UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

THE PREPARATION OF TECHNICAL REPORTS

General Report No. 4

RESEARCH AND GEOLOGY DIVISION

HYD 262

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

MARCH 8, 1948

"What is all knowledge ... but recorded experience?" - Carlyle

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FOREWARD

There has been a need for a number of years for reference material on report writing oriented to laboratory activities. This memorandum has been prepared to meet that need. It is subject to revision based upon actual experience. Any suggestions for improvement will be appreciated.

"Since a report is fundamentally the communication of information or counsel which is desired and which will be used by someone for a particular end, its success depends primarily on its being planned carefully to meet all the conditions under which it is to serve. The introduction should present a clear statement of the subject, of the purpose, and of the plan of organization of the material treated. It often also includes a brief statement of the conclusion, or recommendation, and sometimes a summary of results or findings. The conclusion should agree and balance logically with this introduction. The body of the report should be so written as to make evident the structural design announced in the introduction. Ideally, a report should read coherently and smoothly, and should bear evidence of the writer's mastery of his subject matter in its larger aspects as well as in its minutest details."

From "Writing the Technical Report" by J. Raleigh Nelson.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Research and Geology Division
Denver, Colorado
March 8, 1948

General Report No. 4
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Subject: The preparation of technical reports.

SUMMARY

The material contained in this discussion has been assembled for use primarily by engineering personnel in the preparation of technical reports. It differs from most textbooks in that, not only are the desirable qualities of a good report listed and discussed, but in many cases detailed methods for obtaining these qualities are given. The proposed methods and suggestions have been tested by actual use and should prove helpful to inexperienced writers. Further, the examples and illustrations are intended to establish uniform standards for all writers.

This discussion applies in particular to laboratory reports which usually cover research, development, or testing of any nature. However, parts of the discussion are applicable to field trip reports, form reports, letters, or any other type of written material.

This report is written and assembled in a form suitable for laboratory reports in accordance with the Bureau of Reclamation Stenographer's Handbook. Other than the Summary and Introduction, it consists of four main sections:

1. Types and Functions of Technical Reports
2. Organizing the Report
3. Writing the Report
4. Preparing the Figures

In each section the material has been subdivided to develop systematically the subject indicated by the section title.

The first section defines and classifies reports, discusses the purpose in writing a report, and by considering the different needs of the people for whom reports are written, indicates a method for satisfying the requirements of all groups.

In the second section, the general form of the report is discussed in terms of the report divisions, and preferred methods of organizing data are suggested. The use of an outline in preparing material for writing is recommended and illustrated.

The third section contains a discussion of the general qualities that should be inherent in good technical writing and offers suggestions and examples intended to be useful in preparing the rough draft.

In the fourth section, the devices used to illustrate the text material are discussed in regard to their preparation and use, and desirable qualities of photographs and drawings are presented.

The "figures" have been prepared for two purposes. First, they illustrate some of the suggested methods of preparing the report; and secondly, they suggest an acceptable form for photographs and drawings.

INTRODUCTION

The technical report in the last decade has become increasingly important as a necessary part of scientific progress. The rapidly expanding specialized fields of science and engineering have made it indispensable in summarizing the work and progress of small units, and in coordinating the work of several larger units.

Dr. Glenn Frank 1/ has clearly stated the need for good technical writing. He says, "The practical value of every social invention or material discovery depends upon its being adequately interpreted. ... The future of scientific progress depends as much on the interpretative mind as it does upon the creative mind. ... The interpreter stands between the layman, whose knowledge of all things is indefinite, and the scientist whose knowledge of one thing is authoritative. ... The scientist advances knowledge ... the interpreter advances progress. ... History affords abundant evidence that civilization has advanced in direct ratio to the efficiency with which the thought of the thinkers has been translated into the language of the masses."

Much has been said regarding engineers and technical writing, and some of it has not been of a complimentary nature, (Appendix I). In general, engineers are not noted for the superior quality of their writing. Since the need for clearer, better arranged, and more understandable writing has been fully recognized, attempts are being made by many engineering departments to improve the quality and usefulness of their technical writing. This report is written to further that purpose. It is intended to serve as a guidebook and as an aid in the preparation of technical reports. The text is arranged in the order of preparing a report from its inception to its conclusion. Material contained herein is intended to supplement the rules given in the Bureau of Reclamation Stenographer's Handbook. The section, "Preparing the Figures," should be read before starting work on the report and preferably before starting the investigation.

1/ Author, editor, publicist, Chicago, Ill.

TYPES AND FUNCTIONS OF TECHNICAL REPORTS

In a study and discussion of a technical report, the significance of the word "report" must be made clear. Individual definitions may vary considerably, probably because each definition is applied to a specific type with which the individual is familiar. It is possible, however, to define reports in a general way and to classify them according to type. Further, it is necessary to recognize the purpose of a report, and to realize for whom the report is primarily written.

Definition of a Technical Report

A technical report is a specialized form of exposition or narration, dealing with a display of findings requested or needed by persons for whom the report is primarily written, in a form best suited to their requirements, with sufficient interpretive analysis to fill their need. It is evident from this definition that considerable latitude is possible in the preparation of a report and that there is every opportunity for individuality in writing. However, reports written for the same purpose and covering similar investigations will necessarily assume similar forms, if the suggestions outlined in this discussion are followed.

Classification of Reports

Of the many types of reports, those most commonly encountered are:

1. Field trip reports
2. Laboratory reports

Form reports, letters, or memoranda may also be classed as reports but they will not be discussed individually here. In even a simple report, however, the principles of good writing should be applied.

Field trip reports. Field trip reports summarize the findings of a field investigation and are written to the Chief Engineer. An acceptable sample report illustrating the preferred form is reproduced in Appendix II. These reports should be kept as short as possible, preferably no longer than the sample shown. In reports where "Conclusions" or "Recommendations" are possible or necessary, they should be numbered, labeled properly, and placed at the end of the body of the report. Detailed observations, data, tabular matter, or illustrations may be submitted but should be contained in an appendix following the body of the report. Both text and appendix material should contain the principles of good writing discussed in this report.

Laboratory reports. The laboratory report usually deals with research, development, or tests of one kind or another. In its simplest form, it may contain little more than a bare presentation of test data for record purposes--this will usually be the case when the tests have not led to useful conclusions or when a record of progesss is desired before completion of the project. Such reports usually have very limited distribution, so they may be prepared either as formal reports,

such as this report, or as memoranda addressed to an individual or to "Files." Another type of report may consist wholly of detailed instructions covering certain construction operations, such as the repair of defective concrete, or certain laboratory techniques, such as a use of strain measuring devices. The more usual type of report, however, and the one which is the primary subject of this discussion, will include a description of testing equipment and techniques, presentation of test data, and analysis of test results. The two latter types should always be prepared as formal reports suitable for unrestricted distribution within the Bureau and limited outside distribution. They should be reviewed by a co-worker or supervisor and should be approved by the section or division head.

Purpose in Writing Acceptable Reports

Of the many reasons for recording results of investigations or experiments in report form, some provide little incentive to the engineer to write interesting and fully understandable reports. Others, however, are of vital concern to the engineer himself.

The engineer should realize that he will be judged on the basis of his reports. Indeed, his future progress may depend on his ability to prepare an acceptable report. Further, the report may be needed to refresh the writers' memory at some later date. Unless it is well written, the writer, as well as others, may find himself in the embarrassing position of not knowing just what was done. Thus it is necessary that the engineer provide himself with a clear, complete record of what was done, how it was accomplished, and what was concluded.

In addition to personal and technical reasons for writing reports, there are others. Findings not adequately reported in writing are of no value except to the person who discovered them. Even a great discovery in the laboratory is not a contribution to our knowledge until all the pertinent facts are made known to others. A written report is often the only record of results that have come from months of thought and effort. It is frequently used in judging the quality of the investigation. It may also serve as the basis for determining all future action on the project. If the report is well written, showing careful observations and sound reasoning, and contains no obvious errors, the conclusions and recommendations will probably be accepted. If it is poorly written and contains apparent discrepancies, even though showing careful observations and sound reasoning, the results are open to question since the evidence before the reader indicates a careless or incompetent worker.

In brief, the written report shall "sell" the results. Unless a good "sales talk" is presented the recommendations may not be fully or properly considered, either because of a lack of understanding of their true significance or a doubt as to how they were derived. The "sales talk," however, must above all else be honest and straightforward.

For Whom Reports are Written

Reports are generally written for three groups of readers:

1. Executives whose decisions are often based on reports but whose time for reading them is limited. An executive is interested, primarily, in the overall results or conclusions, and not in the technical details.

2. Engineers and others familiar with the investigation whose interests include those of the executive plus a more detailed knowledge of the basic features of the project or investigation.

3. Engineers concerned with the project and other interested persons not connected with the project, whose interests extend to an examination of the details or methods used in the investigation.

In formulating the outline and writing the report, all three groups of readers should be kept in mind. The executive should be able to find his material in the first page or two; there should be no need for him to thumb the entire report to get an overall picture of the investigation. The engineer interested in the results of the investigation, should be able to find them without working through a maze of detailed calculations and formulae. Such details should be contained in an appendix where they do not cloud the development of the report and where they are available for use by the third group or, on occasion, by either of the other two. Thus, the report should become more and more detailed as it progresses toward the back cover.

ORGANIZING THE REPORT

Preliminary Considerations

Usually, the author of a report has worked with the material he is putting into report form and has in mind a detailed account of the subject matter. In any case, it is necessary to become thoroughly familiar with a subject before attempting to write about it. Lacking this familiarity, an author cannot write authoritatively or with a broad viewpoint, and his product is likely to be an incoherent structure lacking in unity and proper assignment of relative values.

When the subject is fully in mind, the organization of the material becomes a simpler task. By organization is meant the process of grouping subjects or material into proper divisions so that they be presented in logical form.

Beyond doubt, the most important single feature of a report is the proper arrangement or organization of the subject matter. A report may be badly written, present a poor appearance, and contain obviously poor grammar, but its salvage value remains high if its organization has been skillfully accomplished.

In general, a report is well organized when even an extensive amount of highly technical material is presented in an interesting manner, in the least amount of space, without repetition in various phases of the presentation, when it is clear to the reader that he is following a well-planned approach to the solution, and when the text may be read by the persons for whom the report is primarily written without becoming tiresome.

Good organization is best accomplished by full and proper use of an outline.

Form of the Report

Before attempting to formulate a report outline, a thorough understanding of the nature of the contents of each part of the report is necessary. The following discussion gives the main divisions of a report, their sequence, and the usual content of each.

Summary. The summary should be a condensed version of the report that follows. It should not be considered as an introduction to the report, but rather it should be complete in itself, and should contain, as the name implies, a summary of the investigation. More specifically, it should consist of brief statements covering the nature, purpose, or object of the investigation, the method of obtaining the results, and a review of the results obtained. Detailed explanations, narrations, or discussion of limitations on the scope of the work should be excluded. Emphasis should be placed on what has been done rather than on what has been left undone. If it is felt that further explanation is necessary, reference may be made to appropriate portions of the report.

Recommendations may be presented separately or incorporated in the summary, depending upon their nature. If they consist of sharply defined procedures, open to little or no question, they should be grouped together under the heading of Recommendations. If, on the other hand, their adoption is dependent on factors other than those presented in the report, if they are limited in any way, or if alternate choices are given, they should be presented in the proper place in the summary to indicate the basis for the particular recommendation. Also, repetition may often be avoided by following this procedure. Regardless of how they are presented, however, the recommendations should be labeled as such by direct statement. In some reports it may be desirable to use the term conclusions rather than recommendations.

The summary may be difficult to write because the entire investigation must be summarized in a short space in simple, understandable language. It should cover the investigation in such a way that subheadings are unnecessary. Ordinarily, it should be written only after the report or a first draft has been completed. After it is written, it should be checked for clarity and brevity and against the requirements listed below. It should:

1. Add to the usefulness and value of the report.
2. Cover completely the salient features of the report.
3. Be in exact agreement with the statements in the report.
4. Contain only the material which has been discussed in the report.
5. Leave the reader with the feeling that the goal of the investigation has been achieved.

Introduction. The purpose of the introduction is to introduce the subject to the reader who is sufficiently interested to continue beyond the summary. In accomplishing this, it is desirable to give the general history of previous research or the events leading to the present investigation. Certainly it will be necessary to state the need for the investigation, and the exact problem should be made known to the reader as soon as possible.

The plan of the investigation may be given briefly, and some analysis may be required if the plan is unusual or not generally understood, although extensive analysis should be avoided. Limitations on subject matter or scope of the work should be indicated here and not in the summary.

In general, sufficient information should be presented to make the problem and its method of solution clear enough so that the reader may understand it without need for other explanations. Occasionally, this will result in the introduction becoming too long for a well-balanced report. In this event, the more detailed parts should be placed in the introductory paragraphs under appropriate subsections. The introduction should never be so long and involved that it is necessary to use subheadings.

Body of the report. The body of the report usually contains the bulk of the written material and may consist of several divisions indicated by center headings. Considerable latitude is permissible in the number and wording of these headings; but they should be clearly descriptive of the contents of the division.

The body of the report should include information pertaining to the description of apparatus, methods used in the tests, detailed data, sample or indicated calculations, results of tests, and interpretive comment. Material not directly concerned with the investigation, such as elaborate mathematical manipulations or derivations, and discussions pertaining to controversial theories and processes, should be placed in the appendix, with appropriate references in the text. This will not apply, of course, if the report is primarily mathematical or theoretical in nature.

The structural pattern of this part of the report will probably be the most difficult to construct, and no standard form can be given to fit all types of investigations. However, the problem can be met and

solved as any engineering problem is solved. The main problem should be divided into smaller components and each solved separately, keeping in mind the entire problem when working on any part.

The smaller divisions of the main problem should be titled, and proper material should be presented under each title. It is essential that data or other material be presented in a logical and orderly manner. It is not necessary that a chronological order be maintained in discussing a series of tests or subjects. Very often it is more convenient to group tests or subjects on the basis of similar properties or on the effects of different variables. The grouping should be made so that the emphasis is placed on the desired or important parts of the subject. Figure 1 shows two outlines that cover the same material. Different emphasis is obtained in each case.

Reports often lose their effectiveness because of improper organization. Important subjects should not be hidden under minor headings. Regardless of the order of presenting the material, it should be as well organized as the proof of a geometry theorem. Each step should be planned to present the proper facts at the proper moment, in a way that indicates to the reader that he is approaching the solution to the problem.

The reader should be kept foremost in mind when planning this section. At all times he should be aware of the problem, the method proposed by the author for solving it, and the progress of the investigation, purely on the basis of the material presented. It should not be necessary for the reader to have previous familiarity with the investigation to understand the full meaning of the facts presented. The reader should, by scanning the section headings, be able to determine where the investigation leads, and at any time he should be able to judge his progress toward the ultimate goal.

As a further check on the organization of this section, the body of the report should substantiate the conclusions and recommendations and be in exact agreement with the summary.

Appendix. The word "appendix" may be defined as "matter added to a book but not essential to its completeness as a bibliography, notes, or tabular material." This definition may also be applied to material that should be contained in the appendix of a report. It is difficult to predict the type of material that might be encountered in a specific investigation, and hence it is impossible to determine the exact dividing line between appendix and report material. An understanding of the type of material that the appendix should contain, however, will make it possible for the writer to use his own judgment in the matter. Illustrations of appendices are included in their proper place in this report.

As mentioned in the discussion of the "Body of the Report," the appendix should contain, in general, elaborate mathematical manipulations or derivations, discussions pertaining to the details of calibration, construction, or operation of special or new types of

testing equipment and procedures, evaluation of controversial theories and processes, photostats of original data introduced as evidence or proof, bibliographies, and tabular matter not essential to the clarity of the text.

If the appendix covers several different subjects, the material should be carefully organized for presentation, as described for the "Body of the Report."

Use of Sectional and Other Headings

The title on the front cover is of course the main heading of any report, and it should be selected with two points in mind: It should attract the interest of the prospective reader; and it should convey in a few words an accurate description of the contents of the report. Report writers often neglect opportunities to make their titles interesting, and thus lose many readers. For example, the title "Tensile Tests of Concrete" is less interesting than "Studies of the Tensile Strength of Concrete," and the latter is preferable provided, of course, it is accurate--that is, provided the report includes studies as well as test data. Long titles are often preferable from the standpoint of the writer, but it is usually better to conform to convention and restrict the title to ten words or less.

The sectional headings used in the preparation of the outline will appear in the finished report, and it is important that they be well chosen. Since it is important for the reader to know, at all times, his progress with respect to the ultimate goal, the headings should be prepared with this in mind. The use of introductory paragraphs following the sectional headings, as used in this report, will help in this respect. By summarizing in an introductory paragraph the material to be discussed in the following division of the report, the reader is given an overall picture of the subject matter before it is discussed in detail. He is thus able to evaluate the details in terms of the whole before completing the reading of an entire division. The introductory paragraph may also contain material that is too detailed or specialized for inclusion in the "Introduction," and any miscellaneous information that applies to the subject about to be discussed.

A heading is, in reality, a title and should be carefully worded and displayed in a single line. In conforming to these criteria, it will necessarily be brief but in addition it must be significant. It must indicate the exact content of the section it heads. Headings serve two useful purposes: they expedite the reading and understanding of the report, and they facilitate later reference to specific material.

The general arrangement of the headings should be governed by Rule 7, Chapter 15, of the Stenographer's Handbook (7.15.7), and as illustrated by Figure 2. The wording and form of the headings should be parallel in construction to other headings of equal rank or value in the outline, wherever possible. For example:

Spillway Tests		Spillway Tests
Original Spillway		Original Design
Modified Spillway	NOT	Modified Apron
Adopted Spillway		Scheme Finally Adopted

Additional examples of sectional headings are given in Figures 1, 2, and 3 and throughout this report.

The sectional headings should be tested for completeness, clarity, significance, and parallel construction. In addition, the wording and arrangement should be such that they may be used without revision for the table of contents. Indeed, the table of contents should consist of sectional headings and proper page numbers.

Use of the Outline

The outline is an indispensable tool in the organization and preparation of a report. By proper use it will eliminate many of the difficulties usually encountered. The outline may be used, first, to aid in the organization of the material, and secondly, to help in the actual writing of the text.

In reviewing the material to be used in a report or a section thereof, the general form of the report will be formulated in the mind. For example, it may be decided that the report should consist of five parts. These should be recorded as center headings in the outline.

Body of the Report {
- Summary
- Introduction
- The Investigation
- Results of Investigation
- Appendix

The summary and introduction usually need no subdivisions, but the remaining parts should be subdivided into main headings, according to the material available for presentation. For example:

The Investigation

Description of Apparatus
Testing Procedure
Calculation of Unit Pressures

Results of Investigation

Test Results - Series A
Test Results - Series B

Appendix

Calibration of Apparatus
Theory of Pressure Distribution
Bibliography

A similar breakdown procedure should be followed under each main heading until the headings are of an elementary nature.

The Investigation

Description of Apparatus
  Pressure cells
  Loading device
Testing Procedure
Calculation of Unit Pressures
  Determination of total pressure
  Determination of area
  Effect of temperature

Then, under each of the headings, a resume' of the material to be discussed should be made, listing the statements in their proper order.

Description of Apparatus

Pressure cells. Type of cell. Size. Range of cell. Special application in this case, etc.

Loading device. Function of various parts. Method of applying load. Measurements of load. Results of overloading, etc.

Testing Procedure. Cells adjusted. Load selected and applied to loading device, etc.

It should be emphasized that the entire outline should be kept as compact, but still as complete, as possible in all stages of its preparation. Thus, any reorganization and rewriting deemed necessary can be completed without the time-consuming operation of handling excessive amounts of material. Certainly, it is easier to make changes in an outline than in a completed draft of the report.

If the outline in all stages is compact, but still accounts for all necessary basic information, the need for reorganization as the outline is expanded will be less evident.

When the outline has been arranged satisfactorily, it may be further expanded by adding more details to the brief statements already recorded until the entire report has been presented in topic form. It will now be possible to concentrate on small sections without the need for keeping the entire outline in mind, since material that has any rightful place under a particular heading will be presented at the precise moment it is most effective.

It is important, at this stage, to survey the material under each heading to be certain that the heading describes the material being presented,

For example, under the heading "Description of Model" do not describe methods of testing or give some of the results. Confine this particular section to a description of the model.

In some parts of the outline it will probably be evident that only first-order subheads are necessary while in others second-order subheads are necessary or convenient. This occurs in the sample outline previously discussed. Inconsistencies of this nature should not cause concern in themselves since in a well-organized report there is no need for introducing subheads when they are not needed. Any attempt to make the outline consistent in this respect will only result in "padding" which is objectionable even in its mildest form.

The writer should guard against the tendency to make the outline more comprehensive than is justified by the purpose of the report. It is not uncommon for an author, in preparing his outline, to jot down headings for nearly all thoughts which occur to him regarding his subject. If that practice is followed, careful culling will be necessary in order to limit topics finally retained to those that are worth retaining. A topic should not be discussed merely because it fits nicely into the outline--it should be eliminated unless the author really has something to say about it.

Up to this point the outline has been intentionally kept abstract in form with little or no specific information visible, since the first problem is to make the presentation orderly and logical, and too many details tend to mask the general plan of presentation.

The final step in completing the outline consists of replacing the resume' with statements giving specific information rather than abstract references, using the resume' as a guide for determining the order of presentation. These statements should be written in the briefest form possible, even abbreviating words and phases in an attempt to record thoughts rather than sentences. In this way the flow of thought will be least disturbed by the mechanics of writing. Proper choice of words and construction of sentences are problems for later consideration. Finally, the author should not hesitate to revise the outline as the report progresses if he finds, as he frequently will, that the actual writing out of his thoughts leads to new or improved concepts.

Figure 3 shows the specific statements which were used in actually preparing part of this report (Preparing the Figures). Figure 3 may be compared with the written text, Pages 20 to 23, to obtain a fuller understanding of this method.

Variations in this procedure may be made to suit individual preferences, but the basic process is essential to good report writing. Summarizing briefly, the organization of the material should be handled so that reorganization, which is usually necessary, can be done with a minimum of time and effort. The most common cause of faulty organization is the failure to provide a proper place for all material in the original plan of presentation. Sometimes material is "forgotten" until the report is

practically finished. In some instances, this "forgotten" material may be inserted without ill effects. More often than not, however, this extra material makes it necessary to reorganize the entire plan of presentation. Expansion of the outline should be continued until the report has been completed in topic form and the abstract statements replaced with specific information.

WRITING THE REPORT

Before attempting to write the first draft of the report, the outline will have been prepared, expanded, and reorganized if necessary until it is felt that new material will not be introduced in the writing process.

Actual writing of the report then becomes a process of converting the outline into a finished text that is clear, complete, stated as briefly as possible in the simplest terms, and that presents an accurate analysis based on an honest evaluation of the data. These qualities are discussed in detail in the following paragraphs.

Clarity and Logic

The average engineer is interested in all technical things if they are presented in a form that can be understood. Even the best engineers are not experts in all lines, and it should not be assumed that the other fellow knows all about your subject. The very things about a project that you, the writer, take for granted and neglect to discuss because of your familiarity with the subject, are the things the reader must know to appreciate your problem.

It is difficult for a writer to evaluate his own writing, especially with regard to clarity. He is usually familiar with the investigation and in reading his own explanations he subconsciously supplies the missing information. Some degree of evaluation by the writer is possible, however, by comparing a list of the facts given in the written material against a list of known facts.

In striving for clarity, much may be gained by making certain that the logic is good and that the connections of facts or events are presented in a rational way. Good logic is essential to clarity. Proper arrangement of the outline is a first requisite, but it is possible for a poorly worded or misplaced sentence to destroy the logic of an otherwise acceptable paragraph. Care should be exercised to see that the written material leads to a conclusion in a manner that will not be questioned by the reader.

Completeness versus Brevity

A first impression might indicate completeness to be the very antithesis of brevity, but it is possible to achieve one without sacrificing the other.

Brevity may be considered to be the art of stating all the facts in as few words as possible, omitting unnecessary words and phrases that, more often than not, clutter the description and add nothing to its meaning or

value. Completeness, on the other hand, consists of including all the pertinent facts. Brevity should not, be attained by omitting necessary information or by reducing interpretive comment to a point where the presentation is vague and loses all or part of its meaning. Each sentence, paragraph, section, or report as a whole may be tested for these qualities.

Simplicity

The following statement, by a director of a large research organization, is probably true to some degree in all organizations: "We have never had a report submitted by an engineer in our organization in which the explanations and terms were too simple."

The author must be able to write about his own work in simple, understandable terms.2/ Probably the most important part of simplicity in writing concerns the vocabulary. If the vocabulary is simple enough to be understood by a great many people, the usefulness of the report will be greatly increased. Unusual, or highly technical words should be used sparingly or in a way that can be understood.

One of the greatest mistakes made by inexperienced writers is the use of "shop talk" in written material. All groups have a secondary language which they use in place of good clear English. Many of these terms are understood only by co-workers, and have no place in written material intended for distribution. Occasionally a word or expression of this type will be much more descriptive than a conventional counterpart, in which case it may be used, provided that the meaning is made clear to the reader and that some advantage is evident from its use.

Practically all readers of technical reports have sufficient background and intelligence to understand our most technical reports, if the explanation is given in terms that are understandable. Indeed, this is the basis for all our learning. If it were necessary to know all about a subject before we could read about it, nothing would ever be learned. Thus, understanding a technical report is more a matter of vocabulary than intelligence.

Accuracy and Honesty

The qualities of accuracy and honesty contained in a report probably may be traced as far back as the start of the investigation. The final conclusions can be no more accurate or honest than the data on which they are based. If the basic data are inaccurate, or if the test procedures are influenced by a desire to prove or disprove certain preconceived ideas, it will be impossible to make an honest appraisal of the final results. Thus, it is imperative that the writer be accurate and honest from the inception of the investigation.

2/ See article on "Basic English for Science" in Appendix I.

Assuming the data to be reliable, the report should be accurate within itself. Statements based on data should be checked carefully, as should spelling, punctuation, reference to figures, and the figures themselves. Inaccuracies that are evident to the reader reflect upon the quality of the investigation. If errors of any kind are apparent to the reader, he is likely to conclude that errors are also prevalent in the portions of the investigation that he cannot check. This is true especially when the material is of a controversial nature.

The conclusions and recommendations should be based on an honest evaluation of the investigation. Very often in advertising material the conclusions appear to be based on impartial data when they are based actually on carefully selected data. It should be the aim of every engineer to eliminate this type of analysis from his reports. An honest interpretation of all the data will prove invariably to be the safest course to follow.

The Rough Draft

Probably the most encouraging statement that can be made to an author is that even the most experienced writer cannot produce a finished manuscript in the first writing. Considerable rewriting is usually necessary to produce a script that is worthy of the time spent in organizing and preparing the material. Abraham Lincoln, in a letter to a friend, expressed this same thought when he wrote "I am writing you a long letter because I do not have time to prepare a short one."

When starting to write it is essential to free oneself of the attitude many engineers have toward writing. To most, it is a disagreeable task to be disposed of in the easiest way. Some of this attitude can be overcome by mastering the subject in detail, and the remainder by actually getting started. It is easier to criticize than to create, and advantage of this should be taken to free oneself of his inhibitions toward writing. By starting, criticizing, and rewriting, confidence is gained, and with each completed section the task becomes easier.

Of the many criteria for judging the quality of the written material, the four given below are of primary importance. Each is used in a broader sense than a strict definition of the terms would indicate.

Style. The style of the report will govern, to a great extent, the number of people who will read it after scanning the contents. Reports should be written in an attractive manner. By attractive is meant not only the appearance, but the manner of putting thoughts into words. Some written material is difficult to read and to follow, and it requires great effort to finish reading a report of this type. Unless the reader is obliged to read it, he will lay it aside until he has "more time." Some text material is disagreeable to the inner senses, causing an involuntary antagonistic attitude on the reader's part. His attention is thereby diverted from the subject to the method of presenting it. In an ideal situation, the reader is entirely unaware of the mechanics of presentation.

Every effort should be made to encourage the reader to continue his reading. This is best accomplished by never allowing the reader to become confused. Be sure of what you want to say, of why you are saying it, and that you are saying it effectively. Give a clear preliminary view of the subject matter as a whole before starting to explain the details. Endeavor to make using and reading the report as painless as possible. The readers are human, and, in general, do not do any more hard work than necessary. A simple style that diverts none of the reader's attention to complicated methods of presentation is the ultimate goal.

English. A report might consist of a series of pictures and drawings with no written explanation. If the meaning is clear, and if nothing can be gained by inserting explanatory devices, the picture report is acceptable. Usually, however, there is need for more written material than illustrations, because the illustrations need comment and discussion to bring out their full meaning. Thus, the English used in the written material is of paramount importance and must consist of well-chosen words arranged to convey the intended information. Vague or double-meaning statements should be guarded against. The meaning conveyed to the reader must be the meaning intended by the author. By reading aloud the entire text, many errors will be found that are not evident in silent reading.

We hear English badly spoken so often that we are in danger of losing our sense of right and wrong so far as grammar is concerned. Each person has a distinctive conversational style which is usually accepted by others with little or no question, even though it may violate many rules of grammar and composition. When writing, however, much more is expected of the same person and his written material is subjected to close scrutiny and to considerable criticism unless it conforms to the recognized rules of grammar. In addition, the written material should be free of:

1. Slang or colloquial expressions.
2. Expressions in common use in an area or region, but not recognized as good English.
3. Terms classed as "shop talk" that are understood only by co-workers.
4. Hackneyed expressions that, although used and accepted as good English, are badly worn from overuse.

Paragraphs. The paragraph, from the reader's point of view, is a yardstick by which he measures his progress. Each paragraph should be a unit, used to develop a single idea or thought. From the standpoint of reader-interest, short paragraphs are preferable, since a solid sheet of typed material with no open spaces tends to steer the reader away. Use, but do not abuse, the reader's attention. His ability to concentrate on a single paragraph is limited and varies with his interest in the subject matter and the method of presentation. The reader will not object to reading several short paragraphs, but

will hesitate to read the same material if it appears in solid block form in a single paragraph.

To be effective, the paragraph should be designed, not just allowed to happen. The subject of the topic sentence should, when possible, be the same as the subject of the paragraph. Thus, the main thought is made clear as soon as possible. The discussion then follows, and this should be rounded out by some concluding or summary statement.

Sentences. The sentence is the basic element of the report itself and should be carefully constructed. Whereas the paragraph develops a single idea, the sentence states a single thought. Any attempt to do more than that leads to confusion. In practically every case, a long sentence that has lost its effectiveness can be broken down into two or more forceful statements. On the other hand, short choppy sentences used to excess soon lose their effectiveness. To illustrate, most people hesitate to read legal documents because of long involved sentences containing numerous dependent clauses. Even after careful reading and study, the meaning is not always clear. In contrast, first grade readers do not provide interesting reading, even though the sentences are clear, short, and easily understood.

The ideal written text consists of a mixture of medium length, clear sentences and short forceful statements. Sentences may have many things wrong with them that cannot be discussed here; 3/ however, the usual ailments consist of incompleteness, lengthiness, dangling or misplaced phrases, and lack of parallel construction.

Words. The choice of a word is sometimes an important matter in presenting an idea. If any doubt exists that the chosen word conveys the proper meaning, the dictionary will prove to be an impartial judge. Some of our most common words have shades of meaning which should be fully understood. For example, do not say "determine" when "measure" describes the action, or, in using the word "piezometer" be sure that your reference is not to a "water column" or "manometer."

At times it is difficult to find just the right word to describe a particular action or situation. Liberal use of the thesaurus 4/ will increase the effectiveness of a writer's vocabulary and make his statements more forceful. A book of anonyms and synonyms will also prove helpful.

3/ See "On Engineering Writing" and "The Principles of Poor Writing" in Appendix I.

4/ "Roget's Thesaurus of the English Language in Dictionary Form" by C. O. Sylvester Mawson, 1936.

Helpful Suggestions

Experience has shown that certain difficulties in the preparation of a report are common to many writers. The greatest single difficulty is probably in organization, and this has been covered in preceding discussions. More specifically, however, there are other problems that confront the writer, which, if fully recognized and overcome, can do much toward improving the value and quality of technical writing.

Discussion of negative results. Often there is a doubt as to how much of the investigation to include in a report. It is often believed that data and results of a negative nature are of no value and should not be included in the discussion. If only the specific problem at hand is considered, this is true, but in solving problems of a similar nature at some later date, negative results often prevent duplication of work. It has been demonstrated that for a given set of conditions, different groups of analysts working independently will often propose the same solution to a problem. If this obvious solution is found by experiment to be incorrect, and the facts are made known, future experimenters are spared the trouble of learning for themselves the impractical nature of certain schemes.

Checking the outline. If the writer has any doubt regarding the suitability of his outline, it should be discussed with the person who will eventually review the written report. Considerable time and effort may be saved by all concerned if the report is reviewed and basic changes made while the report is in outline form.

Self-criticism. The attitude of some writers is to write anything and then let the reviewer "fix it up." For the more serious-minded writers, however, there are several ways to evaluate their own writing. As mentioned before, reading aloud will help detect faulty sentences, repetition and awkward constructions. Another method is to type the rough draft and allow a day or two to elapse before rereading. Seeing the material in different form after a time interval has elapsed gives the writer a fresh viewpoint for self-criticism. A third method is to assume the reader's viewpoint. Try to put yourself in the reader's place and decide whether the written material states the things he would like to know. As a final test, decide whether the report states the things you yourself needed to know in order to understand the problem, make the investigation, and formulate the recommendations. The chart, reproduced on the inside back cover of this report, will also help to evaluate the finished manuscript.

Specific versus vague statements. In constructing sentences for a report every attempt should be made to give specific information. Often a statement that is vague and indefinite can be made specific by the proper choice of words. For example, the statement "two of the heater elements were badly corroded," provides more information than the statement "two of the heater elements were found to be defective." "Flow at the training wall was unsatisfactory," may be changed to "flow overtopped the training wall." Thus in fewer words the same thought is expressed, but additional information is also given.

Overcondensation. In attempting to prevent wordiness the other extreme is often reached. Do not overcondense. There is a limit to the complexity of the thought which can be presented in a single sentence without overtaxing the reader. Overcondensation results in the reader spending more time deciphering statements than he would in reading a longer but clearer discussion of the same material. For example, the statement, "The decreased excess-air quantity resulted in turbine powerplant efficiency improvement," is overcondensed and should be expanded.

Tables. Tables, like illustrations, may be included in the text near the point at which they are referred to, or they may be placed in a group at the end of the text or in the appendix. The first method is preferable if the tables actually constitute a part of the text and are essential to its understanding. Such tables should be kept as brief as possible and should contain only information which is essential to the text. Tabular material which is included primarily for record purposes or which serves only as supporting evidence should usually be placed at the end of the text or in an appendix. Column headings are usually limited to three or four words, but they must often convey ideas which would ordinarily require a complete sentence. On that account, it is particularly important that careful thought be given to the headings and to the arrangement and order of the columns.

Model and prototype quantities. In referring to lengths, discharges, pressures, or other quantities that are scaled down in a model study, it is preferable to refer only to the prototype quantity even though the discussion centers about the model. For example, a prototype discharge of 1,000 second-feet scaled down in a certain model amounts to a flow of 0.559 second-feet. In discussing the flow through the model it is sufficient to state--"The discharge was 1,000 second-feet."

PREPARING THE FIGURES

The well-known proverb which states in effect, "A picture is worth a thousand words," applies in particular when the picture is used in a report. Proper use of illustrations saves time and effort for both the author and the reader. Figures should be selected and prepared for a definite purpose and no figure should be included in the report unless it has real utility.

Figures may be used for any one of three reasons: first, to clarify the text and avoid the need for long or involved discussions; secondly, to present data in graphic form, which is frequently more useful than tabular form; and thirdly, to add to the interest and attractiveness of the report. The first two factors are usually well understood by technical workers, for they are accustomed to reducing their ideas to drawings or charts. The third factor, that of added interest and attractiveness, requires special consideration. This factor will frequently overlap the

other two, for illustrative material which is primarily informative can often be taken out of the dull and uninteresting class merely by devoting thought to the manner of its presentation. Photographs or wash drawings are usually more interesting than line drawings, and simple graphs which present a limited amount of data in clear fashion will always be more attractive to the reader than complicated charts which can be deciphered only with great effort.

Photographs

Figures consisting of photographs are an important part of an investigation since they expose the investigation to the reader. By proper use of photographs, the reader is made to feel that he is taking part in the investigation rather than merely reading about an event that took place in his absence. Photographs allow the reader to see or judge for himself the effect of different variables on the final result, the appropriateness of the equipment, and to some degree, the quality of the investigation.

For these reasons, photographs should be planned in advance of their need. The report should be kept in mind throughout the investigation and the photographs taken with a view to illustrating the material which must be covered in the report. This method is far superior to that of attempting to select suitable illustrations from a random collection of photographs after the investigation has been completed. With a haphazard system, the most effective pictures are often the ones that were not taken.

Photographs should be made to illustrate definite and specific points. To insure this, it is necessary to envisage the angle at which the photograph is taken as well as the arrangement of the subject in the picture, before the photograph is made. When model-prototype comparisons are possible, photographs should be made from common points.

In cases where extraneous detail is unavoidable in the original picture, a portion of the negative should be enlarged to illustrate the point or points to be emphasized. Pictures that do not show, at once, the features intended by the author discourage the reader and are better omitted. One large photograph, Figure 4, in which the points of interest predominate is often more effective than several smaller prints in which the interesting details are obscure.

One or more photographs may be placed on a single page, depending on the type of material being presented and on the space limitations. If the pictures are related by way of similarity or contrast they may be placed on the same sheet. If they are of different subject material and have nothing in common, they should be placed on separate pages. When more than one photograph is used in a figure, each picture should be lettered A, B, C, etc., and a separate title provided under or appropriate to each picture. In addition, a general title for the entire figure should be provided at the bottom of the sheet. Figure 5 illustrates an acceptable arrangement for this type of figure. It is preferable to mount the photographs so that the top of the sheet has the narrow dimension. Unnecessary

twisting and turning of the report in order to view the figures distracts the reader's attention from the material being presented.

Drawings and Charts

Careful preparation of drawings is as essential to the clarity of a report as the careful preparation of the text. An improperly prepared drawing can confuse as easily as it can clarify. As a matter of economy, drawings made for one purpose are often placed in a report to illustrate another and the resulting clutter of irrelevant details thus confuses the reader and presents a formidable appearance to what is usually a relatively simple problem.

Simple line drawings are usually preferable to construction-type drawings which show complete details and dimensions. By showing only the essential parts of a subject, clarity is obtained and emphasis is placed on the desired part. For example, in showing a series of spillway aprons for the purpose of comparing their performance there would ordinarily be no need to introduce confusing details consisting of expansion, contraction, or construction joints, drainage holes, reinforcing steel, or ground contour lines. The most effective drawing would be a simple sketch showing the outline with the essential dimensions, as illustrated by Figure 6.

Most subjects are best illustrated by the conventional plan, elevations, and sections. Occasionally, however, a subject may be shown more clearly and more effectively by using an isometric or perspective drawing. Figure 7 illustrates the ultimate in the use of a perspective drawing. Although a drawing of this type is difficult to prepare, it portrays in one glance a picture that could otherwise be obtained only by long study of a set of conventional drawings. Figure 8 shows a simpler perspective drawing which is also effective and not so difficult to prepare.

Clarity should be the main objective in preparing drawings for a report. An attempt should be made to present the subject so that its meaning is immediately clear to the reader. If the reader becomes confused his interest lags and full benefit of the author's effort is not obtained.

The appearance of a drawing has much to do with its success as an illustration. It should not be crowded to present a mass of detail in a small space, nor should it be so open that it lacks coherence. Figures 9 and 10 show well-arranged and attractive drawings. Drawings should usually be made for reduction, for those that have been reduced from a larger size present a neater appearance than those printed directly from report-size sheets.

It is often possible to combine several subjects into a single figure, as discussed in connection with photographs. Titles for each part and for the entire figure should conform to the criteria given for the photographs. The use of several drawings in a single figure is shown in Figure 6.

Curves should be drawn to a scale which is compatible with the accuracy of the data. To illustrate, curves drawn from data rounded off to the nearest 10 pounds per square inch should not be drawn so large that the curve indicates accuracy to 1 psi; nor should the scale be so small that a 10-psi difference is not apparent.

Horizontal and vertical scales should, when possible, be identical, to insure easy use. When this is not possible, easy-to-read scales should be chosen. In no case, for example, should the scale show 12 divisions to the inch with the 1-inch divisions marked in increments of 10.

Curves may be combined with sketches or drawings to save space or to make clear the proper use of the curves. In some cases, it may be preferable to use an entire sheet for a curve. The unused portion of the sheet may then be used for an explanation of terms, notations, or other abbreviated material. Figure 11 illustrates an acceptable form for curves combined with a sketch.

Figure Placement and Use in Report

The placement of the figures in the report deserves consideration since the arrangement finally chosen will govern to some extent the ease with which the report may be handled. Several factors govern proper placement.

In reading a report for the first time, it is convenient to have the figures appear in the text following the first reference to them. There are, however, two disadvantages to mixing the text and figures. First, it becomes difficult to find a particular figure if it is referred to more than once, and secondly, if the report is used as a reference the figures are not quickly and easily accessible.

Another system is to place the figures consecutively, in a group, immediately following the text material. Thus, the text material is in an unbroken order indicated by page numbers, and the figures are in an unbroken order indicated by the figure numbers. Regardless of what use is made of the report, the figures are easily found.

For either of the placement schemes, the figures should be arranged to parallel the development in the text. It should be possible by scanning the figures and reading the titles to obtain at least a general concept of the contents of the report.

Figures should be thoroughly integrated with the text by referring the reader to appropriate figure at all points at which he would be aided by such reference.

Figure 1

SAMPLE OUTLINES
TWO METHODS OF DISCUSSING THE SAME MATERIAL

OUTLINE I

Description of Tests

General

Hydraulic Jump Aprons A, B, C, D, and E

- Effect of sloping floor
- Effect of baffle piers
- Effect of end sill
- Effect of downstream excavation

Emphasis on various parts of apron

OUTLINE II

Description of Tests

General

Hydraulic Jump Aprons

- Apron A
- Apron B
- Apron C
- Apron D
- Apron E

Emphasis on particular aprons

Figure 2

SAMPLE REPORT OUTLINE

SPILLWAY AND EMERGENCY OUTLET STUDIES

Summary

Spillway Studies

Emergency Outlet Studies

PART I--SPILLWAY STUDIES

INTRODUCTION

Spillway Design

The Models

- 1:50 scale spillway model
- 1:30 scale emergency outlet model

Spillway Tests--Preliminary Design

- Spillway design
- Spillway test results

Spillway Tests--Recommended Design

- Spillway piers
- Apron performance
- Erosion tests

Spillway Operation--Recommended Design

- Gate operating schedule
- Spillway rating curve

PART II--EMERGENCY OUTLET STUDIES

INTRODUCTION

Outlet Design

The Model

Results of Tests

Outlet Scheme A

Outlet Scheme B--Recommended Design

Figure 3

SAMPLE--FINAL STAGE OF OUTLINE

Preparing the Figures

Picture = 1,000 words, in report.

Use properly, both photographs and drawings.

Figure must have a utility.

Figures of two types, data and explanatory.

Make figures attractive.

Photographs

Photos expose investigation to reader.

Allow reader to judge results.

Plan photos in advance to illustrate important parts of investigation. Determine photo angle and subject arrangement.

Enlarge photos if necessary, one large photo more effective than several small.

Several related photos may be placed on one sheet.

Title for each photo and for each figure.

Arrange to eliminate turning of report.

Drawings

Careful preparation essential.

Make drawings for specific purpose and eliminate unnecessary details.

Simple line drawings most effective.

Use perspective in difficult cases.

Clarity is main objective.

Appearance also important.

Combine several drawings in one figure to save space.

Figure 4

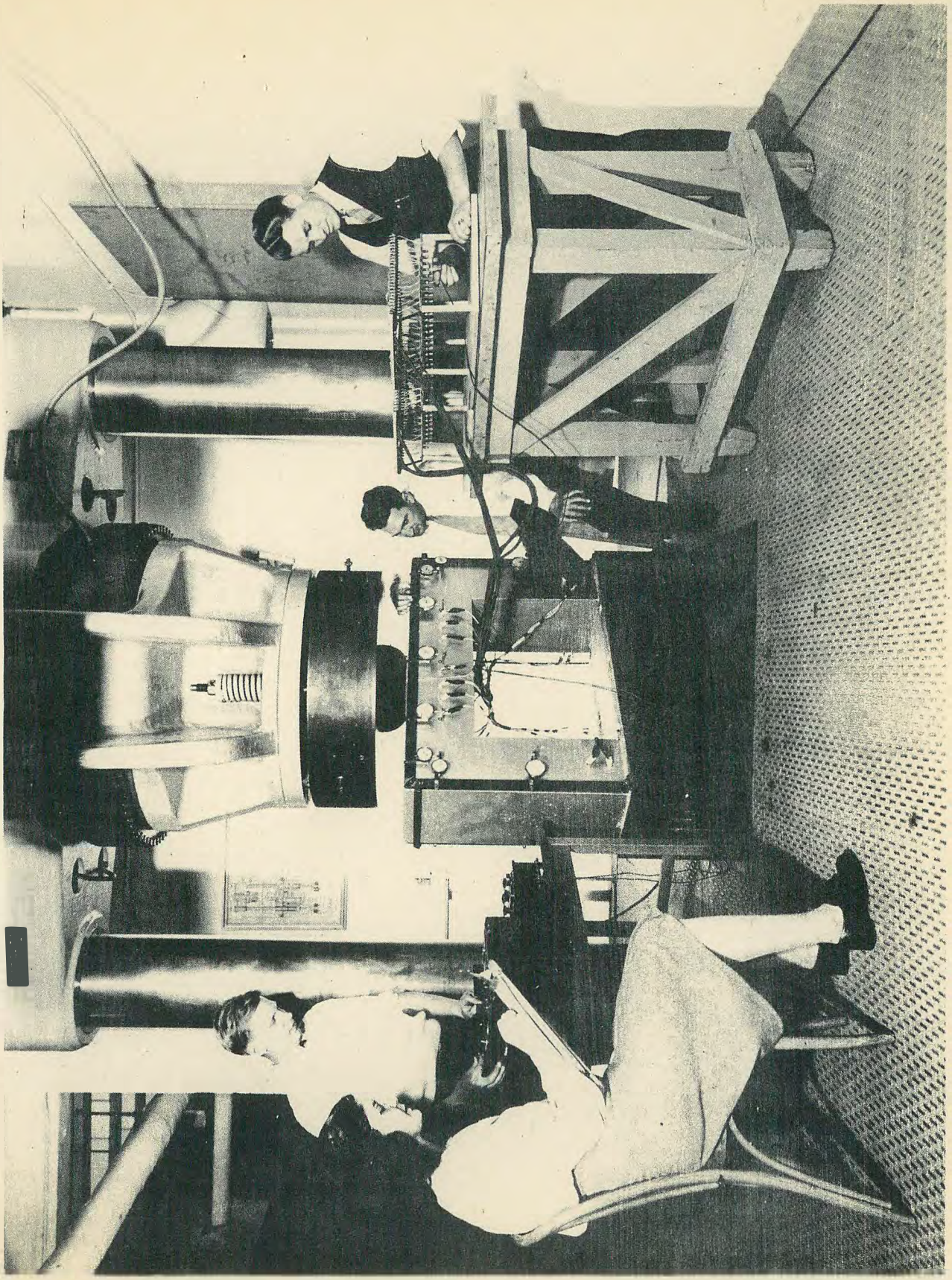
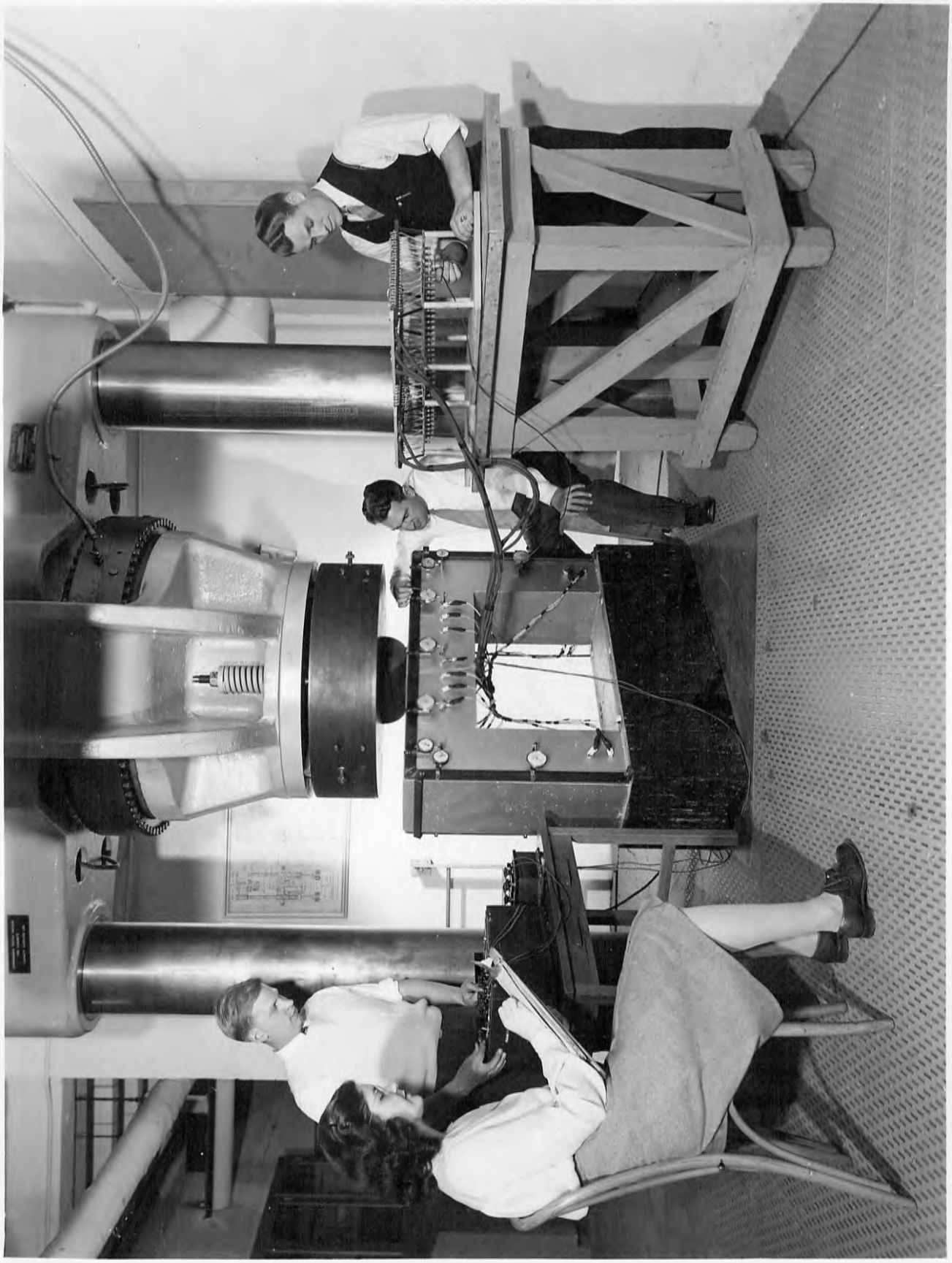


Figure 4



A. Flow concentrated.
Gate 1 open.

B. Flow well distributed.
Gate 4 open.

C. Flow climbs training-wall. Gates 4, 5, 6 open.

D. Flow well distributed.
Gates 4, 3, 2 open.

ROSS DAM
TESTS TO DETERMINE ORDER OF OPENING GATES

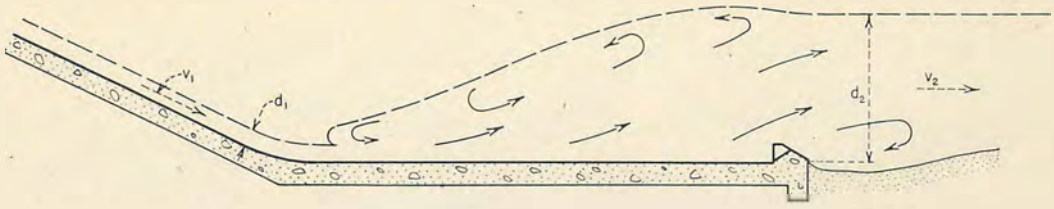
A. Flow concentrated.
Gate 1 open.

B. Flow well distributed.
Gate 4 open.

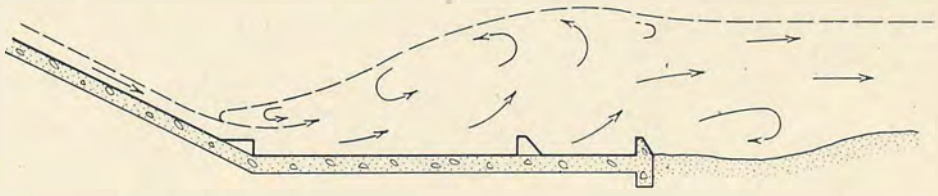
C. Flow climbs training-wall. Gates 4, 5, 6 open.

D. Flow well distributed.
Gates 4, 3, 2 open.

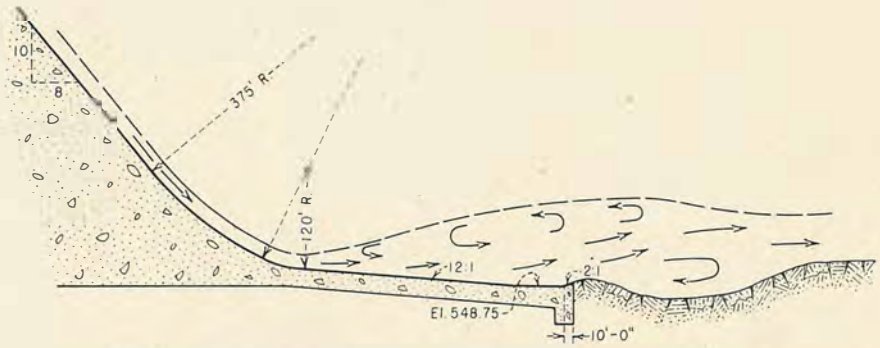
ROSS DAM
TESTS TO DETERMINE ORDER OF OPENING GATES



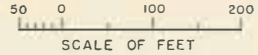
A – HORIZONTAL APRON

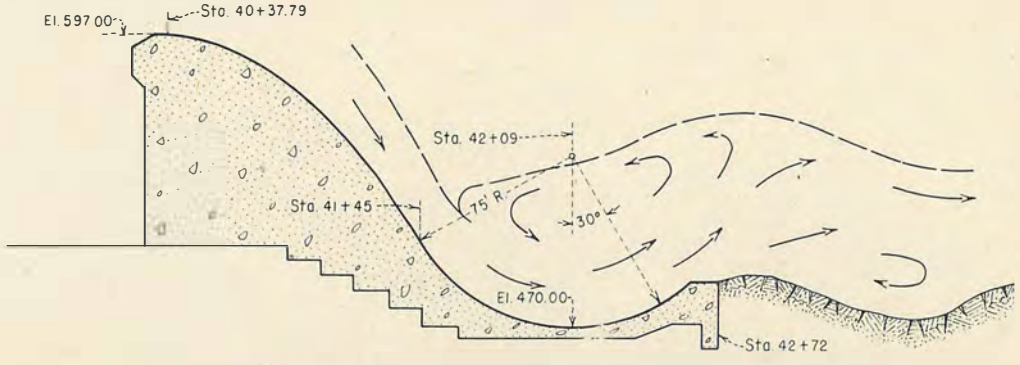


B – HORIZONTAL APRON WITH SPREADER TEETH AND BAFFLE BARS

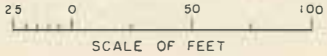


C – SLOPING APRON FOR SHASTA DAM

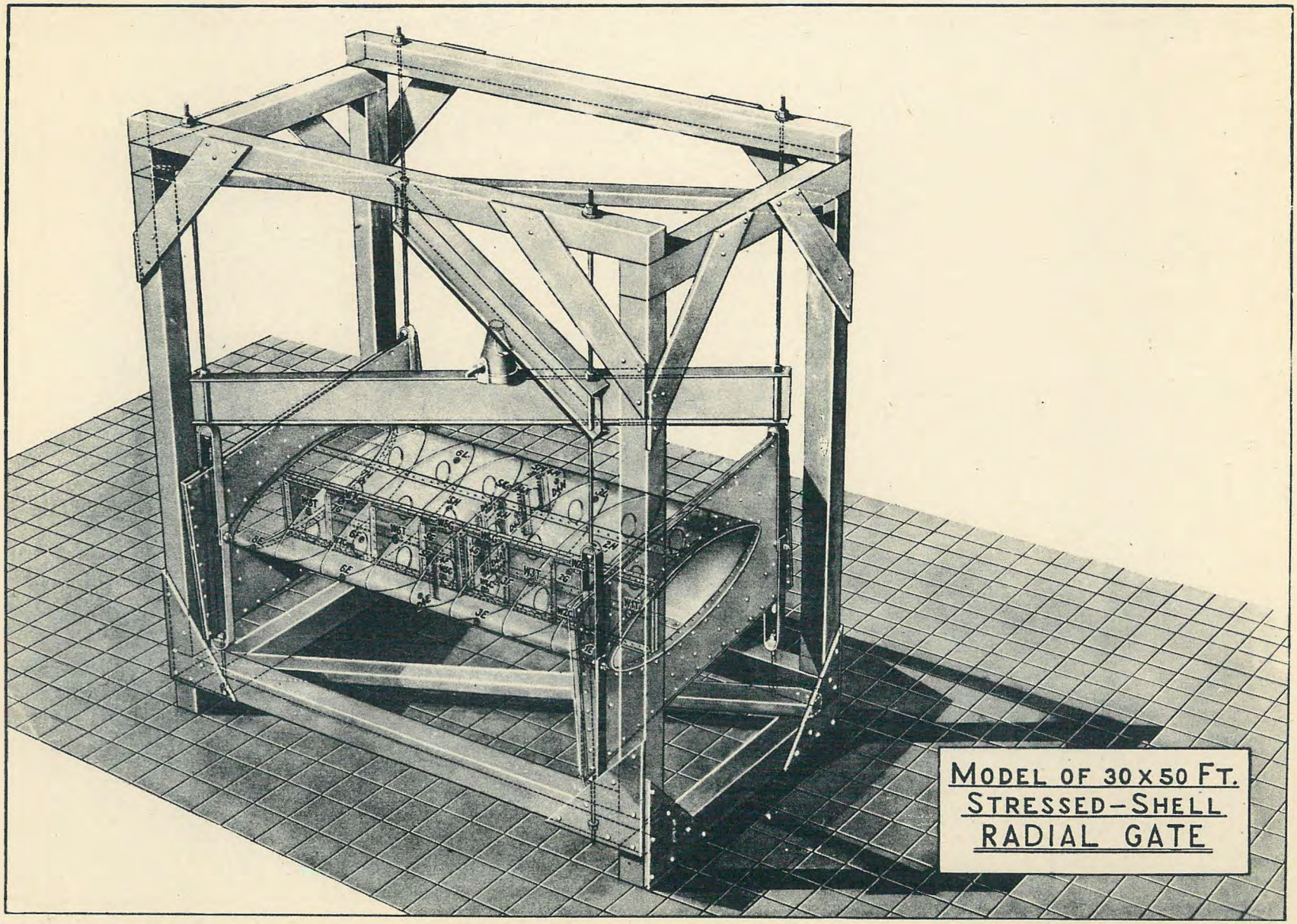




D – ROLLER BUCKET FOR DAVIS DAM



STILLING BASIN DESIGN FOR SPILLWAYS



MODEL OF 30 x 50 FT.
STRESSED-SHELL
RADIAL GATE

Figure 7

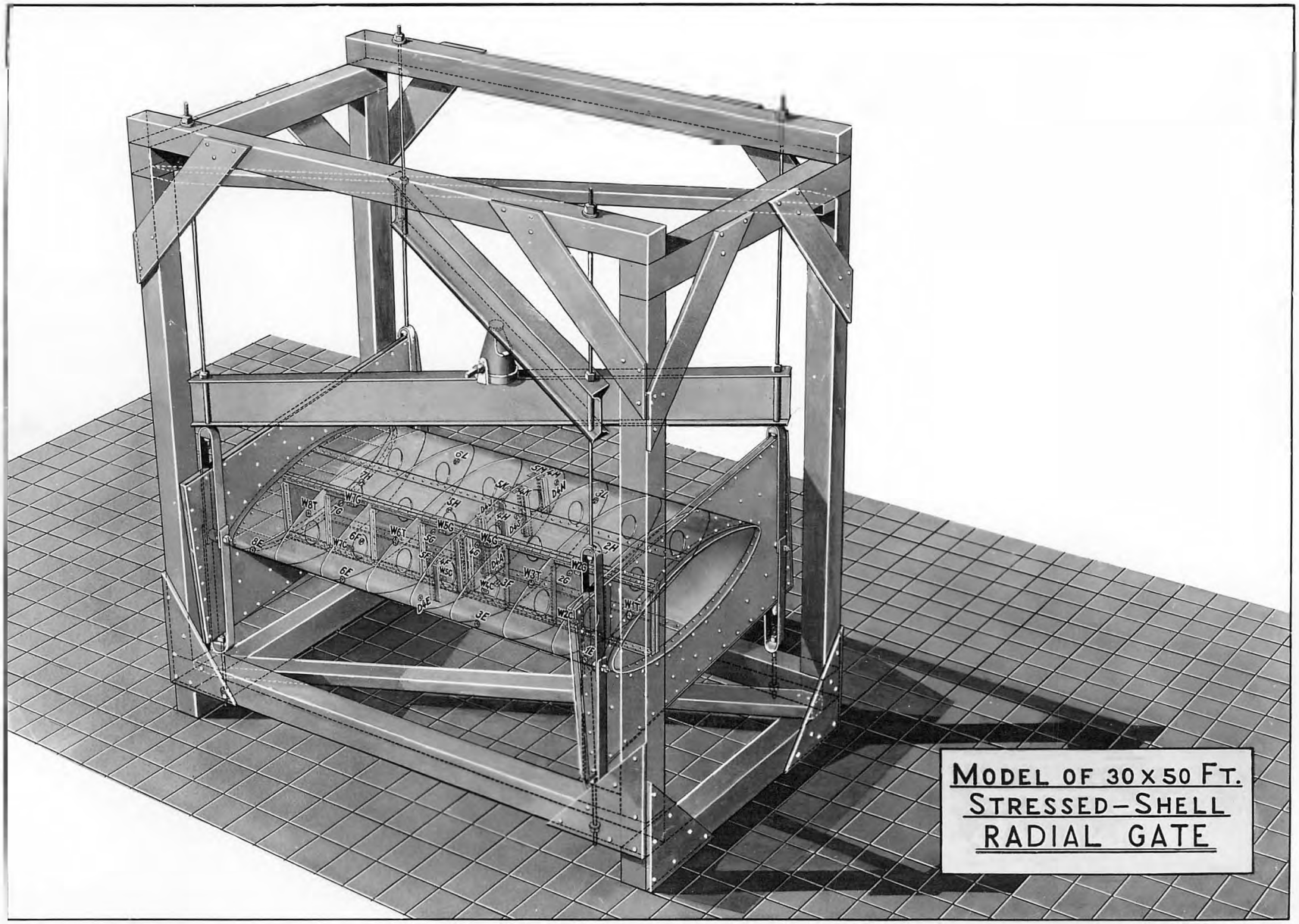
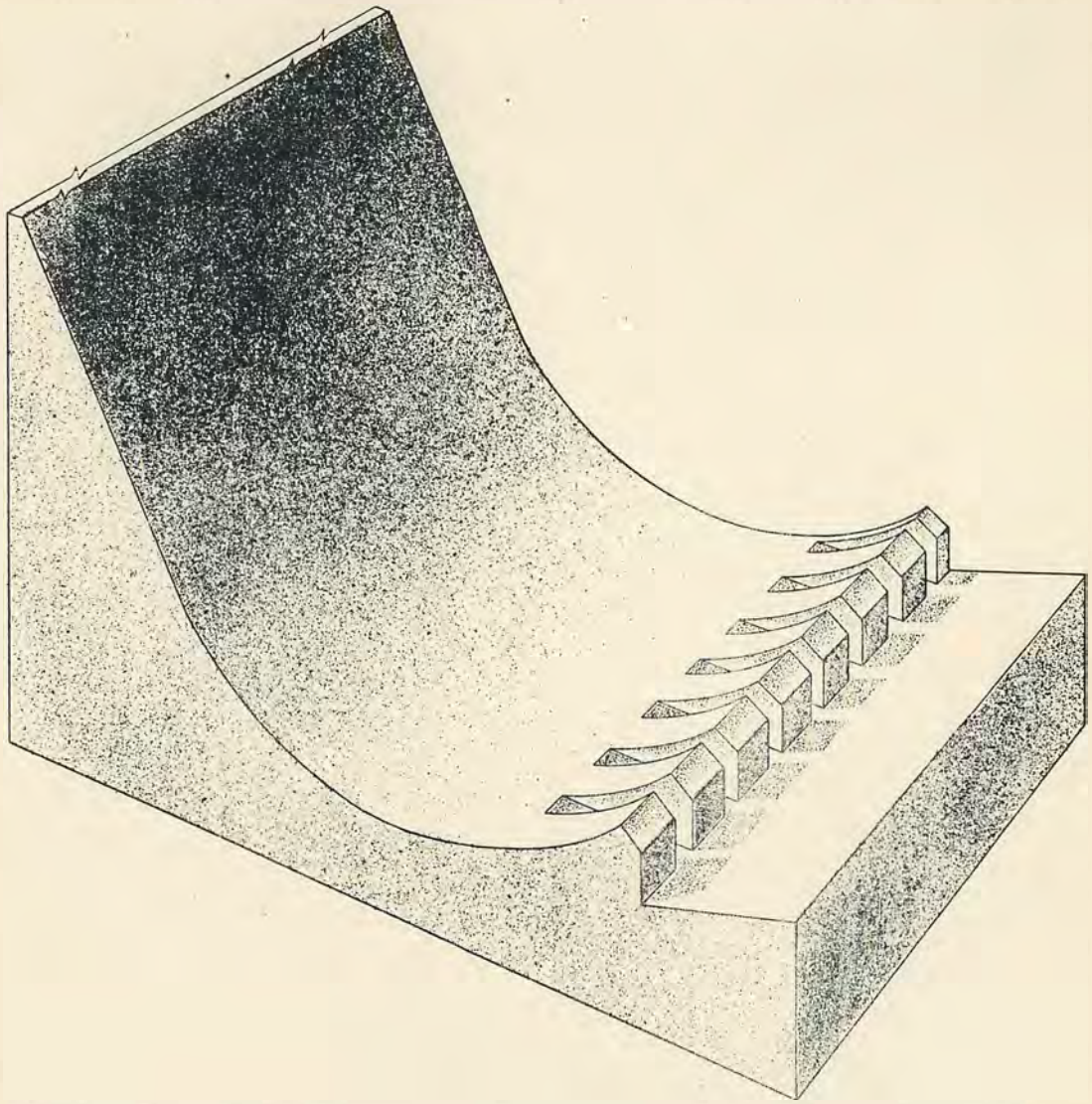
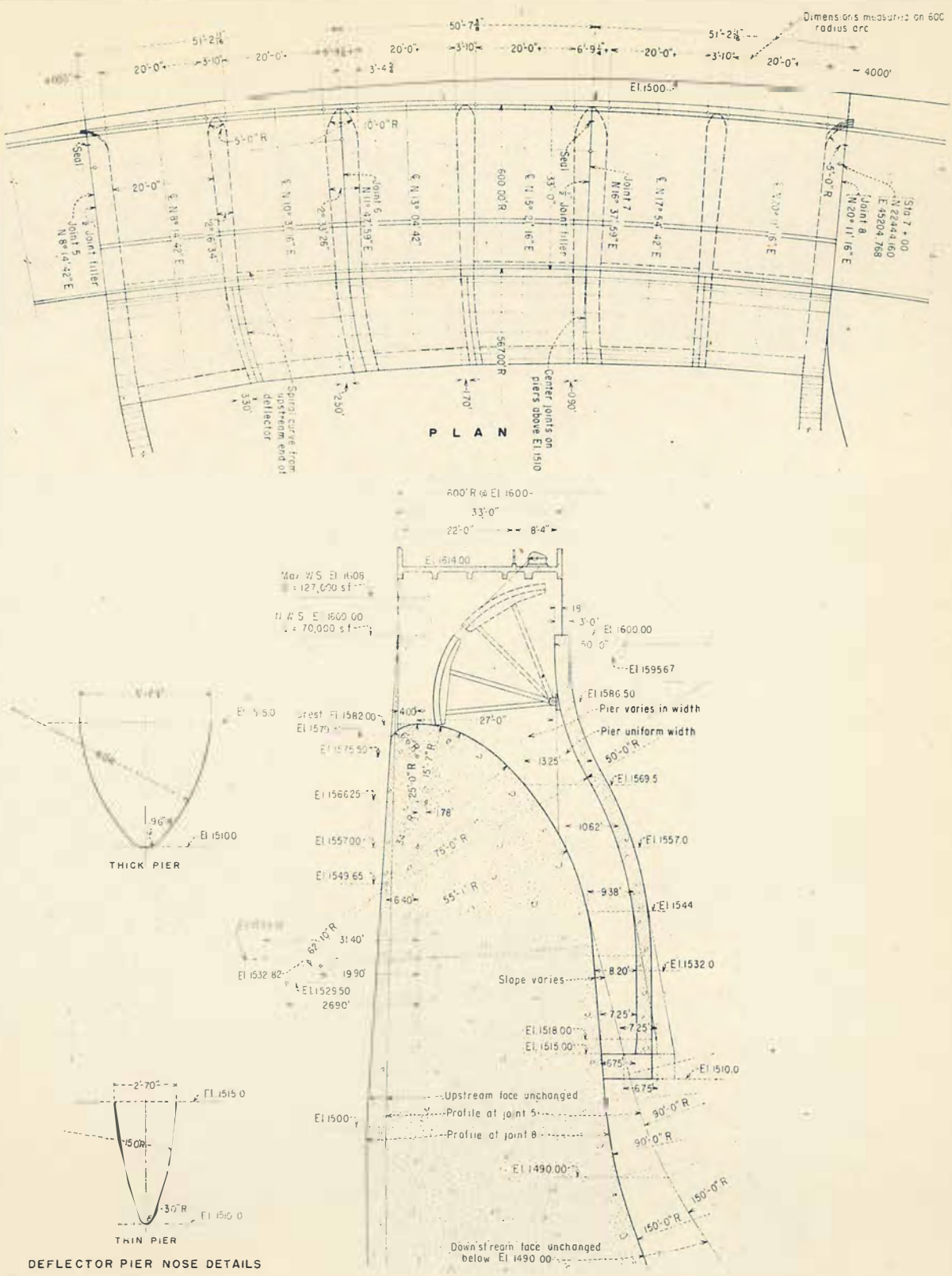


Figure 7



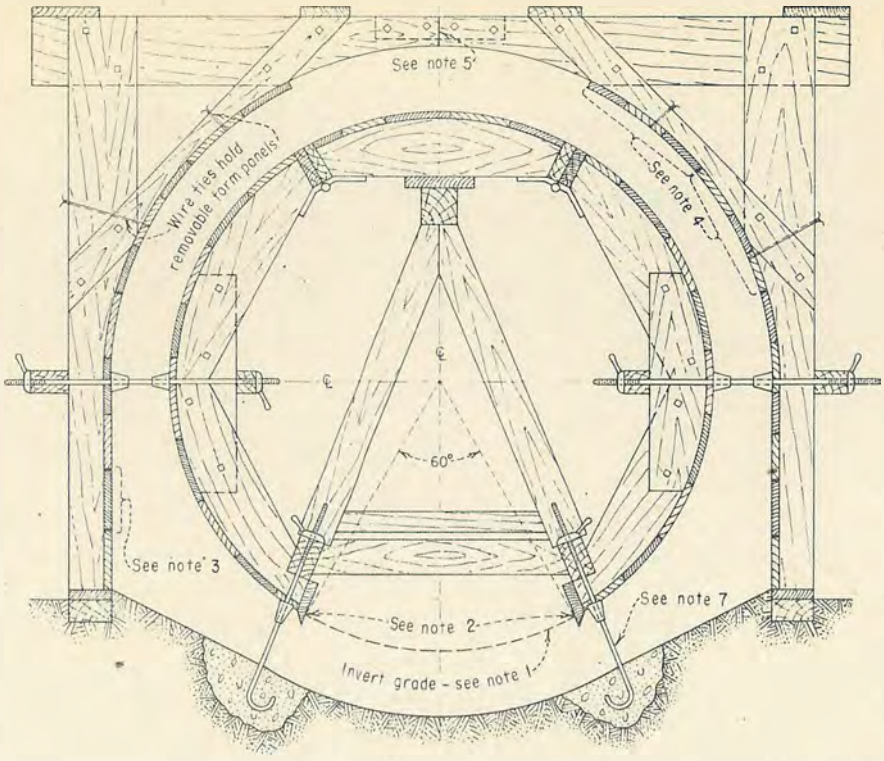
SLOTTED BUCKET USED ON ANGOSTURA DAM

FIGURE 9

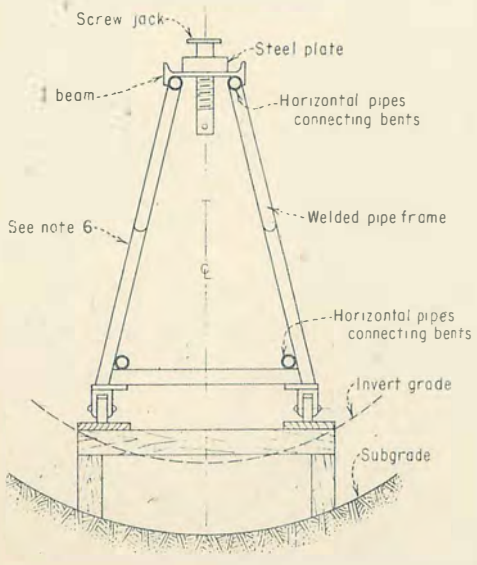


ROSS DAM SPILLWAY
OVERFLOW SECTION 9 - AS RECOMMENDED
RIGHT SPILLWAY

AUG 22, 1946 - R.K.B



STEEL FORMS OF SIMILAR ARRANGEMENT MAY BE USED



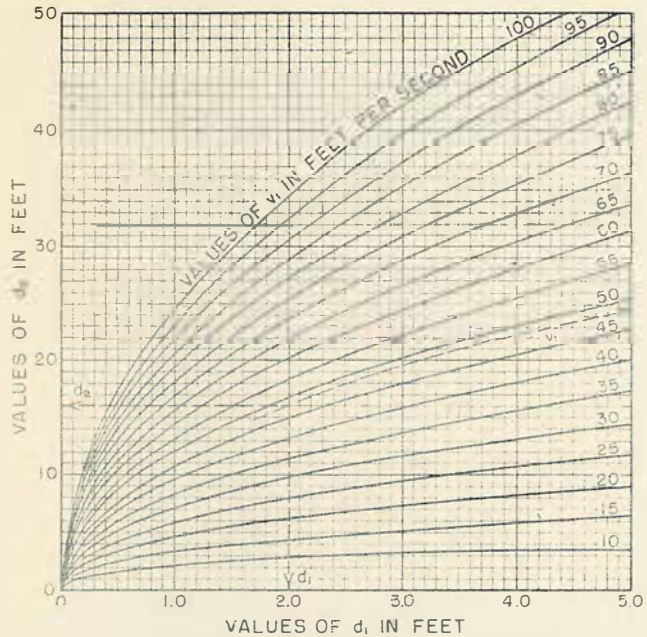
CROSS SECTION THROUGH GANTRY FOR SETTING AND REMOVAL OF INSIDE FORMS

NOTES

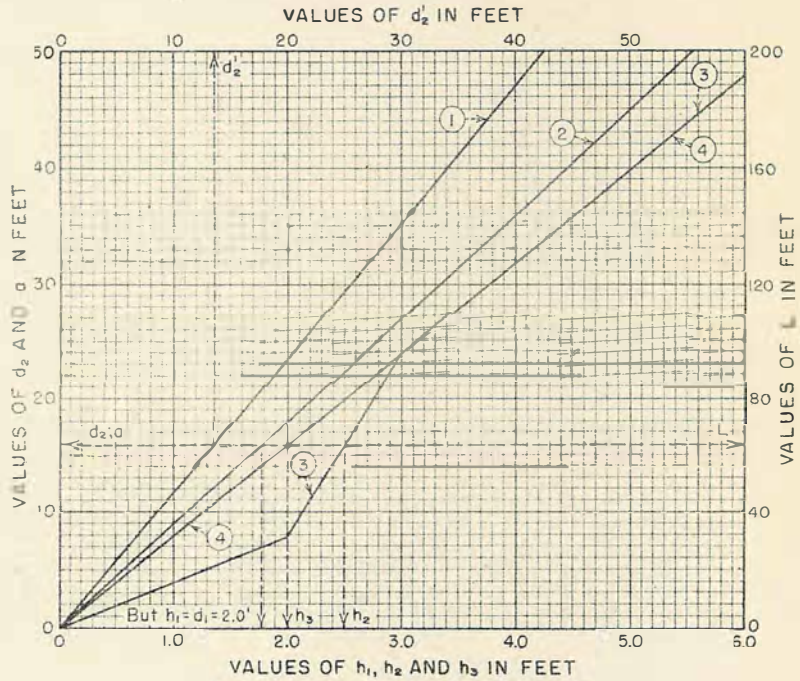
1. Invert concrete is preferably placed direct from inside barrel after placing first lift in both side forms. This avoids detrimental results of over vibration necessary to fill invert from the sides
2. Two-inch stop boards and screed strips prevent concrete from pulling away from forms while screeding. They are removed and the grooves filled when concrete attains initial set.
   Where slope of barrel is steeper than 5 inches per foot, use of temporary, readily removable short panels may be necessary to hold invert shape from bulging At initial set, panels should be promptly removed and the surface finished.
3. Openings are left near the bottom of outside forms of larger siphons to provide access for placing and vibrating concrete
4. Removable form panels 18" to 24" wide, for the outside form above springline are laid on top of barrel until needed, then, one at a time are slipped down, tied in place, and filled.
5. Outside form is taken apart along ℄ at top and moved to new position with dragline or crane.
6. Inside forms are moved as a unit with gantry after pulling them downward and inward with turnbuckles.
7. Anchors should be firmly embedded in concrete pads or sills and fastened to inside forms to prevent floating.

SIPHON FORMS PREFERABLY LEAVE INVERT OPEN FOR HAND FINISHING

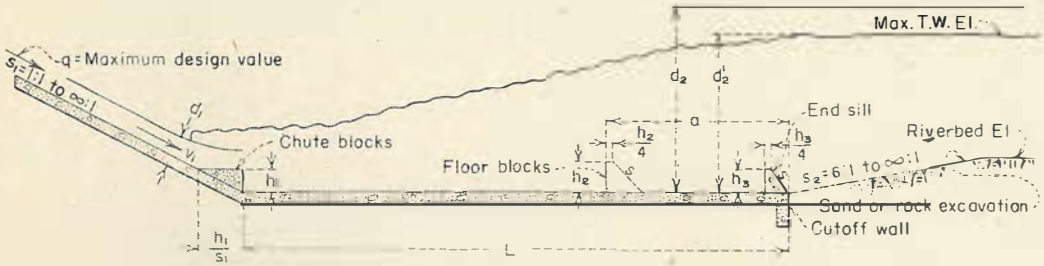
REV	BUREAU OF RECLAMATION – DESIGN AND CONSTRUCTION	SHEET OF
5-1-45	RESEARCH AND GEOLOGY DIVISION	X-D-1119



A. SOLUTION OF MOMENTUM FORMULA



B. STILLING BASIN DIMENSIONS



C. ELEVATION ALONG STILLING BASIN CENTERLINE

MOMENTUM FORMULA

$$d_2 = -\frac{d_1}{2} + \sqrt{\frac{J_1^2}{4} + \frac{2v_1^2 d_1}{g}}$$

(1) For values of d_2'
(2) For values of h_1 when larger than 1.0 d_1
(3) For values of h_2
(4) For values of h_3

EXAMPLE

q = 96.0 sec.- ft. per ft. width	d_2 = 16.0 ft.	h_1 = 2.0 ft.	$h_2/4$ = 6 in.	a = 16 ft.
v_1 = 48.0 ft. per sec.	d_2' = 13.6 ft.	h_2 = 2.5 ft.	$h_3/4$ = 6 in.	s, s_1 and s_2 are all variable.
d_1 = 2.00 ft.	Floor el. = max. T.W. el. − 13.6 ft.	h_3 = 2.0 ft.	L = 64 ft.	

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER OFFICE

RELATIONS BETWEEN VARIABLES IN STILLING BASIN DESIGN FOR RECTANGULAR SPILLWAY CHANNELS BASED ON HYDRAULIC MODEL EXPERIMENTS

REV 12-47 JHH

DRAWN J.H.D. SUBMITTED Harold E. Warnock
TRACED O.E.W.-C.J.L. RECOMMENDED
CHECKED J.H.D. APPROVED

DENVER, COLORADO MARCH 28, 1939

X-D-2619

FIGURE 11

APPENDIX I

Articles of Interest on Technical Writing

THE PRINCIPLES OF POOR WRITING

BY PAUL W. MERRILL

Mount Wilson Observatory, Pasadena

Books and articles on good writing are numerous, but where can you find sound, practical advice on how to write poorly? Poor writing is so common that every educated person ought to know something about it. Many scientists actually do write poorly, but they probably perform by ear without perceiving clearly how their results are achieved. An article on the principles of poor writing might help. The author considers himself well qualified to prepare such an article; he can write poorly without half trying.

The average student finds it surprisingly easy to acquire the usual tricks of poor writing. To do a consistently poor job, however, one must grasp a few essential principles:

I. Ignore the reader.

II. Be verbose, vague, and pompous.

III. Do not revise.

IGNORE THE READER

The world is divided into two great camps: yourself and others. A little obscurity or indirection in writing will keep the others at a safe distance; if they get close, they may see too much.

Write as if for a diary. Keep your mind on a direct course between yourself and the subject; don't think of the reader--he makes a bad triangle. This is fundamental. Constant and alert consideration of the probable reaction of the reader is a serious menace to poor writing; moreover, it requires mental effort. A logical argument is that if you write poorly enough, your readers will be too few to merit any attention whatever.

Ignore the reader wherever possible. If the proposed title, for example, means something to you, stop right there; think no further. If the title baffles or misleads the reader, you have won the first round. Similarly, all the way through you must write for yourself, not for the reader. Practice a dead-pan technique, keeping your facts and ideas all on the same level of emphasis with no telltale hints of relative importance or logical sequence. Use long sentences containing

many ideas loosely string together. And is the connective most frequently employed in poor writing because it does not indicate cause and effect, nor does it distinguish major ideas from subordinate ones. Because seldom appears in poor writing, nor does the semicolon--both are replaced by and.

Camouflage transitions in thought. Avoid such connectives as moreover, nevertheless, on the other hand. If unable to resist the temptation to give some signal for a change in thought, use however. A poor sentence may well begin with however because to the reader, with no idea what comes next, however is too vague to be useful. A good sentence begins with the subject or with a phrase that needs emphasis.

The "hidden antecedent" is a common trick of poor writing. Use a pronoun to refer to a noun a long way back, or to one decidedly subordinate in thought or syntax; or the pronoun may refer to something not directly expressed. If you wish to play a little game with the reader, offer him the wrong antecedent as bait; you may be astonished how easy it is to catch the poor fish.

In ignoring the reader avoid parallel constructions which give the thought away too easily. I need not elaborate, for you probably employ inversion frequently. It must have been a naive soul who said, "When the thought is parallel, let the phrases be parallel."

In every technical paper omit a few items that most readers need to know. You had to discover these things the hard way; why make it easy for the reader? Avoid defining symbols; never specify the units in which data are presented. Of course it will be beneath your dignity to give numerical values of constants in formulae. With these omissions, some papers may be too short; lengthen them by explaining things that do not need explaining. In describing tables, give special attention to self-explanatory headings; let the reader hunt for the meaning of $P_1 r_0$.

BE VERBOSE, VAGUE, AND POMPOUS

The cardinal sin of poor writing is to be concise and simple. Avoid being specific; it ties you down. Use plenty of deadwood: include many superfluous words and phrases. Wishful thinking suggests to a writer that verbosity somehow serves as a cloak or even as a mystic halo by which an idea may be glorified. A cloud of words may conceal defects in observation or analysis, either by opacity or by diverting the reader's attention. Introduce abstract nouns at the drop of a hat--even in those cases where the magnitude of the motion in a downward direction is inconsiderable. Make frequent use of the words case, character, condition, former and latter, nature, such, very.

Poor writing, like good football, is strong on razzle-dazzle, weak on information. Adjectives are frequently used to bewilder the reader. It isn't much trouble to make them gaudy or hyperbolic; at least they can be flowery and inexact.

DEADWOOD

Bible: Render to Caesar the things that are Caesar's.
Poor: In the case of Caesar it might well be considered appropriate from a moral or ethical point of view to render to that potentate all of those goods and materials of whatever character or quality which can be shown to have had their original source in any portion of the domain of the latter.

Shakespeare: I am no orator as Brutus is.
Poor: The speaker is not what might be termed an adept in the profession of public speaking, as might be properly stated of Mr. Brutus. (Example from P. W. Swain. Amer. J. Physics, 13, 318, 1945.)

Concise: The dates of several observations are in doubt.
Poor: It should be mentioned that in the case of several observations there is room for considerable doubt concerning the correctness of the dates on which they were made.

Reasonable: Exceptionally rapid changes occur in the spectrum.
Poor: There occur in the spectrum changes which are quite exceptional in respect to the rapidity of their advent.

Reasonable: Formidable difficulties, both mathametical and observational, stand in the way.
Poor: There are formidable difficulties of both a mathematical and an observational nature that stand in the way.

CASE

Reasonable: Two sunspots changed rapidly.
Poor: There are two cases where sunspots changed with considerable rapidity.

Reasonable: Three stars are red.
Poor: In three cases the stars are red in color.

RAZZLE-DAZZLE

Immaculate precision of observation and extremely delicate calculations....

It would prove at once a world imponderable, etherealized. Our actions would grow grandific.

Well for us that the pulsing energy of the great life-giving dynamo in the sky never ceases. Well, too, that we are at a safe distance from the flame-licked whirlpools into which our earth might drop like a pellet of waste fluff shaken into the live coals of a grate fire.

DO NOT REVISE

Write hurriedly, preferably when tired. Have no plan; write down items as they occur to you. The article will thus be spontaneous and poor. Hand in your manuscript the moment it is finished. Rereading a few days later might lead to revision--which seldom, if ever, makes the writing worse. If you submit your manuscript to colleagues (a bad practice), pay no attention to their criticisms or comments. Later resist firmly any editorial suggestions. Be strong and infallible; don't let anyone break down your personality. The critic may be trying to help you or he may have an ulterior motive, but the chance of his causing improvement in your writing is so great that you must be on guard.

ON ENGINEERING WRITING

BY DONALD M. CRAWFORD

Secretary of the J. G. White Engineering Corporation, New York, N. Y.

On December 10, 1944, the New York Times "Book Review" carried a sad commentary on the writing ability of the engineering profession. Referring to the vast number of technical instruction manuals that the Bell Telephone Laboratories has been required to publish recently for the Army and Navy users of its equipment, the Times said:

> "The company has discovered that it is easier to hire a qualified editor and teach him what he needs to know about the technical terms involved than it would be to take a qualified engineer and teach him what he would need to know about the art of editing and the preparation of manuscript for the printer."

The truth of the premise has long been recognized by the leaders of the engineering profession, namely, that American engineers as a group are deficient in the command of their mother tongue, both spoken and written, and certain of them have long campaigned for greater attention to English in the engineering curriculum. In his commencement address at the Massachusetts Institute of Technology of 1937, Gano Dunn defined engineering as "the art of economic application of science to social purposes" and emphasized the need of the engineer to be able to make his views prevail in society, to persuade and to contend.

However, few practicing engineers have the time or opportunity to avail themselves of formal instruction to develop their writing ability. Improvements can be brought about by the individual if he is aware of his deficiency and if he is willing to correct it. The following notes have been made to assist him in recognizing some weaknesses that are commonly found in manuscripts prepared by engineers:

1. Have a worth-while subject and something to write.

Most engineers know what they want to write. Their subjects are usually well defined and the material is generally factual, not entailing the plot requirements that so frequently confound fiction writers. However, in a well-written article, the thoughts flow logically and smoothly from point to point just as the words themselves flow in smooth order through successive sentences and paragraphs.

2. State your purpose first and end with a conclusion.

Most of your readers will be busy people and you must compete for their interest against other writings, many of which may be more interesting than yours. Tell your reader, if possible in the first paragraph, what "it is all about," much as your favorite newspaper

does in opening its articles, so that he will not be in doubt as to whether or not he wants to read your presentation. If your initial statement of purpose interests your reader, he will probably read it to the end to discover your conclusions.

The concluding paragraph or sentence should refer in some way to the introduction in order to round out the topic and leave the reader with the impression that you have done or proved what you said you would.

The old darky preacher had the right idea when he said about his sermons, "Fust, Ah tells 'em what Ah'se gwine to tell 'em. Then Ah tells 'em, and then Ah tells 'em what Ah told 'em."

3. Define your terms clearly and avoid ambiguity in their use.

This is most important unless you are dealing only with terms that will be readily recognized by all your readers and do not have multiple meanings, such as kilowatt-hours and pounds per square inch. The words "plant" and "unit" are often used ambiguously by engineers as meaning the whole as well as some of its parts and should therefore be used only with care.

Examples of such faulty usage are as follows:

"In the East St. Louis plant, there is a high-octane gasoline plant and a dewaxing plant. The crude oil is heated in a large heater unit, piped to a cracking unit consisting of several Dubbs units.

"Unit No. 1 in the Delray plant consists of a turbine unit and a boiler unit. Boiler water is prepared in a treating unit, and the control room is heated by unit heaters."

Subsequent reference to either plant or unit alone would be ambiguous.

4. Use correct grammar.

The rules of grammar are legion but some of the most common violations by engineers may be avoided by observing the following cautions:

(a) Be consistent with tenses.

If your narrative begins, for example, with the past tense of verbs, don't change in the middle to the present tense or vice versa. If statistics for 1940, "show" something, don't switch later to "they showed."

(b) Don't mix singular and plural forms.

A singular subject takes a singular verb and a plural subject a plural verb, but many writers are tripped by this simple rule. For example:

"It don't prove" is never correct, because it is a contraction of "It do not prove."

(c) Antecedents for pronouns should be unambiguous and not too remote from their modifying pronouns.

"This," "that," or "its" should only be used in such a way that there can be no doubt as to which word is its antecedent. This becomes more difficult when the antecedent is separated from its pronoun by more than one sentence or is in a different paragraph. Note the ambiguity in the meaning of "its" in the following sentence:

"The discussion included the Power Company's principal generating station and its interconnections, its billing methods, and its labor relations."

Also, "this puts that in the best position."

However, the repeated careful use of pronouns, when there is no possibility of misunderstanding their antecedents, may serve as a valuable cohering force in connecting the thoughts.

(d) Try to avoid split infinitives.

A split infinitive results from placing one or more words, generally adverbs, between "to" and the verb that completes the simple infinitive, such as "to quickly recover." This practice, which frequently produces acrimonious debates among writers, is generally discouraged but it is not always wrong. Sometimes a split infinitive is preferable to a word arrangement that suggests stiffness, or permits vagueness or ambiguity; for example:

"He was assigned to personally direct and supervise the erection of the cat-cracker."

This emphasizes the important word "personally" better than:

"He was assigned personally to direct and supervise the erection of the cat-cracker." (Stiff and awkward.)

Or the following:

"He was assigned to direct and supervise the erection of the cat-cracker personally." (Sacrifices emphasis.)

However, don't confuse a split infinitive with the insertion of adverbs or other words between the various auxiliaries or parts of a compound verb. The latter is good practice and frequently determines the emphasis of the sentence. For example:

"To be completely understood"
"To have readily been observed"
"Are also being given"
"Have only been developed"
"He came nearest to really solving the problem"
"Values have rather steadily declined"
"Should certainly maintain its position"

are not split infinitives.

(e) Place modifying words or phrases as close as possible to the words they modify or emphasize.

To do so makes it easier to grasp the thought and avoids ambiguous or stiff and awkward expressions.

"Is the best surface measure of temperature"
should be
"Is the best measure of surface temperature"
since "surface temperature" is the thing to be measured.

The position of modifiers frequently controls the emphasis and meaning, as illustrated in the preceding paragraph, and hence they should be carefully placed. Note the differences in emphasis and meaning in the following:

"Only he cleaned the condenser tubes."

"He only cleaned the condenser tubes."

"He cleaned only the condenser tubes."

(f) Avoid final prepositions.

A preposition at the end of a sentence is not necessarily incorrect. In fact, one is sometimes effective, but more often a final preposition is superfluous or awkward, as illustrated by the sentences:

"A preposition is not a good word to end a sentence with."

"What do you want a book to read out of from for?"

(g) Use words correctly.

Certain words which are similar in form have come by usage to have special meanings which are sometimes confused:

"Ecomonic"--pertaining to man's living.

"Economical"--pertaining to thrift or economy.

"Periodic"--pertaining to a period of time or cycle.

"Periodical"--pertaining to a publication issued at intervals.

Incorrect words, of course, should always be omitted, such as "irregardless" (a bastard word--erroneous attempt to say "regardless" or "irrespective").

5. Try to write in an attractive style.

Wholly apart from grammar and without violating any of its rules, an article or paper may be dull, monotonous, and uninteresting if careful attention is not paid to the manner in which the sentences are put together.

Some engineers never try to write anything more than a series of simple declaratory sentences. These can be just as dull to mature minds as a series of kindergarten sentences, such as: "The dog saw the cat. The dog ran after the cat."

The choice of style will depend on the interests of the intended audience, but no engineering reader enjoys repetition, monotony, redundancy, verbosity, or an obviously incorrect statement or expression.

(a) Be natural.

Try to use language with which you are familiar. Avoid expressions that are pedantic, ponderous, or colloquial.

(b) Avoid monotony.

"The" at the beginning of two successive sentences is generally enough. Don't use three initial "the's" except for deliberate emphasis. Find some other way to start the sentence, as by shifting a phrase expressing time to the beginning, in order to avoid that cause of monotony.

(c) Be brief; omit unnecessary words.

Brevity saves time for the reader and aids coherence. Long sentences and long paragraphs, though sometimes desirable, create a slow tempo and are not conducive to quick comprehension of the ideas you wish to convey. However, even short simple sentences can become monotonous and no one style should be overworked.

Quite frequently, some words or phrases can be omitted without any loss of effect or meaning, for example:

"Very"

"It should be noted that."

"Obviously" (this might be construed as an insult to your reader's intelligence.)

(d) Avoid repetition.

Find synonyms when you are tempted to use the same word more than once, particularly in the same or near-by sentences. If you wish to call attention to the results of some "figures," refer to them variously as "statistics," "calculations," "computations," and what they "show," "indicate," "demonstrate," but preferably vary the form of the conclusions, too.

Don't say the same thing twice unless you are summing up as in a conclusion. If necessary to repeat the thought for emphasis, state it in different words, unless you would rather gain in clarity what you lose in attractiveness.

Avoid redundance or unnecessary repetition of words or phrases having similar meaning; such as the following:

"Co-operate together"

"Potential possibilities"

"The very identical thing itself."

(e) Make clear statements; avoid ambiguity.

Wherever a choice exists, use words of specific rather than general meaning, in order to prevent doubt in your reader's mind as to what you wish to convey.

(f) Avoid parenthetic expressions.

A number of parenthetic expressions or clauses in apposition are undesirable. They are only momentary distractions, they are frequently annoying, and they interrupt the smooth flow of thought toward the desired conclusion. The sentences should be broken up and rearranged without too many thoughts in a single sentence.

In his essay, "The Awful German Language," Mark Twain illustrates from classic German literature how annoying this form of expression may be when carried over into English. It reminds him of the dentist who secures your instant interest in a tooth by gripping it with his forceps, and then drawls through a tedious anecdote before giving the dreaded jerk. "Parentheses in literature and dentistry are in bad taste."

(g) Get the main verb in early.

The German language has a way of stringing out clauses and phrases and making the reader wait for the last few words of a sentence to find the principal verb. Though perfectly good German, such expressions are awkward in English. The verb should appear early in the sentence, leaving the object of the sentence for the climax. For example:

"As a highly desirable procedure supplementary to the use of existing records, whether prepared by governmental or other agencies, aerial photography to determine the conditions on the side was used."

Here the entire principal clause with the subject and verb in normal order should have been advanced, but there are too many subordinate thoughts. Instead, it might be written with an additional verb, as follows:

"Aerial photography has become a highly desirable procedure supplementing existing records, whether made by governmental or other agencies, and was used at Cheyenne to determine the conditions on the site."

(h) Be logically consistent.

Use connecting words and phrases to afford smooth transition from one thought to another and to keep up the interest. In opening sentences or paragraphs with new thoughts, connecting words such as "furthermore," "notwithstanding," "in addition to," "despite," "another," and phrases relating to that which came before or follows, help to avoid jerky narrative or argument and aid in coherence.

(i) Use balanced or parallel construction.

Clarity and quick understanding are aided by balancing similar parts of a sentence. Sentences should be rearranged if the arrangement is such as to cause a reader to reread in order to determine the meaning; for example;

"The natural-gas situation from the economic viewpoint with respect to the number of wells seems to be that the maximum already has been reached and with output diminishing steadily."

might better be rewritten to read

"From the economic viewpoint, it appears that the maximum number of natural-gas wells has already been reached and that their output has steadily been diminishing."

6. Distinguish fact from opinion.

Engineering facts are generally recognizable but the conclusions to be derived from them are often debatable. Hence it is important to make clear the line of demarcation between the uncontested facts and your opinion.

7. Use tabulation and indentation where clarity or legibility may be improved.

Engineering articles frequently lend themselves to outline form, point after point, and the numbering of paragraphs or sections is sometimes desirable. It is certainly preferable when describing or enumerating a list of items, to write them in tabular form, rather than to string them out in sentence or paragraph form. Likewise, the use of indentation by varying the width of margins serves to call attention to quotations, topic headings, or variations in emphasis.

How much clearer it would be to tabulate and rearrange the following properties of modern lubricants instead of running them together in one sentence:

"Modern lubricants must have high film strength, high resistance to oxidation, not form sludge in the engine, no bearing corrosion, have a low oil consumption in the engine, low pour test (wax-free), high viscosity index, and low increase in viscosity during use."

8. Be careful of punctuation.

Some of the rules of punctuation are just as absolute and unvariable as the rules of grammar. However, there are many instances where the use of punctuation is optional, particularly in open style which is direct and relatively simple. Most engineering writers are naturally inclined to a direct and informal style of writing and 'open punctuation' is natural for them. The modern trend is a practical one. All punctuation which is not essential is omitted unless it aids in understanding or reading the sentence, as in indicating the end of a subordinate thought, or a place where a reader would drop his voice and pause if reading aloud.

Innocent appearing little commas can change the meaning of a phrase, if omitted, as for example:

"There was a severe shortage of structural steel, lumber and building materials, rayon materials and machinery and other accessories."

Does "machinery" mean "rayon machinery"? If so, a comma should follow "machinery"; otherwise the sense is entirely different.

Abbreviations, if used, should conform to engineering standards, such as the "American Standard Abbreviations for Scientific and Engineering Terms."

9. Use illustrations where possible.

Photographs or other graphic aids such as charts or diagrams are fundamentally interesting and should be included where possible. They improve the appearance of the printed page by breaking the monotony of solid text. Most engineering articles are based on something which

can be represented by picture or diagram, and one or more such illustrations should be regarded as indispensable to an article.

Charts or drawings should be drawn in such a way as to be readily understood. A clear title should appear on the chart or in the caption, and calibration units should be clearly identified. Lettering should be large and clear enough to be read from a reasonable distance.

If a number of lines or areas on the drawing are to be distinguished, careful attention should be given to the possibility and probable method of reproduction. Although the use of varied colors appeals to the eye, it is practical only on the original in most cases, as engineering articles are seldom reproduced by color process. On the other hand if reproduction is likely, it will probably be in black and white, in which case chart lines must be identified by symbols, and areas distinguished by various forms of crosshatching or Ben Day effect. This is doubly important if the chart may possibly be projected onto a screen or photostated. Lines must be bold and heavy enough to stand out and yet not close enough to run together in reproduction.

The subject of engineering writing and hints to engineers who wish to express themselves on paper presents many facts. However, engineers are not immune to the same requirements for quality of style that confront writers in other fields. These may be summarized as:

Unity--having as far as possible a single subject for every sentence, paragraph, or chapter.

Mass--distributing the mass of material over the various parts of the article in proportion to the emphasis which each should receive.

Coherence--tying the various thoughts together by over-reaching pronouns, references from one paragraph to another, and indications to the reader that he should carry in his mind what he has read.

Before the war, a number of the larger companies and professional societies offered courses in engineering report writing to their employees or members in order to supplement their more formal training. These courses were extremely useful, stimulating, and generally well attended. It is hoped that the courses will be restored and that engineering curricula will be strengthened in this direction, so that eventually the average engineer may be able to express himself more creditably in writing. Engineering writing, which is the only way an engineer can tell his public what he is doing, is something to take care of, and it needs care now.

BASIC ENGLISH FOR SCIENCE

BY TOM BURNS HABER

Department of English, Ohio State University

The following letter (evidently not written to be posted) I found in the English notebook of one of my students in Freshman Composition:

To The Authors of A Textbook of Botany:

> "As a student in the botany course which is given at our university, I have become familiar with your textbook and workbook which are used in connection with the course. I wish to inform you that I am having a great deal of difficulty with botany, and I believe your books are largely responsible.
>
> "The purpose of botany, I believe, is to acquaint the student with the different types of plant life and to help him understand the growth and structure of plants. In my estimation A Textbook of Botany defeats that purpose. The average student is lost in the maze of difficult and highly technical language of your text and in the complexity of the demonstrations and problems in your workbook. For example, in describing the beginning of a leaf you state that 'development of a leaf begins with the proliferations of a primordium'--without any previous hint of what a primordium is!
>
> "As a result of your heavy treatment of the subject, botany is dreaded and disliked by the majority of students on this campus. Many have failed the course because of this dislike--for which your boring textbook is largely responsible. You have, in the eyes of many students, attached a stigma to the useful science of botany."

The evident sincerity of this letter, I hope it will be agreed, entitles it to a fair hearing. What college freshman has not at some time or another felt a similar protest rising within him as he tried to advance through the maze of language between him and the subject he was studying? The writer of the above letter may pass her course in botany and give the lie to her fears. She may even go on to like botany. But what a pity that she must arrive in spite of the language in which her textbooks are written. Much has been said on the teachers' side of the difficulty instructors of physics, of botany, and of chemistry have in getting their students interested in these branches of science. Perhaps the main reason lies not in the students' dislike for the subject itself but for the language in which the subject is presented to them.

Too many college texts in science are burdened with an unnecessarily heavy style. The use of essential scientific words makes for economy; certainly the author is not expected to eschew them to the point of repeating long definitions. But why cannot he occasionally

use "growth" instead of his beloved "proliferation"? "Chain of events" instead of "series of concatenations"? "Scaling off" instead of "desquamation"? It would seem that some authors of secondary science texts think that unless they write in the style of Herbert Spencer's definition of evolution, they cannot impress their readers with the importance of their subjects; as if what is stated simply cannot be worth learning. Clear exposition is a craft which scientific writers ought to regard as highly as the validity of their ideas. Generally speaking, they seem not to be aware of its existence; or, if they are, acknowledge it by keeping as far as possible from it—after the example of Professor Longbore, who used to open his science lectures each quarter with this warning, the only intelligible sentence in his discourses: "I do not intend to make clear to you in twelve weeks what it took me fifty years to learn."

The style of Professor Longbore and his ilk is probably the result of a passive rather than an active state of mind. As one turns the pages of a ponderously written text in college zoology, for example, he begins to wonder whether the author may not have drifted into his style merly by following the course of least resistance. A polysyllabic style is a lazy style. It is easy to master the learned jargon of any science, and mastery of the jargon is too often mistaken by publishers' readers for mastery of the subject. "Easy writing makes cursed hard reading," observed Dick Sheridan; and although laborious writing is not guaranteed per se to make easy reading, it has a good chance to, if the writer knows what he wants to say and tries hard enough to say it. My point is that it is downright hard work to express scientific concepts in a clear, mature style. And yet texts written for college students ought to be worth that much effort.

For some writers, no doubt, there is a fascination in the weighty language of which my student complained. Thus the trap is baited and set for the author's complete undoing: he lets words take the place of thought. He has seen these splendid terms so often; they were right to him in the books he read. Are they not as good in his own? He does not stop to ask what the words really mean, how he expects his reader to interpret them. If by any chance a conscientious student narrows his eyes and carefully examines this lingo, the result is usually a feeling of dismay like that expressed in the letter at the beginning of this article.

Is there, for example, any reason why a book in psychology should be written in this style?

"The apperception of self-motivation is a psychological fact. A concomitant phenomenon is the consciousness that the origin of this motivation is internal and not external."

Is not this what the writer means?

"The mind is conscious that it is self-moving; and at the same time, that the motion comes from within itself."

The last sentence I have is written in Basic English. This simplified English ought to have an especial appeal to scientific writers because its discovery was analogous to the procedure of the scientist seeking basic principles in the natural world. The originators of Basic English, sifting the thousands of words in our language, isolated 850 indispensable terms by which the meanings of the others could be expressed. For science an additional list of 100 words is provided.

The methods by which the Basic word list was determined can be tested by anyone who takes a dictionary in his hand. He will find in reading definitions that certain words keep returning time after time--usually little words such as go, get, make, be, thing, name, true, good, together with necessary conjunctions and prepositions. These words and others of their kind are the basic vocabulary of our language. They make a restricted common ground on which it is possible for writer and reader to meet with the least possible chance for confusion or mistake. In its inductive origin, as well as in its purposes, Basic English is scientific English.

It is not urged here that all writers of college texts in science adopt at once the Basic English vocabulary. The Spartan simplicity of Basic, though it is the hand-maiden of truth, does not always serve other ideals as faithfully. Variety and subtlety, for example, are not main properties of Basic. These virtues and other qualities of a pleasing style ought not to be lacking from the books our science students read. Nevertheless Basic English could have a tonic effect upon these books. It could dispel much foggy thinking, which is the real cause of bad writing. If an author thought in Basic first, he would not write "heliotropic inclination toward the illuminating source." He would see that the meaning of his first word is repeated needlessly in the five that follow and might decide that his whole phrase could be put thus: "turning in the direction of the light"--which is good science and good Basic. No one can compose in Basic without having in his mind a pretty clear idea of what he wants to say. There are no superfluous terms in Basic to get between him and his manuscript. He will often be reminded that between his idea A and the words B that represent it there ought to be the same relation as between an object a held before a mirror and its reflection b. A true reflection requires a good mirror. Basic English has the makings of a good mirror because its vocabulary is level and impersonal--a plane reflector. Even though the scientific writer makes use of a larger vocabulary, if he keep firmly in mind Basic equivalents as he composes his sentences, his writing will gain clearness, whatever words he finally chooses. And his readers--his students or his peers--will call him blessed.

But there is another field of scientific writing where the need for Basic English is far more pressing. I mean the scientific books and magazines printed in this country and Great Britain. A great many foreigners before World War II were coming into English via Basic. Now as an international language Basic is gaining steadily in general esteem everywhere. Public interest in it was greatly stimulated by

Winston Churchill's ardent approval of Basic at Harvard in 1943. No artificial language can meet the stern needs of an international tongue as Basic English can. First, it has behind it the compelling prestige of the Anglo-Saxon tradition; it "looks" like English and it is English, the vital heart and core of the language of Shakespeare and Jefferson. Basic is easy for the non-English speaker to learn. A few weeks' steady effort under skilled direction can make an intelligent foreigner at home in written and spoken Basic. The demand for books in Basic, both here and abroad, is on the upswing. It is one sign of the world-hunger for unity and commonalty among the peoples of our shrinking planet.

In satisfying this hunger the place of science is nothing less than strategic. It remains for science to recognize some of the practical aspects of its position. Science, as an international agency, must create or adopt an international tongue. The scientist today is faced with the problems faced by English traders 500 years ago as they carried their goods and their language into the Seven Seas. Through necessity, between them and their brown-, black-, and yellow-skinned customers, a species of international language slowly developed. The barbarous pidgin ("merchant") English of the Far East is a natural phenomenon brought into being by the needs of men groping toward each other's minds. These needs are a hundred times more imperative today. The very existence of the race may depend upon our finding right answers to them. Science, like trade, now has the earth as its province. More fortunate than trade, science does not have to await the development of a crude, mass-made English. A scientifically evolved speech is at hand; in the words of Mr. Churchill, "a very carefully wrought plan for an international language, capable of very wide transactions."

It is a truism to say that the great impetus felt by scientific research during the past five years will continue and accelerate. Parallel with this step-up of activity in the ranks of the scientists is a keen public concern about what they are doing. Jet-propelled aircraft and atomic bombs have drawn the fearful attention of everyone to the laboratory of the technician. This public interest cannot be written off as mere curiosity. We are hearing it said on all sides: Why, if the scientist is so expert in devising the machines of death and destruction, why cannot he turn his talents as effectively to the service of humanity? This protest is admittedly naive: Burbank and Edison were scientists. But the protest still stands. Its ultimate meaning is that everyone the world over wants to know what the scientist is about.

Modern science has therefore a vast new social responsibility which it cannot ignore. The day of unadulterated "pure" research is about over. Even though the scientist may not, like Terence, agree that "Everyman's business is my business." Everyman is telling the world and himself that "The scientist's business is my business." And Everyman pays the taxes and makes the grants that keep the scientist going. Everyman is a Chinese farmer, a Chicago businessman, a French taxi driver, a Greek fisherman, a Russian fur dealer. All these are invading the hitherto sacred confines of the technician's laboratory. And they have a right to do so.

In practical terms this means that the findings of the technician must be put on paper. Books must be written, articles contributed to scientific and lay journals. At present the chances are twenty to one that the native tongue of our hypothetical scientist will be English. Why should he not address himself to his world-wide audience in a truly international language--Basic English?

Basic is surprisingly easy for the English user to learn. With a little experience a copy writer can translate a full-English draft into Basic about as rapidly as he can compose. It is most desirable, of course, that the scientific writer prepare his own Basic version of his books and articles. Thus the thoughts of such authorities as Sir James Jeans, J. B. S. Haldane, Walter S. Landis, and Sir Arthur Stanley Eddington could go directly to the minds of men all over the earth without the warped meanings and false emphases that lurk in translations.

In facilitating the direct communication between the writing scientist and his universal reader, the American and British scientific journals have a place of unique importance. Their large circulation is a token of the immense service they can render to science and to humanity. By the use of complete articles in Basic English and by special Basic editions and supplements, they can directly interpret the findings of modern science to a circle of readers that in a very true sense is world-wide. In so doing they will be assuming their share in the large responsibilities borne by science in the world today.

I wish to conclude by submitting a brief specimen of Basic translation. The original, which follows, was chosen from Sir Charles Lyell's well-known Progress of Geology:

> "(1) For more than two centuries the shelly strata of the Subapennine hills afforded matter of speculation to the early geologists of Italy, and few of them had any suspicion that similar deposits were then forming the neighboring sea. (2) Some imagined that the strata, so rich in organic remains, instead of being due to secondary agents, had been so created in the beginning of things by the fiat of the Almighty. (3) Others ascribed the imbedded fossil bodies to some plastic power which resided in the earth in the early ages of the world. (4) In what manner were these dogmas at length exploded? (5) The fossil relics were carefully compared with their living analogues, and all doubts as to their organic origin were eventually dispelled. (6) So, also, in regard to the nature of the containing beds of mud, sand, and limestone: those parts of the bottom of the sea were examined where shells are now becoming annually entombed in new deposits. (7) Donati explored the bed of the Adriatic, and found the closest resemblance between the strata there forming and those which constituted hills above a thousand feet high in various parts of the Italian peninsula. (8) He ascertained by dredging that living testacea were there grouped together in precisely the same manner as were their fossil analogues in the inland strata;

and while some of the recent shells of the Adriatic were becoming incrusted with calcareous rock, he observed that others had been newly buried in sand and clay, precisely as fossil shells occur in the Subapennine hills.

"(1) For more than 200 years the shell layers of the small mountains near the Apennines had been a question for discussion among the persons in Italy who first became interested in the science of the earth's history as recorded in beds of rock. (1a) Only a very small number had any idea that like deposits were then forming in the nearby sea. (2) Some had the idea that the rock layers, which had in them a great amount of the dead substance of things once living, had been made not by the decomposition of those things, but by an order of the Almighty when He made the earth. (3) Others gave the explanation that the plant and animal bodies in the stone beds were deposited there by some force of swelling and contraction which was in the earth in its early days. (4) In what way was the demonstration made at last that these ideas were false? (5) An exact comparison was made between the stone plants and animals and the living ones like them, and all doubts that the stone forms had come from living forms were put away at last. (6) The same fact was made clear about the substances in the sea-beds of earth, sand, and lime stone (stone having a great amount of chalk): tests were made of those parts of the sea-floor where shells are now year by year being covered over in new deposits. (7) Donati took samples from different parts of the bed of the Adriatic and made the discovery that the layers forming there were very much like those which made up small mountains over 1,000 feet high in different parts of Italy itself. (8) He made the discovery by taking up samples from the seafloor that living testacea (a species of small shell-covered animals) were there grouped together in exactly the same way as were their like stone forms in the inland layers; and at the same time some of the new shells in the Adriatic were being covered with lime-stone rock, he took note that others had been newly covered by sand and sticky earth, exactly as the stone-covered shells were, in the small mountains near the Apennines."

WHAT'S WRONG WITH ENGINEERING REPORTS?

In the course of engineering progress we have steadily improved the technical caliber of engineers. But at the same time most of them have been given far too little help, either by precept or by example, in making corresponding improvements in the relationship between engineering and the people who should use its findings.

In many cases the engineer's principal means of introducing or explaining his results has been through written reports. The difficulties he has with such reports are typical of those he experiences in all of his contacts with people outside engineering. Concentration on purely technical subjects has made the average engineer an untrained amateur in putting ideas down in clear-cut, understandable language. The unfortunate consequence is that our manner of presentation leads others to infer that we are confused in our engineering thinking.

Let's take a closer look at our engineering reports. They are of two kinds--one to record engineering progress, the other to present an idea or engineering recommendation. They go to different kinds of people, but each is highly important. Many of us dislike reading reports, let alone writing them. Yet many times they represent the principal end product of months of skillful and creative work. Their contents may be a distinct and important contribution to engineering knowledge, and may point the way to significant advancements ... but what does the average engineering report look like? Well, it is probably a reasonably accurate facsimile of the hundreds of other reports that have been prepared over the last twenty years or so. Outside, it has the same drab cover ... apparently the duller and less attractive, the better. Inside it is probably reproduced on cheap paper, by means of one of the less satisfactory methods of duplicating. Little attention has been paid to margins, heading, spacing and similar factors of physical arrangement. Yet those very physical characteristics can do much, either to convey the actual importance of the report or, if neglected, to destroy any feeling of value.

But how about the material inside the report? For one thing, there is little help for the man whose time is limited, but who still should be made acquainted with the principal findings reported. Charts and curves generally require considerable study to dig out their significance. Photographs or other illustrations often are insufficiently identified, so that the reader, unless he is an expert, doesn't know what to look for, or what particular point is being illustrated, without studying the entire report. Too much dependence is placed on inference, rather than direct statement, to get the point across. Instead of being pointed up and emphasized, important facts and conclusions are frequently buried in a mass of detail. Little attempt is made to sum up and interpret the overall significance of the findings. Yet the information is valuable, complete and, in many instances, in advance of any published material. But it is too uninviting, and it is too hard work to dig out the important facts.

Nevertheless these same reports are expected to act as our ambassadors in absentia. They represent us. We send them out unmindful of their forbidding countenance, their unkempt appearance, their complicated jargon and their awkward manners. Is it any wonder our day in court is not always successful?"--From a paper by J. C. Zeder, chairman of the Engineering Board, Chrysler Corp., presented at a recent meeting of the Cleveland Section of SAE.--Published in Machine Design, February 1946.

APPENDIX II

Sample Field Trip Report

Engineering and Geological Control and Research Division
Field Trip Report No. 235

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

February 26, 1947

To: Chief Engineer
Through Chief, Engineering and
Geological Control and Research Division

From: C. W. Thomas, Engineer

Subject: Measurement of irrigation water on Yuma Project.

1. At the request of regional representatives, I attended a conference and inspection pertinent to the above subject while at Yuma, Arizona, conducting tests on the air-admission mechanism of the 96-inch flap valves at Gila Pumping Plant, Gila Project. The results of the air-admission tests are covered in a separate report.

2. A brief conference was held in the office of Mr. W. A. Boettcher, Superintendent, Yuma Project, during the afternoon of January 9, 1947. A hasty inspection of typical canals, laterals, farm ditches, and appurtenant structures on the project was made later. Those attending the conference were Mr. C. L. Sweet, and Mr. T. L. Steele of the Regional Operations and Maintenance Office, Mr. E. A. Haley of the engineering office, Yuma Project, Mr. Ray G. Sparling of Sparling Meter Company, Mr. Boettcher, and myself. Mr. Boettcher did not accompany the party on the inspection.

3. The main points of discussion at the conference were that in the history of the project water measurement and control has not been considered important except on the main canals, but at present the water users and the project are very desirous of getting accurate, totalized, measurements throughout the system, particularly at the farm turnouts. The drainage problem and the year-by-year increase in scarcity of water make it necessary to institute a system of control and accurate measurement. Also, now that the Colorado River water is clear, less land can be covered with an equal flow in a given time than was possible with muddy water. This implies to the consumer that he is now receiving less water than in the past and he demands an increased amount. Being without an accurate system of measurement,

the project finds itself in the position of no defense. Although the amount of water delivered at present is apparently the same as in the past, no accurate records are available, hence no positive proof to the individual that the deficiency is due to clear water rather than reduced deliveries.

4. There are approximately 2,000 farm deliveries on the project, each of a capacity of approximately 15 second-feet. These deliveries are accomplished principally through turnout gates and culverts of 30-inch base by 36-inch height with fillets in the corners. There are some culverts of 33-inch ID concrete pipe and a few of wood approximately 3- by 3-foot. An impeller type of measuring device with totalizing dials could be easily adapted to this type of turnout. Mr. Boettcher stated that consideration has been given to such devices and the water users had indicated further study should be made with a view of including them in the proposed rehabilitation program for the project providing substantial equipment could be provided and protection from moss could be accomplished economically. If these requirements could be met the installations should be included in the main canals, laterals, and farm turnouts.

5. Conclusions. The following conclusions are a result of the brief conference and cursory inspection:

a. Definite recommendations must await further study of the problem. In view of the proposed rehabilitation program and the desire of the water users for adequate control and accurate delivery of water such a study should be made in the near future in order that recommendations may be included in the program.

b. In considering the various means of accomplishing water measurement on the project, standardization of equipment or methods should be sought so far as is practicable with the varying requirements of head loss to be met. This would result in economy of operation and maintenance and should not be difficult since the turnouts are well standardized in respect to dimension and capacity. Siphons and culverts on the main canals and laterals, and the farm turnout culverts provide structures in which propeller type meters and totalizers might be economically placed. Such equipment, suitably protected from moss, would provide accurate, totalized measurements throughout the entire system and should be carefully considered when recommendations are made.

(Sgd.) C. W. Thomas
By D. M. L.

CC-Reg.Dir.,Boulder City,Nev.
Supt.,Yuma Project,Yuma,Ariz.

BC-Canal Engineering Division
R.F.Blanks
J.E.Warnock
C.W.Thomas (2)
Geology files

NOTED: Mar 20 1947
(date)

Walker R. Young
Chief Engineer

APPENDIX III

Bibliography

SUGGESTED READING

Writing the Technical Report
J. Raleigh Nelson

Notes on the Composition of Scientific Papers
Clifford Albut Macmillan, 1923

The Art of Plain Talk
Rudolf Flesch Harper, 1946

On the Art of Writing (V)
Arthur Quiller-Couch Putnam, 1928

REPORT APPRAISAL CHART

This appraisal chart is intended to assist you in planning, writing and editing your own reports or in indicating to others the specific weakness of reports submitted to you for editing.

Before appraising a report, be sure to determine its exact purpose. What response is desired from the reader – or readers?

CAN YOU ANSWER "YES" TO THE FOLLOWING QUESTIONS?

IS THE REPORT:

1. COMPLETE

a. Does it give all the information necessary to accomplish its purpose?

b. Does it answer fully all questions likely to be in the reader's mind?

2. CONCISE

a. Does the report include only the essential facts?

b. Are the ideas expressed in the fewest words consistent with cleorness, completeness, and courtesy; have irrelevant details and unnecessary repetition been eliminated?

3. CLEAR

a. Are all facts arranged in proper sequence; are they directed to the interest of the reader?

b. Is the language adapted to the vocabulary of the reader?

c. Do the words exactly express the thought?

d. Is the sentence structure clear?

e. Is each paragraph one complete throught unit?

4. CORRECT

a. Is the accuracy of all factual information beyond question?

b. Are all statements in strict conformity with policies?

c. Is the report free from: (1) grammatical errors, (2) spelling errors, (3) misleading punctuation?

5. APPROPRIATE IN TONE

a. Is the tone calculated to bring about the desired response?

b. Is the report free from antagonistic words or phases?

c. Is it free from hackneyed or stilled phrases which may suggest that our business methods are as outmoded as our language?

d. Are the facts organized to hold the reader's interest and to carry conviction?

6. ATTRACTIVELY DISPLAYED

a. Can the reader readily know the purpose of the reports?

b. Are the main parts easy to find: conclusions, recommendations, supporting data?

c. Are headings, subheadings, underscoring, italics, tables, charts, and other devices for effective display used appropriately?

d. Will the physical appearance of the page create a favorable impression upon the reader?

HOW EFFECTIVE IS THE REPORT AS A WHOLE?

To what extent is it likely to accomplish its purpose, obtain the desired response, and build good will? In other words, how do you rate its general effectiveness? Underline the word which best express your rating:

OUTSTANDING GOOD PASSABLE[1] UNSATISFACTORY[2]

[1]Passable: Report has minor weakness, but will "do". These weaknesses indicate opportunities for improvement in future reports.

[2]Unsatisfactory: Report has major weaknesses and therefore should be rewritten.

Issued by the Division of Training, Office of Personnel, U.S. Department of Agriculture.