# NOTE TO USERS

# ENGINEERING REPLACEMENT ECONOMY IN IOWA INDUSTRY

by

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# ABSTRACT

Engineering Economy is the title applied to a body of methods used to make the wisest and usually most economic choice among several possible alternatives of such technical complexity that engineering knowledge is essential. The most usual and difficult engineering economy study presents itself when one of the alternatives is the status quo, i.e., the presently existing machine or structure still capable of rendering service if retained. It is in this broad area of replacement studies that much erroneous thinking has occurred. Very little evidence of factual information in this area has been found. None was found that was directly applicable to Iowa.

The investigator desired to secure data about actual replacement economy practices of manufacturing plants in the state of Iowa. To fully describe the replacement economy practices, it was also necessary to secure data on other closely related practices including depreciation, accounting, and appraisal. The stated objectives of the investigation were to secure data on the previously mentioned practices, to compare this data where possible with currently known data, to interpret these data by comparison with conventional or suggested

practice, and to report the results of the investigation back to the Iowa manufacturing plants for their use. The study was intended to be primarily descriptive in nature rather than interpretive.

The total number of plants in Iowa that fell within the scope of the study was known to exceed 2,100. Resources of time and money were inadequate for a complete census of this group. A sampling plan was evolved to contact a smaller representative group of the total. The group of 300 plants finally selected were sent the questionnaire by mail. Actual data were taken from answers to 26 questions. Best statistical procedure was rigidly followed in drawing the sample and analyzing the responses.

Response to the questionnaire was 52 per cent of those contacted which was considered excellent for a mail survey offering no special appeals. Evidence was found that the non-respondent portion of the sample would give answers essentially similar to those of the respondent portion. The average number of employees in an Iowa plant was 91, and about 195,500 persons were employed in manufacturing in Iowa.

The answers to all questions were classified by the size of the plant from which the response came. Number of employees was the measure of size. The practice under study in each question was tested to find if any relationship existed to

size. The more important findings and their relation to size, if any, were as follows:

1. Appraisals, where made, were predominantly for insurance. Large plants made appraisals more often.
2. Nearly one-half the plants calculated depreciation for income tax purposes only. Large plants determined depreciation for more reasons.
3. Slightly over half the plants used the life values from Bulletin F, U. S. Bureau of Internal Revenue exclusively. Large plants relied more heavily on their own experience and opinion of life values.
4. Over four-fifths of the plants use straight line depreciation, although an increase was found in the use of the declining balance method, particularly by small plants.
5. Although nearly half the plants were satisfied with the life values in Bulletin F, nearly three-fourths were in favor of a proposed ruling to allow the plants to choose their own life values. Large plants were less satisfied with the life values from Bulletin F.
6. Almost one-third of the plants would not consider replacement of a machine that was not worn out.
7. The average pay-off period among those who use this criterion for signaling replacement was 3.0 years

which agrees closely with some reported values for the U. S. as a whole.

8. A hypothetical, though typical, problem was submitted to each prospective respondent. The solutions to this problem disclosed the following.
   a. Methods of calculation were extremely variable.
   b. Rated against an arbitrary scale of good practice, the quality of the problem solutions was not related to size of the plant.
   c. Although the problem was stated so that a replacement would be indicated by most methods of solution, only three-fourths of the respondents chose to make the replacement.
   d. Some evidence was found that the largest companies were more conservative about the replacement decision than the smaller companies.

# INTRODUCTION

Engineering Economy is the title applied to analytical techniques and, more basically, to philosophies regarding wise utilization of the assets or resources of an enterprise by engineers. The title as such, however, is not widely known and connotes different meanings to different persons. Engineers acting in their professional capacities seem often to lose sight of the necessity of considering the economics of a situation on at least an equal level with the purely technical engineering aspects. In our competitive economy, imperfect as it may be, the engineer must select the most economic alternative, or society will suffer the consequences however long delayed. The generally good economic health of the United States in the past which has allowed wasteful practices to pass scarcely noticed is not a rational reason to continue these errors of commission and omission. To the contrary it may be expected in the future as our economy matures further that the use of any resource or asset will be more critically examined. Wellington's classic statement (55, p. 1) that "an engineer can do with a dollar what any bungler can do with two after a fashion" points up more of a future promise than an actual present state of affairs.

In the present organization of many enterprises, particularly in manufacturing, the engineer directly or indirectly controls the spending of most of the money. He designs and specifies the structures and equipment, he specifies methods and processes, and he often controls and directs facilities after the original implementation is accomplished. Many times he has the opportunity to choose or suggest the most economic of several alternatives. Engineers have sometimes been guilty of reticence in offering suggestions about "purely business matters". However, the opportunity repeatedly presents itself.

A working definition of Engineering Economy is proposed as follows: Engineering Economy is a body of methods applied to make the wisest and usually most economic choice between several possible alternatives of such technical complexity that engineering knowledge is essential. The subject is a science because the scientific method is applied as rigorously as possible. The scientific method has been defined in many ways, but may be briefly stated as a systematic approach to the solution of problems, based on controlled thinking, aimed at establishment of general truths ( 9 ). The scientific method discerns explicitly or implicitly a certain series of recognizable and verifiable steps including the working hypothesis, the observation of data, the organization of the data, and the generalization (30).

The importance of economic considerations has been pointed up by many writers in the past. The current emphasis appears to be even stronger. Recognition of this importance is apparent in the ever increasing number of engineering colleges (36) that include a study of Engineering Economy in the several curricula. Examinations for registration as Professional Engineer in most states now require a knowledge of Engineering Economy.

The practice of Engineering Economy both past and present has been as a micro-science rather than a macro-science for the most part. It has been applied most often for very particular cases such as choosing the most economic machine from several possible machines or the best process or the best method. It has been logically assumed that a series of most economic parts will result in the most economic whole. Such an assumption may be questioned at least, and the "broad point of view" has been encouraged (28). The approach by parts is both practical and expedient because rarely are major enterprises created overnight. Expansion or replacement of existing facilities is the principal area where Engineering Economy is and will be practiced.

The most difficult Engineering Economy study presents itself when one of the alternatives under consideration is the status quo, i.e., the present machine or structure still capable of rendering service if retained. Except for a new

or expanding enterprise this situation is the usual situation that will be faced. Funds currently available to business for capital expenditure are reported (35) to be used 62 per cent for replacement of worn out or uneconomic facilities and only 38 per cent for expansion. The magnitude of this ratio is verified in other studies. At least one writer feels that in the future almost all capital expenditure will be for replacement of existing facilities rather than for expansion (50). This particular theory may not be completely defensible as it is based on declining population growth which has not yet developed. However, the importance of the replacement situation seems well established.

It is in this broad area of replacement studies that much erroneous thinking has occurred (17). It has been stated that the natural tendency to cling to what is currently providing a necessary service often overpowers the rational results of an Engineering Economy study (51). Such action is understandable because any new machine or structure will be more economical only if the forecasted savings actually develop over the future period. However, these contentions are not documented and represent for the most part individual observations.

The state of Iowa has historically been classed as primarily agricultural. Recent compilations (53) show that the worth of manufactured goods is approximately equal to the

worth of agricultural commodities. This ratio is somewhat dependent on the definitions of manufactured goods and agricultural commodities. When compared to other states, particularly those to the east, Iowa is more agricultural in nature and, hence, less industrialized. Reasons why Iowa may never improve its relative position have been advanced (5). However, published information about the thinking of Iowa industry on matters of Engineering Economy is lacking and represents the sphere of interest for this investigation.

With this brief introduction to Engineering Economy pointing up the need for more information on the subject, the objectives of this investigation may be stated.

1. A survey was made of manufacturing industry to provide basic data on Engineering Economy practices in the state of Iowa. These data will give information of descriptive nature which is of primary interest.

2. Certain practices in Engineering Economy may be compared with available data to evaluate the relative position of the state of Iowa. Because some of the data were to be current, it may be possible to ascertain some of the desires of Iowa manufacturing industry in phases of Engineering Economy affected by legislation and governmental edict.

3. Interpretation of descriptive data will be made in some instances where accepted, conventional, or suggested criteria are established.

4. A report to Iowa manufacturing industry from which the data came will be made when the investigation is completed.

Certain restrictions on the scope of the investigation were imposed by limitations of time and money and by the areas of interest of the writer. Thus, the scope of investigation was to include only manufacturing industry in the state of Iowa. Sampling methods were to be used rather than a complete census. The contacts were to be primarily made by mail accompanied by a limited number of personal contacts in a few cases. As it is hoped that this field of research may be developed in the future through Iowa State College, caution with regard to personnel relations was necessary in this initial investigation. Delimitation of the scope as stated should not weaken the investigation, but should serve to properly define the scope and make the investigation reasonably manageable.

# REVIEW OF LITERATURE

Published information of direct bearing on the subject of this investigation was limited to a few isolated references. However, certain related literature has been found valuable from the standpoint of techniques, comparative data, and historical development. This literature will be reviewed under the following classifications:

Basic data on practices in engineering economy.
Historical aspects of engineering economy.
Statistical techniques of survey design and practice.
Other closely related literature.

## Basic Data on Practice in Engineering Economy

The actual practice in engineering economy was known to be variable (17, 51). Expositions of best techniques have in the past been built upon certain assumptions thought to be representative of actual practice. Passage of time has in some cases indicated these assumptions to be far from actual practice.

All previous investigations have used sampling techniques. The first study that appeared to be adequately documented was made during the decade of 1929-1938 by Rautenstrauch (44).

This study was not primarily about engineering economy, but did delve into many closely associated topics including depreciation and cost accounting.

A series of six surveys of intimately related nature have been made for Factory magazine (35). These surveys, the last of which was made in 1953, were primarily about total capital expenditure and are too general for specific application. Furthermore, the surveys were not made under a random or even systematic sampling scheme and are heavily shaded toward the very largest manufacturing companies.

Perhaps the survey most closely akin to this investigation was made by Terborgh in 1948 for Machinery and Allied Products Institute (32). Its primary subject was machinery replacement policy. It sampled only members of MAPI which is a trade association composed of machine tool manufacturers and business consultants.

Another survey was made in 1947 by Iron Age (26). This survey had three questions that were closely related to this investigation.

These surveys just mentioned were reputedly national in scope. No information has been found relating to any specific area of the country and certainly not to Iowa.

## Historical Aspects of Engineering Economy

Engineering economy was given its first real definition by Arthur Wellington in a book that was revised six times between 1877 and 1906 (55). The technical subject matter of the book was railway design, but its real contribution was to formulate a philosophy of engineering economy. The following considerations or techniques are from this book: recognition of the "time-value" of money, i.e., compound interest; inclusion of interest on the investment as an actual operating expense; strong emphasis of the long-run economy; recognition of the fact that many alternatives are available to accomplish a single ultimate end and all need to be evaluated; warning of social implications of engineering decisions and contention that the best decision provided maximum good to all in the long-run; insistance that all proposals be reduced to the common denominator of dollars. There was a conspicuous absence of the subject of depreciation.

Soon after Wellington's treatise certain engineers realized the need for training in business economics for the engineering profession as a whole. Fish between 1915 and 1923 (16) came to the conclusion that the central problem in engineering economy was investment. He developed the so-called "bond market" model as an approach. In this method

all proposals for investment of engineering complexity were compared to a similar dollar investment in bonds. The bond market model with only slight modification has been employed by all authors to the present day, at least in the instance of long-lived investments.

Grant, writing first in 1930 and revising his ideas last in 1949 (17), has become the most widely recognized writer in the field. He introduced techniques for short-lived situations and also for the circumvention of compound interest calculations. He has suggested the application of certain statistical methods to problems of engineering economy (18).

Three other writers (8, 52, 56) have produced works in the last decade of basic similarity to Grant's. They are characterized by clever adaptations of the same methods. They do serve to bring engineering economy to a wider audience.

Lesser in reviewing the content and aim of engineering economy (28) raised question as to the validity of the bond market model. He did not offer an alternate model. He also questioned whether the academicians are correct in continuing to urge such techniques as compound interest when there exists strong suspicion that these techniques are not used in industry. This investigation aimed to provide some basic data on such questions.

All of the preceding works, except that of Wellington's, came from the college atmosphere. Other recent works have come from sources closer to practical or applied aspects of engineering economy. Terborgh in a widely publicized book (15, 31, 43) disguised the bond market model with a new assumption and a different, though colorful, terminology. This work was described as a "working manual" (51) and has gained certain acceptance due to energetic salesmanship and distribution.

Another recent publication has not been publicly circulated because it was developed by the associated Bell Telephone companies (2) for intracompany use. This work was truly a working manual and was conservative, though very complete. It embodied the principles of Grant and Fish with a section on the impact of income and property taxes on the problems in engineering economy.

Two pamphlets prepared by the National Machine Tool Builders Association (38, 39) have been widely distributed through salesmen of the member companies of this trade association. The pamphlets were simply and effectively written. They were typical of industrial publications used in disseminating information on engineering economy.

## Statistical Techniques of Survey Design and Practice

Modern statistical method and theory has evolved sampling methods that give a high ratio of information gained to cost of gathering the information (13, 25). Surveys based on random or probability sampling have in some cases been more reliable than censuses (24). Surveys based on selective or "quota" sampling enjoy popularity, but allow no estimates of sampling error (13).

Deming (13) described survey theory and derived appropriate estimators of the mean and variance. Jessen and Horvitz (25) have also presented this theory with appropriate explanatory material. Neymen's treatment of stratification of a sample was applied to this investigation (41).

Snedecor (47) presented techniques of analysis of data that were applied to this investigation. Cochran (10) gave methods of analyzing data fitting the multinomial distribution which arose in this investigation.

Lundberg (30) has reviewed and compiled a group of recommended practices in the area of questionnaire layout and design. Included in this group were questionnaire length, questionnaire layout and appearance, leading questions, and open-end questions. Also discussed were methods to improve the response to mailed inquiries.

## Other Closely Related Literature

Articles in the appropriate journals have not been found of particular value to this investigation for the most part. The greater share of these articles although indexed under Engineering Economy fall into one or more of these classifications:

a. Specific applications of general methods to a particular company
b. Compilations of cost data
c. Empirical formulas for estimating cost
d. Popularized, shortened, or sensationalized presentations of the recognized books.

The many examples of each of these will not be discussed and only a representative group are cited (4, 12, 14, 15, 20, 31, 38, 39, 40, 42, 43, 45).

The U. S. Census (53) has provided certain comparative data and definitions. The Iowa Business Digest (5, 27) has discussed in two recent articles the income and economy of Iowa. Capital expenditure by manufacturing industry was analyzed and compared with the agriculture industry. The Iowa Business Digest also presented current data and some future estimates of business activity in Iowa.

Economic theory, particularly that of oligopoly and monopoly, is basic to a study of engineering economy. The

works of Stigler (48), Boulding (7), and Bain (3) were of some application. However, the emphasis was placed on the "short run", i.e., a period of time short enough so fixed resources of the enterprise can not be changed. Engineering economy has dealt principally with capital expenditures which were long-lived, so changes in the fixed resources were basic to the subject.

Terborgh discussed capital replacement as related to economic maturity (50). This book was closely related to the philosophies of equipment replacement. Terborgh attempted to refute the contention of the Temporary National Economic Committee of 1939 that investment opportunity in the United States was dwindling. He contended that normal replacement and modernization offer sufficient investment opportunity because industry has historically lagged with regard to replacement of equipment. If replacements were made more often, more investment funds would be absorbed by industry.

## DISCUSSION OF PROCEDURE

In many investigations apparatus and materials used in the experiment are of principal importance. In this particular instance only the method of procedure was important. Any success in the investigation depended upon a well defined and rigorously followed procedure. Some of the procedure was statistical in nature and the estimates and conclusions drawn were tested where possible by statistical methods. Wherever this procedure departed from simple or usual techniques, complete detail will be given. Reasons for certain decisions concerning procedure are also discussed where appropriate.

The original idea of this investigation was to obtain quantitative data about engineering economy and certain other closely related topics in the manufacturing industries of Iowa. The investigator desired to question Iowa manufacturing plants on whether appraisals were made, the agreement between appraisals and balance sheets, certain relations of depreciation to income tax, the source of life values used in depreciation calculations, the relative usage of several rules of thumb in replacement of equipment, and the actual methods used to make replacement decisions. These desires developed into a series of specific questions that were to be

put to each plant drawn in a random sample. After the idea was conceived, the steps in the procedure fell into a chronological order which is given below.

1. Decision on method of securing data. As data were distributed over a large area and as the possible number of observations was very large, the investigator selected a sampling method in preference to a complete census of all possible observation units. Such a decision sacrificed exact answers, but did provide adequate answers for a much lesser outlay of money. As the investigator worked with limited funds, the number of observation units did not need to become very large before a survey based on proper sampling methods presented the only method by which he could proceed (24). Such was the case in this investigation.

Having decided on sampling methods, the investigator then decided on the methods of actual contact to be used. The most desirable method was thought to be personal contact (30) in which an interviewer poses the questions directly to the respondent. Less satisfactory, but often completely adequate, was a method of distributing a questionnaire by mail. Once again the cost balance dictated the best approach. Preliminary calculations indicated a cost of about five dollars for each personal call and a cost of about ten cents for each mail inquiry. Furthermore, call-backs or follow-ups were necessary and each of these were equally expensive. It

has been established that many of the supposed inaccuracies of mail inquiries can be essentially avoided by proper techniques (24). Consequently, the mail inquiry was chosen as the principal method of contacting respondents. For purposes of verification, the investigator chose a very much smaller group to contact personally. The cost balance of money available against quantity and quality of data was made as carefully as seemed possible.

2. Definition of the population to be sampled. Two basic methods of sampling large areas such as Iowa were known. One was area sampling in which areas from a map are chosen at random to be a sampling unit. Then the particular attributes under investigation are enumerated for each small area. The other method was to work from a listing of possible sampling units such as a census. The actual sample is then taken at random from the listing. The completeness and correctness of the listing is important. A choice between the two methods depends to a great extent on the data desired. In this investigation the manufacturing industries were not logically distributed on an area basis, so using a listing was dictated. Furthermore, a listing of essentially the desired group was available.

The listing used was the 1951 Iowa Directory of Manufacturers (22). Any firm having a manufacturing plant within the state of Iowa was listed. If a particular company

had two or more plants in the state, it was listed once for each location. If a company made any article of commerce or substantially altered the form of some article, the company was considered to be a manufacturer. Thus, mercantile firms as department stores and service firms as public utilities were excluded from the listing. Unfortunately, small bakeries, creameries, and print shops employing only one or two persons were included. It was felt that this group would not contribute greatly to knowledge of engineering economy and related matters. The listing classified all plants by number of employees, the smallest classification being under 25 employees. Hence, the list was culled of all food processing and printing companies with under 25 employees. By this action 1,717 plants of the total of 3,856 were removed leaving a revised listing of 2,139 which were in the actual population sampled.

3. Design and pre-testing of the questionnaire. The data desired in this investigation could only be secured by responses to specific questions. The actual phrasing of these questions and the assembly of the questions into a schedule or questionnaire was a step that could not be cursorily done. A large proportion of any success of the investigation rested at this point (30).

The subject matter of the questionnaire depended solely on the specific area of research. Many general techniques

were known, however, and were used to design the questionnaire (30). Responses, where possible, were to be "yes" or "no". If open end questions were used, a small number of possible answers were to be given for the convenience of the respondents and for clarity of analysis. Leading questions were to be avoided in the investigation or else the responses might be biased. Length of the questionnaire posed a problem about which past experience offered meager guidance. The trend in general seemed to be toward shorter questionnaires (30), perhaps because the questionnaire method has been used much more in the past few years. The advantage of novelty was thought to be less now than formerly (24).

A questionnaire was developed subscribing to the principles just mentioned. Prior to its actual use, the questionnaire was pre-tested by offering it for criticism to a group of 15 people. The group included four college professors whose interests were closely related to the subject matter and 11 persons who were either engineers or managers of businesses in Des Moines and Ames. Suggestions ranged from grammar to subject matter. The final questionnaire which may be inspected in the Appendix incorporated the pertinent suggestions. The pre-test was considered (23) a necessary step in preparation of an effective questionnaire.

4. Drawing the sample and choice of size. The list as printed of Iowa manufacturing plants referred to in (2) of

this section had been classified into six size groups measured by number of employees. Table 1 gives these size classifications with the distributions of the population and the sample.

Table 1

Distribution of Population and Sample by Number of Employees

| Size Code | No. of Employees | No. of Plants in Class | Proportionate Allocation of Sample | No. of Plants Actually Sampled |
|---|---|---|---|---|
| A | 1 - 24 | 1203* | 168 | 100 |
| B | 25 - 49 | 362 | 51 | 50 |
| C | 50 - 99 | 278 | 39 | 50 |
| D | 100 - 249 | 186 | 26 | 50 |
| E | 250 - 499 | 54 | 8 | 25 |
| F | 500 and over | 56 | 8 | 25 |
| | Total | 2139* | 300 | 300 |

*Reduced by 1,717 food processing and printing plants not included.

The size classifications as given were used without change because any subsequent re-grouping between the groups as shown could easily be done.

The total sample size chosen was 300. This number represented about 14 per cent of the total population. The choice of sample size depended upon the desired precision of

any estimates made and the cost of collecting the data. Precision is proportional to the square root of sample size as given in theoretical statistics (47), whereas cost is directly proportional to sample size. Hence, increasing cost does not increase precision proportionately. However, sample size must be maintained as large as cost will allow to give the greatest precision possible. Thus, sample size is in most instances intimately associated with available funds, which in this case dictated a sample size of about 300.

When some criterion of classification is used, the sample is usually drawn to give what is called a stratified random sample (47). The sampling within each stratum is completely random allowing estimates of population parameters for each stratum or group. It is also possible to make unbiased estimates for the whole population by weighting schemes which are derived from theoretical statistics. The allocation of the total sample size to the strata may be done according to any one of several criteria (25). One is "optimum allocation", which proportions the total sample on the basis of the standard deviations associated with each stratum. Symbolically,

$$n_i = \frac{n\, N_i \sigma_i}{\sum_{i=1}^{K} N_i \sigma_i}$$

where $N$ = total units in population

$n$ = total units in sample

$K$ = number of strata

$\sigma_i$ = standard deviation in $i^{th}$ stratum.

Subscript i refers to particular stratum.

This method requires prior knowledge of the standard deviations or assumption of their values. As no previous knowledge about this type of investigation was known, optimum allocation could not be used despite its statistical superiority (41).

"Proportionate allocation" is a method that results directly from optimum allocation if the standard deviations within strata are known equal or assumed equal. Thus,

$$n_i = \left(\frac{n}{N}\right)N_i$$

As experience has often shown the assumption behind proportionate allocation to be essentially correct, this method is most often used (25). It was adopted here with one modification. Table 1 shows the number in each stratum for proportionate allocation. In sizes E and F only eight samples would be drawn, but in size A, 168 samples would be drawn. This situation would give a relatively low precision for the small groups, so the sample size of the small groups was arbitrarily increased at the expense of the large group A. Such an adjustment was desirable as it yielded results

between size groups that were of essentially the same degree of precision. The fact that group A has only about 8 per cent of the total included in the sample, while groups E and F have about 45 per cent, is not critical (10). This modification of proportionate allocation is known as "disproportionate allocation". It does not complicate calculations of mean or variance if the proportion in each stratum of the total sample and the total number in each stratum in the population are known. Both of these conditions were met here.

Many of the questions anticipated in this investigation were to be answered "yes" or "no". Hence, the binomial distribution was appropriate to these cases. The theory of stratified random sampling applies fully as well to finite binomial populations with small adjustments in calculations (47). The extension to the multinomial case is equally appropriate although more involved (10).

With the foregoing decisions made, the actual mechanics of drawing the sample proceeded. All names of companies in the culled listing were consecutively numbered within each group and a table of random sampling numbers was used to select the particular companies. A card file was prepared with names, addresses, and code numbers. This card file served as a running correspondence record and typing list.

5. Detail of mail contacts and interviews. A letter was sent to the General Manager of each company introducing the survey and requesting cooperation. It did not include the questionnaire and its sole purpose was to lay groundwork for the survey. This letter is shown in the Appendix.

Two weeks after mailing of the introductory letter a second mailing was made. This mailing included the questionnaire and an explanatory letter which partially reiterated the first letter.

As completed questionnaires were received, the card file was completed by including the name of the particular person responding for the companies. Returns had stopped about two months after the questionnaire proper was mailed. At this time a random sample of four non-respondents in each size group was chosen to be contacted requesting personal interview. The remaining non-respondents were sent a "follow-up" letter and a duplicate copy of the questionnaire. The follow-up letter was actually two letters, one pointed specifically at the size A group and one for the other five size groups. These letters are also included in the Appendix.

The group drawn for personal interview totaling 24 companies were actually interviewed by the investigator where invited to do so. No attempt was made to secure any information in these interviews except that requested on the questionnaire.

Throughout the conduct of this investigation the considerations of tact were uppermost in mind. The survey was intimately associated with the name, Iowa State College. No special appeals, gimmicks, or undue pressures could be brought to bear on the companies selected. Appeal was made by promise of summarized results of the investigation when completed and through the desire of the college to provide service to the state of Iowa. Effort was made to phrase all mailings toward these ends. No more follow-ups were made as it was presumed that three contacts would elicit response wherever it might be forthcoming.

6. Methods of calculation. Calculations made on the data are purely descriptive in many instances. Where estimates are made or hypotheses are tested, usual statistical methods are used (10, 47) such as confidence intervals, analysis of variance, Chi-square tests, and regression. These methods are noted where appropriate when the results are presented and discussed.

# DISCUSSION OF RESULTS

The investigation used the questionnaire as the means of securing data within the general area of the problem. As 26 questions were on the questionnaire, it was thought desirable to divide the questions into smaller, closely related groups for presentation and discussion. The titles of the groupings are as follows:

Summary of Responses
General Information
Accounting and Appraisal Practice
Depreciation Practice
Equipment Replacement Practice
Hypothetical Problem on Equipment Replacement
Rating of Questionnaire by Respondents.

The groupings were identical with the actual groupings used on the questionnaire form.

In the analysis of the data certain differences were described as significant. This referred to a statistical test of significance at the 5 per cent level, i.e., in only 5 per cent of the cases on the average could sampling variation account for the difference.

Where tables of data were presented, the questions were

not completely restated. Instead, a few key words from the question served to identify it. The text gave a full statement of each question just prior to the data table.

## Summary of Responses

The questionnaire was sent to 300 plants in Iowa. Of the total, 152 responded in some manner and 138 of the 152 gave usable information. The total sample size was reduced to 291 because nine plants were no longer in operation. Table 2 reports the response data in full.

The overall response of 47.4 per cent compared favorably with other surveys of this nature (24). Response to surveys of farmers on crop yields usually have run about 25 per cent of the total sample. A survey of farm equipment dealers was only 10 per cent complete after the original contact although it improved to about 30 per cent with several follow-ups. Readership surveys by popular magazines have seldom exceeded 10 per cent response. One survey of program preference on radio station WOI by rural listeners drew about 90 per cent response. In the field of social studies Lundberg (30) reported that a response of 50 per cent was considered excellent and above the average.

Group A with 24 or fewer employees was below all other groups in percentage response. After the original contact

Table 2

Number of Responses to Questionnaire
(September through December 1953)

| | Size of Company, Number of Employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| Original sample size | 100 | 50 | 50 | 50 | 25 | 25 | 300 |
| Complete responses to original contact | 11 | 22 | 26 | 17 | 12 | 15 | 103 |
| Out of business | 5 | - | 4 | - | - | - | 9 |
| Effective sample size | 95 | 50 | 46 | 50 | 25 | 25 | 291 |
| Follow-up contacts | 80 | 24 | 16 | 28 | 9 | 6 | 163 |
| Complete responses to follow-up | 8 | 1 | 4 | 7 | 1 | 2 | 23 |
| Interview requests | 4 | 4 | 4 | 4 | 4 | 4 | 24 |
| Interviews completed | 1 | 1 | 3 | 3 | 2 | 2 | 12 |
| Total responses of any nature including refusals | 26 | 24 | 37 | 29 | 15 | 21 | 152 |
| Total usable responses | 20 | 24 | 33 | 27 | 15 | 19 | 138 |
| Percentage usable responses | 21 | 48 | 72 | 54 | 60 | 76 | 47.4 |

only 11 per cent of group A had responded. The follow-up letter to group A was phrased to encourage responses from this group. Some success was noted as the total response increased from 11 per cent to 21 per cent, an increase of 91 per cent. In all other groups the follow-up letter succeeded in raising the responses from 47 per cent to 55 per cent, an increase of 17 per cent. The follow-up letter gave additional data, but not as much proportionately as the first contact. No more contacts were made.

The sample for personal interview was a stratified random sample from the non-respondents after the original contact. There were 24 in this sample, four from each size group. Exactly half of this interview sample allowed an interview to be completed or answered by mail. Five more declined or deferred the interview, and the remaining seven did not acknowledge the interview request.

To test the hypothesis that no difference in response percentage existed between size groups, the adjusted Chi-square test was used. The calculated Chi-square exceeded the expected value at the one per cent significance level. Hence, the hypothesis was rejected and it was concluded that a difference between size groups existed. Sampling variation would not explain so large a value of Chi-square.

Knowledge of plants no longer operating was obtained from mail returned by local postal offices. Over a period of

two and one-half years 3 per cent of the plants suspended operation which is an average rate of 1.2 per cent per year. Some of these suspensions were due to business failures, and a smaller portion were due to consolidation of two plants of the same company into only one plant. Comparative data for the United States as a whole calculated for the same period indicated business failures at an average rate of 0.6 per cent per year (1). Other data of limited scope indicated business failure at rates exceeding 5 per cent per year (21). As the difference between the rate in Iowa and the United States as a whole was not significant, the sample should not be biased due to the few business suspensions found.

Those of the sample who do not respond create one of the most perplexing problems in mail surveys. Regardless of careful planning and appeals of various nature, many who received a questionnaire did not return it. In this investigation 52.6 per cent of the total sample did not respond. The basic question was "Did non-respondents have the same proportion of various attributes as did respondents?" Stated another way, "Is there any difference between those who answer and those who do not?" Numerous examples of surveys may be found (32, 35) where this basic question was not considered, and where all conclusions were based on the respondent portion only. This problem is not associated with problems of randomness in the usual sense of the word. The

original sample of 300 in this investigation was drawn according to best techniques of stratified random sampling. The actual returns which were far less than 300 cannot be considered as just a smaller, but still random sample unless evidence shows it to be true.

Statistical methods were available to approach this problem (24). The method was based on the fact that all data were not collected in one period of time. After several weeks had elapsed following the initial mailing, an arbitrary stop on time was called. The data gathered in this period known as the "first response" could be analyzed, e.g., the proportion answering "yes" to a certain question. At the end of this first time period the follow-up contact was made and all data received were then called the "second response". These second responses permit separate analysis giving independent estimate of the proportion answering "yes" to the same question. If these two estimates did not differ significantly, i.e., their difference can be explained by sampling variation, it was concluded that the time of answering did not affect the answers. Although more follow-ups were not used, it was believed the non-respondent portion of the sample would have shown similar answers to the respondent portion if enough money had been spent to get complete response. This method of analysis was not thought to insure complete reliability. However, it did increase the

reliability of estimates based on only the respondent portion of the sample.

The personal interviews provided a "third response" in this investigation. By extension of the methods used for two responses further information about the effect of time was available. The adjusted Chi-square test was used for enumeration data and analysis of variance was used for measurement data. By this particular treatment of data it was apparent that 50 replies to the first contact, 40 replies to a second, and 10 replies to a third yielded more information than 100 replies to only one contact.

The questionnaire was composed of 26 questions. The above technique could be applied to each question, but sampling techniques were again suggested (24). Hence, seven questions were chosen at random from the 26 and analyzed. Table 3 presents the results of this analysis. None of the questions in Table 3 showed a significant difference between the three types of response. The 5 per cent level of significance was used. Hence, time of answer did not have an effect on answers to questionnaires. This increased confidence in using only the respondent portion of the total sample. As cases are on record where time of answer did have an effect (24), the foregoing analysis was necessary to validate this investigation.

Table 3

Analysis of Effect of Time of Answer on Selected Questions

| Question[a] Number | Number replying[b] on First Contact | Second Contact | Interview Contact | Significant Difference at 5% level |
|---|---|---|---|---|
| A-5 Average no. employees | 320 | 411 | 297 | No |
| A-6 | | | | |
| a | 88 | 17 | 10 | |
| b | 6 | 4 | 1 | No |
| c | 8 | 2 | - | |
| B-2(a) | | | | |
| Yes | 46 | 13 | 2 | |
| No | 54 | 10 | 8 | No |
| C-1(a) | | | | |
| Yes | 54 | 12 | 6 | |
| No | 47 | 11 | 4 | No |
| C-8 | | | | |
| Yes | 67 | 1 | 7 | |
| No | 19 | 7 | 1 | No |
| No response | 16 | 5 | 4 | |
| D-1 | | | | |
| Yes | 76 | 14 | 8 | |
| No | 24 | 8 | 2 | No |
| D-3 | | | | |
| a | 15 | 3 | 1 | |
| b | 18 | 18 | 8 | No |

[a]Question statement not given. Refer to Appendix for detail of question.

[b]Except Question A-5 where average number of employees are given.

## General Information

The first section of the questionnaire put seven questions of general descriptive nature to each prospective respondent. The other three sections discussed later were composed of a total of 19 specific questions related to the investigation. The exact statement of the questions of the first section was as follows:

1. Name of company.
2. Address of this plant (this location only if a branch).
3. Name of person to whom correspondence about this study may be sent.
4. Brief description of products manufactured (only those actually made).
5. Average number of employees during past year (this location only if a branch).
6. Is the company organized as a
   - (a) Corporation or stock company,
   - (b) Partnership,
   - (c) Sole proprietorship?
7. (Note--This question concerns only those companies that operate a plant in more than one location. It is suggested that parts B, C, and D be completed before checking this question.)

(a) The policies in parts B, C, and D are generally those of the company as a whole.

(b) The policies in parts B, C, and D apply only to this one branch of the company.

(c) The policies in parts B, C, and D are a combination of (a) and (b) of this question.

The first three questions were asked to provide a correct list for future mailings. All respondents were promised a concise summary of the investigation. Complete confidence regarding responses was pledged from the outset and has been maintained. There was no measurable evidence that identification of the responses reduced the returns of the questionnaire. It has been contended (30) that completely anonymous responses may be less reliable and may result in fewer returns. Observation of the cover letters accompanying completed questionnaires indicated that most companies preferred to be identified and accepted the promise of confidence as sufficient protection.

Question No. 4 provided data on the type of industry as classified by the product manufactured. The Iowa Directory of Manufacturers used in the investigation divided the companies into 19 types which are commonly used for classification purposes in the U. S. Census. Their listing was regrouped into eight types as follows:

1. Apparel and clothing; leather; textile mill products.
2. Machinery, electrical and mechanical; primary metal industries; fabricated metal products; ordnance; transportation equipment.
3. Chemical and allied products; petroleum and coal products; rubber products.
4. Food and kindred products; tobacco products.
5. Furniture and fixtures; paper and allied products.
6. Printing, publishing, and allied industry; photographic equipment.
7. Lumber and wood products; stone, clay, cement, gypsum, and allied products.
8. Miscellaneous manufactured products.

Table 4 compares the proportion of each type in the sample with the proportion in the population as calculated from the listing in the Iowa Directory of Manufacturers. The agreement between the sample and population was unusually high as the sample was not drawn to be random with regard to product classification. No significant difference existed between the sample proportions and the population proportion. Thus, a two way classification of the data might be made; one way by number of employees and one way by product class. However, a three times larger sample would have been necessary to make estimates of similar precision as compared to the one way classification by employees. Previous evidence (17),

Table 4

Classification of Respondents by Product Manufactured

| Size Group, no. of employees | Product Class[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| A, 1-24 | 3 | 8 | 3 | - | 2 | - | 7 | 3 |
| B, 25-49 | 1 | 7 | - | 13 | - | 1 | 1 | 1 |
| C, 50-99 | 3 | 8 | 5 | 10 | 2 | 4 | 3 | 2 |
| D, 100-249 | - | 7 | 2 | 11 | 2 | 2 | 3 | 2 |
| E, 250-499 | 1 | 7 | 2 | 3 | 1 | - | 1 | - |
| F, over 499 | - | 10 | 2 | 6 | - | 2 | - | 1 |
| Total no. | 8 | 47 | 14 | 43 | 7 | 9 | 15 | 9 |
| Total, % of sample | 5.3 | 30.9 | 9.2 | 28.3 | 4.6 | 5.9 | 9.9 | 5.9 |
| Distribution,[b] % calculated from population | 5.8 | 32.0 | 8.6 | 22.4 | 5.8 | 7.4 | 12.2 | 5.8 |

[a]See p. 36 for description of industries included in each product class.

[b]Corrected in A-4 and A-6 where population was reduced by omitting all plants under 25 employees.

though slight, indicated more value would result from an analysis based on size rather than product.

Results of Questions No. 5, 6, and 7 are presented in Table 5. The number of employees in the average Iowa manufacturing plant was shown in Table 5 as the sample average. The weighted average based on the number in each size group in the population was 91.4 employees per plant. Neither the weighted or unweighted averages was considered more than a summary value. Of more importance was the estimate of total number of persons employed in manufacturing in Iowa. The 95 per cent confidence interval on total employees was 195,500 $\pm$ 15,500. Plants employing under 50 persons represented 72.3 per cent of all plants and had 12.5 per cent of the employees. Plants employing over 250 persons represented 5.1 per cent of all plants and had 55.0 per cent of the employees. Nation-wide data for 1947 (53) indicated that plants employing under 50 persons represented 72.1 per cent of all plants and had 15.9 per cent of the employees. Plants employing over 250 employees represented 4.2 per cent of all plants and had 59.4 per cent of the employees. A test of these percentages for Iowa plants against the nation-wide percentages showed no significant difference. The largest single plant in Iowa in the sample had 6,000 employees and the smallest had two employees.

Table 5

Size and Organizational Aspects of Respondents

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 249-499 | F Over 499 | |
| 5. Size | | | | | | | |
| Aver. size, no. employees | 10.5 | 32.6 | 92.5 | 205 | 387 | 1543 | 333.7 |
| Std. error of mean | 1.9 | 4.6 | 13.9 | 41.0 | 40.7 | 302 | 63.2 |
| 6. Organization | | | | | | | |
| Corporation | 7 | 20 | 29 | 25 | 15 | 19 | 115 |
| Partnership | 7 | 1 | 2 | 1 | - | - | 11 |
| Sole prop. | 6 | 3 | 1 | - | - | - | 10 |
| 7. Policy | | | | | | | |
| Company-wide | 3 | 7 | 9 | 11 | 8 | 13 | 51 |
| Local | - | - | 1 | - | - | 2 | 3 |
| Combination | - | - | 1 | 2 | 1 | 1 | 5 |

[a]Only Question No. and key identifying words given. See p. 34 for complete questions.

Capital investment in manufacturing plants has been shown to be related to the number of employees (12). The investment per employee ranges from $7,000 to $12,000 with an average at about $10,000 (12). Large plants show a higher investment per employee than small plants. No estimate of total investment in Iowa manufacturing plants was made in this investigation, but an approximation was in the order of magnitude of two billion dollars.

Organization of Iowa industry was found to be predominantly of the corporate form except in the smallest size group where partnerships and sole proprietorships were of equal magnitude. Excluding the smallest size group, 93 per cent of the plants were under the corporate form. Including the smallest size group and weighting on the population proportions, 59 per cent of the Iowa plants were under the corporate form. Nation-wide, about 55 per cent of all manufacturing was under corporate form (53). It was concluded from this and the data on size of business that Iowa did not depart widely from national averages. Iowa is not known as a manufacturing state because it has fewer plants than other states (53), but the plants it does have are similar in organization and size to plants of the United States as a whole.

The last question of this section dealt only with plants that were a branch of a multi-plant company. The degree of

control over policies on engineering economy by the local plant management was requested of such plants. The percentage of all plants qualified to answer this question was 43.0 of which 86.5 per cent stated they operated under company-wide policies. Of the remaining 13.5 per cent, only 5.0 per cent stated that all policies were of local instigation, and 8.5 per cent stated that the policies were of combination of company-wide and local. The larger plants were allowed more local control by the parent organization than the small plants.

## Accounting and Appraisal Practices

Data applied by a particular company to solve its problems of equipment replacement often comes from the historical records of the company (17). Of principal use are accounting and appraisal records. Hence, the second section was directed toward securing information of practices in these two areas. Five questions were asked as follows:

1. (a) Do you have a Balance Sheet drawn at least once a year? Yes or no.

(b) If "yes", is it prepared by a professional accountant? Yes or no.

2. (a) Have you ever made or had made for you a detailed appraisal of your complete company? Yes or no.

(b) If "yes", what was the reason for this appraisal? Please describe briefly.

3. If 2(a) is answered "yes", how much variation did the appraisal show when compared to the Balance Sheet?

(a) Less than 5%

(b) 5 to 15%

(c) 15 to 30%

(d) Over 30%

4. How often on the average do you physically inventory materials, supplies, goods in process, and finished goods on hand?

5. How often on the average do you inventory machinery, equipment, and properties? Machinery Equipment Other Properties.

Tables 6 and 7 present the results of this section of the questionnaire. Over 98 per cent of the respondents reported a balance sheet was made once a year or oftener. In 83.5 per cent of all cases a professional accountant made the balance sheet. The smallest size group indicated a smaller percentage of professional service, but the difference between size groups was not significant. The respondent was allowed his own definition of a "professional accountant". As several added the information that the accountant was a company employee, but not professional, it appeared that many presumed that an outside Certified Public Accountant was the

Table 6

Accounting and Appraisal Practices of Respondents

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 1(a) Balance sheet | | | | | | | |
| Yes | 18 | 24 | 32 | 25 | 15 | 14 | 132 |
| No | 2 | - | - | - | - | 1 | 3 |
| 1(b) Professional accountant | | | | | | | |
| Yes | 9 | 22 | 27 | 21 | 12 | 17 | 108 |
| No | 7 | 2 | 5 | 3 | 3 | 1 | 21 |
| 2(a) Appraisal | | | | | | | |
| Yes | 8 | 4 | 14 | 18 | 8 | 9 | 61 |
| No | 12 | 20 | 18 | 6 | 7 | 9 | 72 |
| 2(b) Why appraisal | | | | | | | |
| Insurance | 5 | 2 | 4 | 11 | 5 | 6 | 33 |
| Tax | 1 | - | 2 | 1 | - | - | 4 |
| Operation | - | - | 2 | 3 | 2 | 1 | 8 |
| Sale | - | - | 1 | 1 | - | 1 | 3 |
| Re-organize | - | 2 | 3 | 1 | 1 | - | 7 |
| Other | 1 | - | 1 | - | - | - | 2 |
| No resp. | 1 | - | 1 | 1 | - | 1 | 4 |
| 3. Appraisal variation to balance sheet | | | | | | | |
| Under 5% | - | 1 | 5 | 3 | - | - | 9 |
| 5-15% | - | 1 | 1 | 2 | 4 | 1 | 9 |
| 15-30% | - | - | 1 | 3 | 1 | 2 | 7 |
| Over 30% | 4 | 1 | 2 | 8 | 3 | 4 | 22 |
| No resp. | 4 | 1 | 5 | 2 | - | 2 | 14 |

[a]Only Question No. and key identifying words given. See p. 41 for complete questions.

Table 7

Inventory Practices of Respondents

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 4. Inventory current supplies | | | | | | | |
| Perpetual | - | 1 | 1 | - | - | 1 | 3 |
| Weekly | - | - | - | 1 | - | - | 1 |
| Monthly | 1 | 14 | 9 | 7 | - | 5 | 36 |
| Quarterly | 3 | 2 | 2 | 4 | 3 | - | 14 |
| Semi-annually | 2 | 2 | 5 | 5 | 2 | 4 | 20 |
| Annually | 13 | 5 | 14 | 8 | 10 | 8 | 58 |
| Never | 1 | - | - | - | - | 1 | 2 |
| 5. Inventory equip., mach. | | | | | | | |
| Perpetual | 1 | 1 | 5 | 3 | - | 3 | 13 |
| Quarterly or oftener | - | 3 | 1 | - | - | - | 4 |
| Semi-annually | 1 | - | 1 | - | - | - | 2 |
| Annually | 10 | 17 | 13 | 16 | 7 | 9 | 72 |
| 5 years | - | - | 2 | 2 | 4 | 3 | 11 |
| 10 years | - | - | 3 | - | 1 | - | 4 |
| Never | 3 | 2 | 4 | 2 | 1 | 2 | 14 |
| Variable | - | - | - | - | 2 | 1 | 3 |
| No response | 5 | 1 | 4 | 3 | - | 1 | 14 |

[a]Only Question No. and key identifying words given. See p. 42 for complete questions.

only "professional". Thus, 83.5 per cent was felt to be a minimum on the actual percentage of balance sheets prepared by competent accountants not necessarily certified. Accounting practice in Iowa appeared to be consistent with certain minimum standards (11).

Appraisals had been made by 45.8 per cent of the respondents which is equivalent to the weighted average of 43.9 per cent for the population. There was a highly significant difference between size groups on the making of appraisals. The larger the plant, the larger the percentage of plants where an appraisal had been made. Only 34 per cent of the three smaller size plants had made an appraisal, but 62 per cent of the three larger size plants had done so. The reason for the appraisal was requested from those who had made one, and appraisal for insurance was overwhelmingly the principal reason. Insurance accounted for 58 per cent of the total, sound business operational policy and business reorganization accounted for 26 per cent, and taxation, sale, and miscellaneous for the remaining 16 per cent of the total. No published data are known for Iowa or the nation on the distribution of reasons for appraisal of manufacturing plants.

Appraisals of property are made by specialized personnel usually for the purpose of determining a present value measured in dollars. Value has been discussed by many authors (6, 34, 37). Value is stipulated in some instances

by statutory law, government commissions, and judicial review. Usual definitions have searched for synonyms such as worth, desirability of ownership, and exchangeable purchasing power. Many methods to determine value have been proposed and used including actual sales of similar property, capitalization of prospective earnings, and cost to purchase less a reasonable depreciation allowance. Where cost has been used, the cost may be original cost when the asset was built, produced or dedicated to service, or the cost may be a reproduction or replacement cost which in its simplest connotation means original cost converted to current dollars. Value has been elusive of definition because it has been associated with the future which is subject to all vagaries of prediction. Indications of value come from the past, value is determined for the present, and action based on the value will be in the future. Personal opinions, though expert, have caused similar items to be valued differently by different persons.

When the variables affecting value are considered, a variation may be expected between an appraisal and an accountant's balance sheet. The balance sheet is basically a record of original cost which is only one of the several methods of indicating value. The respondents who had made an appraisal were asked in Question No. 3 to compare the appraisal results with the balance sheet. In the sample, 47 per

cent reported the appraisal varied from the balance sheet by 30 per cent or more and 62 per cent reported the variation as 15 per cent or more. The average variation of the appraisal from the balance sheet was 19.8 per cent. The direction of the variation was not ascertained, but price trends in the United States have been upward for the past 20 years. No significant difference between size groups was found on analysis of this question.

Inventory practices for both short term and long term assets were requested of respondents in Questions No. 4 and 5. Inventories provide basic data for both appraisal and accounting. Short term assets including materials, supplies, goods in process, and finished goods were inventoried annually or oftener by over 98 per cent of the plants. Although 43 per cent of the plants inventoried annually, many plants made these inventories more often than annually, and the weighted average time period between inventories was 0.55 years. Only 2 per cent of the plants indicated a perpetual inventory was kept.

Inventory practice for long term assets such as machinery, equipment, and structures was found to be significantly different from short term assets. Although 52.5 per cent inventoried these items annually and 13.8 per cent more often than annually, the remainder of 33.7 per cent inventoried only at periods greater than one year. The weighted

average time period between inventories was 1.37 years. In the sample 10 per cent said they have never made an inventory of machinery and equipment. No significant difference between size groups was found for either inventory question.

## Depreciation Practices

Depreciation has been discussed for several hundred years, principally in works on accounting (29, 46). Depreciation was embraced by the courts of the United States in 1909 in litigation over rates of a public utility (33). Depreciation became the everyday concern of all sizes of business and some individuals in the middle thirties when the Bureau of Internal Revenue, U. S. Treasury Department, issued Treasury Decision 4422, since revised, and Bulletin F (9). However, for many years prior to the issuance of T.D. 4422 well managed businesses had calculated and used depreciation to better manage their business.

Depreciation has been defined by many authors, but the following three definitions summarize and include most (6, 34).

1. Depreciation is the loss in value of some item of property that occurs through time.
2. Depreciation is the stepwise recovery through time of the cost of some item of property, i.e., amortization.

3. Depreciation is indicated physical condition or impaired serviceability.

These definitions have been identified in order as value depreciation, cost depreciation, and physical depreciation. Cost depreciation has also been called accountant's depreciation (34). One of the results of these divergent definitions has been the development of several methods of calculating depreciation. Although value depreciation has been desired ideally, methods to calculate depreciation have been based on cost. Obsolescence has been defined as a reduction in the usable life of the item of property primarily through progress in the arts and sciences. Obsolescence is a value concept, therefore, and does not fit into cost depreciation. Bulletin F circumvented this incompatibility by defining depreciation as a reasonable allowance for the exhaustion, wear, and tear of property used in the trade or business, including a reasonable allowance for obsolescence (9). Reasonableness has been adjudicated by the Bureau of Internal Revenue in the case of federal income tax. Federal income tax aspects of depreciation have overshadowed other applications and obstructed rational investigations of depreciation (19, 51).

Depreciation is of prime importance to engineering economy studies because through depreciation calculations the first cost of long-lived equipment is reduced to an annual cost. Depreciation is one of the several possible costs that

must be considered in an engineering economy study. The period of one year is the most used common denominator in engineering economy studies. As depreciation is an unsettled subject, this investigation devoted a section of eight questions to depreciation practices. The questions were as follows:

1. (a) Do you calculate depreciation for any other reason than Income Tax deductions? Yes or no.

(b) If "yes", for what reasons?

2. (a) Do you use the U.S. Treasury Dept., Bureau of Internal Revenue, Bulletin "F" as the source for "useful lives" or "depreciation rates" regardless of the reason for the depreciation calculation? Yes or not solely.

(b) If "not solely", what other source of lives or rates do you use?

3. What method of depreciation do you use? Check the one or ones.

(a) Straight line

(b) Unit of Production

(c) Declining Balance

(d) Sinking Fund

(e) Other (please name)

4. Do you calculate depreciation on

(a) the Original Cost of the item to you, or

(b) on some other Basis of Cost (please explain briefly)

5. What is the basis upon which depreciation is calculated?

(a) Purchase price of equipment alone

(b) Purchase price of equipment plus installation

(c) Purchase price of equipment plus installation plus overhead charge.

6. Do you in calculating depreciation

(a) Group similar items together

(b) Figure each item separately

(c) Use a combination of these two methods.

7. For your particular business do you feel that the useful lives given in Bulletin "F" are on the average

(a) About correct

(b) Too long

(c) Too short?

8. Would you favor an income tax ruling that allows you to use values of useful life that are less than "true life" (true life may be thought of here as being that period of time that actual experience shows the equipment will be used)? Yes or no.

The first question, Table 8, in two parts inquired about the reasons for calculation depreciation. The respondents indicated that 46.2 per cent calculated depreciation solely for income tax purposes. The remaining 53.8 per cent was divided into five groups: 28.4 per cent calculated depreciation

Table 8

Depreciation Practices of Respondents
(Question Nos. 1 and 2)

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 1(a) Depr. for income tax only | | | | | | | |
| No | 8 | 11 | 18 | 17 | 6 | 12 | 72 |
| Yes | 12 | 13 | 14 | 7 | 9 | 7 | 62 |
| 1(b) Other reasons for depr. calc. | | | | | | | |
| Value | 5 | 2 | 4 | 3 | - | - | 14 |
| Financial | 2 | 7 | 11 | 9 | 5 | 4 | 38 |
| Costing | 1 | - | 1 | 5 | 1 | 8 | 16 |
| Replacement | - | 1 | 1 | - | - | - | 2 |
| Sale | - | 1 | 1 | - | - | - | 2 |
| 2(a) Use Bull. F. only for life | | | | | | | |
| Yes | 9 | 10 | 9 | 7 | 6 | 6 | 47 |
| No | 5 | 10 | 20 | 17 | 9 | 13 | 74 |
| No resp. | 6 | 4 | 4 | 2 | - | - | 16 |
| 2(b) Other source of life | | | | | | | |
| Experience | - | 1 | 12 | 10 | 4 | 6 | 33 |
| Personal | 3 | 7 | 5 | 6 | 5 | 6 | 32 |
| Negotiated BIR | - | 2 | 1 | - | - | - | 3 |
| Other | 1 | - | 1 | 1 | - | - | 3 |
| No response | 1 | - | 1 | - | - | 1 | 3 |

[a]Only Question No. and key identifying words given. See p. 50 for complete questions.

to prepare financial statements, 12.0 per cent for purposes of correctly pricing the product, 10.4 per cent for aid to business judgment, and 3.0 per cent for signaling replacement or for determination of sale price for the company. The reasons aside from income tax for determining depreciation may in many cases justify its calculation. However, nearly half the respondents apparently would not calculate depreciation if income tax did not exist. There was a significant difference between size groups with regard to calculation of depreciation. The larger companies calculated depreciation for more reasons than the smaller companies.

The annual depreciation charge has been a function of time in methods commonly in use. Hence, a forecast of the time some item will endure has been necessary. This time period has been called "life". For a specific item some numerical value of life usually measured in years was required. Most companies had neither the past data nor the knowledge necessary to forecast lives for their own properties. Actual compilation of lives for public use have been incomplete with the exception of Bulletin F. This bulletin has been vigorously questioned as to correctness and applicability (19). Nevertheless, it has not been supplanted by any other compilation. The second question about depreciation inquired into the acceptance of Bulletin F. Of the respondents 38.8 per cent used the life values from Bulletin

F without exception for any depreciation calculation. On a weighted population basis 53.4 per cent used Bulletin F solely. Of those who stated other values of life were used, half based the forecast of life on their actual plant experience. The other half based the forecast on personal or expert opinion. None of these three ways to assign a numerical value to life has been considered necessarily correct or infallible. It would be proper if more plants would combine their own experience and opinion into compiling appropriate values of lives. A significant difference existed between size groups with smaller plants tending to rely more heavily on Bulletin F. It has been shown (19) that a plant need not be large to accumulate evidence to forecast life of property.

Depreciation methods have been devised for several differing assumptions as to the wasting of property. Any method is correct if the assumption is accepted. After reviewing business experience, it has been stated (19, 34) that only four or five methods are in general use. Question No. 3, Table 9, requested a statement of the depreciation method used. On both a sample and weighted population basis, 81.5 per cent used the straight line method, 11.5 per cent used the declining balance method, and the remaining 7.0 per cent used the unit of production, the sinking fund, or some other method. There was no significant difference between size

Table 9

Depreciation Practices of Respondents
(Question Nos. 3, 4, 5)

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 3. Depreciation method | | | | | | | |
| Straight line | 14 | 14 | 26 | 20 | 14 | 18 | 106 |
| Unit. of Prod. | - | 2 | - | 1 | 1 | - | 4 |
| Declining Bal. | 3 | 4 | 5 | 2 | - | 1 | 15 |
| Sinking Fund | - | - | - | 2 | - | - | 2 |
| Other | 1 | 1 | 1 | - | - | - | 3 |
| No response | 2 | 3 | 1 | 2 | - | - | 8 |
| 4. Cost basis | | | | | | | |
| Original | 18 | 22 | 32 | 23 | 15 | 19 | 129 |
| Other | - | - | - | 1 | - | - | 1 |
| No response | 2 | 2 | 1 | 2 | - | - | 7 |
| 5. Depr. basis | | | | | | | |
| Equip. only | 6 | 9 | 8 | 5 | 3 | 2 | 33 |
| Eq. and inst. | 11 | 14 | 23 | 17 | 11 | 16 | 92 |
| Eq. and inst. and overhead | - | 1 | 1 | 2 | 1 | 1 | 6 |
| No response | 3 | - | 1 | 2 | - | - | 6 |

[a]Only Question No. and key identifying words given. See p. 50 for complete questions.

groups. The widespread use of straight line depreciation was previously noted in 1928 by Rautenstrauch (44) who found the straight line method used by 92.0 per cent and the declining balance method by 2.4 per cent. The growth in the use of the declining balance method has possibly been due to income tax benefits resulting from its use under certain conditions (19). Theoretical considerations have indicated (34) that the tax benefits are illusory and do not actually exist, particularly for large companies. In this investigation 13 of the 15 who used the declining balance method were in the smallest size groups.

In the literature of accounting and appraisal, the basis of cost to be used to calculate depreciation has been discussed at length (46). Accounting standards have prescribed original cost of the property as a basis. Depreciation calculations for income tax purposes have been required by law to use original cost as a basis. The principal other basis suggested for depreciation has been reproduction or replacement cost. Reproduction cost has been found by pricing the existing item of property at today's prices, i.e., as if new. Question No. 4 of this section asked if original cost or some other basis of cost was used as the basis for depreciation calculations. Over 99 per cent used original cost.

In the definition of original cost it has been conventional to include more than the bare price of the item of

property. One addition has been installation cost which includes freight charges, sales or excise taxes on the item, and direct labor and material charges necessary to put the item in "ready to produce" condition. Another addition has been overhead cost which includes planning and engineering costs not directly allocable to the item of property. Question No. 5 inquired about the handling of these costs when establishing the cost basis for depreciation calculations. Bare price of the item was used by 25.2 per cent, 70.5 per cent also included installation cost, and the remaining 4.3 per cent included both installation and overhead cost. Best practice has not been defined in the literature for private manufacturing firms. If more costs are included in the basis for calculation depreciation, then less cost is included in current expense. Hence, the return of the installation and overhead costs would be accomplished over the life of the item rather than in one year or less. No significant difference existed between size groups.

Many plants have several units of one particular item of property, e.g., 20 lathes of the same size and type. The depreciation can be calculated individually for each of the similar units or the similar units can be grouped and a single depreciation calculation made. The group method has been used where appropriate and has also been approved for income tax purposes (9). Question No. 6, Table 10, inquired

Table 10

Depreciation Practices of Respondents
(Question Nos. 6, 7, 8)

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 6. Units | | | | | | | |
| Grouped | 8 | 8 | 10 | 9 | 7 | 8 | 50 |
| Individual | 6 | 9 | 11 | 8 | 5 | 7 | 46 |
| Combination | 3 | 7 | 11 | 7 | 3 | 4 | 35 |
| No response | 3 | - | 1 | 2 | - | - | 6 |
| 7. Bull. F lives | | | | | | | |
| Satisfactory | 8 | 6 | 11 | 7 | 5 | 3 | 40 |
| Too long | 1 | 8 | 17 | 10 | 7 | 9 | 52 |
| Too short | 2 | 8 | 2 | 4 | 1 | 3 | 20 |
| No response | 9 | 2 | 3 | 5 | 2 | 4 | 25 |
| 8. Any life for tax | | | | | | | |
| Yes | 4 | 14 | 24 | 16 | 12 | 15 | 85 |
| No | 5 | 5 | 6 | 6 | 2 | 3 | 27 |
| No response | 11 | 5 | 3 | 4 | 1 | 1 | 25 |

[a]Only Question No. and key identifying words given. See p. 51 for complete questions.

into the extent of this grouping procedure. On a weighted population basis 38.0 per cent of the plants grouped units where possible, 35.2 per cent calculated each unit individually, and the remaining 26.8 per cent used a combination of the two methods. No significant difference existed between size groups.

The last two questions about depreciation were pointed at the current income tax regulations on depreciation calculations. Income tax implications of depreciation have been thought to confuse other applications of depreciation to business management (51). Question No. 7 asked for a rating of the values of life given in Bulletin F previously shown to be widely used. Of those who responded 35.7 per cent felt the life values were satisfactory. However, 18.2 per cent of the plants that returned questionnaires did not respond to this particular question. Other questions on the questionnaire except C-8 did not show any appreciable percentage of non-respondents. The conjectural nature of these two questions may have accounted for the non-respondents. Including non-respondents to this particular question, 29.2 per cent felt the life values were satisfactory, 38.0 per cent felt the life values were too long, 14.6 per cent felt the life values were too short, and 18.2 per cent did not respond. Expressions of opinion on this matter (4, 19) have maintained that life values in Bulletin F were too long which resulted in smaller and inadequate annual depreciation deductions for

income tax purposes. These contentions were not completely correct as this investigation showed almost 44 per cent thought the life values satisfactory or too short. There was a significant difference between size groups on this question. As size of the plant increased, plants became less satisfied with life values from Bulletin F. As size of the plant increased, more plants felt life values were too long.

Proposals have been made and are pending before the present Congress that liberalize the regulations of Bulletin F in calculating depreciation. These proposals have included (a) allowance of any value of life the taxpayer chooses, (b) allowance of declining balance methods with a higher annual rate, (c) allowance of two-thirds the life values in Bulletin F, and (d) allowance of one-third to one-half of the cost in the first year followed by regular straight line depreciation. The proposals have been similar to the extent that all resulted in a larger depreciation deduction than has been allowable in the past. Question No. 8 asked if the respondent favored an income tax ruling allowing the use of lives shorter than those given in Bulletin F. Although 18.2 per cent of those returning the questionnaire did not respond to this question, 62.0 per cent favored such a ruling and 19.8 per cent were not in favor. In a survey made in 1947 on a nation-wide basis (26), 72.3 per cent said that an income

tax ruling of this nature would "help" their company's business position. The nature of the "help" was not described. A significant difference existed between size groups. However, if Group A was excluded, there was no significant difference between the remaining size groups. Group A, the smallest size plants, had many non-respondents. All other groups were more positive in favoring the use of shorter lives. Some analysts of business management have recently warned (40) that rapid depreciation of property for income tax purposes may be dangerous to the long-run success of the business. If property remains in service after it is completely written off, it will provide no tax benefit. This effect has been complicated by income tax rates that have varied from year to year.

The inquiries about depreciation were felt by this investigator to be important because engineering economy studies usually include depreciation calculations. A better understanding of the thinking of Iowa industry with regard to depreciation was necessary to understand engineering economy practices.

## Equipment Replacement Practices

The final section of the questionnaire had six questions, the first five of which follow.

1. Will you ever seriously consider replacing a machine that is not worn out and still capable of doing its job? Yes or no.

2. Do you have a general policy as to the "pay-off period" for new equipment (pay-off period is defined as the number of years necessary for the savings realized by the use of the new machine to equal the cost of the new machine)?

(a) 1 year or less

(b) 2 years

(c) 3 years

(d) How many years

(e) No policy.

3. In decisions regarding machinery replacement which of these two factors is the more apt to determine the decision to replace or not:

(a) Securing the necessary capital

(b) Consideration of the savings (or extra profit) to be expected?

Note: It is understood that both factors are important.

4. In decisions regarding replacement of machines (or expansion of capacity) how far in most instances do you attempt to estimate future conditions affecting your business?

(a) Less than 2 years

(b) 2 to 5 years

(c) Over 5 years

5. (a) Do you use any formulas or standardized procedures (such as those of the Machinery and Allied Products Institute) to assist in machinery replacement problems? Yes or no.

(b) If "yes", will you briefly describe these procedures or give a reference to them?

The sixth question of this section will be discussed separately in the following section because of its unusual nature and analysis.

Equipment replacement practice has been in many instances guided by "rules of thumb" (17, 51). Perhaps the crudest of these rules of thumb has been the "replace when actually and finally worn out" rule. This rule has led plants to retain obsolescent equipment thereby sacrificing savings that might be made with newer, more efficient equipment. When asked in Question No. 1 of this section, Table 11, if consideration was ever given to replacing equipment before it was worn out, 31.3 per cent answered no. A survey (26) made six years ago on a nation-wide basis found 13.0 per cent answered no to the same question. Thus, it appeared that an appreciable number of plants do not distinguish between physical life and economic life. Economic life may be defined as the period of time over which a machine has equal or smaller total cost of

Table 11

Equipment Replacement Practices of Respondents
(Question Nos. 1, 2, 3)

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 1. Ever replace before worn out | | | | | | | |
| Yes | 10 | 16 | 22 | 24 | 12 | 14 | 98 |
| No | 7 | 8 | 10 | 1 | 3 | 5 | 34 |
| 2. Pay-off period | | | | | | | |
| 1 yr. or less | - | - | 1 | - | - | 1 | 2 |
| 2 years | - | - | 3 | 1 | 5 | 1 | 10 |
| 3 years | 1 | - | 7 | 2 | 2 | 2 | 14 |
| 4 years | - | 2 | - | 1 | - | 1 | 4 |
| 5 years | - | 2 | - | 1 | - | 2 | 5 |
| Actual life | - | - | - | 1 | - | - | 1 |
| Variable | - | - | - | - | 1 | 3 | 4 |
| No policy | 16 | 19 | 21 | 17 | 7 | 9 | 89 |
| No response | 3 | 1 | 1 | 3 | - | - | 8 |
| 3. More important | | | | | | | |
| Secure capital | 3 | 4 | 8 | 2 | 1 | 1 | 19 |
| Expected saving | 13 | 19 | 23 | 22 | 14 | 18 | 109 |
| No response | 4 | 1 | 2 | 2 | - | - | 9 |

[a] Only Question No. and key identifying words given. See p. 62 for complete questions.

operation than any other machine which might be used as a replacement. Maintenance costs have generally increased with age. The progress of the arts and sciences have been apparent. Both maintenance and progress have tended to make a machine more expensive to operate as the machine became older. Hence, economic life has usually been shorter than physical life. A significant difference between size groups existed. Larger companies were more willing to consider replacement prior to the end of physical life.

Another rule of thumb that has enjoyed wide acceptance has been the "pay-off period" rule (51). This rule is applied by determining the saving due to a proposed replacement over an existing machine. The installed cost of the proposed machine is divided by the saving. The quotient has the dimension of time, years if annual saving is used. A maximum acceptable value is given to this quotient, the "pay-off period", usually by arbitrary decision. If the calculated pay-off period exceeds the chosen value, the proposed replacement is rejected. The method proper has not been criticized so much as the adopted maximum value for the pay-off period. Pay-off periods of one, two, or three years have been common (51) even though foreseeable economic life may be many times longer. An adoption of a short pay-off period has been interpreted as a "safety factor", i,e., the replacement will pay for itself quickly. An even shorter pay-off period

has been thought by some to provide more "safety" in the replacement decision. Carried to the extreme, this rule of thumb has not allowed replacement until the old machine was inoperative. The reasoning behind the "safety factor" approach was fallacious as it often caused the retention of an uneconomic machine. If all costs of operating the equipment were properly considered and if capital was available, the retention of an old machine with a higher operating cost could only reduce the net income. The cost of "safety" has been unreasonably high in a large percentage of cases (17, 51). Question No. 2 asked what pay-off period was used. On a population basis, 69.0 per cent said no fixed policy was used. The investigator felt that this response was a convenient "out" to a possible embarrassing question. This response of "no policy" should not have been included on the questionnaire. Of those who did respond positively the distribution was that 5.0 per cent used one year, 25 per cent used two years, 35 per cent used three years, 10 per cent used four years, 12.5 per cent used five years, and 12.5 per cent used a variable period not over five years. The average pay-off period was 3.0 years. One survey on a nation-wide basis showed a very similar distribution and an average pay-off period of 2.7 years (35). Another survey on a nation-wide basis showed an average pay-off period of 3.3 years (26). Thus, Iowa had essentially similar practice

compared to the nation as no significant difference existed. Data were insufficient to detect the effect of size group on pay-off period policy.

In replacement economy studies a new machine challenges an existing machine on the basis of estimated total costs of operation of each. If the new machine shows a lower cost of operation, the replacement should occur. However, the new machine will entail an immediate outlay of capital for the purchase of the new machine. Business does not have unlimited capital or unlimited ability to borrow. The availability of money becomes a very real problem in replacement decisions. Hence, replacement may not occur even though the new machine has an economic superiority. Question No. 3 asked respondents to state whether securing capital was more important to the replacement decision than anticipation of savings. Securing capital was more important to 14.8 per cent of the plants. Hence, a larger proportion of the plants, 85.2 per cent, implied they could probably secure capital to purchase equipment that would show future savings. This is an implication, but it tends to indicate that the replacement economy study is important because it shows the future savings. A significant difference existed between size groups with the larger companies indicating less consideration for securing capital. No comparative data were found on this subject.

Engineering economy studies compare the alternatives over a future period. As the future is not known with certainty, estimates of future costs, sales, and business conditions are necessary. Question No. 4, Table 12, inquired how far into the future these estimates were made for purpose of replacement decisions. A period of less than two years was used by 27.0 per cent of the plants, a period of two to five years was used by 48.3 per cent of the plants, and a period of over five years was used by 24.7 per cent of the plants. The average could not be stated unless an assumption was made as to the distribution of responses within the three groups. The average was in the order of magnitude of three to four years. A significant difference existed between size groups on the period of estimation. Smaller size plants used the shortest period of estimation to a greater extent than larger sized plants. The longest period of estimation was used to about the same extent by all sizes of plants except size D which had a higher proportion of plants that used the longest period of estimation. A nationwide survey in 1953 (35) asked an almost identical question and found 37 per cent used less than two years, 47 per cent used two to five years, and 16 per cent used over five years. The survey just cited was heavily weighted toward large companies. Iowa practice about the period of estimation did not differ markedly, although the comparison was not made on

Table 12

Equipment Replacement Practices of Respondents
(Question Nos. 4 and 5)

| Question[a] | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| 4. Estimate future conditions | | | | | | | |
| Less than 2 yrs. | 8 | 9 | 8 | 4 | 1 | 4 | 34 |
| 2 to 5 yrs. | 4 | 11 | 16 | 9 | 10 | 11 | 61 |
| Over 5 yrs. | 4 | 4 | 6 | 10 | 3 | 4 | 31 |
| No response | 4 | - | 3 | 3 | 1 | - | 11 |
| 5(a) Use replacement formulas | | | | | | | |
| Yes | - | - | 1 | - | 1 | 3 | 5 |
| No | 16 | 23 | 30 | 25 | 14 | 16 | 124 |
| No response | 4 | 1 | 2 | 1 | - | - | 8 |
| 5(b) Formula used | | | | | | | |
| Private | - | - | - | - | 1 | 2 | 3 |
| Salesman | - | - | 1 | - | - | - | 1 |
| No response | - | - | - | - | - | 1 | 1 |

[a]Only Question No. and key identifying words given. See p. 62 for complete questions.

exactly similar samples.

Writers in the field of engineering economy have deplored the reputed practice of using formulas to assist in replacement decisions (17, 51). Other writers, however, have continued to develop and publish such formulas (38, 39, 51). Question No. 5(a) asked the respondents if they used any formulas to assist in making replacement decisions. As 96.1 per cent of the plants did not use formulas, the practice was negligible in Iowa. Four of the five plants that did use a formula were in the two largest size groups. Three of these four submitted a sample of their formula which was found to be a detailed set of instructions prepared by the company for its own use. The formula prepared under the auspices of the Machinery and Allied Products Institute (51) has been widely publicized (15, 31, 43). Not one instance of its usage was reported in this investigation.

### Hypothetical Problem on Equipment Replacement

The last question of the section on Equipment Replacement Practice is discussed separately because of its unique nature and scope. The question was a hypothetical, though typical, problem about equipment replacement. Actual number data were given and the respondent was asked to submit his solution with all computations shown. It was hoped that the problem would be the equivalent of several individual

questions. Furthermore, it was hoped that the problem would yield data of a more candid nature. If, for example, a respondent claimed to use the declining balance method of depreciation but made calculations by the straight line method, the discrepancy would be apparent. The answer that resulted from the calculation would seem to be the more reliable. The intent of the problem was not to trick respondents into embarrassing contradictions. The primary purpose of the problem was to obtain a large amount of information in a small package.

The exact problem statement and data were as follows:

6. The following situation, while purely hypothetical, might be a typical problem facing your company on the subject of equipment replacement. Actual data are given and space is provided for calculations and a solution that you make. There is no "one way" that is absolutely correct, so much latitude in the solutions is expected. The problem statement is: For the data given, would you replace the present machine with the proposed machine?

| | Present Machine | Proposed Machine |
|---|---|---|
| Physical condition | Good | New |
| Capacity | Adequate | Same as present |
| Cost new, installed | $1100. | $2100. |
| Estimated salvage when retired | $ 100. | $ 100. |
| Expected useful life when new | 10 yrs. | 10 yrs. |
| Present age | 4 yrs. | -- |
| Present value on 2nd hand market | $400. | -- |
| Estimated annual labor cost incl. Soc. Sec., pensions, etc. | $2700. | $2000. |
| Estimated annual maintenance | $ 150. | $ 100. |

Floor space requirements, power costs, taxes, and insurance costs are not expected to change if the new machine is purchased.

Many different solutions to this problem were expected and found. Before describing and summarizing these solutions, a recommended solution will be shown in complete detail. This recommended solution is based on the investigator's judgment of what represents current best practice. The method of solution is described at length by Grant (17).

Recommended Problem Solution. All costs are reduced to annual basis.

| Item | Present Machine | Proposed Machine |
|---|---|---|
| Depreciation (Straight line basis on present market value and expected useful life) | $\frac{400 - 100}{6} = 50$ | $\frac{2100 - 100}{10} = 200$ |
| Interest (On average investment at 10% rate) | $(\frac{1}{2})(300)(0.1) + (0.1)(100) = 25$ | $(\frac{1}{2})(2000)(0.1) + (0.1)(100) = 110$ |
| Labor Costs | 2700. | 2000. |
| Maintenance Costs | 150. | 100. |
| Total | $2925. | $2410. |

Difference in annual costs in favor of

Proposed Machine = $515.

The Proposed Machine should be installed.

Pay-off Period = $\frac{2100}{(2700 + 150 - 2000 - 100)}$ = 2.8 years.

The savings that may be expected by use of the Proposed Machine will repay its cost without interest in 2.8 years.

There are several places in this solution that bear explanation. First, depreciation on the present machine is determined on its present market value of $400., not on its straight line depreciated book value of $700. Many analysts add the difference of $300. to the cost of the proposed machine. The new machine should not be expected to carry this accounting difference which has no relation to its economy. Second, the $400. that could be received if the old machine was sold is not deducted from the new cost of the proposed machine. The $400. could be put in government bonds, for example, without affecting the relative economy. Third, an annual interest charge is made against each machine on the average amount invested. This interest is synonymous with return on the investment. The average investment, if straight line depreciation is assumed, is one-half the new cost less salvage value. This is due to the fact that funds laid aside through depreciation are free to be used elsewhere in the business. The interest charge against the machine is based

on the assumption that each component part of the whole business should earn its proportionate share. The average investment as one-half the new cost is a simplification of the method (17) that replaces one-half by $\frac{(n + 1)}{2n}$ where n is the useful life in years. As $\frac{(n + 1)}{2n}$ approaches one-half as n increases, and as the factor is based on the assumption that depreciation is written off only once each year, this factor is little more defensible than one-half. Fourth, it was necessary to assume a desired rate of return. A rate of 10 per cent was used because corporation taxes would lower the realized rate to the range of 5 to 7 per cent. The rate used in engineering economy studies should be about equal to the rate of return of the particular company. The choice could vary from company to company. Fifth, the pay-off period was calculated by considering only the savings in labor and maintenance costs. The cost of the capital and its recovery was omitted as is often, though not ideally, done.

Another method sometimes used is to assume a pay-off period, say three years. The economy study is then made using three years as the expected life. If the proposed machine has lower total cost, it is said to pay off and would be selected. As previously discussed, the arbitrary choice of too short a pay-off period may postpone investments that other methods would indicate to be economically correct.

Tables 13 and 14 summarize the results and analysis of the hypothetical problem. Although a solution was time consuming, 81.2 per cent of those who returned the questionnaire also submitted a solution to the problem. Of this group 51.2 per cent detailed their solution and 48.8 per cent merely answered yes or no as to whether they would choose the proposed machine. Of those who detailed their solution 73.4 per cent chose the proposed machine. Of those who did not detail their solution 70.3 per cent chose the proposed machine. No significant difference existed between these two groups. The possibility that one group made the calculations mentally or elsewhere on paper but not on the returned questionnaire may be one explanation of this close agreement. Furthermore, no significant difference existed between size groups when only those who did not detail were considered. However, the group that did detail their solution exhibited a significant difference between size groups. This significant difference was due principally to size group F, over 500 employees. Although the data are meager, only 25 per cent in this size group chose the new machine when the solutions were detailed. The proportion who chose the proposed machine in this group was significantly different from all other groups. The rather low percentage of these large companies who chose the proposed machine indicated a reluctance or conservatism not altogether surprising to this investigator. Large companies with

Table 13

Analysis of Hypothetical Problem
(Detailed and undetailed responses)

| Item of Analysis | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| No. responding | 12 | 20 | 29 | 21 | 13 | 16 | 111 |
| No. showing calc. | 4 | 8 | 17 | 11 | 9 | 8 | 57 |
| No. omitting calc. | 8 | 12 | 12 | 10 | 4 | 8 | 54 |
| Of those who omitted calc. | | | | | | | |
| No. who chose proposed machine | 4 | 10 | 7 | 9 | 2 | 6 | 38 |
| No. who refused proposed machine | 4 | 2 | 5 | 1 | 2 | 2 | 16 |
| Of those who showed calc. | | | | | | | |
| No. who chose proposed machine | 3 | 4 | 10 | 9 | 8 | 2 | 36 |
| No. who refused proposed machine | 1 | 1 | 3 | 1 | 1 | 6 | 13 |
| No. who gave not pertinent answers | - | 3 | - | 4 | 1 | - | 8 |
| Of all pertinent responses | | | | | | | |
| No. who chose | 7 | 14 | 17 | 18 | 10 | 8 | 74 |
| No. who refused | 5 | 3 | 8 | 2 | 3 | 8 | 29 |

Table 14

Analysis of Hypothetical Problem
(49 Plants that gave detailed solutions)

| Item | Size Group, no. of employees | | | | | | Total, all sizes |
|---|---|---|---|---|---|---|---|
| | A 1-24 | B 25-49 | C 50-99 | D 100-249 | E 250-499 | F Over 499 | |
| Plus score on test questions[a] | | | | | | | |
| 1 | - | - | - | - | - | 1 | 1 |
| 2 | 1 | 1 | 5 | 2 | 1 | 2 | 12 |
| 3 | 2 | - | 3 | 3 | 4 | 3 | 15 |
| 4 | 1 | 3 | 3 | 3 | 1 | 1 | 12 |
| 5 | - | 1 | 2 | 2 | 3 | 1 | 9 |
| Average plus score | 3.0 | 3.8 | 3.1 | 3.5 | 3.7 | 2.9 | 3.3 |
| No, using pay-off period of 2 or less years | 1 | 1 | 1 | 2 | 4 | 5 | 14 |
| Discrepancy of calculated pay-off period with stated pay-off period | 1 | - | - | - | - | 3 | 4 |
| No. who improperly handled sunk cost in present machine | 4 | 5 | 13 | 10 | 8 | 8 | 48 |

[a] See p. 71 for test questions.

possibly more checks and balances in their organization may move slowly, because a decision not to replace now is in reality a decision to postpone the replacement. Do companies become conservative when they grow large, or do they grow large because they are conservative? This question could not be answered by this investigation, but might well be a subject for future investigation.

Those respondents who detailed their problem solution provided information for further analysis. To rate each solution on a relative scale, the investigator set up eight test questions to be applied to each solution. Each test question covered one appropriate step in a replacement economy study and was phrased so that an affirmative answer indicated inclusion of the step. The questions were as follows.

1. Has the cost of the machine been included in some manner so that it is recovered over the life of the machine, or some period shorter than life? This is usually handled as depreciation.
2. Has an interest charge, i.e., return on the investment, been included in the solution?
3. Have the costs of labor and maintenance been included in the solution?
4. Has the difference between actual present value and calculated book value of the present machine been

regarded as a sunk cost not influencing the economy of the new machine?

5. Has the actual present value of the present machine not been deducted from the cost of the proposed machine?
6. After analysis, has the more economical machine been chosen?
7. If a pay-off period was calculated, was the pay-off period chosen reasonable? (A period of less than three years was adopted by this investigator as unreasonable.)
8. Has the solution been given in the concise and easy to follow manner expected of a competent engineer?

In rating each problem solution a plus was given for each affirmative answer to a test question. Thus, a maximum plus score of eight could be attained. As Question 7 in the list was not necessary to a complete solution, a score of seven would be considered satisfactory. No solution rated as high as six with 18.3 per cent rated at five, 24.5 per cent rated at four, 30.7 per cent rated as three, 24.5 per cent rated two, and 2.0 per cent rated at one. The average plus score was 3.3. No significant difference existed between size groups with regard to plus score. No comparison of this rating of Iowa practice could be made because of the unique method of rating.

More data on the pay-off period were available after this analysis. In the direct question previously reported, 30.0 per cent stated a pay-off period of two years or less was used, and in the problem solution 28.5 per cent actually used a pay-off period of two years or less. Once again the large companies, size group F, used a shorter pay-off period in calculations than they had stated in answer to the direct question.

Sunk cost has been defined (17) as a previously incurred expense that is irrelevant to an economy study which deals with only the future. The problem used in this investigation provides an example. If the present machine is depreciated by the straight line method, its book value would be $700. after four years. At this same date its market value is stated to be $400. The difference, $300., is not relevant to the economy of the proposed machine which depends only upon the proposed machine's price and operating characteristics. However, many analysts add the $300.00 to the cost of the proposed machine. This procedure makes the proposed machine bear changes in estimates of value from the time the present machine was installed to the present time. The book value of $700.00 is academic in a sense because it is based on an arbitrary depreciation assumption. Hence, the $300.00 difference is also academic and is an accounting figure, sometimes unfortunately called "loss on sale". Future profits of

the business will be greater if the more economic machine is chosen regardless of the book difference of $300.00. Previous investigators (17, 51) have observed the reluctance of analysts to recognize that sunk costs are really sunk. Past errors of estimation or poor judgment should not be carried into decisions for the future.

This investigation confirmed the previous observations regarding sunk cost. All but one of the 49 respondents who detailed their problem solution handled the sunk cost of the present machine improperly. The practice of Iowa industry was consistent on sunk cost, but not in agreement with recommended practice.

## Rating of Questionnaire by Respondents

Investigations of this type have been so rare that little guidance was available from experience. Respondents in this investigation were given an opportunity to offer criticism of the questionnaire and the investigation. A question was appended on the last page of the questionnaire for the criticisms. The question was as follows:

If you have been unable to respond to any of the questions, we will appreciate your response to this one question and the return of the questionnaire:

(a) Response was not possible because some of the

questions did not fit our company. Which ones specifically?

(b) Response was not possible because some of the questions were not phrased so that they were understood. Which ones?

(c) Response was not possible because some of the questions would divulge information considered confidential. Which ones?

(d) Any other reason for no responses?

Of the 138 who submitted usable questionnaires, 16 marked this question in some manner. Three companies, all in size group A, said none of the questions fit their company because they were too small. The remaining 13 singled out one or two questions for criticism. Question Nos. C-7 and C-8 which pertained to depreciation for income tax purposes were the only questions consistently criticized. Only one respondent said he could not answer some questions because he did not understand the questions.

As the criticisms of the questionnaire were relatively slight, the investigator was encouraged to believe the questionnaire design was satisfactory and that the investigation was cordially received by the respondents. It was obviously not so cordially received by the non-respondents.

# FINDINGS

The primary purpose of this investigation was to secure basic data about engineering economy and related practices in Iowa. As these practices were to be related to the size of the plant where possible, data on size and form of organization were also secured. The investigation, therefore, was descriptive in nature rather than interpretive. For this reason the section has been given the title "Findings" rather than "Conclusions". Interpretations and conclusions were drawn in some instances but were not the primary reason for the research.

Listed below are the findings of this investigation which the author felt were worthy of inclusion. Certain of the attributes reported were related to the size of the plant. The relationship was tested by the proper statistical technique using the 5 per cent level of significance. Where the relationship was significant, it was so identified. Exact percentages reported in the Discussion of Results have been stated as the closest simple fraction. The findings were as follows:

1. Response to the questionnaire was significantly related to the size of the plant. As the size of the plant increased, the proportion of responses to number sampled

increased.

2. Evidence was found to indicate that the non-respondent portion of the sample would give essentially the same answers as the respondent portion of the sample. Therefore, the uncertainty due to some questionnaires not being returned was reduced.

3. The organization of Iowa plants into corporations, partnerships, or sole proprietorships was essentially in the same proportion as the United States taken as a whole.

4. Where a plant was a branch of a larger, multi-plant company, only one-eighth of such plants were allowed any local voice in policies regarding engineering economy.

5. The average number of employees in an Iowa manufacturing plant was 91. The estimate of the total number of employees engaged in manufacturing in Iowa was 195,500 ± 15,500 (the 95 per cent confidence interval).

6. The distribution of the number of plants in each of the six size groups was essentially the same as that of the United States taken as a whole.

7. Iowa had approximately two billion dollars invested in manufacturing plants.

8. Appraisals, when made, were predominantly for the purpose of insurance valuation. Appraisals were significantly related to the size of the plant. More large plants had made appraisals than small plants.

9. The average appraisal gave a valuation that varied 20 per cent from total assets as shown on the balance sheet for a particular plant.

10. Nearly half the plants calculated depreciation for only one reason, namely, income tax deductions. Larger plants were significantly different from smaller plants, as the larger plants listed several other reasons for determining depreciation.

11. Slightly over half the plants used life values from Bulletin F, U. S. Treasury Department, solely. This practice was significantly related to the size of the plant. Larger plants used Bulletin F to a lesser extent than smaller plants.

12. Over four-fifths of the plants used straight line depreciation exclusively.

13. An increase in the use of declining balance depreciation, particularly by smaller plants, was found by comparison with data reported 15 years ago.

14. About one-third of the plants calculated depreciation separately for each individual item. About one-third grouped similar items of property together wherever possible and calculated depreciation for the group. The remaining one-third combined the individual method and the group method according to the policy of the particular plant.

15. Nearly one-half the plants stated that the values of useful life given in Bulletin F, U. S. Treasury Department,

were satisfactory or too short. This finding was contrary to much published opinion. A significant difference between the various sized plants was found. As the size of plant increased, the satisfaction with the values of useful life in Bulletin F decreased.

16. Almost three-fourths of the plants favored a proposed ruling by the U. S. Treasury Department that would allow the plants to calculate depreciation for income tax purposes with a useful life of their own choosing and shorter than those given in Bulletin F.

17. Almost one-third of the plants would not consider replacement of equipment that was not worn out. A significant difference between the various sized plants was found. As the size of plant increased, the willingness to consider replacement increased.

18. The average pay-off period among those who use it as a criterion for signaling replacement was 3.0 years. This average for Iowa did not differ significantly from two reported U. S. averages of 2.7 years and 3.3 years. Over four-fifths of the plants stated they had no policy on the length of the pay-off period.

19. Securing capital to finance economic replacements was a more important problem to one-eighth of the plants than showing the economy of the replacement. A significant difference was found between the various sized plants. As the

size of the plant increased, the problem of securing capital decreased in importance.

20. Plants in Iowa attempted to estimate conditions affecting an engineering economy study three to four years into the future. A significant difference between various sized groups was found. As the size of plant increased, estimates of conditions were attempted farther into the future.

21. Formulas for determining replacement decisions were used by less than one-twenty fifth of the plants. Where formulas were used, they were an analysis form developed by the plant for its own use.

22. The hypothetical problem yielded information equivalent to several direct questions. The problem technique with further development could be a useful device in studies of this nature. Some findings from the problem were as follows.

a. Actual calculations were observed to be widely variable.

b. Rated against an arbitrary scale of good practice, the quality of problem solutions was not related to size of plant.

c. For the specific data of the problem almost three-fourths of the respondents chose to

replace the present machine with the proposed machine. The problem data were chosen so that a replacement was definitely indicated.

d. Some evidence was found that the largest sized plants were more conservative about replacement decisions than all other sized plants.

e. Sunk costs were improperly handled or not considered at all by every respondent who showed calculations except one.

The objectives of this investigation as stated in the Introduction were or are being attained. Considerable basic data of descriptive nature on engineering economy and related practices in Iowa have been found and reported. These data were never before available. Iowa practice has been compared, when possible, with reported practice for the United States on the whole. The practices have been interpreted in some instances by comparison with conventional or suggested practices. The report of the investigation to the respondents is being prepared for distribution not later than August of 1954.

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The author wishes to express his appreciation to Professor James P. McKean who offered dignified counsel and guidance that contributed inestimably to the completion of this research.

Special thanks are due Professor J. K. Walkup for the assistance in arranging certain operational aspects of this research and for his encouragement through several years of graduate study.

The other members of the author's committee have exhibited patience and understanding that was truly appreciated. They are G. L. Bridger, J. A. Nordin, P. G. Homeyer, Robley Winfrey, and Bernard Ostle. While not on the committee, R. J. Jessen contributed valuable counsel during the planning of the survey procedure.

The author's wife, Helen, has cheerfully accepted sacrifices that can never be repaid and has been a principal motivating influence.

# APPENDIX

IOWA STATE COLLEGE
GENERAL ENGINEERING DEPARTMENT

Survey of certain Business and Engineering Practices
in Iowa Manufacturing Industry

This study is being conducted by asking a representative group of Iowa's some 4000 manufacturing plants the following group of questions. Your responses are, of course, confidential. The primary objectives of the study are: 1) to secure objective information in the subject area of this questionnaire, and 2) to make such information available with the sincere hope that helpful ideas will be suggested.

There may be questions here that do not seem to fit your company. The more of the questions that you can answer, the more valuable will be the final results. If you can not respond to a particular question, please do not feel that you should omit the others.

Please underline, check, or complete the blanks where necessary.

A. GENERAL INFORMATION

1. Name of Company_____

2. Address of this Plant_____
   (This location only if a branch)

3. Name of person to whom correspondence about this study may be sent.

4. Brief description of products manufactured (only those actually made)
   _____
   _____

5. Average no. of employees during past year. _____
   (this location only if a branch)

6. Is the company organized as a:
   (a) ___ Corporation or stock company
   (b) ___ Partnership
   (c) ___ Sole proprietorship ( a single owner ) ?

7. (Note: This question concerns only those companies that operate a plant in more than one location. It is suggested that parts B, C, and D be completed before checking this one question).
   (a) ___ The policies in parts B, C, and D are generally those of the company as a whole.
   (b) ___ The policies in parts B, C, and D apply only to this one branch of the company.
   (c) ___ The policies in parts B, C, and D are a combination of (a) and (b) of this question.

(Please see back of this sheet)

B. ACCOUNTING AND APPRAISAL PRACTICES

1. (a) Do you have a Balance Sheet drawn at least once a year? Yes or no.
   (b) If "yes", is it prepared by a professional accountant? Yes or no.

2. (a) Have you ever made or had made for you a detailed appraisal of your complete company? Yes or no.
   (b) If "yes", what was the reason for this appraisal? Please describe briefly._____

3. If 2(a) is answered "yes", how much variation did the appraisal show when compared to the Balance Sheet?
   (a)_____less than 5%
   (b)_____5 to 15%
   (c)_____15 to 30%
   (d)_____over 30%

4. How often on the average do you physically inventory materials, supplies, goods in process, and finished goods on hand?_____

5. How often on the average do you inventory machinery, equipment, and properties? Machinery_____ Equipment_____ Other Properties_____

C. DEPRECIATION PRACTICES

1. (a) Do you calculate depreciation for any other reason than Income Tax deductions? Yes or no.
   (b) If "yes", for what reasons?_____

2. (a) Do you use the U.S. Treasury Dept., Bureau of Internal Revenue, Bulletin "F" as the source for "useful lives" or "depreciation rates" regardless of the reason for the depreciation calculation? Yes or not solely.
   (b) If "not solely", what other source of lives or rated do you use?
   _____

3. What method of depreciation do you use? Check the one or ones.
   (a) Straight line_____
   (b) Unit of Production_____
   (c) Declining Balance_____
   (d) Sinking Fund_____
   (e) Other (please name)_____

4. Do you calculate depreciation on
   (a)_____ the Original Cost of the item to you, or
   (b)_____ on some other Basis of Cost (please explain briefly)
   _____

5. What is the basis upon which depreciation is calculated?
   (a)_____ Purchase price of equipment alone
   (b)_____ Purchase price of equipment plus installation
   (c)_____ Purchase price of equipment plus installation plus overhead charge

6. Do you in calculating depreciation
   (a) Group similar items together_____
   (b) Figure each item separately_____ or
   (c) Use a combination of these two methods_____.

7. For your particular business do you feel that the useful lives given in Bulletin "F" are on the average
   (a)_____about correct
   (b)_____too long
   (c)_____too short?

8. Would you favor an income tax ruling that allows you to use values of useful life that are less than "true life" (true life may be thought of here as being that period of time that actual experience shows the equipment will be used)? Yes or no.

D. EQUIPMENT REPLACEMENT PRACTICES

1. Will you ever seriously consider replacing a machine that is not worn out and still capable of doing its job? Yes or no.

2. Do you have a general policy as to the "pay-off period" for new equipment (pay-off period is defined as the number of years necessary for the savings realized by the use of the new machine to equal the cost of the new machine)?
   (a)_____1 year or less
   (b)_____2 years
   (c)_____3 years
   (d) How many years ____
   (e) No policy.

3. In decisions regarding machinery replacement which of these two factors is the more apt to determine the decision to replace or not:
   (a)_____ securing the necessary capital
   (b)_____ consideration of the savings (or extra profit) to be expected?
   Note: It is understood that both factors are important.

4. In decisions regarding replacement of machines (or expansion of capacity) how far in most instances do you attempt to estimate future conditions affecting your business?
   (a)_____less than 2 years
   (b)_____2 to 5 years
   (c)_____over 5 years.

5. (a) Do you use any formulas or standardized procedures (such as those of the Machinery and Allied Products Institute) to assist in machinery replacement problems? Yes or no.
   (b) If "yes", will you briefly describe these procedures or give a reference to them?_____

6. The following situation, while purely hypothetical, might be a typical problem facing your company on the subject of equipment replacement. Actual data are given on the back of this sheet and space is provided for calculations and a solution that you make. There is no "one way" that is absolutely correct, so much latitude in the solutions is expected. The problem statement is: For the data given, would you replace the present machine with the proposed machine?

(Please see back of sheet)

| | Present Machine | Proposed Machine |
|---|---|---|
| Physical condition | Good | New |
| Capacity | Adequate | Same as present |
| Cost new, installed | $1100. | $2100. |
| Estimated salvage when retired | $ 100. | $ 100. |
| Expected useful life when new | 10 yrs. | 10 yrs. |
| Present age | 4 yrs. | -- |
| Present value on 2nd hand market | $400. | -- |
| Estimated annual labor cost incl. Soc. Sec., pensions, etc. | $2700. | $2000. |
| Estimated annual maintenance | $ 150. | $ 100. |

Floor space requirements, power costs, taxes, and insurance costs are not expected to change if the new machine is purchased.

IMPORTANT: If you have completed the questionnaire, please refer back to question No. 7 on page 1.

If you have been unable to respond to any of the questions, we will appreciate your response to this one question and the return of the questionnaire:

(a)_____ Response was not possible because some of the questions did not fit our company. Which ones specifically?_____.

(b)_____ Response was not possible because some of the questions were not phrased so that they were understood. Which ones?_____

(c)_____ Response was not possible because some of the questions would divulge information considered confidential. Which ones?_____

(d)_____ Any other reason for no responses?_____

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
AMES IOWA

DEPARTMENT OF GENERAL ENGINEERING

August 17, 1953

Dear Iowa Manufacturer:

As a research project of the General Engineering Department of Iowa State College which has as its purpose service to Iowa industry, we are doing a study on certain current business and engineering practices among various Iowa manufacturers. This letter will serve only to introduce the project to you. Later you will be asked to answer a few questions on certain of your business and engineering practices by mailed questionnaire, personal interview, or both.

Your company has been selected as one of the representative manufacturing firms in Iowa. It is our intention to group information obtained from all firms so that a correct idea of current practices may be obtained permitting you to compare your firm with the group. With many companies of all sizes and types pooling this information through a common clearing-house, it will be possible to suggest new ideas or revisions of current business and engineering practices. Each company that participates will receive the completed report as soon as it is finished. Any information you provide will be held in the strictest confidence.

The usefulness of the results depends primarily upon the cooperation of all the companies selected. About one hour of time by someone in your company who is acquainted with your policies and practices will be necessary to complete the questionnaire. You will receive it in about two weeks. May we urgently request your cooperation?

Sincerely yours,

J. P. Mills

J. P. Mills
Assistant Professor

JPM:drs

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
AMES, IOWA

DEPARTMENT OF GENERAL ENGINEERING

August 29, 1953

Dear Iowa Manufacturer:

On August 17, 1953 we wrote to you about our study of certain business and engineering practices of Iowa manufacturing industry and advised you of our selection of your company as a representative Iowa manufacturing firm. Enclosed with this letter you will find the actual questionnaire. It inquires into Accounting and certain Engineering topics including Appraisal, Depreciation, and Equipment Replacement. We will appreciate your placing the questionnaire in the hands of the person or persons best qualified to complete it.

As we mentioned in our previous letter, the success of this study will depend on your responses. We have already had indications of enthusiasm from numerous Iowa firms. Your cooperation in returning the questionnaire will, indeed, be appreciated and will give us the information that may be summarized and reported to you.

Strictest confidence will be maintained. Responses to particular questions will be summarized in the form, "72 out of 168 answered Yes to No. 2". Thus, it will not be possible to identify your individual answers. Your company's name appears on the questionnaire so that we may send the summary to you when it is compiled.

This study is intended to be of service to Iowa manufacturing industry. On this basis we appeal for your participation. We take this opportunity, also, to thank you in advance for your cooperation. We hope to begin our tabulation of information on September 15.

Sincerely yours,

J. P. Mills

J. P. Mills
Assistant Professor

JPM:drs

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
AMES, IOWA

DEPARTMENT OF GENERAL ENGINEERING

November 20, 1953

Concerning: Iowa State College business survey

Dear Sir:

During August of this year, we wrote you introducing a research study on business and engineering practices of Iowa companies. We then sent a questionnaire to you hoping that you would respond to the questions and return it. To this date we have not received your reply.

We want this survey to be fair, especially to the smaller companies of Iowa. As a matter of fact, one-third of the questionnaires were sent to randomly selected companies listed by the Iowa Development Commission as having less than 25 employees. There are approximately 3,000 such companies in our state, so you can appreciate what an important segment of Iowa manufacturing industry these companies represent. Responses from this group, of which you are one, are as highly prized as any others.

Perhaps you felt in reading our original letters that this study was not for you. May we assure you that it most definitely is. If some of the questions do not seem appropriate, omit them, but please consider and answer those that you can. To reiterate, our primary objective in this study is service to Iowa industry, if we can possibly give service through the results of the study.

We are taking the liberty of enclosing a duplicate copy of the questionnaire should the original be misplaced. We wish to thank you for your time and consideration and we hope for your reply in the near future.

Sincerely,

J. P. Mills

JPM:jrc
Enclosure

J. P. Mills
Assistant Professor

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
AMES, IOWA

DEPARTMENT OF GENERAL ENGINEERING

November 20, 1953

Concerning: Iowa State College business survey

Dear Sir:

During August of this year, we wrote you introducing a research study on business and engineering practices of Iowa companies. We then sent a questionnaire to you hoping you would respond and return it. To this date we have not received your reply.

If our study is to give a true picture, we need information from a high percentage of the representative group of which you are one. The responses to date have been encouraging, but with more responses we could expect greater reliability of the results. You may remember that our objective was to provide a service to Iowa manufacturing industry, but the necessary data must come from you, its only source.

To this end, we are taking the liberty of sending you a duplicate copy of the questionnaire, should the original be mislaid. The answers will be held completely confidential, and your response will be most highly prized. May we suggest that your Accountant or Cost Engineer or the person closest to these functions is perhaps the person best qualified to complete the questionnaire.

We wish to thank you for your time and consideration and we hope for your reply in the near future.

Sincerely,

J. P. Mills

JPM:jrc
Enclosure

J. P. Mills
Assistant Professor

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
AMES, IOWA

DEPARTMENT OF GENERAL ENGINEERING

Proper date

General Manager
Name of Company
That town, Iowa

Dear Sir:

Late in August I wrote you introducing a survey of Business and Engineering practices being conducted through the General Engineering Department of Iowa State College. A questionnaire followed this introduction. My records show that to date no response has been received from your company.

You can appreciate that if the results of our survey are to be as correct as possible, we must have completed returns from the companies included in the survey. In order to accomplish this coverage, I have selected from the group that did not respond a smaller group to actually interview. This is the purpose of my writing to you at this time.

If you are interested in cooperating with us on the completion of the survey, I would appreciate your response to this letter, which is asking you to do one of two things. Complete the enclosed questionnaire, which is a duplicate of the one your company received before and return it to me by mail, or permit me to come to your plant and assist in completing the questionnaire. If you prefer the personal interview, I would like to know the name of the person within your company whom I should contact upon arrival. Possible times of my arrival would be Monday, Dec. 7; Monday, Dec. 14; Tuesday, Dec. 15; or Friday, Dec. 18. As my travel will likely cover our state from east to west and from north to south, it would be difficult for me to specify a particular day that I might arrive at your plant. This is, of course, contingent upon the condition of the highways which is certainly unpredictable at this time of year.

You will remember from my previous letters that the primary purpose of this survey is to be of service to industry in the state of Iowa. We really need your cooperation to make the survey as effective as possible. Replies are completely confidential. If for any reason, however, you do not feel that you can supply this information, such decision will have no bearing upon any other relationships with the college. The college desires to be of service to you whenever possible.

I am looking forward to your response to this letter, and sincerely appreciate your consideration.

Cordially yours,

J. P. Mills
Assistant Professor

JPM:—

Enclosure