SIMPLIFIED ENGINEERING GRAPHICS AND THE APPLICATION TO INDUSTRY

By

John Douglas Wilhoit, Jr.

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

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THESIS APPROVED:

Associate Professor and Head, Department of
Trade and Industrial Education

Dean of the Graduate School
Oklahoma State University

PREFACE

"Simplified Engineering Graphics and The Application to Industry" offers a comprehensive study toward an economical method of reducing drafting cost in industry. The material illustrates methods for solving graphical problems based upon the principles of orthographic projection.

The material for this thesis has been organized with the full understanding that all industry has a different viewpoint on simplified drawing and that little has been accomplished toward standardization of simplified practices. The writer feels that an intelligent solution to this problem is of vital necessity and offers the following material as partial fulfillment to that solution.

The objective is to determine and prove that industry and technology is ready for simplified engineering graphics and to establish the necessity for the American Standards Association and the Military Standards Department to issue standardization bulletins on simplified engineering graphics.

The writer of this study wishes to express his appreciation to Professor T. Pete Chapman, thesis advisor, and Dr. Roy Dugger, United States Office of Education, for their valuable assistance in the planning and completion of this thesis; also to Mr. Joe Ables, Oklahoma State Supervisor of Technical Training Service, for his advice and suggestions, and to those in industry who so graciously furnished information for this study.

Grateful acknowledgement is also made to my parents whose self-sacrifice made possible the education upon which this thesis is based.

Gratitude is extended to my wife, Rose Marie Wilhoit, to my daughter Terry Lynn Wilhoit, and to my son John D. Wilhoit, for their tolerance, inspiration and encouragement throughout the preparation of this thesis.

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CHAPTER I

INTRODUCTION

Engineering drawing as we know it today is a graphic language used by draftsmen and engineers to convey a description as to the size and shape of an object. Certain standards are to be maintained by the draftsman and engineer while performing his drawing task.[1] An understanding of the theory of projection and dimensioning is essential, and he must be familiar with the standards described by the American Standards and Military Standards publications.

I-1. The Problem Stated. The increasing demand of industry for the highly skilled technical draftsman has been brought about by an engineering change. No longer is it the responsibility of the engineer to prepare the drawing. The engineer directs the preparation of the drawing and conveys his ideas, calculations and sketches to the draftsman. A continued inspection of the draftsman's work assures the engineer that his ideas are conveyed correctly.

The engineer to draftsman ratio is three to one. The purpose of this thesis is to present a logical simplification system that would enable this ratio to be reduced. Less draftsmen hours would be necessary on a working drawing and yet communicable working relations would exist with shop and engineer.

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[1]Giesecke, Fredrick E., Mitchell, Alva, and Spencer, Henry C., Technical Drawing, ed. The Macmillan Company, 1958, p. 1.

I-2. Purpose of the Study. The success of a simplification system depends entirely upon its acceptance by the American Standards Association and the Military Standards Publication. Industry's fear of simplified engineering graphics is based upon the breakdown of communications between each other. Standardization among all industry, through the American Standards Association and the Military Standards Publication, will remove this fear. An assurance will have been established that a legible graphic communication is assured throughout the United States. Engineering simplification released to all industries will enable them to use graphic simplifications with complete confidence that each will have a working knowledge of the other's drawings. This will allow industries to farm the manufacture of their product to other manufacturers and utilize simplification methods of time-saving hours in their own engineering drafting department. The purpose of this study is not to set forth the simplification standards, but rather to present the simplification methods and what they can do in this field of endeavor.

Although drafting instruments and equipment have improved steadily over the past decades, it was not until recent years that improvements in reproduction methods were discovered and used as a means of simplifying the draftsman's work. This cost "time" saving, through use of sepias, mylars and other diazo processes, brought to the attention of the draftsman that other cost "time"-saving techniques may be applied to the world of graphics and serious consideration has been given the improvement of conventional drawing presentation. In years past, the normal procedure called for the inclusion of every detail, regardless of its repetitious or superfluous nature. This type of thinking was all right for the slowmoving world of yesterday; however, today's scientific world finds the technician in great demand. [This shortage of technical people in the drafting and design field has brought a need for simplified procedures. The general tempo of our industrial life began quickening. Larger, faster, and better machines have increased production. Prices through this type of production have been lowered to the point where the average family can now afford goods that have been considered luxury items. This has increased competition between manufacturers. Since, in competitive marketing, price is the important factor, manufacturers searched for methods of reducing prices. Engineering cost and production cost were found to be the prime factors in the general cost structure.

[The industrial engineer, by means of time-study groups, has produced a more efficient production shop. Very little thought has been given to the procedure of simplified drafting in the engineering departments of industry.]

[Two industrialists, A. H. Rau and W. L. Healy of General Electric (Co-authors of Simplified Drafting Practices, John Wiley and Sons) introduced a series of concepts that have had profound effects throughout the industry and provided material for controversy.

The question in the minds of the proponents of simplified graphics has been, "What are the minimum data necessary for complete understanding?"[2] It is, however, to be answered from many different viewpoints. The following material in contribution to the problem, is but one viewpoint and will be governed by the limitations of the writer's background and knowledge. The extent to which simplified graphics should be

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[2]Kuller, K. Karl, Electronics Drafting, ed. McGraw-Hill Book Company, Inc., 1962, p. 193.

governed is by the ability of the average machineshop and foundry worker to accurately interpret the drawing without error.

Simplified engineering graphics differs from engineering graphics only as an analytic simplification of the standard graphics. A definite thought process must be observed by the draftsman and a logical sequence must be followed. Certain standards must be observed before the graphic language of engineering communication is achieved universally.

I-3. Need for the Study. Widespread unrest exists among industries specializing in custom work for larger industry. This presents a communication problem to their shops and engineering departments. The basis for most of this communication problem can be defined as a breakdown of the graphic language due to inadequate standardization of simplification procedures.

The American Institute for Design and Drafting through its committees and journals has been persistent in its interest and concern for the improvement of graphic standardization. The Institute further indicates that one solution to the drafting technician crisis may be overcome by standardization and graphic simplifications.[3]

Only by continual, active study, resulting in recommendations and modern materials, can fusion of correct modern simplifications and sound pedagogy be expected.

The first part of the study was made to meet the immediate needs of the writer for a better understanding of the basic philosophy that has been credited with the non-acceptance of simplified graphics by industry. An understanding of this philosophy was needed in order that

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[3]Rayfield, John, A.I.D.D. Educational Seminar Paper, American Institute for Design and Drafting, May, 1961.

the writer might formulate a workable plan of endeavor; also, aid in the establishment of objectives that would guide him in a feasible presentation of graphic simplifications that would be acceptable to industry, the American Standards Association, and the Military Standards Bureau.

The three immediate objectives of this study are: (1) to obtain a background of information concerning the non-acceptance of engineering graphics simplification by industry, the American Standards Association, and the Military Standards Bureau, (2) to analyze the need of acceptance, and (3) to present workable graphic simplifications, that through standardization, could relieve the critical demand for drafting and design technicians. This would be accomplished by decreasing the number of clock hours spent on engineering drawings.

I-4. Extent of the Study. The first chapter is a presentation of conventional practices of engineering graphics that must be the foundation of graphic simplifications. The following chapters are feasible graphic solutions and working drawing examples of simplifications based on the accepted practices used in industry today. The conventional drawing practices accepted by industry are the same in all industry due to the bulletins and releases of organizations such as the American Standards Association and the Military Standards Bureau. The latter chapter is a study of the standards observed and the willingness to accept graphic simplification standards by industry in the Northeastern Oklahoma A and M College area.

The hypothesis of this research is that industry is: (1) using departmental standard manuals, (2) ready for graphic simplifications, (3) purchasing and using drawing templates for increasing drafting efficiency, (4) placing emphasis on simple, concise and instructive drawings rather than elaborate pictorials, (5) eliminating superfluous views and dimensions, and (6) acutely aware of the high engineering cost due drawing "time".

The method of research to be used in substantiating the hypothesis is a sample survey of industry within a 250-mile radius of Miami, Oklahoma. The type of industry is intended to be quite broad, so that conclusive evidence may be acquired on which type of industry is employing standard manuals, graphic simplifications, extensive template usage and whether or not the templates are furnished by the company; also, if the engineer to draftsman ratio is actually three to one. The survey and accompanying letter are included in the Appendices A and B.

Types of industry included in the survey are manufacturers of aircraft, automotive tires, drilling rigs, batteries, missle engines, refrigerators, air conditioners, heating units, lead and zink, truck trailers, oil and gasoline, and steel. Service companies and organizations such as electrical power, natural gas, geological survey and state engineers were also included in the sample.

The accepted technical drawing standards and objectives supplying a background for the study will be presented in Chapter II.

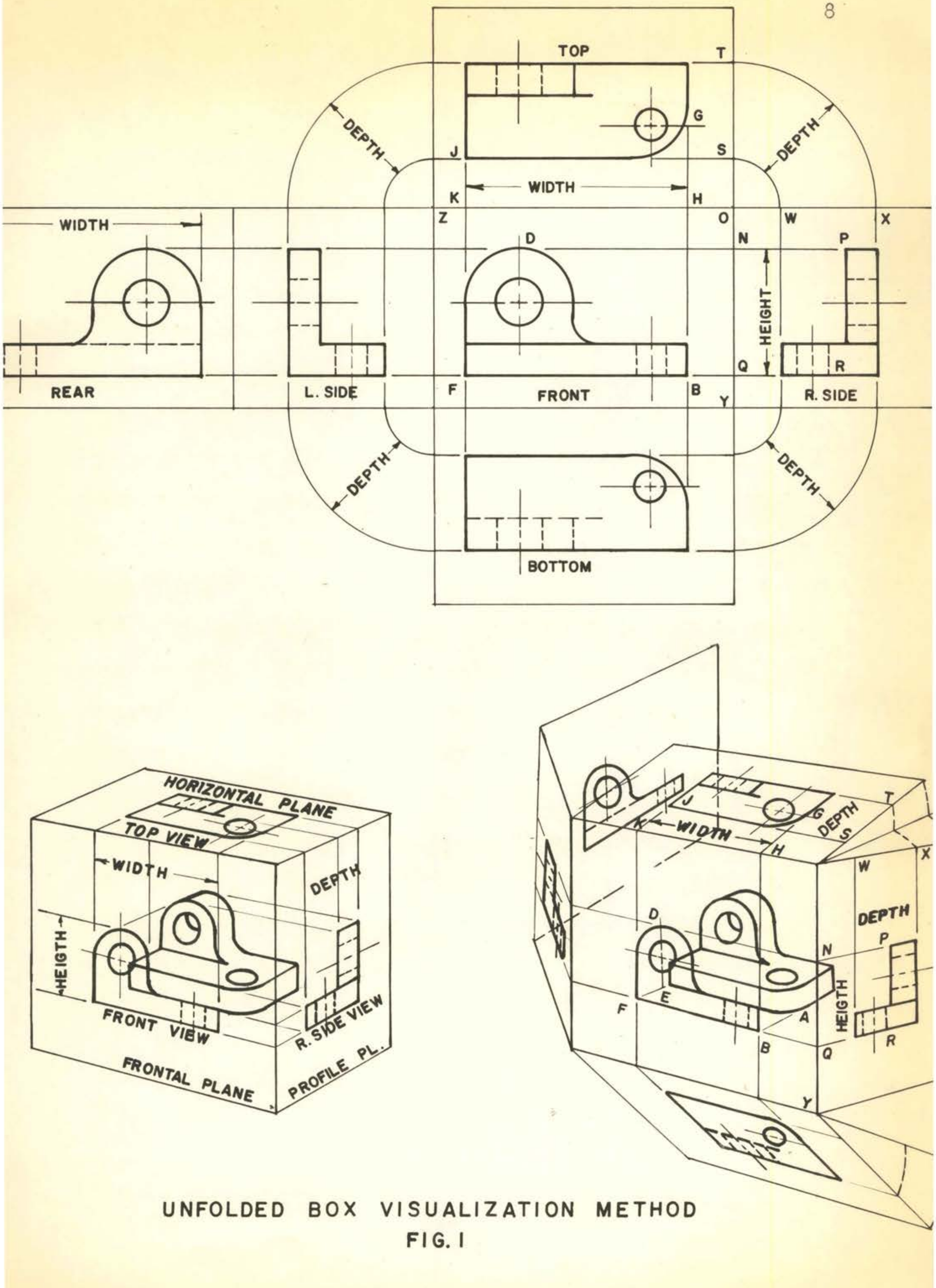
CHAPTER II

MULTIVIEW DRAWING

II-1. Technical Drawing. The medium of drawing is one of the oldest and most effective methods of communication. Truly, a picture is worth a thousand words. This may be conveyed by a photographer's print, an artist's painting, or a technical draftsman's working drawing. Man has developed drawing along two distinct lines, according to his purpose: (1) artistic and (2) technical.[4] Technical drawing, based on the principles of orthographic projection, provides a complete description as to the size and shape of the object to be constructed. Multiview drawing is a class of orthographic projection in which it is possible to obtain views of an object from which true measurements can be made.

The technical draftsman's primary concern is in the construction of drawings requiring orthographic projection. An application of the multiview drawing results in a drawing consisting of the front view, left side view, right side view, rear view, top view and bottom view. The established front view illustrated in the unfolded glass box (Fig. 1) shows the true width and height of the object. The depth dimension is not obtainable from this single view. An additional view of the object, which is perpendicular to the front view, becomes necessary

[4]Giesecke, Fredrick E., Mitchell, Alva, and Spencer, Henry C., Technical Drawing, ed. The Macmillan Company, 1958, p. 2.



UNFOLDED BOX VISUALIZATION METHOD

FIG. I

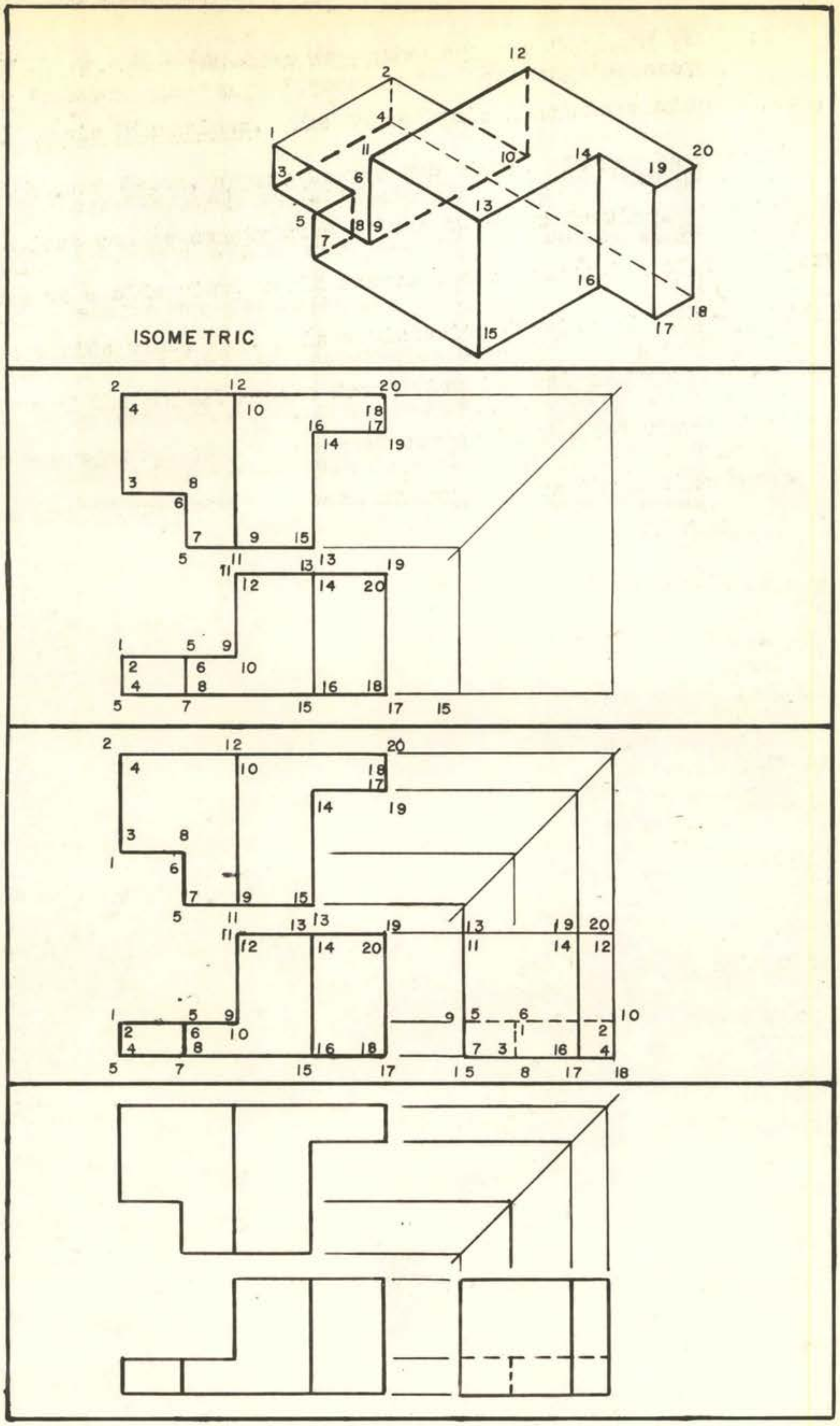
to obtain the depth dimension. This view, known as the top view, also appears with the width dimension while the height appears only in the front view.

II-2. Basic Dimensions. The three basic dimensions of an object, width, height and depth, appear in the two views. It may be assumed that the object can be constructed by the two-view drawing. A third view, known as a side view, would assure the construction of the object. To procure a side view, Fig. 2 is a pictorial drawing of a given object. Each corner of the object in the front view is assigned a number. The numbers are projected to the assigned corner in the top view and side view. It is well to note that each number appears three times; once in the top view, once in the side view and once in the front view. A point that is visible in a given view has the number placed on the outside, the numeral is placed inside when invisible.

The standard form of multiview drawing of an object requires three or more views; whereas two or more views are often sufficient to illustrate the object.

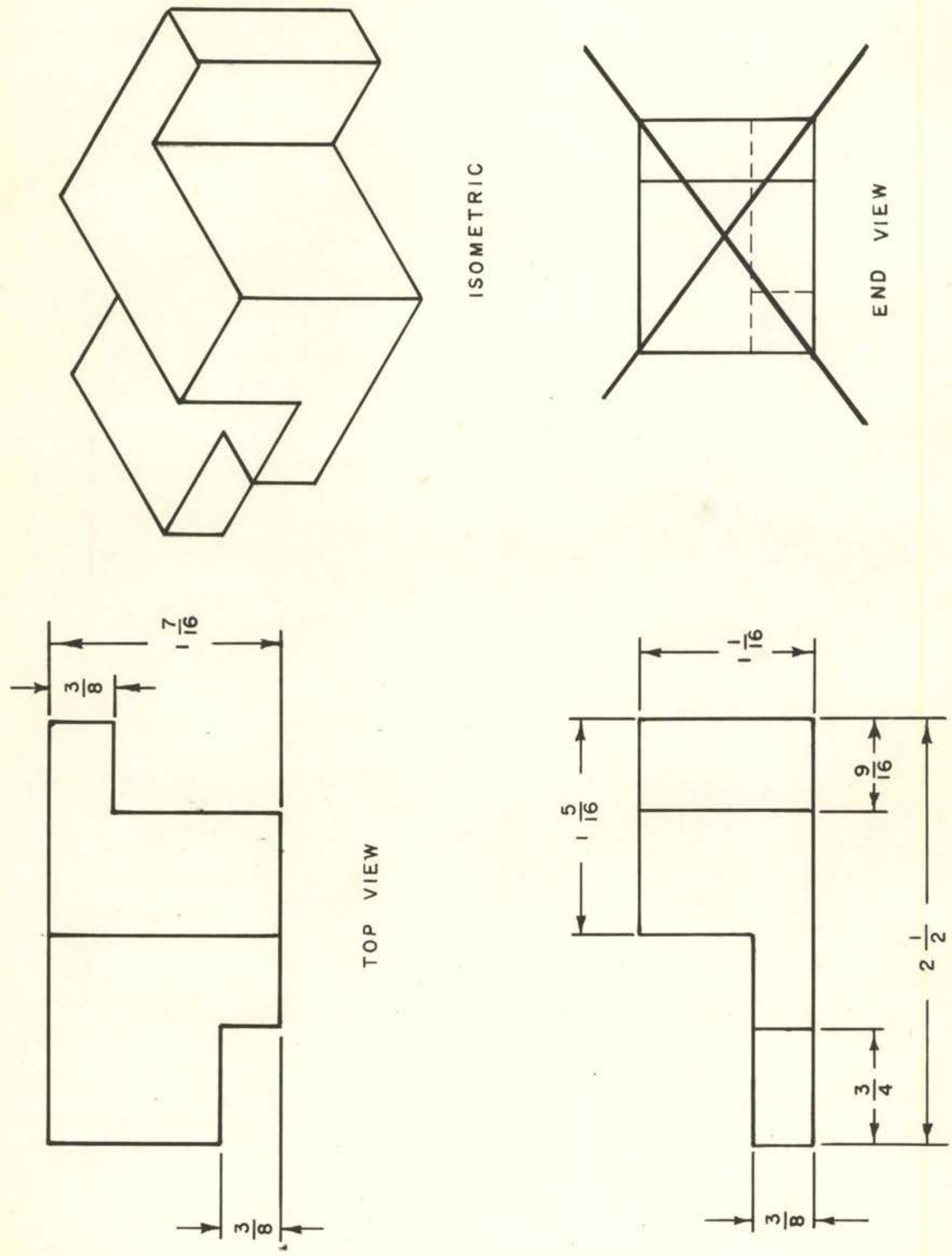
Simplification of engineering documents must first originate at this stage of the drawing. Again, refer to Fig. 2. Note that each view is acquired by projection points from the other views; but only the front view and a top view are necessary for dimensioning the object in its entirety--see Fig. 3.

The top view of Fig. 3 was selected in preference to the side view. Hidden lines appear only in the side view. In standard practice, hidden lines should be omitted; unless they are needed for clarity. This rule should be observed in simplified drafting only when a choice of view selection is possible, such as in Fig. 3. Quite often



3RD. VIEW BY USE OF NUMBERS

FIG. 2



ELIMINATED VIEW

FIG. 3

irregular shaped objects make this rule impossible to apply to simplified drawings. It may be necessary to show three views of the irregular shaped object; thus eliminating this portion of simplification. The draftsman must be resourceful and use his discretion as to how the multiview drawing should be presented. Limitations to the presentation of simplified drawing are inherent in the draftsman; however, when limitations of the application to the usage of simplification arise, he should readily adapt himself to the conventional standards of drafting.

II-3. Conventional Methods for Multiview Projection. The two most common methods of obtaining multiview projection are the glass box, (Fig. 1) and the folding line--Fig. 4. Both are adaptable to first and third angle projection; however, in descriptive geometry, it is advantageous to employ the folding line method.

Simplification of engineering graphics does not necessarily imply that those simplifications will also work in descriptive geometry. Orthographic projection being the principle source of idea communication of each, often gives this illusion. Descriptive geometry is the science of graphic representation and solution of space problems.[5] The solutions may be either in first or third angle projection. Space problems require deep concentration and exactness in dimension transfer. The elimination of definite procedures to achieve simplification could be disastrous.

Simplified graphics in multiview projection is limited to the selection and elimination of superfluous views and dimensions. The elimination of views is a new look in the graphics field. It does not

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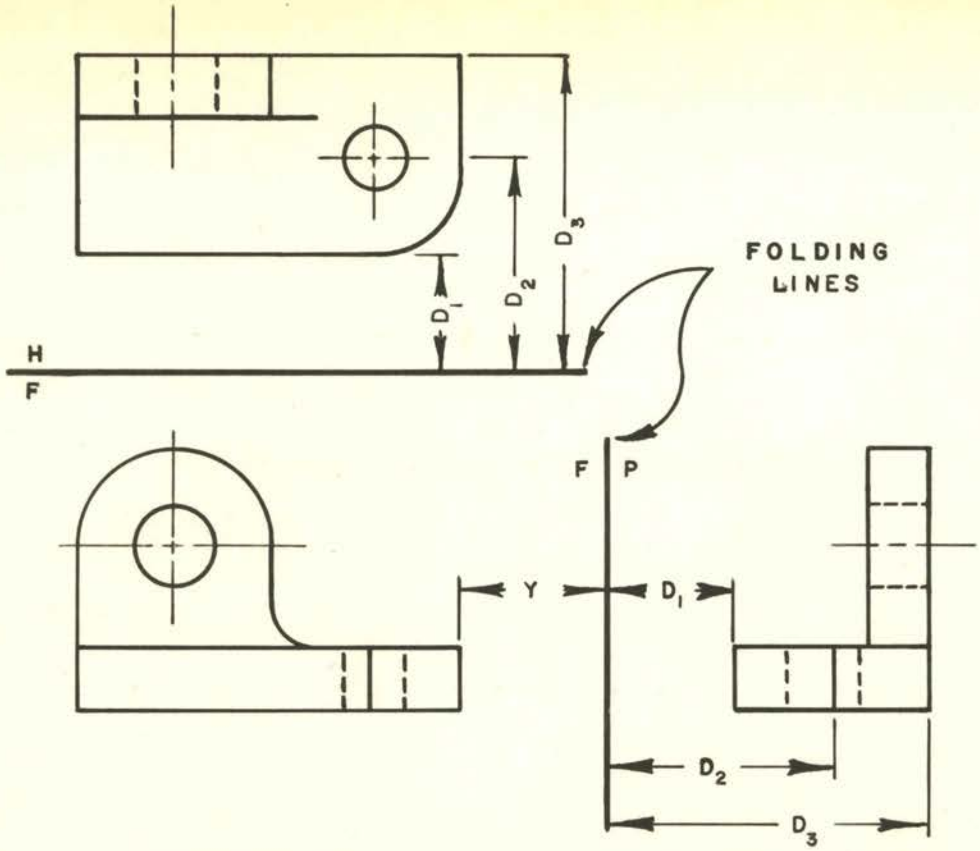
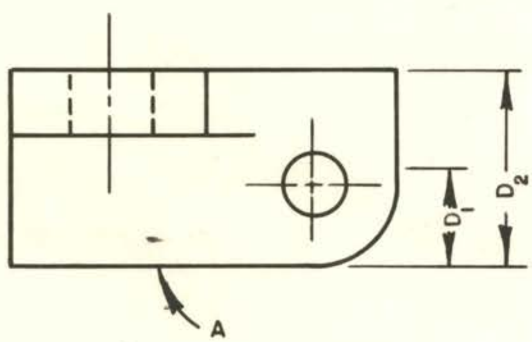
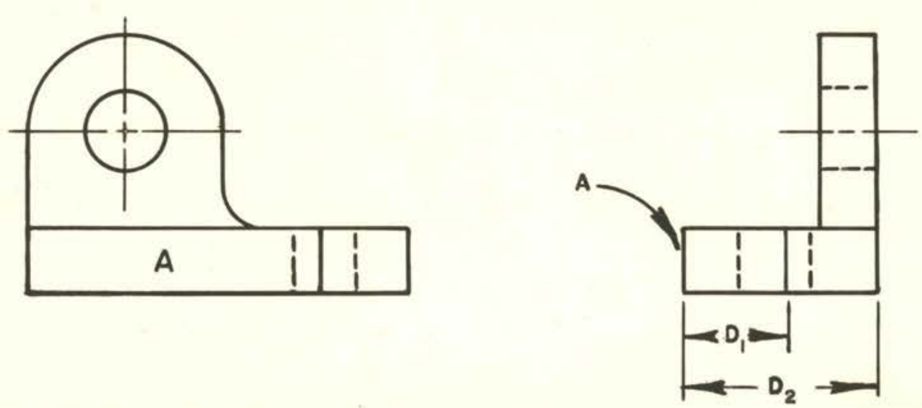
[5]Pare, E. G., Loving, R. O., and Hill, I. L., Descriptive Geometry, ed. The Macmillan Company, 1956, p. 1.





FOLDING LINES OMITTED



FOLDING LINES
FIG. 4

matter how well a drawing is presented, if it lacks simplicity and instruction, the purpose is defeated. Complexity of views that are superfluous requires time of the blueprint reader and introduces the potential error involved in the intricate reading of the blueprint.

Simplification of multiviews can lead to a number of significant improvements. Where it is applied, output can be increased and efficiency improved measurably. The engineering-draftsman ratio previously stated can possibly be reduced and the technician shortage may be relieved in this manner.

II-4. Drafting Objectives. The draftsman must treat an engineering drawing as a highly technical document and not as a work of art. Too often the necessity of a view is not analyzed; and the draftsman will consider it sacrilege not to show the three principle views of an object. The beauty of the drawing receives the emphasis, and the efficiency along with the intended purpose, meets with failure.

A drawing fully executed will possess four qualities; simplicity, legibility, accuracy and neatness. There can be no compromise with this fundamental concept. It must have enough lines to convey what was in the mind of its creator, no more, no less.[6] It must be legible as well as simple, permitting the common shop man to interpret its meaning. Accuracy must be of the highest quality. Projection and dimensional errors can be costly to industrial manufacturing concerns. The draftsman should strive for neatness. If the drawing is to have accuracy and legibility, it is essential that neatness be of the utmost importance in the mind of the creator.

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[6] Rau, A. H., "How ti Simplify Engineering Drawing", ed. The Iron Age, December 27, 1958.

Emphasis on creative thinking is the major part of an engineer's or draftsman's job. The drawing is a minor part of the job. If less time is spent on the drawing, more time may be allowed for creative thinking. Simplification and standardization of documental drawing is the answer to this "time" problem.

Simplification of forms, such as bills of material that accompany the multiview working drawing, is another means of time saving. They govern the form and determine the work flow through engineering and production. Simplification of the design of these forms through the areas of operation definitely result in time saving.

Standardizing simplifications, other than eliminating superfluous views, must be considered. The existing views and dimensions are also subjects for simplifications; however, before partial views, non-elaborate pictorials, symbols, photography and mechanical aids are discussed, the draftsman and engineer should be cautioned. Over simplification, without standardization, can break down the flow of communication and defeat the time saving purpose. Again, the question presented in Chapter I by Rau and Healy, "What are the minimum data necessary for complete understanding?"[7] must be asked before undertaking the graphic simplification of an engineering document.

Proposed simplified drawing practices and simplified graphic examples will be presented in Chapter III.

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[7] Healy, W. L., Rau, A. H., Simplified Drafting Practice, ed. John Wiley and Sons, 1953.

CHAPTER III

SIMPLIFIED DRAWING PRACTICES

III-1. Drafting Standards. Drafting room standards are far different from those of yesteryear. Techniques have been revised and drawing papers are being replaced with synthetics such as mylar and other polyester films. Opaque white paper and manila paper were the accepted engineering document materials; whereas today, the diazo process has eliminated this material from all drafting departments. All drawings were inked in with carefully graduated lines. To further achieve an artistic look, colored inks were used. Every bolt, nut, etc., was drawn in complete detail. The lettering resembled that of a commercial artist with fancy frills and, quite often, not too legible. Time was of no importance and drafting costs were never considered as an important item to engineering.

Today, time is money and American industry is looking for all valid cost reductions. The engineering and drafting departments are no exceptions to this rule, they must be restricted to the bounds of a budget.

Competitive manufacturing brought about cost-conscious engineering and drafting departments. Shading, shadowing and coloring is beginning to disappear and eventually most ink drawing will probably be the exception, rather than the rule.

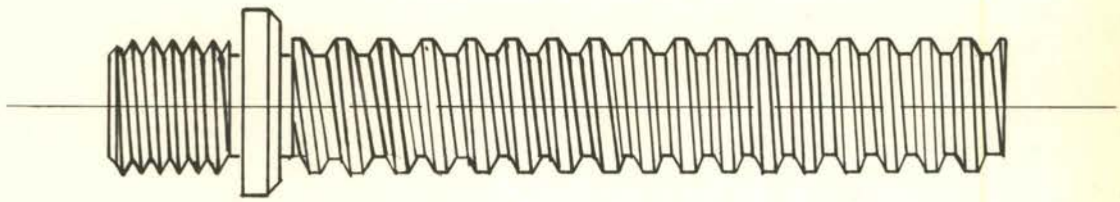
III-2. Acceptance of Simplification. Industry is beginning to feel that drafting practices should be further simplified. The individual company procedures of simplification have produced poor drafting and illogical theory. The damage from this type of simplification has been inflicted on companies that are hesitant to use simplification until it has been accepted by the American Standards Association or Military Standards. To further examine the penalty inflicted on the hesitant company, one must analyze their predicament. A company under government contract cannot use any form of simplified drawing. All drafting procedures must meet the requirements of the Military Standards publications and blueprints of individual parts. A bill of materials must accompany the purchase requisition. Standard purchased parts, taken from vendors' catalogs are included in the demand. If simplified drafting was used by the vendor, it would be necessary for the company, which is under government contract, to redraw the part, observing the practices of the Military Standards. This is not only a cost burden but also one of time. The results of this would be that they are sympathetic with the basic idea, but under government contract would not be receptive to any phase of simplified drafting. The immediate answer in overcoming this undesirable situation lies with the acceptance or complete rejection of simplified drafting by the two recognized standards committees, American Standards Association and Military Standards Publication.

III-3. <u>Standard Practices of Simplified Drawing</u>. A summary of practices advocated in simplified drafting is as follows:

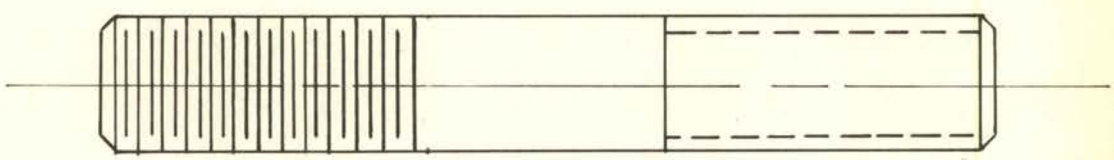
1. Word description on a drawing form should replace the drawing wherever practicable.
2. Eliminate an unnecessary view.

3. Draw partial views wherever possible.
4. Draw half views of symmetrical parts.
5. Coordinated preplanning of drawings.
6. Establish a standard parts cross index system.
7. Avoid elaborate pictorials and repetitive details.
8. Represent bolts, nuts, rivets and other hardware by center lines.
9. Omit section lines wherever possible.
10. Represent holes by means of center lines on bolt circles.
11. Use simple delineations for common objects. (Symbols)
12. Use free-hand drawing wherever practicable.
13. Keep lettering to a minimum and avoid lettering instruments.
14. Use time-saving devices such as templates and overlays, wherever practicable.
15. Use photography when applicable to drafting.
16. Use cannon abbreviations and symbols.
17. Use preprinted engineering forms and fade-out guide line papers.

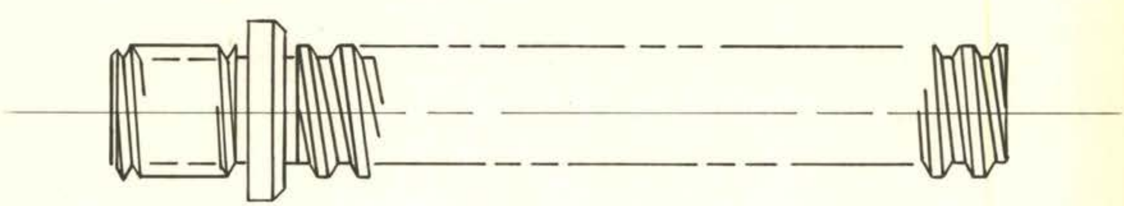
III-4. Simplified Drafting Applied. The application of the above practices are simple and, quite often, the normal reaction of the draftsman's thinking. Thread symbols, for example, are one form of simplified drafting that has been accepted by both the American Standards Association and Military Standards. The symbol is the same for all thread forms, such as, V, square, acme, unified, etc. Fig. 5 illustrates the use of the symbol, the phantom line, and the conventional method of drawing threads. Time savings are greatly increased by the use of the thread symbols.



CONVENTIONAL THREAD
REPRESENTATION



THREAD SYMBOL
REPRESENTATION



PHANTOM LINE REPRESENTATION

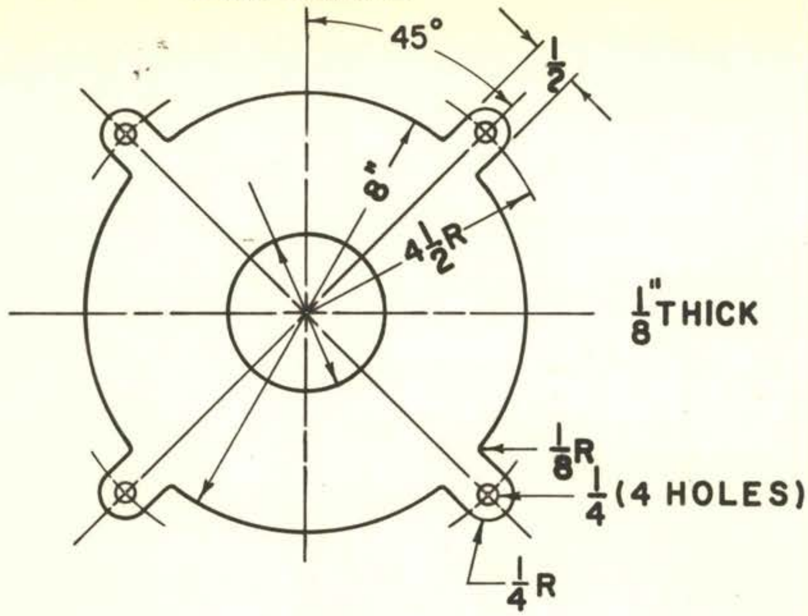
METHODS of THREAD REPRESENTATION
FIG. 5

A partial view of a symetrical part, Fig. 6, utilizes simplicity in drafting to the highest degree. A partial view of a symetrical object not only communicates the necessary information for its construction but reduces the complexity of its construction and eliminates the potential of errors. The simplicity of a partial view allows the part to be drawn on a larger scale and a smaller drawing paper. Drawings normally requiring C, D, and E size sheets could be on either A or B size sheets. This would allow them to be filed without folding.

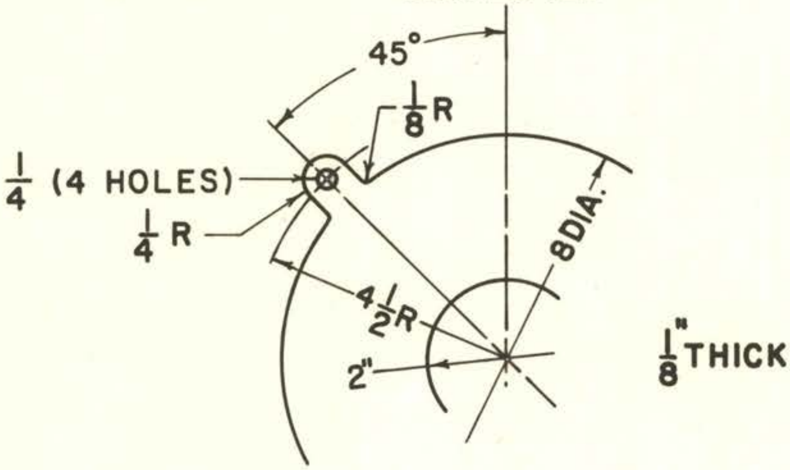
III-5. Superfluous Views. A view without dimensions or instruction often can be omitted. Superfluous views lead to complexity for the blueprint reader and are time consuming for the draftsman. A general rule to be observed by the simplified style draftsman is that all views contributing information that cannot be illustrated elsewhere must be shown; those views that lack dimensions, notes and vital information are to be considered superfluous. An example of a superfluous view is illustrated in Fig. 7. Note that this view does not reveal any information vital to the manufacture of this part.

III-6. Elaborate Drawings. Elaborate pictorials are costly and confusing. The draftsman's self pride in the work he is doing often leads to this drawing style. As was mentioned in part two, the two types of drawing are technical and artistic, and the two types should never be combined. The elaborate pictorial type of draftsman is combining the two major styles in an attempt to gain self satisfaction or recognition by producing a beautiful work of art. Recognition is often gained; however, it is not the desired type of recognition. The employer is seeking simplicity, accuracy and speed, which the elaborate pictorial lacks. Simplicity cannot be achieved by any form of pictorial. Accuracy

ELABORATE

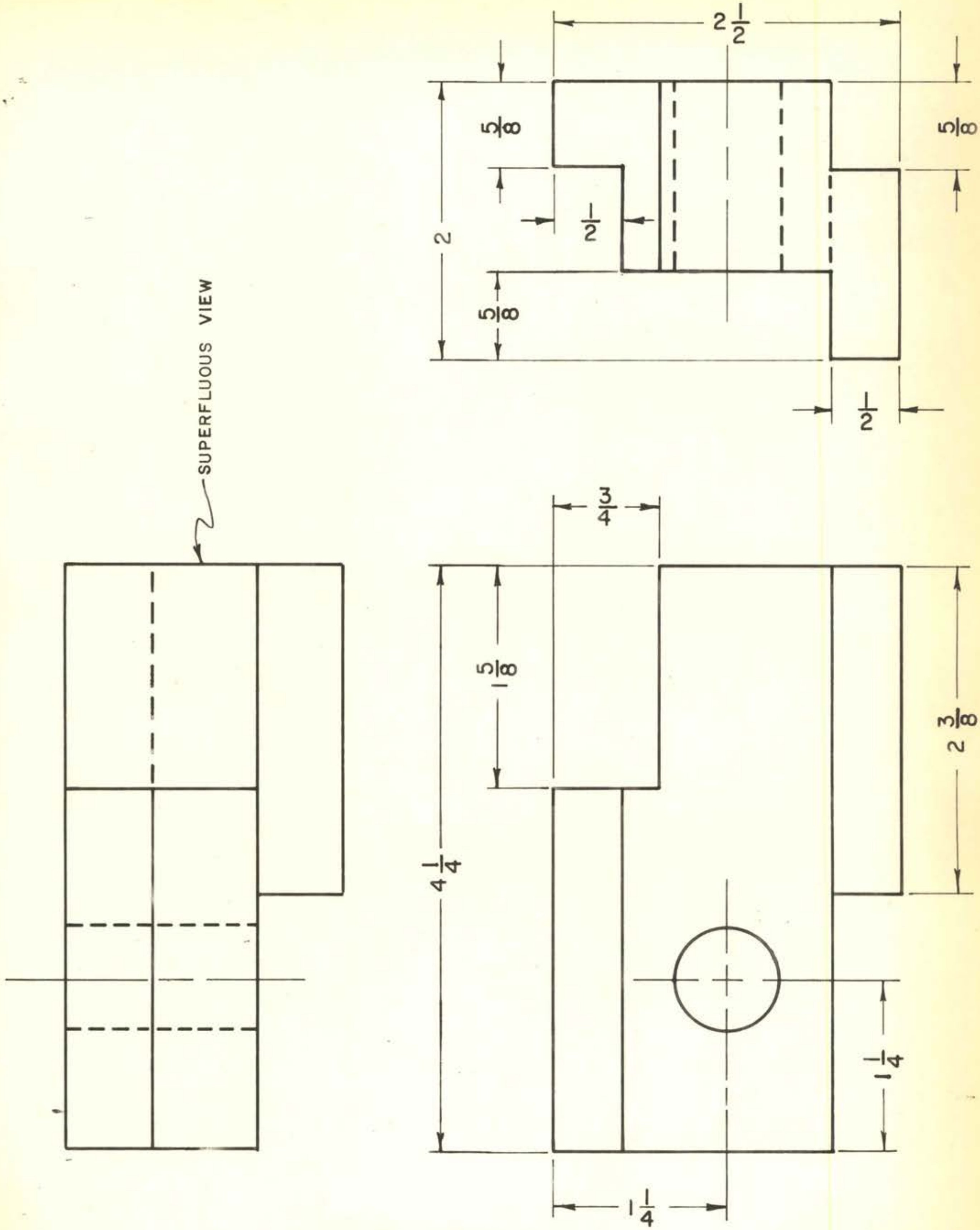


SIMPLIFIED



PARTIAL VIEW

FIG. 6



SUPERFLUOUS VIEW
FIG. 7

is quite often lost by the employment of perspective to gain the natural shape and appearance of the object as it would be seen by one's normal visualization. Speed is sacrificed when artistic abilities are used. Art should be restricted to the production illustration department, and there used in a limited manner for catalogs, part sheets and brochures. Manufacturing and production are not interested in beautifully executed drawings and layouts. Their objective is to receive a complete, concise, simple and accurate engineering drawing on time. Fig. 8 is an example of simplified versus elaborate pictorial.

III-7. Symbolic Drawing. Symbology in the graphics field has developed in an evolutionary manner. The more prominent fields employing symbols are the piping drafting, electrical and electronic drafting, and architectural drafting (plumbing, wiring and heating-air conditioning facilities); while others are still experimenting with the detail of limitations.

The limitations concerning most manufacturers are those of standardization. Again, may we state that symbology has developed in an evolutionary manner and, in so doing, has created the revisions of many symbols. An example of symbol evolution is the inductor and capacitor, Fig. 9. Note that the inductor (a) resembles the actual industor, as if it were a picture, (b) is the first simplification; but still resembles the part itself, (c) and (d) are both approved standard symbols for induction coils with emphasis being p.aced on (c). The capacitor has followed much the same evolution pattern with the emphasis being placed on (e).

Symbol standardization faces difficulty today because of the elapsed time before a form of standardization was introduced. An

TABLE I

STANDARD SHEET SIZES ACCEPTED BY BOTH

AMERICAN STANDARDS ASSOCIATION

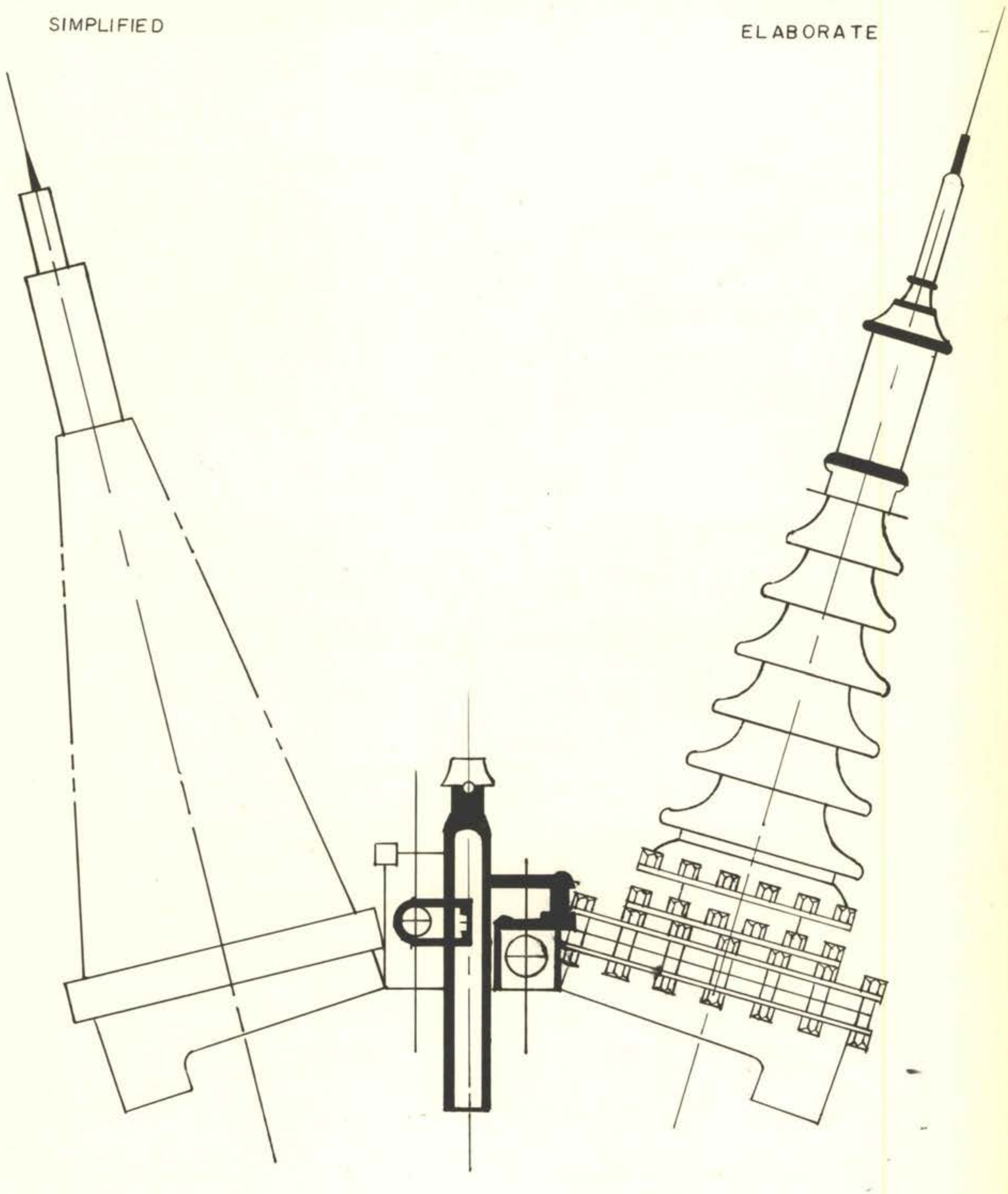
AND MILITARY STANDARDS BUREAU

PREFERRED

Description	Sheet Size
A	8½" x 11"
B	11" x 17"
C	17" x 22"
D	22" x 34"
E	34" x 44"

ACCEPTED, NOT PREFERRED

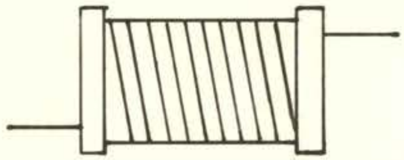
Description	Sheet Size
A	8½" x 11"
B	10" x 15"
C	18" x 24"
D	24" x 36"
E	36" x 72"



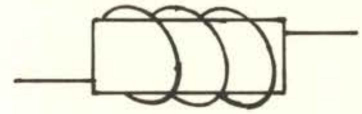
ELABORATE PICTORIAL V.S. SIMPLIFIED

FIG. 8

INDUCTORS



OLD DRAWING



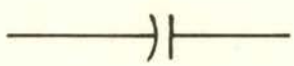
SIMPLIFIED DRAWING

(A)

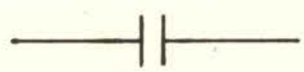
(B)

(A) AND (B) APPROVED STANDARDS FOR INDUCTOR SYMBOLS TODAY

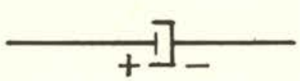
CAPACITORS



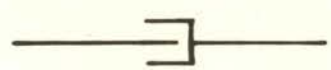
TODAY'S STANDARD



OLD SYMBOL



SYMBOL SOMETIMES USED FOR ELECTROLYTIC CAPACITOR



OLD SYMBOL STILL USED IN INDUSTRIAL ELECTRONICS FIELD

ELECTRICAL SYMBOL EVOLUTION

FIG. 9

example, such as Fig. 9, indicates that the inductor symbol accepted by the American Standards Association can be either (c) or (d). The admission of this statement is to admit that standardization does not exist with our standardizing bodies. The point made in the above example is a simple one; standardization, to be effective, must be a well thought out plan and enunciated well in advance of industrial acceptance. Once industry becomes the instigator, it is inevitable that standardization will meet with the difficulties in establishing adopted policies.

This difficulty has occurred in symbolic electrical and electronic drawing. Standardization by the American Standards Association, ASA Y32.2-1954, ASA Y15.1, ASA Y32.9-1943, ASA Z32.2.3-1949 and ASA Y10.9-1953, has served as the guiding factor for accepted procedures. The simplicity of symbolic piping drawing is illustrated by Fig. 10. Note that symbol interpretation is aided by the naming of each part. This should not be standard procedure for simplified drafting practice and should be eliminated from an industrial type drawing. Part names are permissable but should not be recommended. If a full utilization of drafting simplifications is realized, the elimination of part names must be omitted from the drawing.

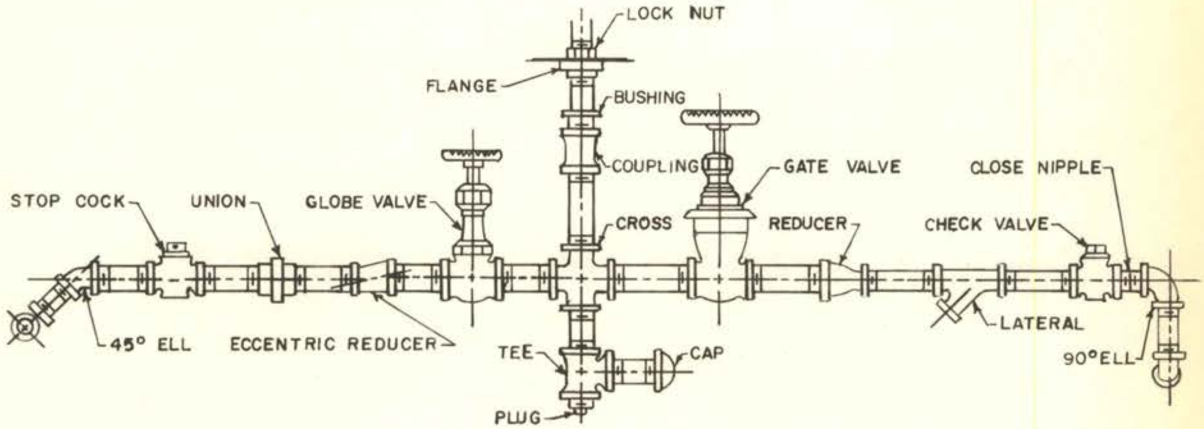
An additional time saving procedure can be employed by the use of templates. Both symbolic and conventional templates are available from various manufacturers, such as Rapidesign Incorporated. The utilization of templates should be encouraged in industrial drafting departments and will be discussed further in section III-10.

III-8. Note Descriptions. Views, and quite often a drawing in its entirety, can be eliminated by a note. This procedure is utilizing simplified drafting practices to the utmost extremities. Successful usage of this type of simplification is dependent upon simple parts in the raw stage and vendors' items. It should never be attempted on parts requiring drilling, machining, welding, or other intricate shop procedures. Full realization of this practice is limited; however, many drawing hours and manufacturing cost can be reduced by its practice.

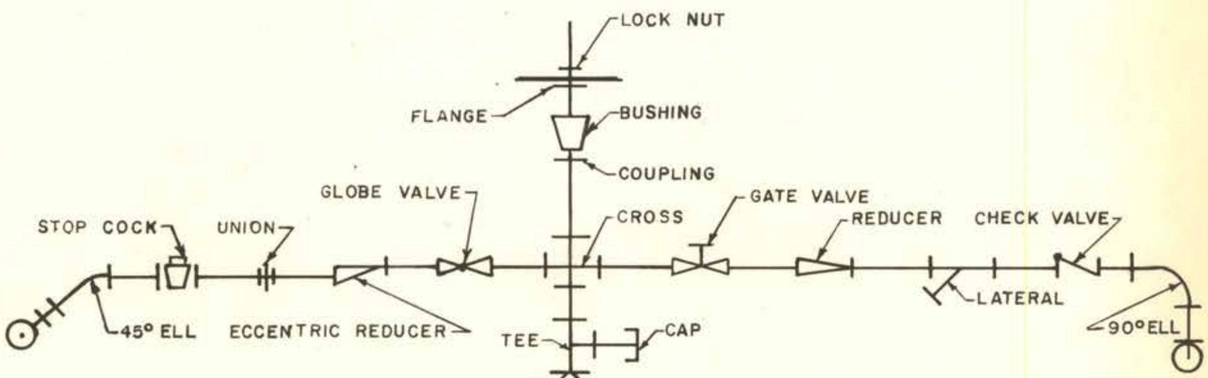
The conventional multiview drawing, compared with the simplified note method, is illustrated in Fig. 11 and 12. Each are complimented with exact detailed communication to the blueprint reader. A bill of materials will accompany both to the manufacturer's shop. The note, however similar it may be to the bill of materials, should not replace this description. In most engineering and drafting departments a part, regardless of its simple design, requires a given part number. Once this number has been issued, a drawing of the part must be drawn and a permanent document filed.

The simplicity of the note system makes it desirable, but discretion should be employed. Misuse can lead to communication breakdown between shop and engineering, and create many undesirable situations for liaison personnel.

III-9. Mechanical Drafting Aids. Mechanical aids simplify drafting. Automation designs for other phases of industry have been reflected back to the drafting field. The designer has realized that automation can be used to help relieve the draftsman shortage. The Boeing Company has met this challenge and has partially completed one innovation that will ease the load of the engineer and draftsman. This innovation has been named a "Plotter-Verifier" which is capable of drafting from instruction dictated by computer tapes. This machine was constructed originally for verifying magnetic tapes, used for numerical control machining; but it



PIPING DIAGRAM



SYMBOLIC DIAGRAM

PIPING SYMBOLS
FIG. 10

also has the capability of making line drawings, airfoils, three-view drawings of parts, charts, or any other drawing that can be defined through the use of computed point data.[8] The tape computer has a ball point pen that responds to instruction from the tape and moves in the quadrant directions of x, y, and z. A savings in time and an increase in accuracy are significant benefits. An added feature is that once the taper is prepared, it can be catalogued and stored. At any future time the drawing can be reproduced within seven to ten minutes.

Other more common mechanical aids include drafting machines, mechanical pencils, electric erasers, electric calculating machines, electric drafting typewriters, plastic cutout templates, cellulose acetate appliques, self-adhering layout tapes, etc. The mechanical aids are probably the most recognized time savers; however, a very important complimentary feature is the reduction of the mental and physical efforts of the draftsman.

III-10. Templates. A large selection of templates are available for specialized needs. A template may be found for drawing any symbol that has been approved by either American Standards Association or Military Standards. The templates receiving the most popularity are the circle and ellipse; however, there are others that justly deserve their place on a drafting board.

Utilizing the time saving templates is the responsibility of all simplified type draftsmen. The template is accurate and, in most cases, to a closer tolerance than can be drawn by the draftsman.

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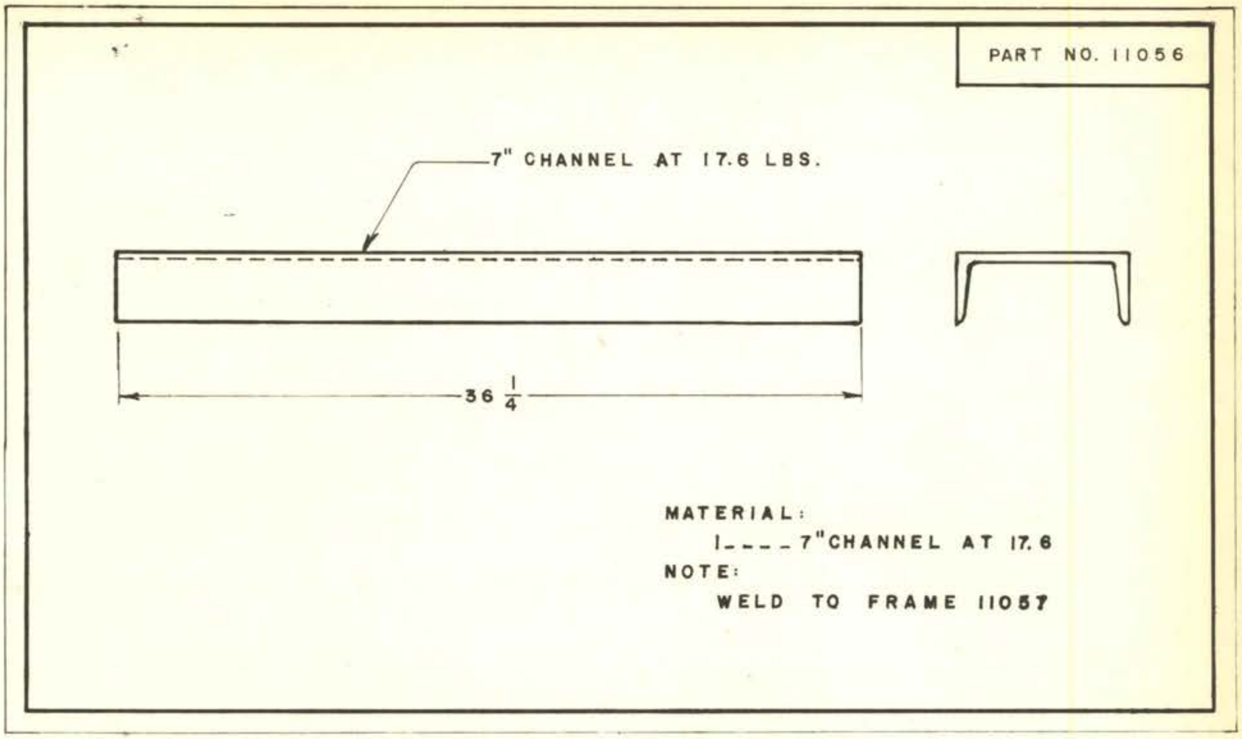
[8]Nelson, Leonard A., "Training For Change in Drafting and Design," ed. Reproduction Engineer, July, 1961, p. 250.



STANDARD DRAWING PRACTICE

PART NO. 11056

NOTE:
SAW CUT 7" CHANNEL AT 17.6 LBS.
36 1/4 AND WELD TO FRAME NO. 11057

MATERIAL:
1 - - - 7" CHANNEL AT 17.6 LBS. X 36 1/4

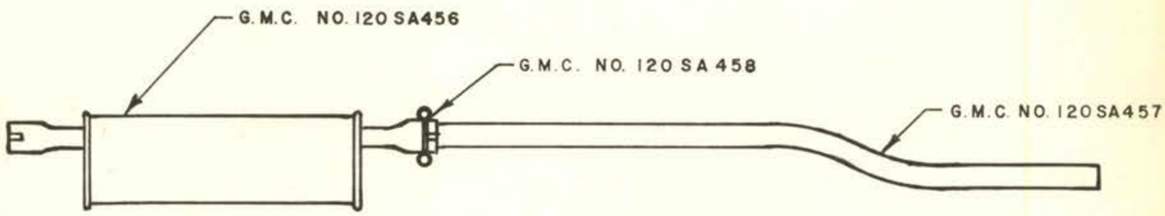
SIMPLIFIED FORM OF DRAWING

RAW MATERIAL DRAWING BY NOTE

FIG. 11

STANDARD DRAWING

ASSEMBLY NO. 14072



MATERIAL:

1------ G.M.C. MUFFLER NO. 120 SA 456
1------- G.M.C. EXHAUST PIPE NO. 120 SA 457
1------- G.M.C. PIPE CLAMP NO. 120 SA 458

SIMPLIFIED FORM

ASSEMBLY NO. 14072

NOTE:

ASSEMBLE PIPE NO. 120 SA457 TO MUFFLER NO. 120 SA456 BY MEANS OF CLAMP NO. 120 SA 458.

MATERIAL:

1-------- G. M. C. MUFFLER NO. 120 SA456
1-------- G. M. C. EXHAUST PIPE NO. 120 SA 457
1-------- G. M. C. PIPE CLAMP NO. 120 SA458

VENDORS PART BY NOTE (SIMPLIFIED)
FIG. 12

The shapes of some templates are so designed that they replace the 45° triangle, 30°-60° triangle, and French curve; thus, eliminating the expense of purchasing two devices, plus, decreasing the number of instruments required on the drawing board while working. The templates are generally made of .030 inch matte finish mathematical quality plastic, giving them a durable finish.

An additional feature of interest to the simplified type draftsman is the specially designed template which may be ordered in quantity, per customer's specification. This can prove to be beneficial for use on company insignias, title blocks and special notes that are placed on each drawing. The aid of a template allows the draftsman to trace rather than draw this special material. Cost of the special template may often be prohibitive; however, a cost analysis of the job often reveals that the special template will warrant the high cost involved.

An extensive selection of templates to aid engineers and draftsmen are available by manufacturers, such as Rapidesign, Post, Handy, Roark, Dietzgen, Timely, Keuffel and Esser, and Wrico.

Lettering templates are also available but are not recommended for use by the simplified draftsman. Contrary to other templates, they are more time consuming than the free-hand style of lettering. With the emphasis being placed on drawing time, the simplified type draftsman should practice a legible, neat, modified gothic style of free-hand lettering. The aid of an Ames Lettering Guide, or equivalent, should be employed. With this instrument, uniformly spaced sets of guide lines are accurately and easily constructed. The choice of different ratios for the spacing within each set of guide lines is provided. These ratios allow various sizes of inclined or vertical type of letters to be made. Lettering devices, other than Ames, may be purchased. They are the

Braddock and Wrico. Each is incorporated into a 45° triangle, which makes it universal for other uses.

The simplified draftsman should keep well informed on new template products being placed on the market. He should diligently employ templates wherever possible and be familiar with the various time-saving qualities of each template. The template may be regarded as one of the most important instruments used by the simplified style draftsman.

III-11. Complexity. Complex parts can be described more readily and economically with a drawing than by conversation. The purpose of an engineering drawing that demands an engineer or draftsman's explanation to accompany the drawing is defeated before it leaves the drawing board. Costly revisions are generally inevitable and will be necessary before the part can be manufactured economically.

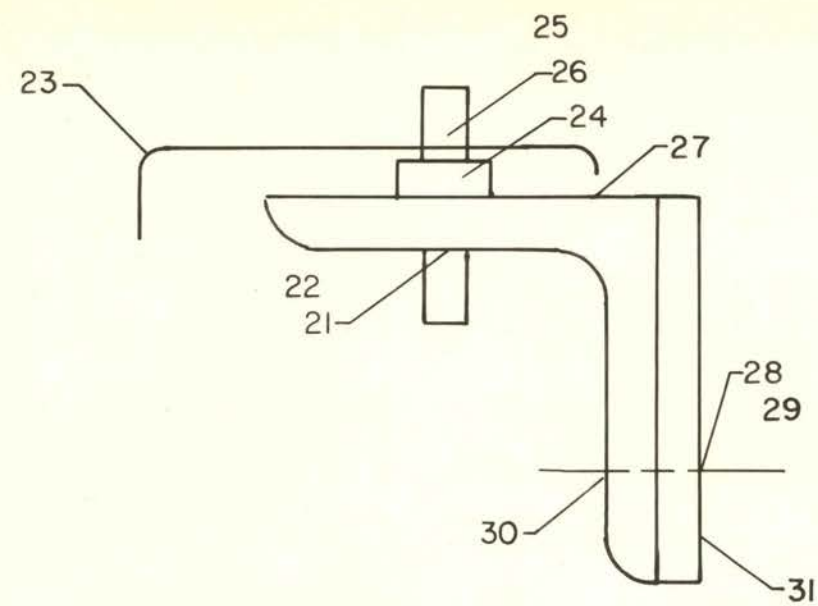
Complexity can be obtained within a drawing by such simple things as line weights, arrows, notes, circles, etc. To avoid this type of complexity, the draftsman must adopt certain simplified practices. Some of the major practices have been discussed in the preceeding paragraphs. It should be accepted that the large time savings are achieved by the major practices; however, there is much to be said in behalf of the small minute practices.

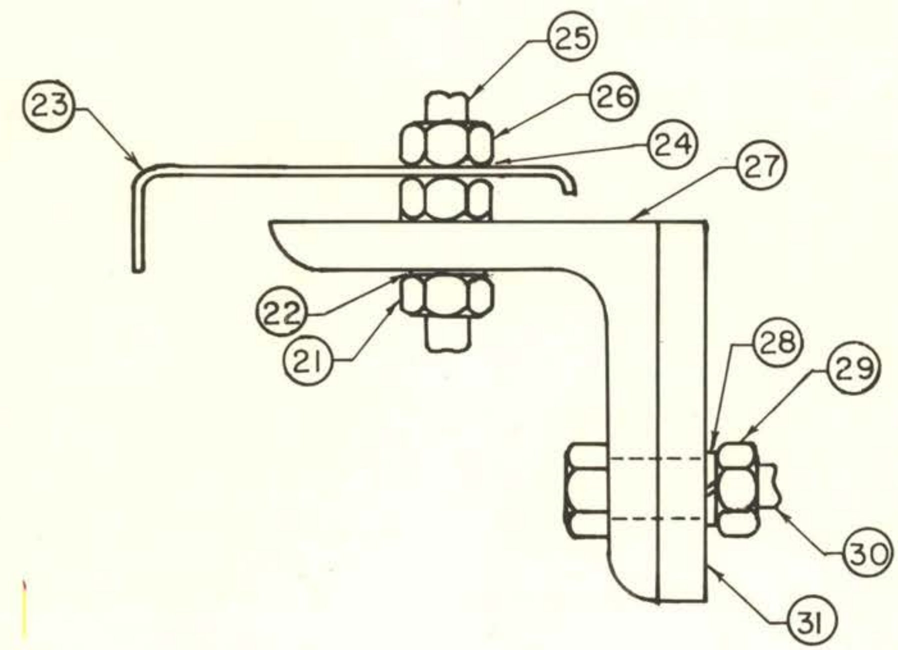
Architectural draftsmen have been credited as the first to eliminate the arrowhead. This small but quite significant symbol, indicating the extent of a dimension or leader, has long been a problem for the beginning draftsman. Its size and shape has varied from one draftsman to another. American Standards Association recommends that a uniform size and style be maintained. The length of one-eighth inch should be average and the width approximately one-third of the length. They should be uniform in size and style throughout the drawing; regardless of the size of drawing or the length of the dimension.

Arrowheads should be omitted except where necessary for clarity. When arrowheads are drawn by the dozens in terms of the "time" needed to draw each, they add up to a sizeable amount of drafting time. To simplify and initiate a more controllable means of indicating the extent of a dimension or leader, the architect has introduced the point method. Much can be said in favor of the simplicity and uniformity of the point method. These favorable facts are: experience is not a necessity for the construction; a sharp pencil lead is not necessary; simple one-stroke construction; prints well; envolves no side arm movements; and is clear, distinct and uniform. See Fig. 13. The conventional arrowhead can offer no advantages over the point methods, and is indeed a "time consumer" compared with the point.

Another complexity is the circle placed around the material identification number and revision letters. The significance of the circle is to allow the number to stand out and set it off from the other features on the drawing. See Fig. 13. However valid this may seem, no proof can be given for this reasoning. An experienced blueprint reader will first read his print, next the bill of materials and then revision block. At this point he will correlate the three and will be familiar enough with the drawing to isolate most material numbers that are of significant value. The circle, to the blueprint reader, has served no value other than indicating completeness. This type of completeness is not desired or necessary in simplified drawing.

The final complexity to be discussed is line weights. This is important to both the technical and simplified style draftsmen. Although line weights are a problem in inking as well as in pencil, the latter





ARROWS AND CIRCLES LEAD

TO COMPLEXITY

FIG. 13

will be of the most importance to the simplified draftsman. We normally think of ink drawings being in other forms than simplified. This should not imply that inking of simplified drawings is not permissable. It should be understood that simplified drawing is employed as a "time saver" and inking drawings is a "time consumer"; therefore, it is not likely that the company desiring to speed up their drafting department, would slow them down by using inks.

Pencil lines should be sharp and uniform the entire length of the line. The distinction between object lines, hidden lines, center lines and guide lines should be pronounced. The simplified draftsman will use this medium to boldly present the outline of the object being drawn. This will capture the blueprint reader's eye and immediately concentrate his attention on the construction procedures of the part. This line should be of medium width and very black.

Of secondary emphasis is the hidden line. This is the part of the object which is hidden from the selected view presentation. It is a dashed line and is classed with that of the auxiliary lines. The darkness and width of the line is slightly less than that of the object line.

Center lines should be used to indicate axes of symetrical objects, bolt circles, and paths of motion.

In simplified drafting, the center line is used more extensively than in conventional drafting. As was illustrated in Fig. 6, the center line shows symmetry of the partial and in Fig. 8, the center lines represent the basic outline of the elaborate part. To illustrate the center line, a long dash, which may vary in length from three-fourths inch to one and one half inches, is followed by a short, one-eighth dash line, with a one-sixteenth inch space between them. The line should be thin enough to contrast well with the existing lines; but dark enough to reproduce well.

Guide lines, construction lines, or preliminary lines should be drawn dark enough for the draftsman to see, but light enough that they become invisible at an arm's length. In simplified drawing, these lines should never be erased whereas in conventional drafting, they are often erased.

When drawing a line, the pencil should be inclined at about 60° in the direction the line is being drawn. Rotate the pencil very slowly between the thumb and index finger. Never push the pencil; but it should be pulled at the same inclination for the full length of the line. This will maintain a straight uniform line and will aid in preserving a conical point on the pencil. Sharpening the pencil often will improve line weights and control uniformity.

III-12. Dimensioning. After the shape of the object has been illustrated by orthographic or pictorial views, it becomes necessary to place dimensions on the drawing that describe the size of the object.

The dimensions placed on the drawing are those required for producing the object represented. Before dimensioning the drawing, the draftsman should study the part from the machinist or pattern-makers viewpoint. A mental picture should be formed and the dimensions arranged to best give the information in the simplified form.

The factors to be considered in simplified dimensioning practices are:

1. Dimensioning Technique. The first requisite is a thorough knowledge of the function of the object and the procedure for

producing the part. A systemized pattern of spacing dimensions, the making of arrowheads, and the placing of notes, becomes an integral part of the draftsman's visual picture.

2. Placement of Dimensions. A practical simple arrangement with maximum legibility should be achieved. The placement should be a logical and practical item from the blueprint reader's viewpoint. The three basic dimensions introduced in Part 6, height, width and depth, should be placed in the same arrangement on each object of each drawing. This simplification allows the blueprint reader to readily pick out the three major dimensions by scanning the drawing.
3. Standard Dimensioning Features. The utilization of dimensioning standards such as, Military Standard 1A, 8A, and 8B,[9] and American Standards Association Y14.5-1957 should be employed.[10]
4. Choice of Dimensions. The first choice of dimensions is determined by the function of the part; secondly it is determined by the manufacturing process; and the final consideration is placed on the review of the existing dimensioning to see if improvements can be made from the standpoint of shop procedures.

The purpose of the dimension is to give the distance between two points, lines, or planes. The numerical value given (fractional or decimal) is the exact distance indicated between the two arrows or dots. Extension lines as in Fig. 14, illustrate the method used to remove the dimension from the object.

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[9] Superintendent of Documents, Military Standards, 5th Edition, March, 1961.

[10] American Standards Association, Catalog of American Standards, A.S.A. Incorporated, February 1, 1961.

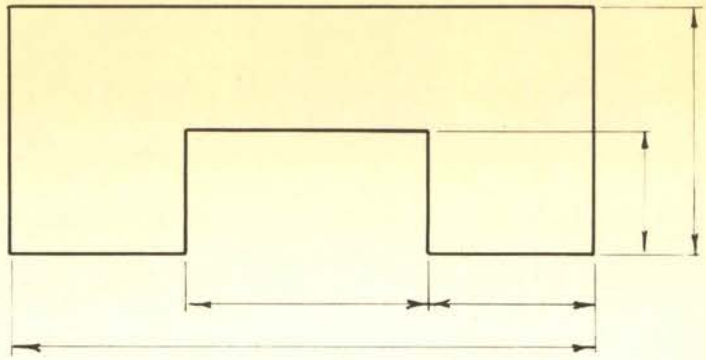
Dimension removal allows the blurprint reader a more legible reading of the drawing and permits the object lines to stand out.

Dimension lines, extension lines, and leaders are drawn with the same line weight. A medium hard pencil, such as, a 4H to 6H should be used and a sharp lead should be maintained. A fine full line the same width of a center line will be the result, and a sharp contrast will exist between these lines and the object lines.

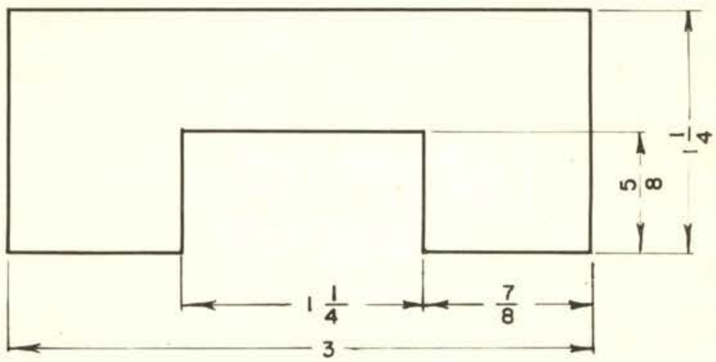
Over simplification of dimensioning practice can become hazardous. Simplified dimensioning must not be thought of as the deletion of dimensions, but rather a concise, systematic means of dimension placing. The uniformity of basic dimension placing between one drawing and another is this form of simplification.

The deletion of repeated dimensions is the only form of removing dimensions from a drawing. This form of superfluous dimensioning is generally not intentional on the draftsman's part and would normally be removed from a drawing. Groove dimensioning as in Fig. 15, would not be considered superfluous dimensions, due to the possible variations in groove width. A note in simplified form would eliminate the necessity of group dimensioning as in Fig. 15; would also allow a more legible interpretation of the drawing.

A drawing lacking proper dimensioning becomes a picture. A very costly picture to manufacturing. A verbal explanation must accompany this type of drawing and manufacturing machines are made idle during this explanation. Again it should be stressed that "minimum data necessary for complete understanding," does not give permission to delete dimensions vital to the manufacture of parts. The acceptance of graphic simplification is dependent upon a well-analyzed engineering document. Simple, without superfluous dimensions, yet complete in size description.



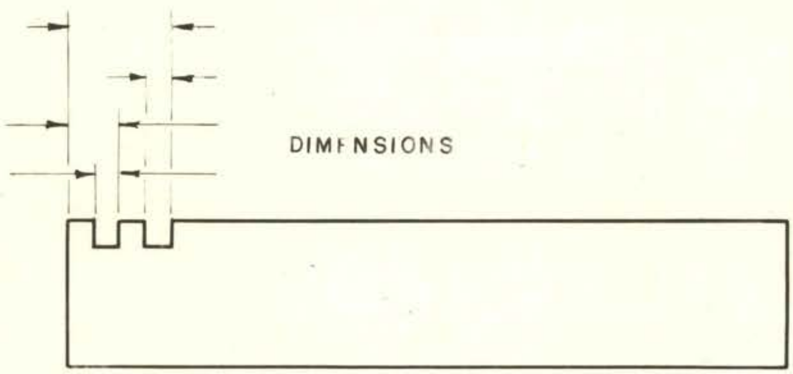
EXTENSION LINES

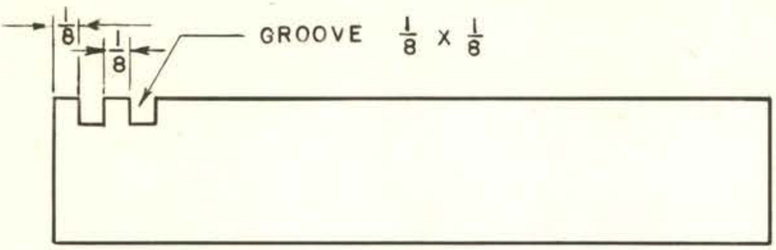


DIMENSION LINES

DIMENSION EXTENSIONS

FIG. 14





DIMENSION BY NOTE

GROOVE DIMENSIONING

FIG. 15

CHAPTER IV

PHOTODRAWING AS A FORM OF SIMPLIFICATION

IV-1. Photodrawing. Photodrawing, as a simplified drawing procedure, is the method of making and using photographs to convey dimension, identification, position and spatial-relationship information in the same manner as engineering drawings. It is very similar to conventional drawing. The only difference is that the draftsman has made a photograph of the subject matter rather than a pencil drawing.

The photodrawing method of simplification is dependent upon the object being built before being drawn. Usually this is not the case; but in certain aspects of research and development this situation does exist. However, manufacturing revisions of a part are often completed before the original drawing is revised. This is an ideal situation for photodrawing. The term "simplified drawing" applies to any subject to be drawn, whether it be a simple tool or a complex machine. When the subject exists before the final drawing is made, a natural situation for photodrawing exists. Countless hours of costly drafting time may be saved through simplification methods. Furthermore, the use of photodrawing has resulted in two major achievements. These are unfailing photographic accuracy and infinite subject detail.

The process is quite inexpensive, relative to drafting time. More pictures can be used to show prospective and concealed detail, whereas with drawing, the number would be restricted due to the costly drafting time involved.[11]

The advantages of photodrawings are numerous; but the most significant advantage is that they promote quick understanding and correct action by the ultimate user. Other uses are of equal value, but restricted to a specific job. They are: high speed photography used to record mechanical motions which are happening too fast for the human eye to observe; black and white and also color photographs can be used to record for analysis, the stress patterns formed when a plastic replica of a part is subjected to undue stress.

When making the photographs for a photodrawing, it would be well if an experienced draftsman were the photographer. However, in the absence of such a draftsman, a draftsman may serve as a consultant to an experienced photographer and assist him in achieving the desired angle for the photodrawing.[12]

The procedure for making a photodrawing is as follows: the draftsman would first take a few basic measurements and then take as many photographs as is deemed necessary. Usually an elevation, plan, and an isometric photograph will suffice for most subjects. With the photographs and basic dimensions, the draftsman can now prepare an accurate drawing of the subject, should the occasion arise. This would be done only if the object photographed was placed on a production basis.

Equipment modifications are quite often made in the field. It is not feasible for the draftsman to take the master document and make the changes or additions under field conditions. A hand sketch of the

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[11]Kupler, Dale, "Photodrawing", The Kodak Bulletin, May, 1961.

[12]Eastman Kodak Company, "What's a Photodrawing", ed. The Kodak Compass, 2:1-12, 1961.

modification is generally employed. This is returned to the drawing board and the changes are made on the master document. This is not only time consuming, but leaves an opportunity for errors and the possibility of vital dimensions being overlooked.

A photodrawing is extremely valuable from the standpoint of accuracy and detail. Overlooked dimensions can be readily scaled and a return to the field is eliminated.

When first preparing photographs for use in photodrawings, a photographic supplier should be consulted. Continuous revisions in the field of photography are taking place each day, and the process and procedure used today will change tomorrow.

Maximum quality is essential. The photographs used for photodrawing require considerable magnification, therefore, the utmost in sharpness, detail, and contrast must be achieved.

The use of long focal length lenses helps to reduce the distortion of converging and diverging lines. This effect is usually apparent in a box camera snap shot taken in a small room. Vertical lines become distorted and appear to lean outward. This must be eliminated before scaling of the photodrawing is achieved.

Continuous tone proof prints should be made from all of the negatives in order to ascertain which photographs contain the desired views and necessary detail. It is usually quite difficult to make these decisions by looking at the image in the ground glass of the camera. Taking extra pictures gives assurance that the whole story is on record.

Making proof prints is good economy, as all of the photographs made will not always be required. Proof prints will help make the decision as to what is necessary for photodrawing, and which are of no value other than a photograph.

The negatives should be cropped to the desired size and a final screen positive made on a matte polyester film. The size change involved, when converting the continuous tone negative to halftone positives, will necessitate the use of an enlarger or a process camera. Due to large magnifications involved in making most photodrawings, a powerful light source in the camera, or enlarger, will be helpful in overcoming long exposure times.

The process as stated above, complete; an enlarged screen positive image of the model on a matte polyester film gives a desirable positive matte surface for the draftsman to work on. The addition of pencil lines can be made or the deletion of existing lines can be achieved by eraser or cutting blade. The screened image is desirable, in that it produces a far superior quality on diazo and blueprint paper than does a continuous tone image.

IV-2. Microfilm. Microfilming was first conceived for the purpose of miniaturazation and space conservation. However, there are additional advantages to microfilm that apply to engineering simplification procedures. They do not necessarily apply to drawing simplifications, but do apply when drawings are old and worn and normally would need to be redrawn before being restored to active use. The microfilm aperture can be enlarged to normal drawing size, a positive matte polyester film made, and a workable drawing achieved. Intermediate cost can be cut considerably by this restoring process.

The photodrawing as a form of simplification and the dependency of prerequisites before satisfactorily fulfilling graphic simplifications was presented in Chapter IV.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to collect data pertaining to engineering graphics simplification and the application and acceptance of these simplifications by industry; present and give proof that simplified drawing is a functional working drawing with purpose in each and every line, legend, note and view placed on the drawing; and to give justification for the elimination of superfluous views, elaborate pictorials, hidden lines, and repetitive detail.

Graphics simplified, as this problem has presented, is an analytic approach to the standard procedures based on sound engineering graphics, to relieve the time stress placed on today's engineer and draftsman.

Data for the study were obtained by visiting various types of industry, and a survey that was mailed to engineers and draftsmen who work directly with the problem presented.

V-1. Problem Summarized. A study was made on simplified engineering graphics and the application to industry within a 250-mile radius of Miami, Oklahoma. The problem was found to be quite complex and it is not implied that Chapter III is the graphic standards to be accepted by industry, American Standards Association or the Military Standards Bureau. The survey taken does indicate that foundation does exist for graphic simplification and the need is evident.

The approach made by this study was based on sound engineering graphics taken from recognized authorities in the field of study, and by standards now recognized by the American Standards Association and Military Standards Bureau.

V-2. Conclusions. The following conclusions were made from this study based on the results obtained:

1. The average engineer to draftsman ratio is three to one.
2. Engineering Standard Manuals are being used in most engineering documents.
3. Engineering Standard Manuals are made current as the revision is being initiated.
4. Industry Looks to the American Standards Association and the Military Standards Bureau for the rules of standardization of engineering graphics.
5. Industry is lax in providing their personnel with standard manuals of company graphic policy.
6. Accuracy of engineering drawing is sacrificed to speed up certain jobs having deadlines.
7. Industry has no place for the draftsman with fancy frills added to his drawing.
8. The draftsman's work is creative.
9. Simplification standards are needed and wanted by the draftsman and engineer.
10. Industry is not using simple deleneations for common objects.
11. The utilizing of drawing templates is apparent to the draftsman. This is verified by the draftsman's furnishing his own templates.
12. Inked drawings are almost obsolete, with the exception of mapping and production illustration.
13. Engineering departments are utilizing pre-printed forms.

TABLE II

ENGINEERING-DRAFTING

STANDARDS MANUAL

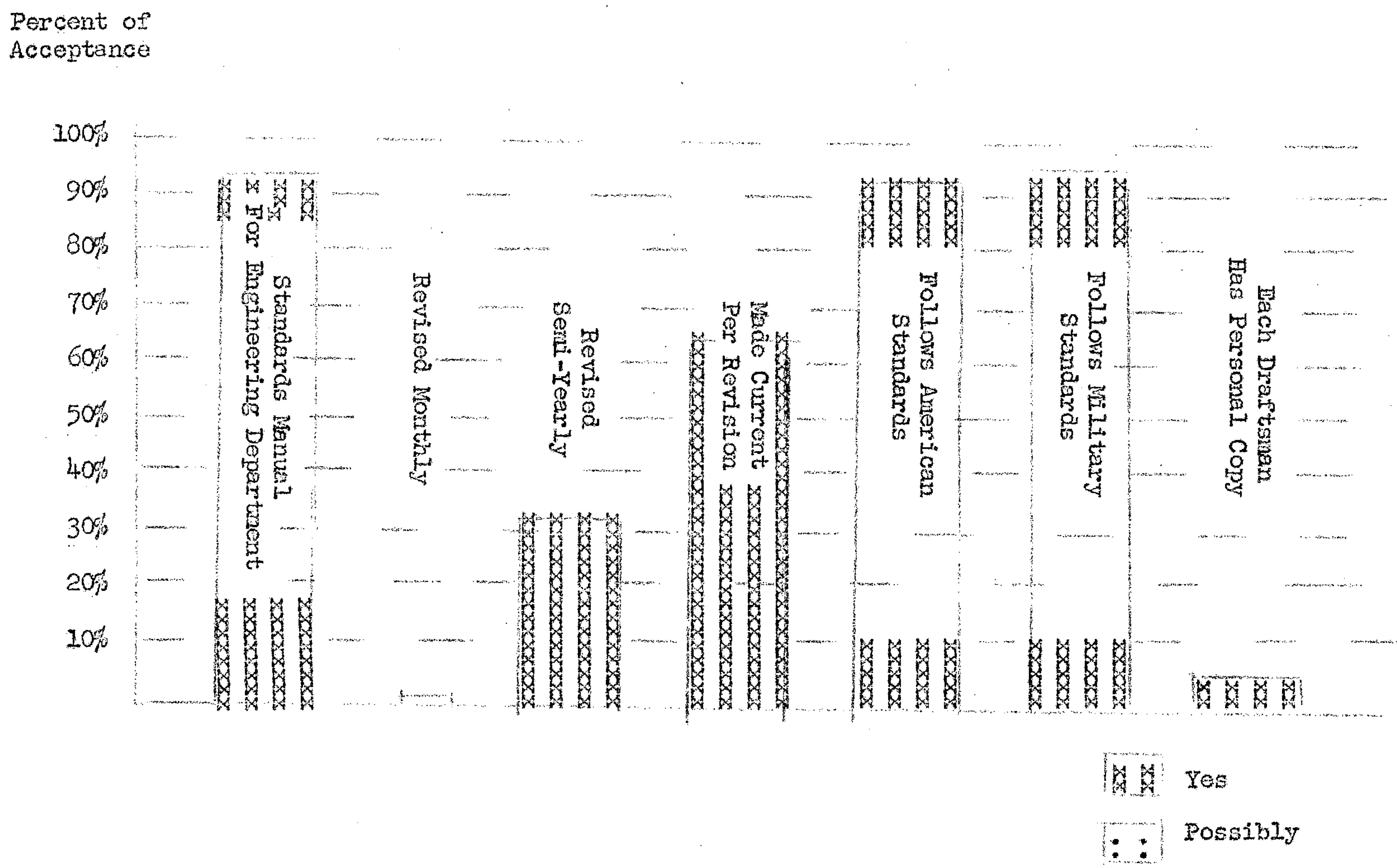


TABLE III

GRAPHIC SIMPLIFICATION STANDARDS

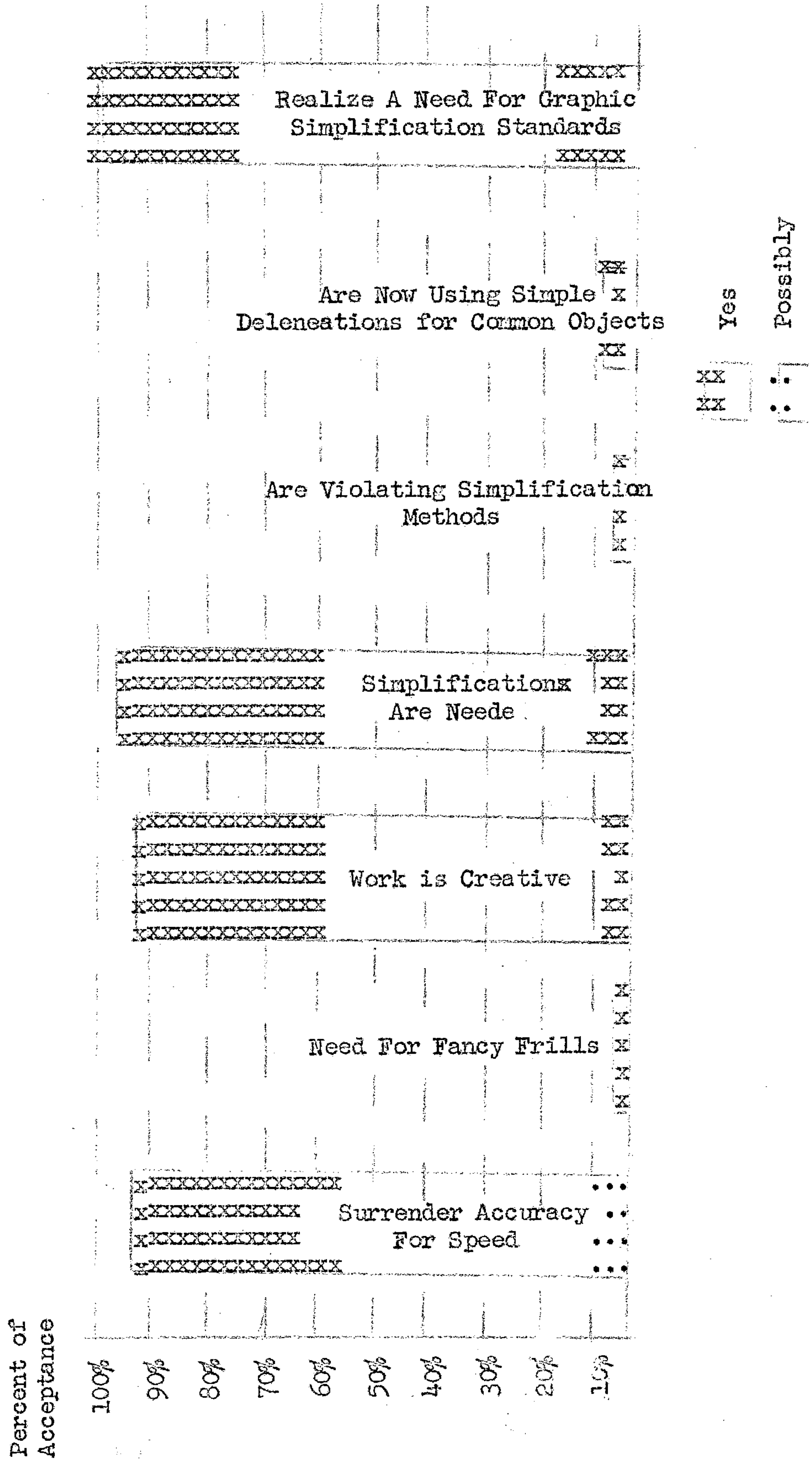


TABLE IV

ENGINEERING DEPARTMENT DESCRIPTION

ENGINEER TO DRAFTSMAN RATIO

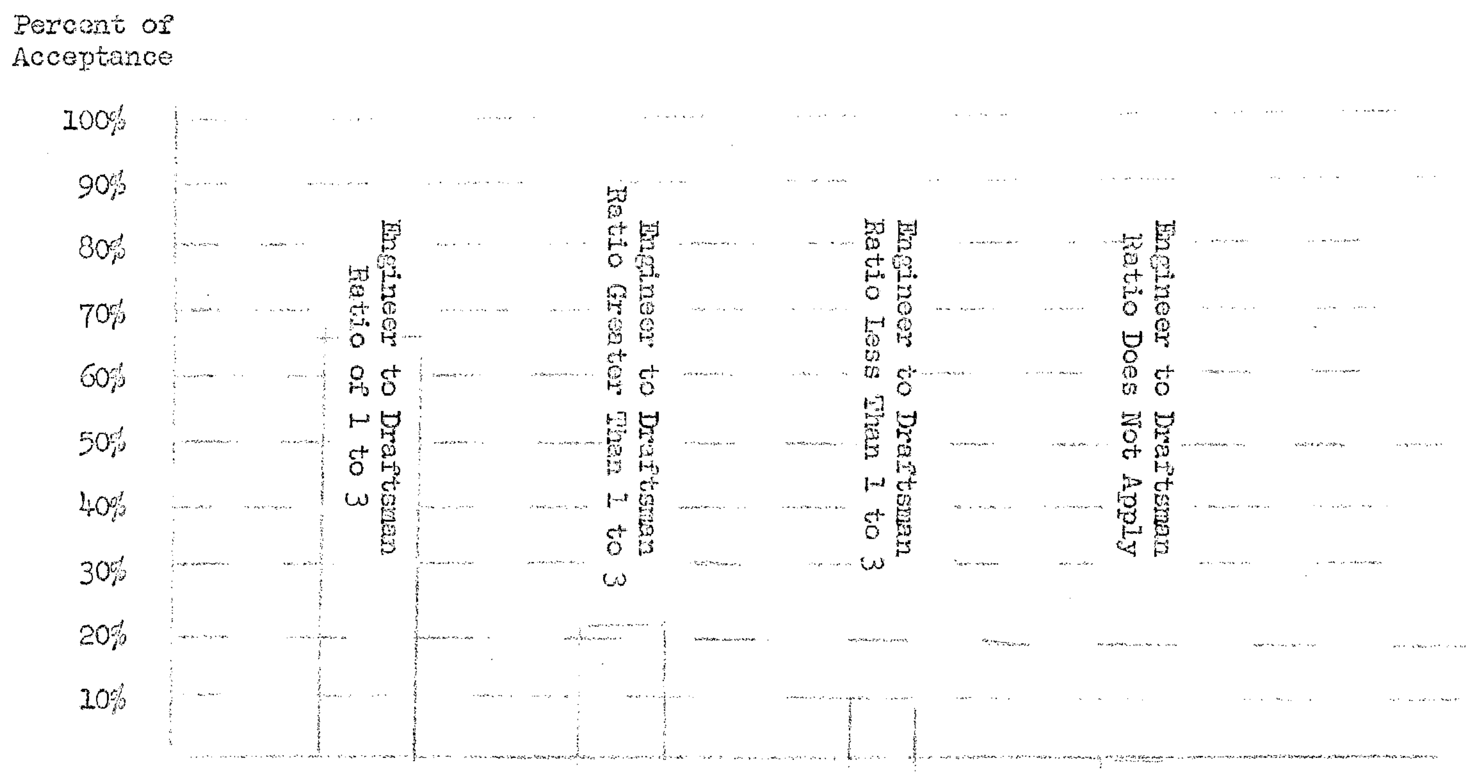


TABLE V

DRAFTING DEPARTMENT

WORK DESCRIPTION

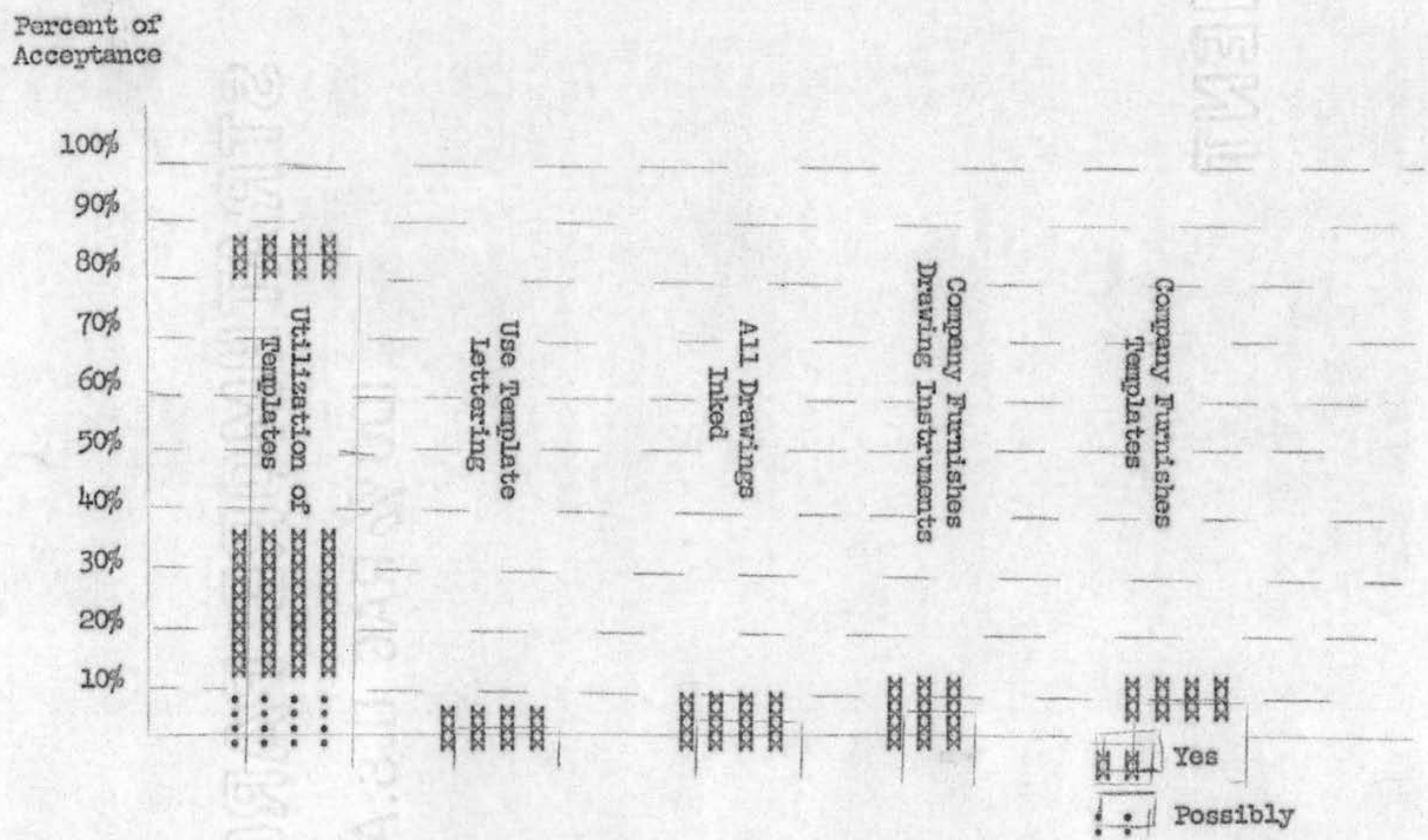


TABLE VI

TYPE OF ENGINEERING

AND DRAFTING

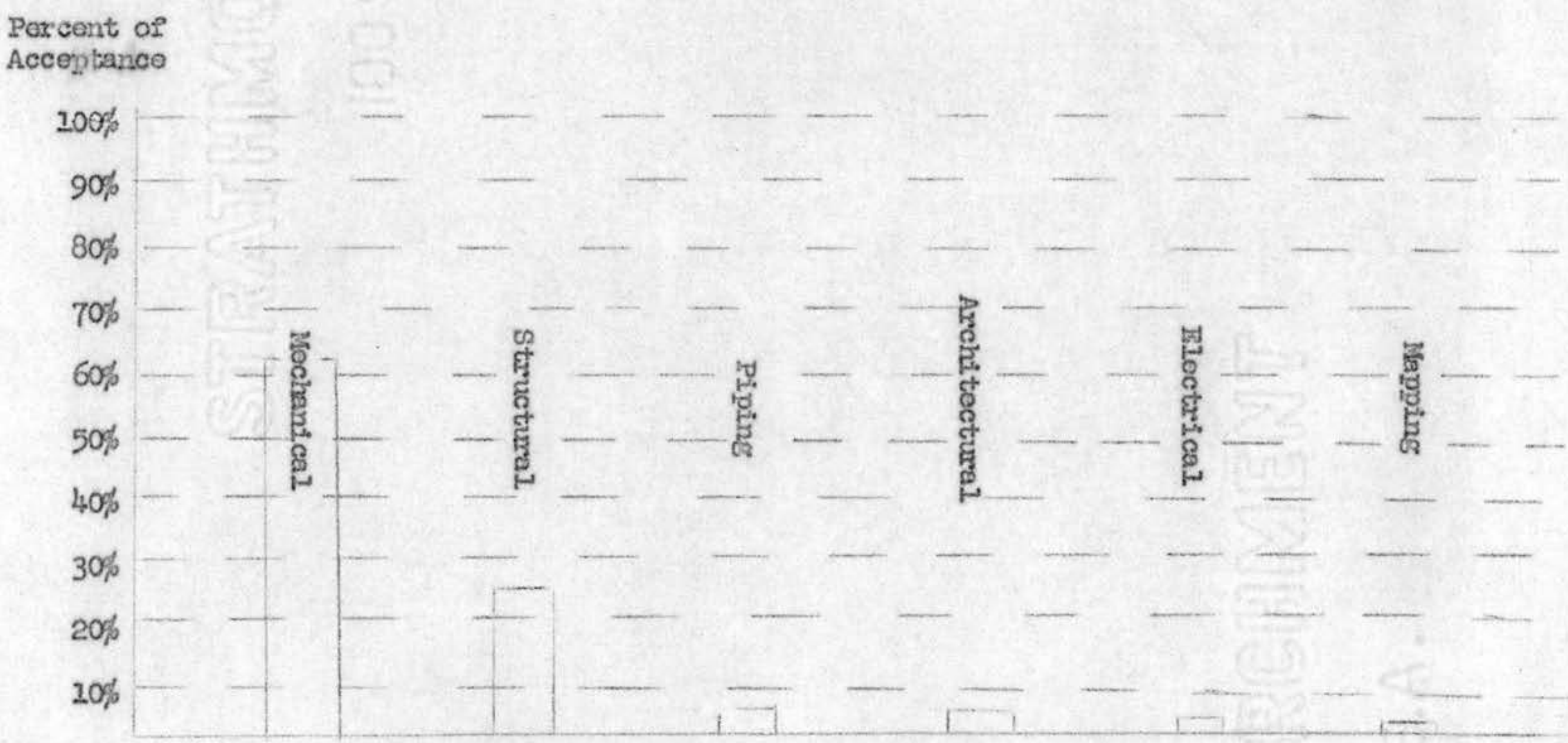


TABLE VII

ENGINEERING COST TRENDS

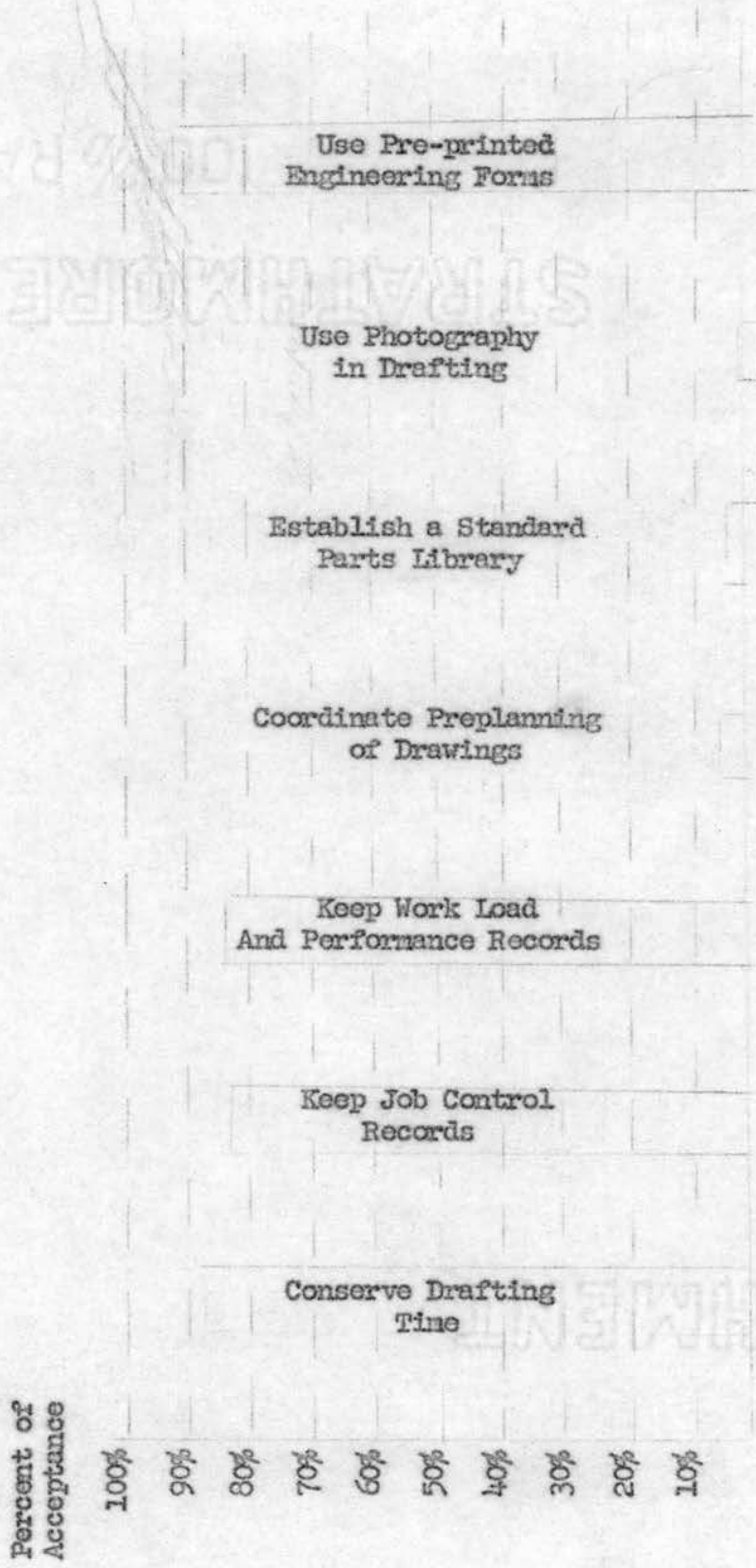
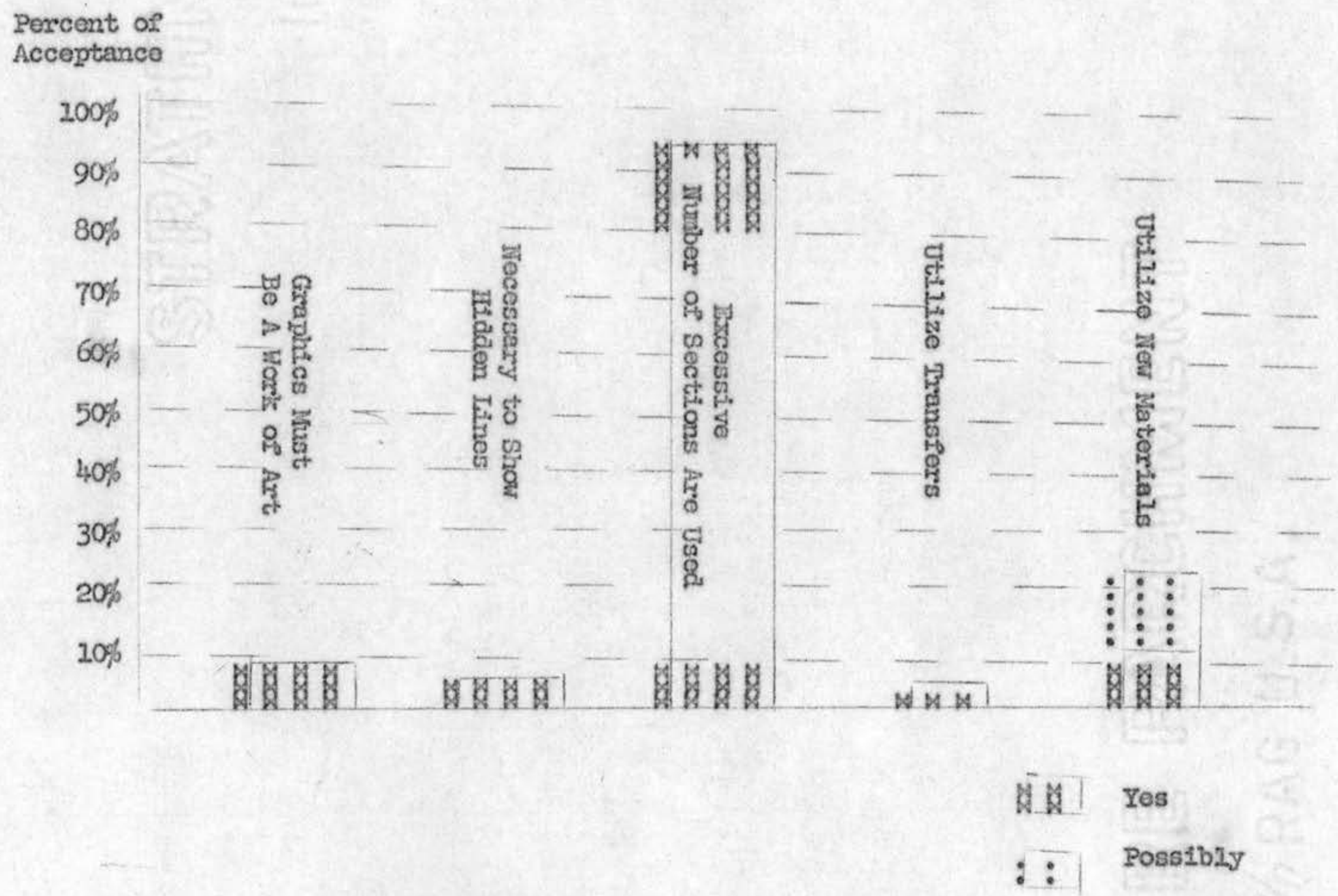


TABLE VIII

DRAFTSMAN TRENDS



14. Standard parts library is being used in most industries.

15. Photodrawing has not been accepted or utilized by industry.

16. Excessive numbers of sections are used to overillustrate a part.

17. It is not deemed necessary to show hidden lines on a drawing when clarity is not dependent upon their use.

The pre-stated conclusions are based on the Tables II, III, IV, V, VI, VII and VIII compiled from the survey in Appendix B.

V-III. Recommendations. The following recommendations, based on the research revealed by the industrial survey and personal interviews, are:

1. Further studies be made to the division of time and the engineer to draftsman ratio.

2. Eliminate elaborate pictorials on working drawings, "Reserve the right to use pictorials and elaborate views in catalogues and brochure presentations."[13]

3. Adopt company standards to meet those of American Standards Association and Military Standards Bureau.[14]

4. Cross-sectioning should be employed only if clarity or understanding is dependent upon it and then only partial cross sectioning should be considered.[15]

5. Superfluous views that lack dimensions or written instruction thereon should be omitted.

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[13] Personal Interview, Production Illustration Department Head, Phillips Petroleum Company, Bartlesville, Oklahoma, May 29, 1962.

[14] Written Interview, Huey M. York, Design Draftsman, The Eagle-Picher Company, Joplin, Missouri, May 23, 1962.

[15] Rau, A. H., "How to Simplify Engineering Drawing," The Iron Age, December 27, 1958.

6. Delineation of commonly used objects are substituted by the use of symbols traced from templates.
7. Photodrawing should be realized on equipment revisions and research projects developed before formal engineering drawings are made.[16]
8. Typing should replace free-hand lettering for extensive parts list and lengthy informative notes.
9. Free-hand drawing should replace mechanical drawing when the situation permits.
10. Special reproduction papers, such as mylars, sepias, and other synthetics should be utilized when the situation permits.

The following recommendations and statements were extracted from written interviews received with the industrial survey.

"We would welcome universal accepted simplification standards. Presently we are in the process of starting a manual which will, as far as possible, follow American Standards."[17]

"Whenever applicable, our standards have been made to conform to American Standard recommendations of drawing and drafting room practices."[18]

"There is definitely a need for simplified drafting practices used in industry. It would be a great asset in saving time and money."[19]

"We do not have a standards manual for procedures, but we do have

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[16] (No author given), "What's A Photodrawing?", The Kodak Compass, February, 1961, pp. 1-12.

[17] Written Interview, Lowe, K. B., Chief Engineer, Rogers Ironworks Company, Joplin, Missouri, June 8, 1962.

[18] Written Interview, Neff, Windell, Illustrator, Phillips Petroleum Company, Bartlesville, Oklahoma, June 10, 1962.

[19] Written Interview, Huey M. York, Design Draftsman, The Eagle-Picher Company, Joplin, Missouri, May 23, 1962.

some simplified drawing for particular types of natural gas settings."[20]

"We are opposed to over-simplification, free-hand drawing, etc. Our drafting manual calls for good, solid drafting conventions minus unnecessary fancies."[21]

"We are of the opinion that simplification is good up to a point. We think extremely simplified drawing leads to shop errors."[22]

"We are a young company with three engineers and do our own drafting. There is no engineer to draftsman ratio."[23]

A thorough theoretical study of the problem is lacking; therefore, it is impossible to determine the acceptance of simplified graphics by industry. The results of this study are favorable. Simplified graphic standards, infused by an accepted standards association, would be accepted by most industries.

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[20]Written Interview, Allen Aiden, Chief Draftsman, Oklahoma Natural Gas Company, May 29, 1962.

[21]Written Interview, Nelson, Leonard A., Engineer, Boeing Aircraft Company, Wichita, Kansas, June 5, 1962.

[22]Written Interview, Cupps, Fate, Design Drafting Head, Amerada Petroleum Company, Tulsa, Oklahoma, June 2, 1962.

[23]Written Interview, Schuermann, K. W., Ditchwitch Company, Perry, Oklahoma, June 5, 1962.

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APPENDICES

APPENDIX A

Letter which was mailed to the cooperating engineers and draftsmen in industry.

Dear Sir:

The development of a sound industrial-education research project is based on the consultation efforts of authorities in industry and education. The desired result of industrial education research can only be obtained through the cooperation and guidance of these authorities. We are requesting your participation in obtaining the desired research data regarding the acceptance and application of simplified engineering graphics in industry.

This research project is under the guidance of Dr. Roy W. Dugger, United States Office of Education, Mr. Joe W. Ables, Oklahoma State Title VIII and Manpower Supervisor, and the Drafting and Design Technology Department of Northeastern A&M College.

The request for your participation consists of your evaluation of the enclosed questionnaire and offering any additional comments or pertinent factors in the development of this research project.

If company policy permits, samples of your graphic simplifications and the bulletin regarding simplifications from your engineering drafting manual would be greatly appreciated and would be an asset in developing the desired result of this research project.

We would like to take this opportunity to express our appreciation in the cooperation you have extended us. The results of this research can be obtained upon your request.

Sincerely,

J. D. Wilhoit,

Enclosures:

Survey that was mailed to the cooperating engineers and draftsmen in industry.

Engineering Graphics Simplified

ections: Place check mark (✓) in appropriate column.

0 -- Does not apply
1 -- No
2 -- Possible
3 -- Yes

Engineering-Drafting Standards Manual

	0	1	2	3
1. Does a standards manual exist in the department				
2. Is it made current monthly				
3. Is it made current semi-yearly				
4. Is it made current per revision				✓
5. Does it follow American Standard Association				
6. Does it follow Military Standard Specification				
7. Each draftsman has a personal copy				
8. Revisions determined by Chief Draftsman				

ments:

Engineering Department Description

	0	1	2	3
1. Is engineer-draftsman ratio 1-3				
2. Greater than 1-3				
3. Less than 1-3				
4. Are drawing templates utilized				
5. Is template lettering used				
6. All drawings inked				
7. Some inking, but not majority				
8. Does company furnish drawing tools				
9. Does company furnish templates				

nents:

Type of Enginerring and Drafting

	0	1	2	3
1. Mechanical				
2. Structural				
3. Piping				

4. Architectural
5. Electrical
6. Mapping
7. General

ents:

Degree of Drawing

1. Place for art
2. Simple, concise and instructive
3. Complex
4. Emphasis is placed on creativity

ents:

Engineering Cost

1. Conserve draftsmans' time
2. Keep job control records
3. Keep work-load and performance records
4. Coordinate preplanning of drawings
5. Examine and expand design data
6. Establish library of standard parts
7. Use of photography in drafting
8. Abbreviations in reducing the amount of lettering
9. Use preprinted engineering forms
10. Use mechanical aids

ents:

Draftsman Trends

1. Must be a work of art
2. Necessary to show excessive hidden lines
3. Excessive number of sections
4. Full utilization of transfers
5. Addition of fancy frills to drawings
6. Surrenders accuracy for speed

7. Work is creative
8. New materials are utilized
9. Simplified views are desired
10. Views of symmetrical parts are shown as partials
11. Violate over-simplifications methods
12. Use of simple delineation for common objects such as nuts, bolts, and etc.
13. Elimination of superfluous views
14. Restricted use of all graphic simplifications
15. Desire for simplification standards to be initiated by American Standards Association and Military Specification Burea concerning engineering drawings.

ments:

APPENDIX C

List of persons who participated in the survey.

Allen, Aiden, Drafting Head, Oklahoma Natural Gas Company, Oklahoma City, Oklahoma.

Autry, Vann, Draftsman, Capitol Steel Company, Norman, Oklahoma.

Booth, Larry, Engineer Aid, Goodrich Company, Miami, Oklahoma.

Burnham, James L., Draftsman, Fife Manufacturing Company, Oklahoma City, Oklhoma.

Clark, Marion E., Draftsman, Oklahoma Geological Survey Company, Oklahoma City, Oklahoma.

Cunningham, Joe, Draftsman, Capitol Steel Company, Oklahoma City, Oklahoma.

Cupps, Fate, Design Drafting Head, Amerada Petroleum Company, Tulsa, Oklahoma.

Esslinger, R. T., Chief Draftsman, Acme Iron Works, Joplin, Missouri.

Ford, Dwight, Draftsman, Champlin Oil Company, Oklahoma City, Oklahoma..

Fourier, Earl, Design Draftsman, George E. Failing Company, Enid, Oklahoma.

Freling, Nick, Production Illustration Head, Phillips Petroleum Company, Bartlesville, Oklahoma

Gohrs, Theodore, Chief Draftsman, Kerr-McGee Oil Company, Oklahoma City, Oklahoma.

Grubbs, Seth, Engineer, Oklahoma Natureal Gas Company, Tulsa, Oklahoma.

Harris, Donald, Draftsman, D-X Sunray Oil Company, Oklahoma City, Oklahoma.

Harris, Douglas, Draftsman, Oklahoma City, Oklahoma.

Hicks, Marrion, Instructor, Oklahoma City University, Oklahoma City, Oklahoma.

Hirst, J. W., Engineer, Oklahoma Gas and Electric Company, Enid, Oklahoma.

Hoel, Clyde, Draftsman, Tinker Air Base, Midwest City, Oklahoma.

Lee, Gary, Draftsman, Kipp-Roderts Company, Miami, Oklahoma.

Lowe, K. B., Chief Engineer, Missouri Steel Company, Joplin, Missouri.

Maulsby, Lindell, Draftsman, Greystone Company, Oklahoma City, Oklahoma.

Moore, John, Draftsman, Oklahoma City Service, Oklahoma City, Oklahoma.

Neff, Windell, Illustrator, Phillips Petroleum Company, Bartlesville, Oklahoma.

Nelson, Leonard, Engineer, Boeing Aircraft Company, Wichita, Kansas.

Riggs, Bernard, Draftsman, Phillips Petroleum Company, Bartlesville, Oklahoma.

Schuermann, K. W., Engineer, Ditchwitch Company, Perry, Oklahoma.

Simpson, Bill, Engineer, The Eagle-Picher Company, Joplin, Missouri.

Snyder, Byron, Engineer, George E. Failing Company, Enid, Oklahoma.

Snyder, Harold, Chief Draftsman, D-X Sunray Oil Company, Oklahoma City, Oklahoma.

Sutton, Max, Chief Draftsman, Rocketdyne Company, Neosho, Missouri.

Weeks, Earl, Head Draftsman, Champlin Oil Company, Enid, Oklahoma.

Wilson, Jack, Draftsman, Oklahoma Highway Department, Oklahoma City, Oklahoma.

York, Huey, Design Draftsman, The Eagle-Picher Company, Joplin, Missouri.

Young, Jerry, Draftsman, Crane Company, Miami, Oklahoma.

Personal Interviews

Cupps, Fate, Design Drafting Head, Amerada Petroleum Company, Tulsa, Oklahoma.

Fourier, Earl, Design Draftsman, George E. Failing Company, Enid, Oklahoma.

Freling, Nick, Production Illustration Department Head, Phillips Petroleum Company, Bartlesville, Oklahoma.

Grubbs, Seth, Design Draftsman, Oklahoma Natural Gas Company, Tulsa, Oklahoma.

Hirst, J. W., Engineer, Oklahoma Gas and Electric Company, Enid, Oklahoma.

Johnson, Loyd, Educational Director, Rocketdyne Division of North American Aviation, Neosho, Missouri.

Schuermann, K. W., Engineer, Ditchwitch Company, Perry, Oklahoma.

Snyder, Byron, Engineer, George E. Failing Company, Enid, Oklahoma.

York, Huey, Design Draftsman, The Eagle-Picher Company, Joplin, Missouri.