twenty-four firms indicated that "some" of the beginning draftsmen were aware of this necessity, while only three firms checked that "most" beginning draftsmen were aware of the importance of revisions. A total of sixty-six of the sixty-eight respondents had checked this question. A follow-up question was used in the survey to determine who made the revisions that were necessary for certain drawings. The data revealed that draftsmen revised their own drawings in fifty of the sixty-eight replies. There were eleven of the returns indicating

that a dual practice was used where special draftsmen were employed to make revisions as well as the original draftsmen doing some of his own revising. None of the firms indicated that special draftsmen were employed to handle all revisions work. Seven of the respondents had not checked the manner in which the revisions were handled.

To further determine the importance of changes that must be made on drawings, a question was included to see if more drawings should be assigned by instructors that would require certain revisions. The results of this question appears in Table XIV.

TABLE XIV

IMPORTANCE OF DRAFTING ASSIGNMENTS THAT REQUIRE THE USE OF REVISIONS

Should instructors assign more drafting problems that will require the use of revisions?	Number of firms Checking
Yes	55
No	9
Not checking	4

Sixty-four firms checked this question with fifty-five of the replies stating that more drawings requiring revisions should be used; nine firms checked this practice as un-necessary.

As pointed out earlier in this chapter, a great many revisions are made on drawings by erasing the undesired work and adding the correction. On certain occasions, at workshops and seminars, industrial drafting

personnel in Arizona have pointed out that some instructors have placed so much emphasis on neatness that beginning draftsmen are reluctant to erase on a drawing that may need revisions. Table XV indicates the emphasis concerning erasing on a drawing.

TABLE XV

IMPORTANCE OF INSTRUCTION CONCERNING ERASING ON DRAWINGS

Are beginning draftsmen reluctant to erase on a drawing when changes are necessary?	Number of firms Checking
Most	17
Some	27
Few	20
Not checking	4

The question concerning the reluctance of beginning draftsmen to erase when changes were necessary, indicated that of sixty-four firms completing this question, twenty-seven respondents checked that "some" draftsmen were reluctant to erase; twenty firms checked that only a "few" draftsmen were reluctant to erase, while seventeen indicated that "most" beginning draftsmen were reluctant to erase in order to make a change on a drawing.

The technical information that must accompany many drawings today has brought about an increase in the number of notations and specifications that are required to fully describe a drawing or set of plans.

Since a certain amount of notations and specifications are common to most drawings, it was desirable to include in the survey some particular questions that would reveal the views of industry as they relate to notations and specifications on drawings and the manner in which this information was to be placed on the drawing. Table XVI describes the view of industry concerning notations and specifications.

TABLE XVI

EXPERIENCE OF BEGINNING DRAFTSMEN CONCERNING THE USE OF NOTATIONS AND SPECIFICATIONS

Have beginning draftsmen received adequate training in applying notations and specifications to a drawing?	Number of firms Checking
Most	4
Some	10
Few	50
Not checking	4

Fifty of the replying firms checked that "few" beginning draftsmen had been adequately trained in the use of notations and specifications that apply to a drawing or set of plans. Ten of the respondents indicated there were "some" beginning draftsmen properly trained in this respect, but only four firms checked "most" beginning draftsmen had been adequately trained in the use of notations and specifications.

To further evaluate the practices concerning the specifications that usually accompany a drawing, respondents were asked to check the

method or practice used by their firm in writing these specifications that accompany a set of plans. For the results of this reply see Table XVII.

TABLE XVII

METHOD OF APPLYING NOTATIONS AND SPECIFICATIONS TO A DRAWING

Method used to apply notations and specifications to a drawing.	Number of firms Checking
Lettered	36
Typed	9
Both of the above used	21
Not checking	2

Sixty-six firms answered the question with thirty-six replies checking that specifications were lettered; nine replies indicated this information was typed, while twenty-one firms made it a practice to use both typing and lettering. Some of the firms responding to this question inserted additional comments that were of value to the study as listed below.

"A special type face is used on drawings by typing on stick on material."

"Typing is hard to change and impossible on large drawings."

"Notes and legends are lettered - long legals are typed."

"All notations on drawings larger than 8½ x 11 are lettered."

"Specifications are generally typed on orange back vellum and inserted in the drawing with special drafting tape."

The comments pointed out some of the latest methods that are being practiced concerning lettering. Another device in use by some firms is a special typewriter with an especially long carriage. This particular typewriter is equipped to receive a special type that resembles hand lettering. The style of lettering to be used is inserted in the typewriter and produces lettering on a drawing which has been typed.[2]

Some changes in drafting practices have taken place very rapidly while others take on a gradual change. Such is the case when inked drawings are being considered. The inking of drawings has been in use since Egyptian times where lines were first scribed in stone and drawn over with ink and reed pen. Up to 1925 most drawings were still inked but in 1934 the use of penciled drawings was greatly accelerated and during the next two years there was a veritable revolution as draftsmen made use of the pencil for drawing on almost any material.[3] This trend continued to increase during World War II; although many improved techniques and inking tools in use today indicated that the trend of inking drawings might be changing again. A question in the survey was designed in an effort to determine the percentage of drawings that are being inked in the firms of Arizona replying to the survey. The results of this question can be noted in Table XVIII.

There were thirty-two of the sixty-eight replies that did not use ink for their drawings. One firm failed to check the question and the remaining thirty-five firms used ink for a part of their drawings.

---

[2]Demonstrated at Motorola Incorporated, June 1964, 8201 East McDowell, Scottsdale, Arizona.

[3]V. and E. Manufacturing Co., Historical Note on Drawing Instruments. A booklet prepared by the Vemco Drafting Company. Pasadena, Californis, 1950, pp. 11-13.

Three of the four firms listed in the ninety-one to one-hundred percentage of Table XVIII indicated that they did all of their drawings in ink.

TABLE XVIII

APPROXIMATE PERCENTAGE OF DRAWINGS THAT ARE INKED

Percentage of drawings inked as indicated by the replies	Number of firms Checking	Percentage of 68 replies
0	32	47.0
1-10	11	16.1
11-20	4	5.8
21-30	0	0
31-40	0	0
41-50	7	10.2
51-60	1	1.4
61-70	1	1.4
71-80	3	4.4
81-90	4	5.8
91-100	4	5.8
	Total 67	

In the space left for additional comments on this question, the firms checking that none of their drawings were inked, made the following statements:

"Illustrations and special work is sometimes done in ink."

"We ink only drawings that will be displayed or reduced and published."

"Modern methods make this almost unnecessary."

"Except when contract requires."

"We use ink mostly for pre-line or presentation drawings - not for working drawings."

"We are using plastic lead on mylar."

"Technical illustrations are inked for reproduction."

The following comments to the question on inking was made by the firms that did ink some of their drawings. To make the comment more valuable, the percentage of drawings that were inked by the firm commenting is listed at the end of each statement.

"Pencil drawings must be adequately prepared for Good reproduction prior to inking." (80 per cent)

"Shop drawings pencil, outside drawings inked." (20 per cent)

"Architectural drawings pencil - Engineering drawings inked." (60 per cent)

"Expect only senior draftsmen to do this work." (10 per cent)

"Use of rapidograph technical fountain pen." (15 per cent)

"Most drawings are india ink on linen or clearprint." (85 per cent)

"Our drawings are put on public record or in files of government agencies and are reproduced many times." (100 per cent)

"All new construction in ink." (50 per cent)

"Both linen and vellum are used." (45 per cent)

"Advertising illustrations and internal specifications are inked." (10 per cent)

"Since going to rapidograph pens and mylar, we are doing more inking." (15 per cent)

"Only electrical drawings intended for some publication purposes." (65 per cent)

"Ink on linen." (100 per cent)

The comments listed were valuable to the study for the different uses, techniques and materials that are associated with inked drawings. The types of drawings carried out in the firms of Arizona are varied and call for a number of different approaches in the rendering of a drawing.

The increased emphasis on the space program and military projects have been instrumental in supplying some of the firms of this state with contracts or sub-contracts that require drawings to follow military specifications. There was a desire to try to determine in this study the number of firms in this state that did work for the government which required them to comply to military specifications. Table XIX shows the results of this question.

TABLE XIX

FIRMS ENGAGING IN WORK FOR THE GOVERNMENT THAT REQUIRE DRAWING TO MEET MILITARY SPECIFICATIONS

Is your firm engaged in any work that require drawings to meet military specifications?	Number of firms Checking
Yes	29
No	34
Not checking	5

The replies revealed that twenty-nine firms engaged in drawings that require them to comply with military specifications. There were thirty-four firms that did not follow military specifications for any of their work. In the course of visiting some of these firms in early preparation

for the study, there were some comments made by drafting supervisors that would indicate a trend was being developed for industries to pattern their standards to follow military specifications. A question was included in the survey in an effort to establish some factual data concerning this view. Table XX gives the results of this question.

TABLE XX

VIEWS CONCERNING THE TREND OF INDUSTRY TO PATTERN THEIR DRAFTING STANDARDS TO FOLLOW MILITARY SPECIFICATIONS

Is industry developing a trend to pattern their standards according to military specifications?	Number of firms Checking
Yes	20
No	27
Uncertain	16
Not checking	5

There were twenty firms indicating a trend was developing in this direction while twenty-seven checked that they did not feel any standard of this nature was developing. There were sixteen firms undecided about such a trend. Military specifications are very exacting and in some cases difficult to understand. A great deal of criticism has been leveled at military specifications as they apply to drawings. In order to better understand the position of firms concerning the possibility of a trend to pattern their standards after military specifications the reader is directed to the following comments as taken from the survey.

"For our type of work, mil. specs. would be too costly. We have to use as many, (short cuts), as possible to meet deadlines and keep cost to a minimum."

"Standards are necessary on drawings but not as per military specs."

"More and more companies are going into the space program either directly or indirectly and they must conform to all applicable mil-specs or lose business."

"To follow mil-specs would be very costly and time consuming."

"Industries are tending to adopt mil-specs. Since government purchasers are buying a larger variety of products and requiring documentations, industry is anticipating the need and documenting to these specs."

"A trend is (unfortunately) developing to follow mil-specs."

"State and city eng. depts. as well as corps. of Engrs. require specific lettering height for ½ reduction."

"Industries are too varied to adopt one standard that will meet the requirements of each."

"All of our customers request that mil-specs-70327 be followed and all drawings be microfilmed upon completion."

"I hope not"

"Government mil-specs are almost a must in any of the larger companies in the Western Area."

The use of some type of standardization is almost a necessity for any firm that participates in drafting as a part of their activities. Many times these establishments devise their own standards when they are not obligated to adhere to the policies of other agencies. This has made standardization of drafting practices a very complexing problem which continues to exist. This problem has been solved to a certain extent by the adoption of the American Standards Association, the American Institute of Architects, The American Welding Society and many other well known agencies that devise the standards used in many areas of drafting.

Students should be advised and instructed in the use of standards and their importance. They should further be introduced to the fact that they need to adopt themselves to the standards of the firm for which they will be employed. No one institution can possible create situations that will suit the demands for each individual firm using drafting in the production of goods and services. Not only is the above true in the case of a set of standards; the tools and materials with which a draftsman must work will also vary from one firm to another.

The materials draftsmen use to place their drawings on are changing to a certain extent due to technical advances in reproduction and documentation. An important factor of the study was to try to determine what type of materials are best suited for drafting.

TABLE XXI

PERCENTAGE OF MATERIALS USED FOR DRAWINGS

Materials	Number of firms checking the per cent of use for each material. 100	75	50	25	*Not used
Manila paper	1	0	0	5	
Tracing vellum	27	17	10	9	
Plastic film	2	2	4	19	
Tracing cloth	1	4	3	9	

Read thus: Twenty-seven firms make it a practice to use tracing vellum for all of their drawings; seventeen firms use tracing vellum for 75 per cent of their work; ten firms do 50 per cent of their drawing on vellum and 9 firms use tracing vellum for 25 per cent of their work.
*Note: The data for the last column was not tabulated due to the lack of responses.

A list of four different materials was included in the questionnaire to be checked according to the percentage used by the firms participating in the study.

A glance at Table XXI, page sixty-one, reveals tracing vellum as the most used drafting media in the firms replying to the survey. Only one of the replies failed to answer this particular question. Another interesting fact concerning the use of these materials is that thirteen of the firms using vellum seventy-five per cent of the time also checked the use of plastic film for the remaining twenty-five per cent of their drawings.

Included in the section on drafting practices was a question to

TABLE XXII

PERCENTAGE OF USE FOR DRAFTING INSTRUMENTS

Instruments	Percentage of use for each instrument 100	75	50	25	*not used
T-square and Triangles	4	3	3	6	
Drafting Machines	26	5	7	6	
Parallel Rule and Triangles	15	7	2	8	

Read Thus: The T-square and triangles were used 100 per cent of the time by four firms, 75 per cent of the time by three firms, 50 per cent by three firms and 25 per cent of the time by six firms.
Note* The column "not used" was omitted due to a lack of response.

determine the straight line instruments used for technical drafting. Respondents were asked to check the types of instruments used by draftsmen under their supervision and the percentage of use given each type.

The data in Table XXII points out that firms in Arizona, for the

most part, are using drafting machines and parallel rules with triangles for the bulk of their drawings. It is evident according to this survey, that these instruments should be included in the training of technical draftsmen.

A study of drafting practices would hardly be complete without some attention given to the basics of dimensioning. There are two common methods used for placing dimensions on a drawing, the aligned and the unidirectional. Each respondent was asked to indicate the practice they followed for placing dimensions on drawings. Fifty-two firms checked this question with twenty-two using the aligned system, twelve used unidirectional with the remaining eighteen firms indicating both methods were used. The persons completing the questionnaire was then asked to check the importance of ten dimensioning practices that should be stressed by drafting instructors.

A study of Table XXIII, page sixty-four, quickly reveals that more emphasis should be placed on accuracy as applied to dimensioning. All of the other practices were checked as being very important or important, in the majority of cases. The four areas checked the most often, as not being important were:

1. Dimensioning with fractions
2. Tolerance and tolerance build up
3. Tolerance ranges and surface roughness
4. Position tolerance

The data presented concerning dimensioning, revealed that considerable attention should be given to this area of drafting instruction.

In summary this section of the study revealed that adequate training in basic practices is very important to drafting students. Beginning draftsmen are especially weak in their ability to letter properly, use

TABLE XXIII

IMPORTANCE OF DIMENSIONING PRACTICES DRAFTING INSTRUCTORS SHOULD STRESS

Dimensioning Practices	Importance indicated by number of firms checking Very Important	Important	No Importance
Placement and spacing of dimensions on drawings	43	19	1
Dimensioning with decimals	25	29	6
Dimensioning with fractions	22	23	15
Tolerance and tolerance build up	25	10	17
Tolerance, ranges and surface roughness	15	18	18
Position tolerances	14	18	17
Accuracy in dimensioning	58	6	0
Classification and practice in dimensioning fits	12	25	12
Use of datum points	24	28	7
Co-ordinate dimensioning	24	29	5

symbols and make necessary revisions to a drawing. Other important values indicated that most industries make it a practice to use drafting machines in their work. The majority of drawings are done on tracing vellum using penciled lines rather than inking their work. Certain practices concerning dimensioning have caused problems for beginning draftsmen when working on drawings. An important feature of this section of the study is the fact that these weakness have been identified and can be helpful in the training of future draftsmen.

CHAPTER VI

PROBLEM SOLVING AND VISUALIZATION

One of the principal values to be obtained from a study of the graphic language is the training to visualize objects in space, that is, to use the "constructive imagination". The ability to think in three dimensions is a most important requisite of a successful draftsman.[1] Drafting students should use every opportunity to study visualization of drafting problems until they can express themselves quickly and accurately through the correct use of the graphic language.

TABLE XXIV

THE EXPERIENCE OF BEGINNING DRAFTSMEN TO PROPERLY PLAN AND SPACE THE VIEWS ON A DRAWING

Have beginning draftsmen been adequately trained in the planning and spacing of views on a drawing?	Number of firms Checking
Most	10
Some	33
Few	21
Not checking	4

The purpose of this chapter was to determine as near as possible how well beginning draftsmen had been trained in the basics of visual-

[1] Frederick E. Giesecke, Alva Mitchell and Henry Cecil Spencer, Technical Drawing (New York: The Macmillan Company, 1964), pp. 8-9.

ization and problem solving, and where instruction in this phase of drafting might need improvement according to the view of industry.

A question in the survey was designed to determine how well beginning draftsmen were able to carry out the problem of planning and spacing the necessary views of a drawing on paper. The question asked drafting supervisors to check if "most", "some" or "few" of these beginning draftsmen had the necessary experience to carry out this practice. The results of this question appear in Table XXIV, page sixty-five. There were sixty-four of the sixty-eight respondents that checked this question. Ten of the respondents were of the opinion that "most" beginning draftsmen had the necessary experience to plan and place views on the paper. There were thirty-three replies checking "some" and twenty-one checking "few" to this question. Comments on this question were as follows:

> "Sheet layout or design not pleasing, usually spend time on one detail or area of sheet.(over work areas). Know what is important." Some of them
>
> "Not necessary a criticism; usually because of not enough school type of work on larger projects to be able to think space out. Best attribute is a good letterer and line work." Few of them
>
> "Each sheet layout is discussed with supervisor." Few of them
>
> "Their biggest problem is centering a drawing on a paper (Planning ahead)." Some of them
>
> "Mostly they do not anticipate and allow space for dimensions and or auxiliary views that may be required." Few of them
>
> "Eliminating unnecessary views that should be stressed." Some of them
>
> "Problem is not visualizing, teach them to plan and arrange views for dimensions and clarity." Few of them

Comments of this nature can be helpful in understanding where some of the difficulties exist. A careful study of these comments could be

very worthwhile in helping to improve instruction in this practice. Some comments made on the replies were very closely related to parts of the following question which listed some of the possible areas that inexperienced draftsmen might find difficult when visualizing objects to be drawn.

There were seven possible trouble spots listed on the survey to be checked if the supervisor completing the form felt any of these were difficult for beginning draftsmen.

TABLE XXV

DIFFICULTIES ENCOUNTERED BY INEXPERIENCED DRAFTSMEN VISUALIZING OBJECTS TO BE DRAWN

Difficulties listed in survey	Number of firms Checking
Placing the views on the paper to the best advantage	37
Selecting views that are necessary in describing the object	45
Unable to visualize a sketch into a mental three dimensional picture	30
Breaking down a view, plan or assembly into the necessary details	37
Using the correct scale for the drawing	27
Selecting the correct size paper for the drawing	23
Slow in visualization	29

There was space provided at the end of the question for other difficulties and added comments. The results of the reply concerning the seven listed difficulties are given in Table XXV above.

The difficulty most inexperienced draftsmen seem to encounter in visualizing objects to be placed on paper is the selection of views necessary in describing the object. Another problem, checked as second in difficulty, was planning the views on the paper to the best advantage. Other difficulties written in on more than one questionnaire included: too many details, (four checking) speed, (two checking) and beginning draftsmen didn't know how to direct their work to another section of the drawing when a problem developed, (three checking). A few added comments were noted and read as follows:

> "Beginners are generally slow to grasp ideas new to them."
>
> "Drafting students should be subjected to an intense course in descriptive geometry."
>
> "Heavy emphasis should be placed on all items in this area, the drawing tells the story, should read clearly as a well written composition."
>
> "Most beginning draftsmen do not know what is required to make a detail work or an object complete."

Although the number of comments were rather limited on this question, they brought out some important points for consideration.

Since the description of material objects are a major part of many types of drafting, a question was included to determine the difficulties beginners might experience when drawing the required details. Eight difficulties were listed to be answered by a check mark as "most difficult", "difficult", or "not difficult". Table XXVI, page sixty-nine, describes the results of the replies.

Table XXVI indicated that beginning draftsmen are most deficiant in drawing the necessary details often required to describe an object. This listing was checked the largest number of times by the firms replying. There were only three firms checking this practice as "not difficult",

the remaining forty-nine firms checked this particular listing as being "most difficult" or at least "difficult" for beginning draftsmen.

TABLE XXVI

DIFFICULTIES EXPERIENCED BY BEGINNING DRAFTSMEN IN ILLUSTRATING NECESSARY DETAILS TO ADEQUATELY DESCRIBE AN OBJECT

Difficulties to be checked	Number of firms Checking		
	Most Difficult	Difficult	Not difficult
Failure to use symbols	2	18	18
Failure to use correct symbols	8	21	19
Auxiliary views often omitted	6	19	19
Failure to use sectioned portions	6	18	15
Scale of details often too small or inadequate	15	16	12
Details labeled incorrectly	6	14	23
Details are often drawn of unnecesary parts and standard items etc.	16	14	15
Necessary details often omitted	31	18	3

Visualization of objects can often become a difficult task, especially for the person who lacks the basic knowledge and practice that is necessary to describe many objects. One of the accepted subjects for teaching visualization of objects is descriptive geometry. In addition to its importance for visualization, descriptive geometry is important in the solution of many drafting problems, especially when dealing with special relationships of points, lines and planes. The extent to which descriptive geometry was necessary in the solution of

problems, according to the firms that participated in the study, appears in the data given in Table XXVII.

TABLE XXVII

NECESSITY OF DESCRIPTIVE GEOMETRY FOR THE SOLUTION OF DRAFTING PROBLEMS

Necessity of Descriptive Geometry	Number of firms Checking
Very necessary	17
Occassionally used	26
Seldom	18
Never	4

Descriptive geometry is used by firms in Arizona to some extent for the solution of drafting problems. Only four firms indicated that they never use it. The importance of this subject should be pointed out to students majoring in drafting for its value in visualization and as a practical method for the solution of many problems.

Two final questions in section one requested persons to indicate the type of pictorial drawings they were using in their work and what demand might exist for pictorial illustrators, in their firm or employment.

The first question listed five types of pictorial drawings to be checked by the firms. Table XXVIII gives the responses to this question.

The two most often used types of pictorial drawings, according to the survey, are isometric and perspective. Oblique was used to some

extent with twelve firms checking this type while dimetric and trimetric were seldom used.

TABLE XXVIII

TYPES OF PICTORIAL DRAWINGS USED BY REPLYING FIRMS

Types of Pictorial Drawing	Number of firms Checking
Isometric	41
Dimetric	6
Trimetric	6
Oblique	12
Perspective	30

The question concerning the demand for adequately trained pictorial illustrators revealed that twenty-one firms had a demand for draftsmen in this area, while thirty-six firms replied that there was no demand.

CHAPTER VII

COOPERATION OF INDUSTRY WITH EDUCATIONAL INSTITUTIONS

Up to this point in the study, the emphasis has been on drafting practices, how beginning draftsmen have been trained and where such training might need improvement. Chapter VII was intended for the purpose of determining industrial views concerning the improvement of instruction in drafting and the nature of cooperation that could be expected from the replying firms.

Technological changes in industry often occur at a rapid pace, with firms experiencing difficulties within their own ranks in keeping up with these changes. Educational institutions, likewise, experience similar difficulty in keeping courses, curricula and instruction abreast of these changes.

TABLE XXIX

THE VIEW OF INDUSTRY IN HELPING TO UPGRADE TECHNICAL DRAFTING PROGRAMS

Would industry benefit by helping technical schools upgrade their programs?	Number of firms Checking
Yes	57
No	0
Undecided	7
Not checking	4

There are a number of reasons for this difficulty and one is the lack of communication. This particular section of the study was designed to examine the gap in the communication link between the school and industry.

Drafting supervisors in the industrial firms were asked to indicate if they believed it would be to their advantage to cooperate with educational institutions in upgrading the course content of technical programs. The reponse to this question is given in Table XXIX, page seventy-two. Of the sixty-eight replies, sixty-four firms responded to this question. Of the three choices listed, "yes", "no" or "undecided", fifty-seven firms answered "yes". They thought this type of cooperation would be beneficial. Seven firms were "undecided", while no firms replied in the negative. A joint cooperation in this type of endeavor could be mutually valuable to education as well as to the firms that employ the graduates of these technical schools.

The instructors in technical drafting are expected to have had some industrial experience in the field of drafting in order to meet qualifications for teaching in this area. Most state certification agencies require such experience for drafting and other instructors who teach technical subjects. Arizona has this requirement. The respondents were asked to check the recency in years they believed technical drafting instructors should have had in actual work experience as a draftsman. Table XXX, page seventy-four, gives the results of this question.

Twenty-seven of the replies indicated that experience should have been as recent as the past three years; twenty-eight indicated six years was recent enough. A total of these first two figures shows that fifty-five or 82 per cent of the respondents were of the opinion that this experience should have taken place in the past six years.

Recent experience in any field is sometimes difficult to arrange in the case of educational instructors. Some employment opportunities exist during the summer months for instructors not on a full year contract; an ideal method of keeping up-to-date. However, many drafting instructors must spend their summers attending school for such reasons as keeping a certificate in force or for professional advancement. Combinations of educationally qualified and industrially qualified instructors are often very difficult to find.

TABLE XXX

RECENCY IN YEARS THAT TECHNICAL DRAFTING INSTRUCTORS SHOULD HAVE HAD INDUSTRIAL EXPERIENCE

Recency in years	Number of firms Checking
1 to 3 years	27
4 to 6 years	28
7 to 10 years	7
10 to 20 years	0
Recent experience not necessary	2

Read thus: Twenty-seven firms indicated that drafting instructors should have had industrial experience as a draftsman no longer than three years ago.

In view of the difficulty of finding and keeping instructors abreast of the latest technological changes, persons participating in the survey were asked to check five possible solutions to this problem. The respondents were to check five methods as "necessary", "helpful" or "not necessary". Table XXXI is a list of the five methods and the manner

in which they were checked.

The method most often checked as necessary was a summer workshop of two weeks in length carried out in industrial firms.

TABLE XXXI

METHODS FOR KEEPING TECHNICAL DRAFTING INSTRUCTORS UP-TO-DATE AND IN LINE WITH INDUSTRY

Method	Number of firms Checking		
	Necessary	Helpful	Not necessary
Summer workshops of one or two weeks in length carried out in various industrial firms.	16	32	3
Workshops in colleges representing a joint effort between industrial draftsmen and college instructors.	11	39	4
A workshop consisting of a tour of the industrial firms in Arizona that rely heavily on drawings for production.	12	32	9
College seminar courses with drafting supervisors as guest speakers from the various fields of drafting represented in Arizona.	9	29	12
A series of two or three day (on the board) workshops, at one of the state institutions with a drafting supervisor from one of Arizona's industries for each two or three day period.	11	32	8

This procedure was also checked as being helpful by thirty-two firms while only three replies indicated that this type of training was not necessary. The second method also met with general approval among the respondents with thirty-nine stating that workshops in colleges carried

on as a joint effort by industrial draftsmen and college instructors would be helpful. Eleven respondents believed that this type of program was "necessary", while only four firms checked it as "not necessary". The total group of possible methods of improvement were checked, for the most part, as at least "helpful". The method checked as least satisfactory, or "not necessary", was the college seminar course with speakers from the various fields of drafting. This listing showed that nine regarded it as "necessary", twenty-nine as "helpful", with twelve as "not necessary".

Nine respondents commented that drafting instructors should gain recent experience in the field through summer employment as draftsmen. In two other comments, it was implied that instructors should spend more time talking with firm superintendents, chief draftsmen and designers in an effort to keep abreast of the changing practices of drafting.

The data revealed that nineteen of the replying firms had participated in workshops or seminars for drafting instructors. Forty-nine supervisors replied that their firms had not participated in any activity of this nature. One last question in the survey was asked of all respondents. It concerned the number of persons that would participate in a workshop or seminar, for drafting instructors, providing the cost and place of instruction was satisfactorily approved by their firm. Table XXXII, page seventy-seven, gives the responses to this question. Thirty-one would be willing to participate in such a program; twenty-five indicated that they might participate; only five replied that they would not take part in such a seminar or workshop.

TABLE XXXII

PARTICIPATION OF DRAFTING SUPERVISORS IN WORKSHOPS TO UPGRADE TECHNICAL DRAFTING INSTRUCTION

Indication of supervisors concerning their willingness to participate in drafting workshops.	Number of Supervisors Checking
Yes I would participate	31
No I would not participate	5
Maybe I would participate	25
Not replying	7

In addition to a check of this question, some of the respondents, willing to participate, commented as follows concerning workshops and seminars:

"Any time I could be of value."

"I believe seminars and workshops are the answer to many problems. I have appreciated this opportunity to answer this questionnaire."

"If time is available when notified."

"If time permits, I would only be too glad to participate."

"Availability would depend on the work load."

"Scheduling the time required to participate."

"Providing it was worked out with Mr. - - - our chief engineer and Mr. - - - our President."

"We might be interested if the program is basically architectural, provided that such things can be fit into the scheduling problems, of project deadlines normal to most arch. practices."

Further comments written at the end of the survey read as follows:

"The basic problem we find in a beginning draftsmen is not a lack of technique, but a lack of understanding of what they are doing and why they are doing it."

"Instructors should keep up with latest drafting techniques - published by drafting supply companies - very latest information."

"A good draftsman in his field should have enough knowledge of this field to pass an engineering technician examination (or equivalent) in this field."

"Our work is confined mostly to large area topographic mapping; large area earthwork construction excavation and fills; highway construction plans, right of way maps; property and boundary control maps; land subdivision plots, water system or sewer system designs, etc. Most students are trained in mechanical drawing."

"One of our greatest lacks is in draftsmen, capable of professional quality free-hand lettering. There are, perhaps, 200 draftsmen employed at topographical and map drafting work in Arizona today, but the emphasis in college seems to be applied to machine shop drafting.

"I feel today the problem is, that the "on the board" training program in our schools is much too short and that good draftsmen are the result of practice, practice, practice, and more practice."

"Teach'em Rapidograph and Leroy! Layout!"

"We are more interested in the design work getting out so we can get things build - not too concerned with altering drafting techniques."

"We have worked with local educators in developing drafting training courses. Participated in, Siminar of American Institute of Design and Drafting, where educators were in majority of attendance.

"Recent experience necessary. Mechanized graphics making fast advances."

"With the many changes in construction and industry new techniques come about with them, therefore, I recommend a two (2) week workshop every year."

These comments are points of emphasis the respondents wished to make. Such comments should not be overlooked in an endeavor to upgrade and improve technical drafting instruction.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this final chapter is to briefly summarize the essentials of the study, and to draw such conclusions and recommendations as the data may warrant. There is a need to point out the problems as revealed by the survey, which could be used as guideposts by technical drafting instructors for improvement or enrichment of technical drafting programs.

According to the responses of drafting supervisors there is considerable activity in the state of Arizona in the following types of drafting.

A. Architectural
B. Civil
C. Construction
D. Electrical
E. Electronic
F. Illustrative
G. Machine and Mechanical
H. Map and Topographic
I. Structural
J. Tool and Die Design

The majority of firms in Arizona employ from one to ten draftsmen. There were 993 draftsmen employed by the firms participating in the study and 615 of the 993 draftsmen work in the larger firms that employ from 50 to 100 draftsmen.

Over fifty per cent of the replying firms, at the present time, make it a practice to hire beginning draftsmen. The data revealed that other firms had hired beginners in the past but found them inadequately trained. Only two firms who hired beginning draftsmen made an indication that most of them had been adequately trained in basic drafting practices and seventeen of the firms made it a practice to administer some type of further training before these draftsmen were assigned to working drawings for

their employer.

A need for improvement in basic drafting practices has been established by the survey. Certain practices were indicated as needing more improvement or up-to-date instruction than other areas. The replies further pointed out that instruction in technical drafting could be improved and most of the respondents were willing to participate in programs leading to this improvement.

Throughout this study the need for a closer cooperation of industrial firms and educational institutions has been established. There is a need for both groups to fully acquaint themselves with the problems and limitations of each as they strive to improve these conditions.

Conclusions

The factual data that were obtained through this study brought forth evidence of a substantial nature that seem to indicate the following:

1. Early educators were instrumental in the development of drafting as a technology. Many of their ideas were adopted to fit the needs of industry which has brought about continual change in the methods, tools and materials in drafting practice and in the teaching of drafting as a technical subject.

2. Students majoring as technical draftsmen should be required to take college mathematics courses that would include algebra and trigonometry or a course in technical mathematics of such a nature as to include the algebra and trigonometry, basic to the solution of drafting problems. The science courses should include general science, physical science and/or technical physics that would be required according to the area of

specialization.

3. Related courses that support the various types of drafting should, when possible, be included as a part of the drafting sequence. Courses directly related to the drafting students major field should be required courses. For example, a student specializing in map and topographic drafting should be required to take surveying.

4. Increased emphasis should be placed on dark lines to meet the requirements of high quality reproduction and the contrasts of the drawing should come about by different line widths.

5. There should be a continued emphasis placed on lettering until each drafting major becomes skilled in the art of hand lettering. The increased importance of reproduction methods, legibility, military specifications and the critical eye of a drafting checker will demand a high degree of skill in this respect. All styles of lettering are important but the majority of firms in Arizona are using vertical capital lettering.

6. Drafting students should become skilled in the appropriate use of templates and take advantage of their value for a faster, more accurate drawing. This does not mean that a student no longer needs to learn the basic practices of drawing the figures found on templates.

7. Continuing practice in the use of correct symbols should become a part of the training of future draftsmen. The use of notes and lengthy explanations should be dispensed with when an appropriate symbol could be used for the same purpose.

8. There was evidence supporting the fact that drafting instructors should make use of more drawing assignments which would require revisions. Drafting trainees should be made aware of the fact that revisions are common practice in almost any firm using drafting in their work.

9. Proper erasing is an important factor, especially in revision or correction work; beginning draftsmen should not be reluctant to erase in necessary cases; neatness is important; however, speed and accuracy are of more importance.

10. There is a need for draftsmen to have a working knowledge and practice in the art of inking a drawing; however, the trend of most firms in Arizona is for penciled drawings. Students desiring to do illustrative or other work that requires inking should become skilled in inking procedures.

11. Beginning draftsmen need more experience in applying notes and specifications to drawings. This application, for the most part, should be through the practice of hand lettering with some instruction concerning typed specifications.

12. The number of firms participating in drawings that must comply to military specifications support the fact that instruction in the use of these specifications is necessary.

13. Tracing vellum should be used for most drawings, with additional instruction and practice carried out on plastic film, tracing cloth and other transparentized materials.

14. Drafting trainees should be instructed in the proper use of T-squares and triangles; however, the bulk of their work should be done with drafting machines and parallel rules.

15. All dimensioning practices are important, but training students to be accurate in dimensioning is by far the most important of all these practices.

16. Technical drafting teachers should evaluate their program and

make certain that students receive adequate training and instruction in the following practices.

a. Selecting views that are necessary in describing the object.
b. Placing the views on the paper to the best advantage and breaking down a view, plan or assembly into the necessary details.
c. Ability to visualize a sketch into a mental three dimensional picture.
d. Slow in visualization.
e. Using the correct scale for the drawing.
f. Selecting the correct size paper for the drawing.

17. Beginning draftsmen experience the most difficulty in illustrating details of a drawing because they fail to include the necessary details that are required.

18. Descriptive geometry should be a required course for drafting students. It is valuable for its training in visualization and important to some degree in problem solving.

19. The types of pictorial drawings used by most firms in Arizona are isometric and perspective. Drafting students should be well informed of their importance and receive adequate training in drawing these types of pictorial rendering.

20. Firms in Arizona would benefit by helping technical programs upgrade their course content and instruction.

21. Technical drafting instructors should have had industrial experience within the past six years to be adequately trained in this field.

22. Drafting instructors in order to keep up-to-date and in line with industry should attend a summer workshop each year if possible, one or two weeks in length carried out in various industrial firms. Other activities that should be attended by drafting instructors when they are offered would be:

a. Workshops given in colleges through a joint effort between industrial draftsmen and college instructors.

b. A workshop consisting of a tour of Arizona's industries that rely heavily on drawings for production.
c. A series of two or three day (on the board) workshops, at one of the state institutions with a drafting supervisor from one of Arizona's industries for each two or three day period.
d. College seminar courses with drafting supervisors as guest speakers from the various fields of drafting represented in Arizona.

23. Fourteen supervisors or chief draftsmen in this state have participated in these programs in the past. Thirty-one representatives of the firms are presently willing to help with workshops and seminars while twenty-five additional representatives indicated they might be able to partake in such a program.

24. Stress should be given to the fact that Arizona as a state is advancing in scientific and technical know-how at a tremendous rate. The rapid growth in this direction will have a direct relationship on most technologies as well as the field of drafting. The educational institutions and the employers of their graduates must work together in an all out effort to provide the following, in adequately trained technicians.

a. Use the best combined resources to improve individual competence, present and prospective, without regard to race, sex, age or physical handicap.
b. Strive to place every technician in a job that best fits his talents and encourage his continued improvement along with his experience.
c. Encourage and train our technicians to develop a sense of purpose and pride in his work.
d. Make them aware of the changing manpower needs which will call for changing technologies and continuous study.

Need for Further Study

Research beyond the limit of this study has been deemed necessary to explore industry in a more detailed manner in an effort to obtain the views of industry concerning each of the ten types of drafting most often

used in Arizona. Research in this direction should be conducted so as to secure the most advanced practices and particular details as they relate to each type of drafting.

Recommendations

1. In order to solve some of the problems for improving drafting programs, educational institutions that have not already done so, would benefit by organizing an advisory committee for this purpose. The success of these committees in Arizona has been established for some technical programs, while others have been reluctant to take this approach. Successful programs of this nature have included the combined efforts of industrial representatives, technical instructors and the State Supervisor of Technical Education.

2. Administrators of technical programs should see that drafting instructors are provided the time, transportation and expenses to visit industrial firms, to gain a first hand knowledge of the tools, methods and materials that are common to their work in drafting. Employers, too, should make the same provisions for drafting supervisors or draftsmen of their firm to take time to visit technical drafting programs and indicate where improvements might be made, or perhaps learn why some teaching procedures are possible and others extremely different.

3. Workshops and seminars should be made available in the summer that would include programs carried out in educational institutions and industrial firms. The content of these programs should be co-ordinated through the State Supervisors office and lay committees of all sections of the state that would be involved.

4. An additional recommendation would be that technical drafting instructors should evaluate their own program to see if they are:

a. Using the latest practices in their instruction.
b. Using tools and materials common to industrial firms.
c. Informing students of the latest technological advances in drafting.
d. Making an attempt to explore industrial situations and pattern their drafting assignments to parallel industrial methods as closely as possible.

5. Drafting supervisors should evaluate the conditions in their own firm to see:

a. If technical programs can adequately train a draftsman to meet the specific requirements of their firm and other firms throughout the state.
b. How they might contribute in an effort to provide a better qualified graduate that might some day be under their supervision.
c. How they might be able to help institutions prepare a draftsman that would result in a shorter pre-training period once the graduate is employed.
d. Where drafting instruction in Arizona's institutions can be improved in order to be of value to their program.
e. Some of the accomplishments that have been made in the nation's industries directly or indirectly by educational institutions and their graduates.

6. A concluding recommendation would be to challenge instructors of drafting and firms in Arizona that employ draftsmen to join equally in an attempt to solve a difficult and complex problem. The combined efforts could provide industry with technical draftsmen that have a sound education in mathematics, science, related subjects and up-to-date drafting practices. This should be especially rewarding to the three that are directly concerned: the graduate, the firm and the instructor.

BIBLIOGRAPHY

Books

Baer, C. J., Electrical and Electronic Drawing. New York: McGraw Hill Company, 1960.

Bennett, Charles A., History of Manual and Industrial Education Up to 1870. Peoria, Illinois: The Manual Arts Press, 1926.

_____. History of Manual and Industrial Education 1870 to 1917. Peoria, Illinois: The Manual Arts Press, 1937.

French, Thomas E., and Charles J. Vierck, Fundamentals of Engineering Drawing. New York: McGraw Hill Company, 1960.

Giesecke, F. E., A. Mitchell, and H. C. Spencer., Technical Drawing. New York: Macmillan Company, 1960.

Henninger, Ross G., The Technical Institute in America. New York: McGraw Hill Company, 1959.

Hoelscher, R. P., and C. H. Springer., Engineering Drawing and Geometry. New York: Wiley Company, 1961.

Luzzadder, W. J., Graphics for Engineers. Englewood Cliffs, New Jersey: Prentice-Hall Company, 1962.

Bulletins

"Governor's Committee on Technical-Vocational Education," Education for a Changing World of Work. Phoenix, Arizona: State Department 1962.

Goldberg, Arthur J., Secretary., Manpower Challange of the 1960's, United States Department of Labor, Washington: Government Printing Office, 1961.

V. and E. Manufacturing Company., "Historical Note on Drawing Instruments." Pasadena, California, 1950.

Periodicals

Bureau of Census, "1962 Annual Survey of Manufacturers." The World Almanac and Book of Facts. New York: World-Telegram and the Sun, 1965.

Moss, Jerome, Jr., "Industrial Education Program Offers Option to Prepare Teachers of Technical Curriculums," Technical Education News, XXI (June, 1962), pp. 17-18.

Washburn, R. P., "Today's Tools and Techniques of Engineering Graphics," Engineering Graphics, (February, 1965) pp. 12-17.

Unpublished Materials

Davis, Art., "Motorola's Drafting Organization Procedures and Educational Training Program." Unpublished article, Phoenix, Arizona, 1964.

Davis, Art., "Vocational Training od Draftsmen Industry's Point of View." Unpublished Article, Phoenix, Arizona. 1963.

Moffett, Thurben J., "Thinking Outloud! Phoenix, Arizona: Drafting Workshop., 1963. (Zerox copy.)

APPENDIX A

Correspondence

COPY

Dear Mr. Oliver:

Thank you for your comprehensive questionnaire. We have great difficulty in securing draftsmen who can do the type of drafting we prefer.

Enclosed are several examples of the kind of drafting we use and expect of our draftsmen. This usually requires about one year of training in our office. By the time a draftsman receives our training he usually can get a job anywhere.

Thank you for your interest in improving drafting.

Yours very truly,

Gene E. Anderson
Consulting Engineer
Tucson, Arizona

COPY

Dear Mr. Oliver:

Thank you for sending us your questionnaire on basic drafting practices. For some-time now, I have wondered when someone would start doing something about the schooling of future draftsmen and their instructors. This has been quite a problem to us as well as other offices, I'm sure. Our training period is normally six (6) months long, which costs time and money. Better schooling, with up to date examples would allieviate this considerably.

Thanking you again I remain,

Very truly yours,

WHEELER - PETTERSON - COFFEEN

Roy B. Aros, Engineer
Tucson, Arizona

COPY

Dear Mr. Oliver:

The following comments are submitted to clarify or supplement information contained in your questionnaire.

In regards to type of drafting, I have checked off the basic type performed at my company. However; since I am only associated with the preparation of product drawings, all comments are related only to those drawings. To further clarify the mechanical designs, they are in the field of Gyroscopecs, Flight Instruments and Power Driven Actuators. These mechanical devices are densely packaged and a draftsman must be well acquainted with tolerances and geometric requirements.

In regards to the number of personnel in my design department, I've listed the total number rather than just listing the number of draftsmen. I 've felt that this type of information would be of more value to you. We also use approximately 10 sub contract draftsmen during our normal period of operation. During peak periods this number goes as high as 20 draftsmen.

As far as educational background of draftsmen, I've found that personnel with some college background advance more readily than those who did not have this background. It is our practice to up-grade deserving draftsmen to designer classifications. Therefore; those with better scholastic backgrounds will make better designers.

In regards to drafting practices, we follow rules set forth in Mil-D-70327 which is the basic military document for preparation of drawings. This spec in turn invokes many other specs in regards to drafting procedures. Copies of this spec and associated specs may be obtained from the following:

Commander, Headquarters
Wright Development Center
Wright-Patterson Air Force Base
Ohio

COPY

As previously stated my responsibility is for the preparation of production drawings. We also prepare pictorial drawings for overhaul and instructional manuals which are done in our publications department. If you desire information in this regard, write to Mr. Keith Roe at the same address noted on your questionnaire.

I have participated in cooperating with Phoenix College and Phoenix Union High School in regards to educational requirements of draftsmen. Tours of our manufacturing and drafting areas were conducted at my company and proved to be quite beneficial. I've also attended seminars with the above school instructors and other industry personnel in attendance.

In regards to the latter, there was quite a bit of confusion as far as scholastic requirements were concerned. The main problem was that the various industrial representatives wanted to have programs set up for their companies' requirements. This would force a high degree of specialization which I don't believe would be in the best interest of any school or their students.

I would gladly cooperate with you in any way possible. At present we are very busy and don't believe that I could spend time attending any seminars.

Do not hesitate if any additional information is desired as I am quite enthusiastic about up-grading the drafting profession.

Your's Sincerely,

John Binaski
Sperry Phoenix Company
Phoenix, Arizona

COPY

Dear Mr. Oliver

Your questionnaire has been passed on to me from our office here and also from our mill in Flagstaff.

I am afraid I cannot be much help to you as we do not, in the ordinary course, employ draftsmen. As you know, we have several mills but there is no engineers only maintenance staff at them. Our Pulp and Paper Mill in Snowflake, Arizona does employ a Plant Engineer and four other engineers, but they do their own drafting for the particular project they happen to be on.

As far as this office is concerned, we design quite a lot of equipment, but here again it is done by engineers.

I am sorry I cannot be of more help to you but if in any way in the future I can help please do not hesitate to call on me.

Sincerely yours,

Douglas W. Dron
Chief Engineer
Southwest Forest Industries

COPY

Dear Mr. Oliver

At the present time our design and drafting staff is almost non-existant. We have, in the past, employed up to about sixty draftsmen and will unqoubtedly have a drafting crew again at some time in the future. Our chief draftsman, Mr. John Hoey, has answered your questions on the basis of our past experience.

If we can be of further assistance, please do not hesitate to contact me.

Yours truly,

R. B. Larsen
Mgr., Engineering
Hughes Aircraft Company
Aerospace Group
Tucson, Arizona

COPY

Dear Mr. Oliver:

We are returning, herewith, the drafting practices questionnaire which you recently sent us. As you requested, we have completed the form and trust that the answers supplied will be of help in continuing your training program.

Although we indicated in the first question that several types of drafting are used in the Highway Department, we have completed the questionnaire as it related to drafting procedures in the Plans Division. Our work is substantially, if not entirely, different than that in "Industry". Therefore, some of the answers may appear to be incompatible with your program, however, we feel that they are fundamentally sound.

Thank you for the opportunity to be of service.

Very truly yours,

WM. N. PRICE
State Highway Engineer

LLOYD E. MARTIN
Assistant Engineer of Plans
Arizona Highway Department

COPY

Dear Mr. Oliver:

We sincerely regret the delay in answering your letter dated February 26, 1965. However, we had discussed this without making any final conclusions, which were to be covered by letter. With my knowledge of the employment opportunities in this area in the field of technical drafting, we find there is a limited, but a growing demand for this type of work.

Our City and County Planning and Development Departments are using draftsman. Construction companies usually employ an engineering firm to handle their work; two of such firms are located in Yuma. Some other employers, such as the Bureau of Reclamation, Yuma Proving Grounds, and Marine Corps Air Station usually have higher headquarters perform this function. No doubt, if qualified workers were available, more of this work would be performed locally. If the community continues its growth, more and more firms will require this type of technical work and qualified applicants are very limited.

Any assistance or additional training that the college would offer in this technical vocational training would certainly be worthwhile and very timely to go with the rapid expansion of Yuma.

Very truly yours,

Fred L. Flint, Manager
Yuma Local Office
Arizona State Employment Service

COPY

Dear Dan:

I'm enclosing a copy of the Drafting Survey conducted by Carl Squires and Kent Brown of Phoenix Union High School. I am presuming that Carl sent you the copy of this.

Also, I am enclosing the "Directory of Manufacturers in the Phoenix Area" published by the Phoenix Chamber of Commerce. This publication was sent over by the Employment Security Commission. This is the only help they have given us thus far. I have made two follow-up calls to them, and as they accumulate information and forward it to me, I will see that you get it immediately.

Kindest personal regards.

Sincerely,

Dean Frey, State Supervisor
of Technical Education
Department of Vocational Educ.
Phoenix, Arizona

COPY

Dear Mr. Oliver:

It has been my pleasure to offer the assistance of the State Department of Vocational Education in formulating your survey regarding technical drafting programs in the state of Arizona.

Research in this area is much needed, and I hope that individuals and industry, in general, will cooperate with you in helping to provide answers to your questionnaire.

We would be most happy to assist you in the publication of a condensation of your summary and conclusions.

Please let me know if this department may be of further assistance to you in this project.

Sincerely,

Dear Frey, State Supervisor
Technical Education
Department of Vocational Education
Arizona State Building
Phoenix, Arizona

COPY

Dear Dan:

During our conversation last week you asked for a source of information concerning those firms in Arizona who employ draftsmen. My "pipeline" has set up a contact for you in Mr. Woody, of The Arizona State Employment Service at 209 East McDowell Road, Phoenix. His phone is AL 4-5631. You may call him at any time. Friday morning would be preferable. You may say you were referred to him by Mr. Jack Roth.

Good luck with your project.

Sincerely,

Herb Robinson
Supervisor of Central
Drafting Division
Motorola, Inc.
Scottsdale, Arizona

A P P E N D I X B

Questionnaire

COPY

Dear Sir:

The cooperation of your head draftsman in completing and returning the enclosed questionnaire, concerning basic drafting practices of industry, will help in providing better drafting graduates. The check-type questionnaire is accompanied by a self-addressed, stamped envelope.

Your cooperation will be appreciated and you will be doing educational institutions a real service in helping them to better understand industries' point of view as it relates to the training of future draftsmen.

Sincerely yours,

Daniel R. Oliver
Arizona Western College

COPY

Dear Sir:

Enclosed is a questionnaire that was sent to industries in Arizona that employ draftsmen. Since you are one of the industries that have not replied, I feel the questionnaire may not have reached you or may have been misplaced.

A reply by one of your Chief draftsmen will be of great importance in helping to further this study. A self-addressed envelope is enclosed for your convenience.

Yours very truly,

Daniel R. Oliver
Arizona Western College

COPY
Arizona State Employment Offices

Dear Sir:

I am employed as a Technical Drafting Instructor at Arizona Western College. I need your help in conducting a survey in an effort to upgrade technical drafting programs in Arizona's educational institutions. This study is being carried out in cooperation with the State Supervisor of Technical Education and the Dean of Technical-Vocational Education of Arizona Western College, Yuma, Arizona.

The purpose of this study is to determine where present weaknesses may exist in drafting programs and reveal any possible methods that would improve these conditions. The findings of this study would be very helpful in training a higher qualified technical draftsman.

Mr. Woody of the State Employment Office in Phoenix has suppled me with a list of firms in the Phoenix area that employ draftsmen. After checking with the city of Yuma, I have found that some of the smaller industrial firms, blueprint companys, city planning and zoning offices, sometimes make it a practice to employ draftsmen. With your knowledge, if you could supply a list of the firms in your area that employ draftsmen, you will be helping in the solution of a difficult problem that will help to upgrade the education of drafting students in Arizona

Thank you for your professional assistance in this study. Enclosed you will find a letter rendering the support of the State Vocational Office in regards to the study.

Sincerely,

Daniel R. Oliver
Professor of Technology
Arizona Western College

SUGGESTIONS FROM INDUSTRY CONCERNING IMPROVEMENT OF TECHNICAL DRAFTING PROGRAMS IN THE STATE OF ARIZONA

Name _____ Firm _____

Address _____ Title _____

Check the main type or types of drafting carried out in your firm.

A. Architectural	( )	G. Structural	( )
B. Construction	( )	H. Tool and Die Design	( )
C. Electrical	( )	I. _____	( )
D. Electronic	( )	J. _____	( )
E. Illustrative	( )	K. _____	( )
F. Map & Topographic	( )	L. _____	( )

SECTION ONE

Directions: Please indicate your practice concerning each statement by inserting a check mark or numerical rank, which ever applies, in the appropriate space. Additional comments you make will be appreciated and will add to the value of the study.

Employment and Plant Operations

1. How many draftsmen are employed in your department_____(number).

2. Does your firm hire beginning draftsmen? Yes ( ) No ( )

3. If your answer to the above question was yes, do you find these inexperienced draftsmen adequately trained in basic drafting practices? All ( ) Some ( ) None ( )

4. Does your company give beginning draftsmen any further training before they go to work on usable drawings? Yes ( ) No ( )

5. What is the length and nature of this training?_____

_____

Related Areas and their Importance to Draftsmen

1. Check the mathematic courses of college level that you think should be required for students planning to become draftsmen.

   A. General college mathematics ( )
   B. College Algebra ( )
   C. College Trigonometry ( )
   D. College Calculus ( )
   E. Technical mathematics (generally includes basic algebra, trigonometry and calculus as applied to technology ( )
   F. Other ( )

2. Indicate the science courses you recommend for technical drafting students.

   A. Introduction course in Physical Science ( )
   B. Introduction course in Chemistry ( )
   C. Technical Physics ( )
   D. Technical Chemistry ( )
   E. General Science ( )
   F. Other ( )

3. Check the courses below as they relate to the training of drafting students.

	Necessary	Helpful	Of no value
A. General Metals	( )	( )	( )
B. Machine shop	( )	( )	( )
C. Electricity	( )	( )	( )
D. Electronics	( )	( )	( )
E. Photography	( )	( )	( )
F. Mechanics	( )	( )	( )
G. Surveying	( )	( )	( )
H. Metallurgy	( )	( )	( )
I. Wood construction	( )	( )	( )
J. Design	( )	( )	( )
K. Other (specify) _____	( )	( )	( )
L. _____	( )	( )	( )

Drafting Practices

1. Indicate your practice concerning the construction of the following lines.

	Darkness of line			Weight of line		
	Dark	Medium	Light	Thin	Medium	Heavy
A. Object line	( )	( )	( )	( )	( )	( )
B. Hidden line	( )	( )	( )	( )	( )	( )
C. Center line	( )	( )	( )	( )	( )	( )
D. Extension	( )	( )	( )	( )	( )	( )
E. Dimension	( )	( )	( )	( )	( )	( )
F. Cutting plane	( )	( )	( )	( )	( )	( )
G. Section line	( )	( )	( )	( )	( )	( )
H. Short break line	( )	( )	( )	( )	( )	( )
I. Short break line	( )	( )	( )	( )	( )	( )
J. Phantom or repeat	( )	( )	( )	( )	( )	( )
K. Other _____	( )	( )	( )	( )	( )	( )
L. _____	( )	( )	( )	( )	( )	( )

2. Have instructors placed too much emphasis on different width and darkness of lines? Yes ( ) No ( )

3. In what manner do you terminate dimension lines? Arrowheads ( ) Dots ( )
If neither is used explain below.

4. In your experience, have beginning draftsmen, received adequate training in lettering?
Most of them ( ) Some of them ( ) Few of them ( )

5. Check the practice that is followed concerning the style of lettering that is used in your work.
   A. Draftsmen follow standards set up by our company ( )
   B. Department standards are followed with some modifications ( )
   C. Military specifications are followed ( )
   D. Draftsmen select their own style ( )
   E. Other _____ ( )

6. What style of lettering is most often used in your department?
   A. Capital Vertical ( ) Inclined ( )
   B. Lower case Vertical ( ) Inclined ( )

7. Are capital and lower case letters ever used on the same drawing? Yes ( ) No ( )

8. Are beginning draftsmen adequately trained in the use of templates?
Most of them ( ) Some of them ( ) Few of them ( )

9. Have beginning draftsmen, received adequate knowledge and training concerning the symbols used in your area of work?
Most of them ( ) Some of them ( ) Few of them ( )

10. Are beginning draftsmen, fully aware of the fact that revisions on drawings are a necessary part of drafting practices?
Most of them ( ) Some of them ( ) Few of them ( )

11. How are revisions on drawings handled in your department?
   A. Draftsmen make their own revisions ( )

B. We employ special draftsmen for revision work ..... ( )
C. Both of the above methods are practiced ..... ( )

12. Are beginning draftsmen reluctant to erase on a drawing when changes are necessary?
Most of them ( ) Some of them ( ) Few of them ( )

13. Should instructors use more drafting problems thaat will require revisions? Yes ( ) No ( )

14. In your department what approximate percentage of your drawings are inked?____% None ( ) All ( )
Comment:

15. Have beginning draftsmen received adequate training in the notations and specifications that must accompany most drawings?
Most of them ( ) Some of them ( ) Few of them ( )

16. What is the general tendency used in your department when applying notations or specifications to a drawing or set of plans?
Specifications are generally: Typed ( ) Lettered ( ) Both used ( )
Comment:

17. Does your department do any work for the government that requires drawings to comply to military specifications? Yes ( ) No ( )

18. To your knowledge, is there any trend being developed to indicate that industries might pattern their standards to follow military specifications? Yes ( ) No ( ) Uncertain ( )
Comment:

19. Approximately what percentage of the materials listed below does your firm use for their drawings?

	100%	75%	50%	25%	Not used
A. Manila paper	( )	( )	( )	( )	( )
B. Tracing vellum	( )	( )	( )	( )	( )
C. Plastic film	( )	( )	( )	( )	( )
D. Tracing cloth	( )	( )	( )	( )	( )
E. Other _____	( )	( )	( )	( )	( )

20. What percentage of the draftsmen use the following instruments in your firm.

	100%	75%	50%	25%	Not used
A. T-square and triangles	( )	( )	( )	( )	( )
B. Drafting machines	( )	( )	( )	( )	( )
C. Parallel rule and triangles	( )	( )	( )	( )	( )

21. What method in respect to reading the dimensions of a drawing are practiced by your department?
Aligned system ( ) Unidirectional ( ) Both ( )

22. Indicate the importance of dimensioning practices that drafting instructors should stress.

	Very Important	Important	Not Important
A. Placement and spacing of dimensions on drawings	( )	( )	( )
B. Dimensioning with decimals	( )	( )	( )
C. Dimensioning with fractions	( )	( )	( )
D. Tolerance and tolerance build up	( )	( )	( )
E. Tolerance, ranges and surface roughness	( )	( )	( )
F. Position tolerances	( )	( )	( )
G. Accuracy in dimensioning	( )	( )	( )
H. Classification and practice in dimensioning fits	( )	( )	( )
I. Use of datum points	( )	( )	( )
J. Co-ordinate dimensioning	( )	( )	( )
K. Other _____	( )	( )	( )

Problem Solving and Visualization

1. Do beginning draftsmen, have the necessary experience and skills to properly plan and space the views of a drawing on paper?
Most of them ( ) Some of them ( ) Few of them ( )
Comment:

2. Indicate the difficulties inexperienced draftsmen encounter in visualizing objects to be drawn.
A. Placing the views on the paper to the best advantage ..... ( )
B. Selecting views that are necessary in describing the object ..... ( )
C. Unable to visualize a sketch into a mental three dimensional picture ..... ( )
D. Breaking down a view, plan or assembly into the necessary details ..... ( )

E. Using the correct scale for the drawing ( )
F. Selecting the correct size paper for the drawing ( )
G. Slow in visualization ( )
H. Other ( )
I. Other ( )
Comment:

3. Where do beginning draftsmen experience the most difficulty in illustrating necessary details to adequately describe an object.

	Most Difficult	Difficult	Not Difficult
A. Failure to use symbols	( )	( )	( )
B. Failure to use correct symbols	( )	( )	( )
C. Auxiliary views often omitted	( )	( )	( )
D. Failure to use sectioned portions	( )	( )	( )
E. Scale of details often too small or inadequate	( )	( )	( )
F. Details labeled incorrectly	( )	( )	( )
G. Details are often drawn of unnecessary parts and standard items etc.	( )	( )	( )
H. Necessary details are often omitted	( )	( )	( )
I. Other	( )	( )	( )

4. Indicate the extent to which descriptive geometry is necessary in your department for the solution of drafting problems. Very necessary ( ) Occasionally used ( ) Seldom ( ) Never ( )
5. Are beginning draftsmen adequately trained in trigonometry and the use of logarithms pertaining to your department of drafting? Yes ( ) No ( ) Unnecessary ( )
Comment:

6. Indicate the type of pictorial drawings used in your department.
Isometric ( ) Dimetric ( ) Trimetric ( ) Oblique ( ) Perspective ( )
7. Is there a demand for adequately trained pictorial illustrators in your area? Yes ( ) No ( )

SECTION TWO

Cooperation of Industry with Educational Institutions

1. Do you feel industry would benefit by helping technical programs upgrade their course content?
Yes ( ) No ( ) Undecided ( )
2. Indicate the recency in years, which you feel technical drafting instructors, to be adequately trained, should have had industrial drafting experience. 1 to 3 years ( ) 4 to 6 years ( ) 7 to 10 years ( )
10 to 20 years ( ) Recent experience not necessary ( )
3. Which of the methods listed below, do you think, would be most satisfactory for keeping technical drafting instructors up-to-date and in line with industry?

	Necessary	Helpful	Not Necessary
A. Summer workshop of one or two weeks in length carried out in various industrial firms	( )	( )	( )
B. Workshops instructed in colleges through a joint effort between industrial draftsmen and college instructors	( )	( )	( )
C. A workshop consisting of a tour of Arizona's industries that rely heavily on drawings for production	( )	( )	( )
D. College seminar courses with drafting supervisors as guest speakers from the various fields of drafting represented in Arizona	( )	( )	( )
E. A series of two or three day (on the board) workshops, at one of the state institutions with a drafting supervisor from one of Arizona's industries for each two or three day period	( )	( )	( )
F. Other	( )	( )	( )

Comment:

4. To your knowledge, has your department or any other department in your company ever participated in any of the instructional methods listed in question three? Yes ( ) No ( )
5. Providing the cost and place of instruction was satisfactorily worked out and approved by your firm, would you be willing to participate in a workshop designed to upgrade technical drafting instructors?
Yes ( ) No ( ) Maybe ( )
Comments:

NAME OF COMPANY	TYPE OF DRAFTING: MECHANICAL	ELECTRICAL	ARCHITECTURAL	STRUCTURAL	TOPOGRAPHY	TECHNICAL ILLUSTRATION	MONTHLY SALARIES: LOW	AVERAGE	HIGH	NUMBER OF DRAFTSMEN EMPLOYED	AGE OF YOUNGEST DRAFTSMAN	AVERAGE AGE OF DRAFTSMEN	EMPLOYMENT OUTLOOK: EXCELLENT	GOOD	FAIR	SUGGESTED COURSES IN HI SCHOOL: DRAFTING	MATHEMATICS	TRIGONOMETRY	BUSINESS AND ENGLISH	GRAPHIC ARTS	SCIENCE — CHEM. OR PHYSICS	ELECTRONICS	MACHINE SHOP	ART	JOB CLASSIFICATIONS: TRAINEE	JUNIOR DRAFTSMAN	DETAILER	LAYOUT DRAFTSMAN	GENERAL DRAFTSMAN	CHIEF DRAFTSMAN	DRAFTING SUPERVISOR
ACME STEEL CO.				X				450		6	24	35			X			X	X	X								X				
AiRESEARCH CO.		X	X		X		X																									
								350	610	680	35	20	35			X			X	X	X	X						X		X	X			
ARMER AIR COND. CO.		X							560		1	35				X			X	X												
BENHAM-BLAIR CO.				X		X																										
								450	575	725	8	25	28			X			X	X			X						X	X	X		
BULMAN CORP.		X	X	X			X		600		5	24	40			X			X	X			X						X			
GOODYEAR AEROSPACE		X	X																													
								430	550	585	100	22	32			X				X		X							X	X			
KNIGHT DESIGNS		X	X	X	X		X				1	40	40			X				X			X		X							
LESCHER-MAHONEY ARCHITECTS		X	X	X	X																											
								360	440	600	30	25	35		X				X	X							X	X	X		X		
MOTOROLA, INC.		X	X				X																									
								300	588	730	130	20	36		X				X	X				X			X	X	X	X	X	X	
PARAMOUNT DESIGNS		X	X				X																									
								280	480	650	95	19	26		X				X		X							X		X	X	X	
CITY OF PHOENIX TRAFFIC ENGR. DIV.						X					5	22	31			X			X	X		X										
REYNOLDS METALS CO.		X	X		X																											
								550	625	650	4	45	50			X				X	X	X	X	X				X			X	X	
SCHOOL SYSTEM P.U.H.S.				X																												
								480	520	560	3	23	27				X			X		X							X			X	X	X
SALT RIVER PROJECT POWER DISTRICT		X	X	X	X	X																										
								440	480	570	15	20	33			X			X	X	X	X											
SALT RIVER PROJECT WATERUSERS ASSOC.		X			X	X	X																									
								400	480	570	10	24	36				X			X	X	X							X			X	X	
SPERRY PHOENIX		X	X				X																									
								335	410	570	14	21	26				X				X			X					X	X		X	X	
TECHI-BUILDERS INC.		X			X				600		4	29	40		X					X	X			X								
VOLT TECH. CORP.		X	X				X																									
								200	400	640	23	17	32				X			X	X									X	X		X	
WEBB, DEL CORP.				X				360	400	500	10	25	30				X			X							X				X		
CITY OF PHOENIX PLANNING DEPT.						X		308	469	630	8	19	28				X			X	X	X		X									
								AVER.	AVER.	AVER.	TOTAL	AVER.	AVER.																					
COMPOSITES								375	524	624	507	25	33																					

INDUSTRIAL ARTS DEPT.
PHX. UNION HIGH SCHOOL
C. SQUIRES——K. BROWN
1964

ARIZONA FIRMS REPLYING TO QUESTIONNAIRE

Chandler

Mr. Glenn McCollum, Engineer

Clarkdale

Phoenix Cement Company

Flagstaff

City of Flagstaff
City Planning and Zoning

City Engineer
City of Flagstaff

Kingman

Rader and Associates

Thyregod-Vaness. Engineers, Inc.

J. T. Jordan Engineering Inc.

Mohave County Planning and Zoning Commission

Litchfield Park

Goodyear Areospace Corporation

Mesa

Mr. Marvin Williams, Architect

City of Mesa
Planning and Zoning

General Motors Proving Ground

Horlbeck and Hickman Associates

Talley Industries

W. T. Baker,
AIA Architects

Rocket Power, Incorporated

Phoenix

Reynolds Metals Company

General Electric Company
Peoria Ave.

Arizona Sand and Rock Co.

D-Velco Manufacturing of Arizona

Phoenix, continued

Cannon Electric Company

Goettl Brothers Metal Products, Inc.

Varney, Sexton and Sydnor, Assoc.

Dwight L. Busby, Busby Assoc.

Maddock and Clouse Company

National Castings Company

City of Phoenix, Planning Dept.

Salt River Power District

Motorola Incorporated Controls
Systems Division

Arizona Highway Department

Techni-Builders Incorporated

Sperry Phoenix Company

International Metal Products

Acme Steel Company

Airesearch Manufacturing Co.

Allison Steel Manufacturing

Arizona Sash Door and Glass Co.

Volt Technical Corporation

Gilbert Engineering Company

General Electric Company
Black Canyon Highway

Del E. Webb, Corporation

Scottsdale

Knight Designs for Business

Central Drafting, Motorola,
Incorporated

Dickson Electronics Corp.

Tempe

McConnell and Peterson

City of Tempe
Planning and Zoning

Tucson

Reisdale Associates, Architects

Friedman and Jobusch, Architects
and Engineers

Mr. Rod Gomez, Consulting Engr.

Wheeler, Petterson and Cofeen
Engineers, Inc.

Place and Place, Architects

Lunar and Planetary Laboratory
University of Arizona

Gene Anderson Engineering Corp.

Planton and Cole, Architects
and Engineers

Tucson, continued

Cella and Barr, Engineers

Kitt Peak National Observatory
Aura Incorporated

Hughes Aircraft Company

Marum and Marum Inc.

Arizona Gear and Manufacturing

Mr. William Wilde

Infilco Division of Fuller Company

Krueger Manufacturing Incor.

The Lusk Corporation

Vail

Radio Corporation of America

Yuma

City of Yuma
Planning and Zoning

Yuma Engineering

Assessor of Yuma
Yuma Court House

Arizona Title Trust