Bulletin No. 1203
September 1956

Job Performance and Age:

A Study in Measurement

UNITED STATES DEPARTMENT OF LABOR
James P. Mitchell, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

Reports on the Department of Labor's Older Worker Program:

Job Performance and Age: A Study in Measurement

Older Workers under Collective Bargaining:
Part I. Hiring, Retention, Job Termination

Older Workers under Collective Bargaining:
Part II. Health, Insurance, and Pension Plans

Pension Costs in Relation to the Hiring of Older Workers

Older Worker Adjustment to Labor Market Practices:
An Analysis of Experience in Seven Major Labor Markets

Counseling and Placement Services for Older Workers

How to Conduct an Earning-Opportunities Forum in Your Community

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Preface

One of the most pressing problems confronting this Nation concerns the difficulties of the older worker in securing and retaining employment. The U. S. Department of Labor, aware of these difficulties, has undertaken a broad program to examine these problems, and, if possible, to find means for overcoming them. As part of this program, the present study examines the problems of measuring the relationships, if any, between age and work performance.

Numerous studies have recorded the attitudes of employers on this subject, and have revealed a rather widespread set of unfavorable beliefs concerning the work performance of older workers.

It is a fair presumption that there is some relationship between these attitudes and the problems mentioned above. It is important, therefore, to examine, through objective measurements, the question of how age actually affects job performance.

A basic factor in establishing the need for this study was the almost total lack of past surveys, of any extensive scope, in this field. Since it is extremely uncommon, in productive enterprises, to find large groups of workers performing the same task, previous studies of age and work performance have made little use of on-the-job performance records between age and job performance.

Although not minimizing the difficulties of conducting such a study, the Bureau of Labor Statistics thought that it would be possible, through the development of suitable techniques, to overcome many of the obstacles to using actual performance data derived from plant records.

The Bureau also recognized that these difficulties were not purely in the area of statistical manipulation, but involved an interplay of statistical problems with problems of data collection. It was concluded, therefore, that although the necessary statistical tools were undoubtedly at hand in the available literature, the actual application of these tools could best be worked out in a pilot study, in which all of the important obstacles would have to be faced in a practical way.

In the actual conduct of the study, it was found that certain techniques which seemed initially to meet the needs of this program were, in practice, unsuitable. In these cases, alternative methods were developed and tested. For example, it was believed that classification of workers into 5-year age groups would be an appropriate means of identifying the age factor. In attempting to apply this procedure, however, it was discovered that the number of observations in each group was too small to permit meaningful comparisons, and 10-year classifications were substituted. In another instance, it was assumed that skill levels for each occupation could be determined through the use of the Dictionary of Occupational Titles. This was also found to be unworkable and a different method of skill-level classification had to be used.

Such difficulties are inherent in the subject matter of this survey. Company records show little or no uniformity, and are not designed to yield the type of information needed in a program of this sort. Yet some standardization of data-collecting procedures was obviously needed in order to provide statistics that would be comparable among the various plants. This standardization required a detailed examination of the records actually maintained in industrial plants, followed by an analysis of how these records might be used to derive coherent measures of job performance. The analysis had to make provision not only for variations in recordkeeping, but also for differences in the basic definitions employed by various companies. For example, it was found that the distinction between terminations and leaves of absence was not clear cut, and varied from plant to plant. Similar problems of interpretation arose in each of the other areas.

It was anticipated that there would be a certain amount of trial and error, and that this would tend to reduce the quantity of data that would come out of a study which had to be completed in a given period of time. It was believed, nevertheless, that such a study could meet an important need by developing and testing various new approaches to the investigation of relationships between age and work performance.

By its nature, this program was not expected to produce any extensive findings with respect to these relationships. Nevertheless, many of the procedures used were similar to those which might be required in a full-scale survey, and the results of these procedures are, therefore, presented as statistical findings in the body of the report. These statistics apply only to the particular plants that were covered in this survey, however, and are not in any way intended to represent conditions that might be found to exist if an entire industry had been surveyed.

This study was conducted in the Division of Productivity and Technological Developments under the direction of Jerome A. Mark, who prepared the report with Wolfram Liepe and Bernard Rein, assisted by Robert E. Malakoff and Stanley Miller.

The statistical formulas were derived with the assistance of Morton Raff of the Bureau's Office of Statistical Standards.

The Bureau wishes to express its appreciation to those firms whose wholehearted cooperation made this work possible. They generously made their records available to the Bureau's representatives and offered many helpful suggestions.

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Job Performance and Age: A Study in Measurement

Summary

The present study of job performance and age was undertaken by the Bureau of Labor Statistics as part of a general program of the Department of Labor to investigate the employment problems of older workers, and to find ways to meet these problems.

This study, exploratory in nature, was designed to develop objective measures which would be useful for comparing the performance of production workers in different age groups. It was intended only as a pilot investigation to guide future and more extensive work.

Four indicators of work performance, ostensibly straightforward but in fact quite complex, were carefully defined. It was found that at least three of these can be used to relate age to job performance--output per man-hour, attendance, and separation rates.

Research was confined to 8 manufacturing establishments in 2 industries--footwear and men's clothing. Output data were obtained for 2,217 production workers--933 in the footwear industry and 1,284 in the clothing industry. Attendance data were collected for 4,009 production workers of which 1,758 were in the footwear plants and 2,251 were in the clothing plants. Data on industrial injuries were collected for 2,637 workers, of whom 729 were in footwear plants and 1,908 in clothing plants. Records of separations (quits, layoffs, and discharges) were kept in detail at only 4 of these plants; they provided figures for 2,734 workers over the period of a year or more.

Data obtained in the course of this pilot survey, while describing the experience of the plants visited, were not expected to (nor do they) furnish definitive results of these industries. The main emphasis was on the development of techniques suitable to a full-scale investigation.

Findings in the Plants Surveyed

It was found possible to draw conclusions of only a limited nature with respect to the relationships between age and work performance. In the case of output per man-hour, the data showed, in general, a stable average performance level through the age of 54, with some falling off occurring in the average for the 55-64 year group. Although the declines were, in most cases, statistically significant, the indexes of output for this age group were within approximately 10 percent of those for the age groups with peak production.

Variations in the output of persons in the same age group were very large--in fact, they were greater than the differences in average output among age groups. This means, for example, that many workers aged 55-64 had output rates which were actually higher than the average rate in the age group with peak production. Conversely, many younger workers had output lower than the

average output of older workers. Insofar as practical implications are concerned, these data emphasize the fact that an employer in considering an applicant for employment should evaluate the potentialities of the individual rather than immediately drawing conclusions from his chronological age.

The age-output curves by industry, sex, type of operation (hand or machine) and earnings levels followed the same general patterns in each industry both in regard to averages for age groups and variations of the output of individuals within the same age group.

With respect to attendance, only small differences were found among age groups. In the shoe plants, indexes of attendance for the six age groups varied by only 3 percent, and in the clothing plants by only 7 percent.

With regard to industrial injuries, the study did not provide data which could be used to make comparisons between age groups. This was due partly to the lack of uniformity in company injury records, and also to the fact that a survey with wider coverage would be needed to produce meaningful results. Many age groups showed no injuries during the years studied.

Information on separations was collected, but the adequacy of this information varied among the several plants surveyed, and it was found possible to present findings for only four of these plants. The data showed, in general, a high rate of quits and discharges for cause for workers under 25 years old. In two plants there were extremely low rates for the age group 45 to 64; in the others no pattern was found. After 65 retirement influenced the results markedly. In view of the relatively small coverage of the study, it is not possible to identify any significant differences in the age-separations patterns shown by the various groups. In a larger scale survey, however, it would probably be important to retain the categories used here, in which distinctions are made according to sex, industry, and length of service.

Measures of Job Performance

Four indicators of work performance--output per man-hour, attendance, industrial injuries, and separations--were selected for comparing age groups because they afforded objective measures, and data for them were thought to be directly available from plant records.

Output per man-hour was measured by comparing the average hourly piece-rate earnings of individuals working at the same operation. Many plants which use a piecework system maintain records on individual average hourly earnings. No means were found to measure the output of timeworkers, nor were data available on quality of work produced by individual employees.

Attendance was defined as the ratio of days worked to days scheduled. Although this is a relatively straightforward measure, the lack of uniform and complete plant records created difficulties in deriving attendance rates.

Industrial injuries. Serious problems were encountered in measuring industrial injuries. Differences in recordkeeping practices of plants, particularly with respect to nondisabling injuries and the frequent lack of data on total hours worked by individuals for as long as a year were the most serious. Moreover, the extremely low incidence of injuries would have necessitated the collection of data for a long period of time. This was found to be prohibitive within the time and funds available for this study, and therefore the data provide no injury rates by age for the plants covered.

Separations. Some plants did not maintain detailed records of quits, layoffs, and discharges. Problems were also encountered in distinguishing separations from extended absences. The records available were so varied in detail that it was found possible to present illustrative findings for only four of the plants.

Statistical Methods

Since the data collected in the plants pertained only to individual workers, it was necessary to apply some process which would lead to findings of a more general nature. This was done in the following way:

Each worker was classified by age, into one of six groups. The workers were then further classified into groups by characteristics which might be related to work performance, such as sex, plant where employed, occupation, and length of experience. The particular characteristics employed as criteria varied with the measure sought; the purpose, in each instance, was to group together the workers who could be considered homogeneous with respect to the non-age factors affecting the measure under consideration. Direct comparisons were made among individuals within these groups. For output per man-hour each occupation was treated separately, since it was believed that the nature of the specific occupation has a bearing on output. For attendance, on the other hand, it was felt that the specific occupation of a worker would have little influence on his attendance rate but that the general earnings level of his job might affect it.

In analyzing data for workers within one of these homogeneous groupings, any difference in performance among age groups can be more clearly related to age. These differences were measured by calculating indexes for each age group average, with the 35-44 year group as the base. This was done separately for output per man-hour, attendance, and separations.

Through the use of indexes and the classification system, the influence of non-age factors was substantially eliminated, since each worker was being compared only with other workers who had these factors in common with him. The indexes could then be combined to obtain larger groupings by averaging the indexes, with each component of the average being assigned a weight which depended on the number of individuals represented.

* * * *

The present study has clarified and solved some of the most important problems that must be faced in objectively measuring the relationship of age to work performance.

Information about the availability and adequacy of plant records was obtained and procedures were developed for obtaining data.

A means was found for comparing the performance of workers in different occupations.

Methods were devised for appropriately combining data into larger aggregations in order that more general and more reliable conclusions could be obtained.

The results shown in this report although not furnishing conclusive answers to the question with which it deals, represents an important preliminary step toward further work in this area.

Purpose and Scope of Survey

How age affects work performance is a subject on which little factual information is available. Nevertheless, the belief that work performance declines as age increases is widespread, and constitutes one of the most important barriers to the employment of older workers. Studies of employers' attitudes toward older workers have consistently shown that this belief is one of the reasons most frequently cited for failing to hire older workers.

The Temple University Bureau of Economics and Business Research conducted a study in conjunction with the Pennsylvania Bureau of Employment Security, the results of which were reported in 1953 at the Second Conference on the Problems of Making a Living While Growing Old. In response to the question "What factors in your view tend to limit the feasibility of hiring older workers?" the survey found that companies offered a variety of reasons for restricting the hiring of older workers, but the most important of the reasons given were "rate and quality of production." 1/

Similarly, in the Employment Security Review of December 1950, it was reported that "several surveys conducted by the Bureau of Employment Security in cooperation with affiliated State agencies reveal that the reasons most frequently given for not hiring older workers are: (1) Fear the hiring of older workers would increase workmen's compensation and insurance costs, (2) less productive and unable to meet physical requirements, (3) greater injury rates, (4) difficulty in retraining, and (5) promotion from within policies. 2/ 3/

Consequently, it is believed that data on job performance by age can be used to test, within selected occupational areas, whether these notions are in fact valid. The results obtained can provide additional information for employers and may indicate in what occupational areas there are real problems.

1/ Millard E. Gladfelter, provost and vice president of Temple University, Age and Employability in Pennsylvania (in Proceedings of the Second Conference on the Problem of Making a Living While Growing Old). Commonwealth of Pennsylvania and Temple University, 1953 (p. 27 and table XII, p. 398).

2/ William Mirengoff, Older Worker Employment - Benefit or Burden, Employment Security Review, December 1950 (p. 9).

3/ Similar findings regarding the importance of employers' attitudes on work performance as a barrier to the employment of older workers can be found in other studies. See, e.g., The Employer and the Older Worker by the Personnel Club of New York (in Making the Years Count), New York State Joint Legislative Committee on Problems of Aging, Legislative Document 32, 1955 (p. 88); also Personnel Policy and Older Workers--an Overview by Lazare Teper, Director of Research, International Ladies' Garment Workers' Union (in Age Barriers to Employment, Proceedings of the Third Joint Conference on The Problem of Making a Living While Growing Old, 1954 (p. 45); and New York State Legislature, No Time to Grow Old. New York State Legislature Document 12 of 1951 (p. 115).

Before this study of on-the-job performance data for production workers in manufacturing establishments was undertaken, it was recognized that many methodological problems existed and the techniques used in other studies of the performance of workers did not apply directly to the special needs of the current investigation.

The methodological problems which were recognized affected each of the three important areas in this research--selection of appropriate performance indicators, techniques of data collection, and statistical methods. It was determined, therefore, the present study would aim at providing the tools necessary for future work in this field, rather than accumulating extensive data through less refined methods. Consequently, the current work was designed as a pilot investigation of relationships which might exist between work performance and age, but data obtained were not expected to furnish definitive results for testing general notions about older and younger workers.

More specifically, the objectives of the current study were to: (1) Determine which of the available indicators could be utilized to compare the job performance of workers of different ages, (2) establish and refine procedures for collecting data on these indicators, (3) devise statistical techniques for developing valid measures of job performance, and (4) if possible, present findings of the current study on any observed relationships between age and work performance for the limited number of plants studied.

How to Obtain Performance Data

Information on the comparative performance of individuals of different ages can be obtained in various ways. Past studies on work performance and age are of three general types--laboratory experimental studies, opinion surveys based on supervisors' ratings, and investigation of on-the-job performance derived from company records.

The laboratory studies generally deal with specific physical or psychological characteristics, such as manual dexterity, strength of grip, and learning ability. 4/ These studies are valuable for providing insight into the mechanics of the aging process. However, they are of limited applicability to actual job performance, since they do not take into account the complex interactions of innumerable physical and psychological characteristics, nor

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4/ See, e.g., A. J. Welford, Skill and Age, an Experimental Approach, published for the Trustees of the Nuffield Foundation by Oxford University Press, 1951. W. R. Miles, Psychological Aspects of Aging, Chapter 28 in E. V. Cowdry's Problems of Aging. Baltimore, Williams and Wilkens, 1939.

of environmental factors. Moreover, job performance is not a static concept, but represents rather the continuing operation of all specific factors of which it is composed. Most laboratory studies, on the other hand, can only reflect observations made over a short period of time.

The opinion surveys in which employers and foremen are asked for their evaluation of workers' performance suffer from the shortcomings of subjectivity and a lack of standardization in the criteria employed.

The job performance studies using plant records have the advantage of being objective and reflecting the results of all factors in the job situation. But adequate analysis requires output records by age for a substantial number of employees engaged in similar jobs. It also requires the selection for study of jobs in which speed is governed by the workers themselves.

The difficulty of obtaining such data limits the number and scope of these surveys considerably. It is, however, this type of study, which is most useful as an evaluation of the comparative on-the-job performance of employees of different ages. 5/

5/ One such study was conducted for the Bureau in 1939 covering some textile plants and nonferrous foundries in New England. See Influence of Aging on Employment Opportunities, Monthly Labor Review, April 1939 (pp. 765-780).

Another study of the relationship between age and productivity of production workers in cigar factories was developed in the Bureau. See Individual Productivity Differences, BLS Serial No. R. 1040, February 1940 (pp. 1-22).

For another Bureau study of performance and age, see Absenteeism and Injury Experience of Older Workers, Monthly Labor Review, July 1948 (pp. 16-19).

Indicators of Work Performance: Definitions and Methods of Measurement

Work performance is an inclusive term covering many aspects of an individual's work activity. In selecting appropriate indicators of work performance for comparing workers of different ages, the following criteria were applied:

1. The indicators must be objectively measurable;
2. They must be clearly definable;
3. They must be workable in terms of both collection techniques and subsequent processing; and
4. They must be amenable to the drawing of practical conclusions.

Discussions with plant and union officials and examination of plant records narrowed the choice to four indicators of job performance. These were output per man-hour, attendance, industrial injuries, and separations. Other indicators, such as quality of output, dependability, and versatility, were found lacking in at least one of the above criteria.

Output Per Man-Hour

Basic to any evaluation of a worker's performance is his productivity. The definition of productivity used in this investigation is his physical volume of production per hour worked, i.e. his output per man-hour. This is probably the most familiar of the various aspects of an individual's productivity and is also the aspect in which greatest interest is centered.

A necessary step in measuring an individual's output per man-hour is to reduce to common units the various products he may produce. Where an individual is engaged in one process in the manufacture of one product, his productivity is simply the number of physical units of product he produces during 1 hour. Where an individual works on a number of products, however, there is a choice available for measuring his physical output. His output can be measured as the total value of all units he produced. In this case his productivity is the dollar value of his physical production. This value can be measured in terms of various prices, but the price of most immediate practical application would be the one relating to the factory cost per unit of product.

The worker's output can also be measured as the total "normal" production time represented by his physical production. In this case his productivity is the total production time equivalents he produced per hour. These time equivalents could be determined from standards based on time studies. However, it is usually not possible to obtain time rates for all operations on all products in a plant since some plants conduct studies of selected operations only and most plants are reluctant to furnish the time standards they use for various operations. In addition, records of the actual number of units of each product produced by individual workers are not readily available in most plants. Consequently, although this measure of output would be desirable, as a practical matter an alternative measure must be selected.

An approximation to measuring output in terms of production time is to use piecework earnings per hour. Here, the assumption is made that the task performed on a particular product is related, by its piece rate, to the time required to perform the job. For example, where a worker performs the same operation on a variety of products, any difference in the time normally required to complete the operation on the various products would tend to be reflected in the various piece rates paid for the products.

This assumption was supported by information obtained from company officials in the plants visited. It was pointed out that time required to perform a job enters into most piece-rate formulas. In those cases where piece rates might be inaccurate in terms of time required for work on a given model, each worker tended to be alert to these differences and would insist on receiving an equitable share of the more desirable models. In any case, it can be expected that any inaccuracy in the data originated in this way will be of a random nature and will not affect one age group more seriously than another.

Output per man-hour was measured, then, by average straight-time hourly piecework earnings during the period surveyed. All earnings on overtime work or holiday work were adjusted to straight-time levels by removing premium earnings. Similarly, all timework earnings were removed from the earnings of individuals who worked both on piecework and timework during the survey period.

The man-hours included refer only to those hours actually worked in the production of the output. Thus, all vacation hours, paid holidays and other time paid for but not worked, as well as all hours spent on timework, were excluded from the hours counted.

In order to use average hourly earnings as a measurement of output per man-hour, it is necessary to insure that there are no special restrictions affecting piecework earnings. Therefore, in the exploratory work, certain jobs were excluded for which management imposed a limit on earnings in order to maintain high quality standards. 6/

Limitations of Comparing Employed Pieceworkers. It is recognized that the performance of pieceworkers may not be entirely representative of all production workers. Some of the factors influencing the productivity of pieceworkers in a specific age group may be different from those influencing the productivity of all production workers in that age group.

For example, the particular jobs classified as piece-rate jobs may place greater emphasis on speed, dexterity, and other characteristics which are affected by aging. Performance measures limited to these occupations may

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6/ In the plants visited these limits were expressed in terms of a maximum number of units produced daily.

result in a comparison unfavorable to older workers. Despite this possibility, however, it is important for those plants where the majority of the production workers are paid on piece rates (or some other form of individual incentive system) to have information on the comparative job performance by age group.

It may also be argued that since only employed persons were included in the study, the older workers who are still present in the occupations studied actually represent a selected group, since many of the younger persons will have gone into other occupations which were not included in the study. However, there are actually two types of selection operating here, which may be expected to cancel each other out to some extent. In the first instance, the exceptionally superior workers may be assumed to have gone into better paying occupations. At the same time, the marginal workers, who could not maintain the minimum standards required for their jobs, would also have left to enter other occupations. Thus, the older workers' average output rates would be influenced by the removal of these two extremes, and, therefore, would be logically comparable with those of the younger groups.

There are no lifetime job histories of workers in the industries studied which show the extent to which workers enter either as time or piece-rate workers and move from one type of work with its associated pay procedure to another over their life span, or the extent of movement from production to supervisory or entrepreneurial work on the one hand, and to custodial jobs on the other. Therefore, it was not possible, within the scope of the present study, to determine the extent these situations prevail in the plants surveyed. Since their effects are offsetting, the net result is not believed to be very great.

Observation Period. The observation period selected for output per man-hour measurement ranged from 4 to 8 weeks. This is a compromise between a period of maximum length, which would tend to even out atypical influences of a temporary nature, and a very short period, which would permit the inclusion of a large number of individuals (since the samples included only those employees who were working during all or nearly all of the observation period).

A period of full production was chosen for observation in order to minimize any influence from individuals sharing work, which often occurs during slack periods. There is, of course, the possibility that during periods of full production the incentive for individuals to maximize production is reduced after a certain earnings level is attained. Should this influence affect age groups differently, the measure would reflect not only any relationship which existed between productivity and age, but other factors as well.

Groups for Direct Comparison. In order to compare job performance by age, the influence of factors other than age must, of course, be eliminated. This means that comparisons must be limited to individuals who are similar in many respects and who are exposed to the same working conditions. In the case of productivity, as measured by average piecework hourly earnings, direct comparisons can be made only among workers with a similar degree of experience

on the same specific job within a plant. If the basic cells are widened and workers on different jobs or on the same job in different plants are compared directly, extraneous factors such as differences in pay scales, machinery used, and job requirements will be introduced. In that case differences in productivity between age groups could be the result of the influence of these factors rather than age.

During the pilot work, direct comparisons were made only among individuals of the same sex who were performing the same job or series of operations within a plant. Job titles from personnel records alone were not used to determine a worker's occupation because these records generally do not describe the operations an individual performs. The titles listed in the personnel records for individuals were compared with those entered on the payroll records for consistency. Appropriate plant officials were also consulted as to whether individuals were in fact performing the same operations.

To avoid comparisons between fully experienced workers and beginners, employees with less than 6 months' service in a job were excluded from the output per man-hour sample. It was not always possible because of the limitation of plant records, to detect the employees who, while meeting the minimum service requirements, had been transferred from some other job. In addition, the learning curve for some occupations will continue to rise for a longer period than 6 months. On the other hand, a considerable portion of new employees may have had previous experience elsewhere.

Attendance

Attendance, for purposes of this study, has been defined as the ratio of the number of days an individual is present to the number of days he is scheduled to work. An individual was considered absent when he was away from the job for a full day or more at his own initiative. Layoffs, holidays, shutdowns, and regular vacations were not counted either as days absent or days scheduled.

Most difficulties in obtaining adequate attendance data related to limitation of plant records. Of the plants surveyed, only one maintained individual absenteeism records. For the remaining plants, it was necessary to reconstruct individual records of attendance from daily timecards.

Timecard data, however, do not usually distinguish between absence which is due to production layoff and absence at the employee's initiative. To make this distinction, the daily attendance records for individuals were compared, and where a significant proportion of workers in an occupation were absent for an identical period, they were assumed absent as a result of a production layoff. By using a period of full production as the observation period for attendance the influence of production layoffs was believed to be minimized.

It is also difficult in some cases to distinguish extended absences from separations. Company practices vary as to the length of time an absent worker is carried on the rolls. Some companies consider an individual separated after

1 week of absence and drop him from their records; other companies maintain an employee on the current rolls until he has been gone for a considerable length of time or until he informs them definitely that he is not coming back. In order to obtain a consistent measure for all plants in the pilot work, company payroll records were compared over a period of time to determine when an individual on extended absence could be considered separated.

Observation Period. For attendance, as in the case of output per man-hour, the observation period must be long enough to avoid atypical situations. Seasonal factors, such as particular sport seasons, may affect the attendance of individuals in various age groups differently. Any measure limited to such periods does not necessarily yield representative results. A period ranging from 8 to 12 weeks during which it was believed seasonal factors would be minimal was selected for study. Parts of that period coincided with the observation period for output per man-hour.

Groups for Direct Comparison. In contrast to output per man-hour, the attendance rates of individuals in specific occupations were believed to be directly comparable, yet there are some occupational characteristics which no doubt influence attendance. It is probable that persons in lower paid occupations may have different attendance motivations from those in higher paid occupations and attendance comparisons by age, ignoring these differences, might then reflect the influence of the occupational concentration rather than age.

To obtain attendance comparisons which reflect the influence of age alone, only individuals of the same sex in the plant on the same system of payment and in the same occupational earnings level were directly compared. 7/

Industrial Injuries

Nondisabling and disabling injuries were selected for study in this exploratory work. Although sufficient data could not be obtained in the actual collection because of the limited coverage, many of the problems in deriving these indicators from existing plant data were examined.

Nondisabling Injuries. A nondisabling injury was defined as an injury experienced in the course of an individual's work which did not involve the loss of a full day or more. Although the definition appears relatively straightforward, three major problems present themselves when attempting to derive a measure of the frequency rate of nondisabling injuries: First, plant definitions of work-connected and nonwork-connected injuries vary. Plants with broad overall medical programs for their workers do not make the same distinctions as plants with limited medical programs. Second, plant

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7/ The basis for classifying higher and lower paid occupations in this study is explained in a later section. (See pp. 47-48.)

requirements with respect to the immediate treatment for nondisabling injuries are by no means uniform. These requirements are also usually related to the type of general medical care program provided as well as safety practices and policies employed in the plant. Third, plant practices for recording nondisabling injuries vary considerably. Some plants record all minor injuries whereas others record only the major ones. Should these differences between plant practices affect age groups differently, the validity of any nondisabling injury comparisons between age groups is reduced. It is doubtful, because of these limitations, that nondisabling injuries can be used as an indicator of comparative work performance.

Disabling Injuries. A disabling injury was defined as an injury experienced in the course of an individual's work for which a day or more of worktime was lost. In this case, company practices concerning the definition and recording of disabling injuries are much more uniform. Workmen's compensation reports generally furnish standard information, and these reports are similar for the various States. The definition of a disabling injury is usually the same for most plants.

On the other hand, the incidence of disabling injuries for a given exposure period is much lower than that of nondisabling injuries so that a very large sample of observations is necessary to avoid unreliable comparisons. This need for a large sample of observations limits the use of this indicator to very large plants or to very long observation periods.

Where industrial injury data are available, three measures can be used for making age group comparisons--the frequency rate, the severity rate (number of hours lost during an exposure period), and the average severity (number of hours lost per injury).

Observation Period. The observation period for the injury measure must, of necessity, be longer than for either the output per man-hour or attendance measure. Because of the relatively small incidence for all age groups, it is necessary to insure that any lack of incidence is not merely the result of selecting a short survey period.

As mentioned above, the injury measures require data on the number of hours worked (the exposure hours) during the observation period. Data on hours worked by individuals over long periods are often difficult to obtain. Most plants surveyed in the exploratory work did not maintain summaries of hours worked by individuals over periods longer than 2 weeks. In these cases, it was necessary to derive the total number of hours worked from weekly timecards. This is quite time consuming and costly, especially for an extended injury period, and it was found to be prohibitive in this investigation for periods longer than 1 year. Yet, except for very large plants, a 1-year period does not furnish sufficient data to permit meaningful comparisons by age group.

Individual exposure hours data can be estimated from other plant records, but these procedures may involve assumptions which are not necessarily valid. One procedure attempted in the pilot work involved dividing the annual earnings of individuals by the average straight-time earnings for a representative period. However, use of this method is limited to periods during which individuals in different age groups share equally in overtime work.

Groups for Direct Comparison. The fundamental consideration in making an analysis of injury by age group is to insure that direct comparisons are made among workers subjected to equal injury hazards. It is, however, virtually impossible to classify each worker according to injury hazard. In this investigation an attempt was made to derive direct comparisons between age groups for workers classified according to the following characteristics: sex, hand or machine operations, department and plant, as an approximation to equalizing hazard.

Separations

Separations as defined in this survey include quits, discharges for cause, retirement, death, and military service among production workers. Excluded are separations for the convenience of the employer such as layoffs.

The measure obtained is the ratio of the number of separations to the total number of production workers in different age groups. This measure attempts to ascertain how many of a group of workers employed in the plant on a given date were separated in the following year. It was selected as a performance indicator because it is, to a certain extent, a measurable reflection of the stability of groups of workers.

As mentioned above, plant records sometimes do not distinguish extended absences from separations, but by comparing current and past payrolls, it is possible to obtain an indication of whether a separation did in fact take place. Information on reasons for leaving, however, is not as readily available. Several approaches were attempted including interviews with foremen, but because of the possibility of lapse of memory on the part of foremen, only those plants which recorded specific reasons for separations were included. Four of the plants surveyed during the pilot work maintained such records.

Groups for Direct Comparison. Separations are usually greater among a group of relatively new employees than a group of workers with long years of service. Company pension programs, community ties, and other factors may influence the decision of an employee with long years of service to remain with a company, whereas a new employee may not be as strongly affected by such factors. Similarly, differences in plant policies will also affect production workers of age groups differently.

The influence of these factors was taken into account in designing the basic divisions within which comparisons between age groups could be made. Within each plant, production workers of the same sex were divided into groups with more than 2 years' and less than 2 years' service. It was believed that these classifications would reduce the influence of factors other than age and at the same time afford sufficient observations to warrant meaningful comparisons.

Industry and Plant Selection

Because statistics on the performance indicators are more readily available from firms engaged in manufacturing than from nonmanufacturing establishments, this initial examination was limited to manufacturing industries. Within manufacturing, however, it was possible to examine plants within only two industries because of the limited resources of the pilot study.

Several criteria were used to select the industries within which plants were surveyed. A large proportion of employees over 45 years of age to total employees, the existence of some form of individual incentive payments in most plants in the industry, and the importance of the industry in terms of number of workers employed were among the factors taken into consideration.

It was believed that industries with a large proportion of employees over 45 would include plants employing a sufficient number of employees in the older age groups as well as younger age groups to afford useful comparisons. As mentioned above, the use of individual incentive system of payments is necessary in determining individual output data.

The footwear and men's clothing industries were selected for study from the industries meeting these requirements. According to the 1950 Census Bureau Report on Industrial Characteristics, 32.5 percent of all employees in the footwear industry and 33.1 percent in the apparel and fabricated textile products industry were 45 years of age and over. In all manufacturing industries the percentage was 31.1 Since the men's clothing industry is one of the most important segments of the apparel group and has a more balanced distribution between male and female employees than other apparel industries, it was selected as the specific industry to be examined.

Each of these industries is characterized also by incentive systems of payment for production workers. According to the Bureau of Labor Statistics' survey in 1946 on the extent of incentive pay in selected manufacturing industries, 89 percent of 347 footwear plants studied and 85 percent of plants manufacturing apparel had incentive systems of payment. 8/ Similarly, 65 percent of all production workers studied in the apparel industry and 69 percent of all workers studied in the footwear industry were on incentive pay. 9/ Most of the incentive plans were individual plans (usually straight piecework) affording measures of individual output.

8/ Incentive Pay in American Industry, 1945-46, Monthly Labor Review, November 1947 (pp. 535-538).

9/ Idem.

The geographical concentration of these industries made it possible to limit plant visits during the pilot work to the New England and Middle Atlantic regions. In 1954, 69 percent of all establishments in the United States manufacturing men's suits and coats employing 60 percent of the total production workers were located in these regions. In fact, over two-fifths (41 percent) of the establishments and one-fourth of the production workers in the industry were in one State, New York. Of the 1,200 footwear establishments in the United States in 1954, approximately 60 percent were located in these regions, with 55 percent of the total production workers in the industry. In this industry more than 36 percent of the establishments and 29 percent of total production workers were located in Massachusetts and New York. 10/ Although there may have been some changes in the geographical composition of these industries since 1954, it is doubtful that any marked shift has occurred.

Plants were selected for study from a list of establishments in these industries, in the regions mentioned. Only large-size plants with persons in all age groups doing the same work could furnish adequate comparisons. Consequently, plants which had more than 400 production workers were included. All these requirements resulted in a limited number of plants from which the sample could be drawn. Selection of the plants surveyed was not made by a random process. Visits were made to plants about which the Bureau had some knowledge concerning the nature of the records and the total number and distribution of employees, by sex. The main emphasis of the work was testing tentative questionnaires and developing measurement techniques. During the pilot work 10 plants were visited, 2 of which were eliminated from the sample--1 because it employed only a small number of piecewerkers, and the other because it maintained inadequate plant records for this study.

10/ U. S. Bureau of the Census, Advance Report, 1954 Census of Manufactures.

Data Collection Procedures

The amount and complexity of the information to be obtained from the plants for this study precluded conducting a mail survey. The loss of control over the type of data collected in a mail survey would seriously limit the accuracy of any derived results. In addition, the length of time required for the participating establishment to assemble and furnish the data would reduce the chances for cooperation. In many cases, the nature of plant records would not permit assembling the data directly but would require deriving the information from a variety of sources usually maintained for other purposes. Consequently, personal visits by trained agents were required. All data obtained in this investigation were collected by project staff visiting the plants. On the average, the time needed to obtain the data for a plant employing 500 piece-rate workers was about one man-month.

A schedule for collecting the data was developed and tested in the plants visited. 11/ It consisted of two parts--a questionnaire and a set of standardized worksheets. The questionnaire requested information of a general nature concerning the records and placement procedures of the plant. Answers to the items on the questionnaire permitted the agent to select (within certain limits) the appropriate period for study and furnished a guide to the particular record sources in the plant which should be examined in order to derive the required data.

The questions on placement procedures were developed to ascertain, if possible, some of the factors which might be associated with different results from different plants. A plant which had physical, aptitude, and job examinations as well as specific programs for retraining and reassignment might well have a distinctly different pattern of job performance and age relationships from another lacking such procedures. None of the plants included in the pilot investigation had specific programs along these lines.

The worksheets were designed for recording personnel information and data on each of the performance measures separately for each individual. They were constructed for use in either machine or hand processing of the data, and were adaptable to different types of plant records. In the exploratory work various forms were attempted and it was found that the use of a separate card for each worker was the most efficient procedure for transcribing the data from company records.

Worksheet 1 (see p. 66) was the basic worksheet on which data for all measures were recorded. It consists of four major sections covering personnel information, earnings data, attendance, and industrial injury data generally derived from different sets of records. Personnel and separations data were usually available from personnel records although occupational titles were not necessarily accurate. Earnings and hours data were usually available

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11/ A copy of this schedule with accompanying instructions for agents is reproduced in the appendix of this report.

directly from payroll and production records, but in order to obtain information on only piecework hours and earnings, it was sometimes necessary to compute the straight-time piecework earnings of each individual from the daily piece tickets turned in during the survey period. Attendance data (days worked and days scheduled) usually had to be computed from individual timecards. Nondisabling injury data were available from dispensary or nurse's records where they existed. Disabling injury data could be derived from workmen's compensation records.

Worksheet 2 (see p. 67) was developed to supplement the productivity information obtained on worksheet 1. It was designed to test, if possible, the relationship between piece rates on various products with standard times. During the pilot work, it was hoped that the additional detail would be useful especially when individuals performed a variety of operations on many products. It was not possible, however, during the pilot work to obtain information on worksheet 2 and the statistical results reported here were derived entirely from data recorded on worksheet 1.

Statistical Methods

The statistical procedures applied to the raw data were, in essence, those necessary for combining a large number of individual observations into broader findings. The results of the study were intended to show:

1. The performance of several age groups as compared with each other;
2. Any differences in the influence of age on the performance of men and women in various types of jobs and industries; and
3. Individual variation in the performance of workers.

The information recorded during the plant visits would not yield these results unless the raw data were processed further. The procedures used for the four types of performance indicators, although similar, were not identical and are presented separately for each indicator. Prior to discussing the particular methods applied, it might be well to indicate the age groups which were selected for comparison.

Age Groups

In order to secure results of maximum precision, it would have been desirable to classify workers in narrowly defined age groups. Classification of workers in 5-year age groups was attempted for this study but the sample was too small to yield meaningful results. Consequently, for all of the performance measures, workers were classified into 10-year age groups. These were under 25, 25-34, 35-44, 45-54, 55-64, and 65 and over. In a larger scale survey, the use of 5-year groups might prove feasible.

Output Per Man-Hour

As mentioned earlier, in order to obtain meaningful measures of output per man-hour, the basic groups for direct comparison consisted of experienced employees of the same sex working at the same specific occupation in a plant. Each of the plants surveyed, however, was characterized by a large number of different occupations with relatively few individuals in each occupation. In many occupations, only 2 or 3 of the age groups were represented. Therefore, if all comparisons had been made only between individuals in the same occupations, the results would have been extremely limited.

It was necessary to apply some procedure which would convert the output per man-hour scores (average hourly piecework earnings) of workers in specific occupations into some measure which would, thereafter, be entirely independent of the particular occupation in which the workers were found.

The procedure adopted consisted of converting each output score for workers in the same occupation into an index. The 35-44 age group for the occupation was assigned an index of 100, and the index of each of the other age groups was simply the ratio of the average score of that age group to the

average score of the 35-44 year group. 12/ Thus, a comparable measure was derived for each age group, each measure reflecting the relative performance of a given age group as compared with the corresponding 35-44 year group. By transforming the scores of age groups into indexes, the possible distorting influence of variations in absolute pay levels in different operations or in different plants was eliminated. The measures could now be treated as a homogeneous group of indicators, and it was no longer necessary to be concerned with actual scores of individuals, nor the plant in which they worked.

Occupational Groups. The indexes, up to this point, represented only output measures of workers in specific occupations within plants. In order to derive results which would reflect larger numbers of individuals than were available in these fine occupations, some means had to be found for combining the indexes. This was done by establishing occupational groups in which the effect of factors other than age could be expected to be fairly uniform for all age groups.

In summarizing the data, indexes for workers in specific occupations were grouped according to the following characteristics:

1. Sex;
2. Hand or machine occupations 13/;
3. Higher or lower paid occupations 13/; and
4. Industry.

If these distinctions had not been made, then differences between the index of one age group and another might be due, in part, to the different distribution of these characteristics in the two age groups. Consequently, through the use of these classifications, valid comparisons among age groups could be obtained.

Procedure for Combining Indexes of Specific Occupations. As mentioned above, each of the age group indexes for the specific occupations was derived from the scores of individuals in a particular age group and the corresponding base group within a single plant. Some were based on a very small number of individuals in both the age and base groups whereas others represented larger groups. In combining the age group indexes for a specific occupation to obtain a measure for an occupational group, it was necessary to assign a weight to each index reflecting its relative importance in the measure for the occupational group. This weighting procedure took into account the number of workers in the age group as well as the number of workers in the base group for each occupation. 14/

12/ A procedure was also applied which permitted the use of the 25-34 year group transformed to the 35-44 year group as the base. This method enabled the use of more observations. It is described more fully in the appendix. (See p. 49.)

13/ The basis for classifying occupations into higher or lower paid and hand or machine operations is discussed in the appendix. (See pp. 47-48.)

14/ The formula for these weights is included in the appendix. (See p.49.

Combining Indexes of Occupational Groups. In addition to indexes for specific and combined occupation groups, it was considered desirable to obtain more generalized indications of the relative performance of the various age groups. For example, age-group indexes were obtained for all male employees in the clothing plants, whether they were working at hand or machine operations, or in higher or lower paid jobs.

In order to derive these indexes a procedure was required to insure that the influence of factors other than age would be constant for all age groups. The simplest method for accomplishing this was to assign, to each occupational group index, a constant weight for all age groups. When combined through the use of these weights, the four occupational groups indexes yielded an index which was not influenced by the shifting proportion of, say, higher and lower paid occupations, from one age group to another. The weighting scheme actually used was based on the total number of workers of all ages within an occupational group.

Individual Variation. As mentioned earlier, one of the purposes of this study, in addition to measuring the relationships between age and work performance was to determine the extent of individual variation within each age group. It is important to know whether the index derived for a particular age group reflected the performance of individuals whose output scores showed considerable uniformity, or whether, on the other hand, their scores varied widely about the average for that group. An employer, for example, would logically give greater consideration to the characteristics of an individual applicant rather than to his age, if he knew that performance differences between age groups is less than the individual variation in any one age group.

The measure of dispersion which was employed reflects the difference between the age group average and the individual scores for each occupation. The actual measure was the coefficient of variation, which is expressed as a percentage of the group score.

As in the case of the age group indexes, the dispersion measures for the specific occupations were combined to obtain a measure for the occupational group. Again, it was desirable to combine these dispersion measures with weights which would reflect their relative importance in the combined measure. In this case, the weight applied took into account only the number of workers in the age group for the occupation.

Similarly, it was considered useful to obtain a dispersion measure for combinations of the occupational groups. The same weighting procedure as used in combining the indexes of output per man-hour for the specific occupations was employed.

Attendance

As noted above, the basic group in the attendance comparisons was not the specific occupation, as in the case of output per man-hour, but rather the type of occupation (higher or lower paid). It was believed that in the two industries covered the specific occupation had little bearing on the attendance rate of an employee. Thus, to obtain comparable attendance rates for the various age groups, individuals were grouped according to sex, plant, and occupational earnings level.

For each of these classifications, age group indexes were derived by dividing the average attendance rate for an age group by the average rate of the 35-44 year group. 15/ In this case, as in output per man-hour, a common measure was derived from all rates reflecting the relative performance of a given age group as compared with the corresponding 35-44 year group.

This approach yielded indexes which included a considerably larger number of workers than those obtained from single occupations in the output per man-hour indexes. However, each of these series referred to individual plants. What was desired were results which would cover broader groups. Therefore, plant attendance indexes for each age group were combined in a manner similar to that used for combining output per man-hour indexes for specific occupations. The weight assigned to each plant in this case took into account the number of workers in the age group, the number of workers in the base group, and the number of scheduled workdays of the survey period. 16/

It was also considered useful to derive attendance measures for a combination of these groups. These, like the combinations of output per man-hour occupational groups, required a weighting procedure which would not permit the influence of factors other than age to enter into the measure. A similar fixed weighting system was employed which assigned the same weight to each age group index pertaining to the same earnings level.

Dispersion measures were not calculated for attendance, since it became evident at an early stage that such measures would have limited usefulness. The average attendance rate was very close to the maximum attainable rate (100 percent) indicating there could be only small differences in magnitude above the average.

15/ A procedure similar to that employed for the output per man-hour indexes making use of the 25-34 group in addition to the 35-44 year group was carried out here. For details of the procedure, see appendix p. 49.

16/ The formula for this weight is shown in the appendix. (See p. 49.)

Industrial Injuries

In order to minimize the influence of factors other than age, as noted earlier, basic comparisons of injury experience should be made among individuals of the same sex within the same plant performing the same type of operations (hand or machine). An attempt was made to draw such comparisons. However, industrial injuries occur infrequently and to draw such comparisons either a large number of workers or a long observation period for a smaller number of workers would be required. In the plants surveyed there had been no injuries in many age groups. These groups, therefore, had injury rates of zero. The use of age group indexes, consequently, was found to be impracticable because base groups for several series had zero injury rates. Even if there had been injury incidence in all base groups, comparisons with zero rates for other age groups would be misleading since, given a longer period of observation or a large number of workers, it is probable that a zero rate would not occur.

In view of the extremely limited nature of the data obtained, only the incidence of injuries for several of the plants visited rather than the indexes, are shown in this report. These are included for illustrative purposes.

Separations

The basic groups for comparison were established in terms of plant, sex, and length of service, and age group indexes were derived. As in the case of output per man-hour and attendance, the age group separation rates were related to the separation rate for the corresponding 35-44 year age group.

Combinations were made of indexes of each of the basic comparison groups in a manner similar to that used for the other measures. The weight applied to each index took into account the number of workers in the age group, the number of workers in the base group, and the length of the separation observation period in the plant.

Separations, like injuries, occur infrequently, and consequently, require a greater number of observations for adequate measures than productivity or attendance. Since the separations data obtained in this survey were very limited, the indexes shown are primarily illustrative.

Findings in the Plants Surveyed

The measures of work performance included here were derived from data obtained in plants visited during the exploratory work. The results show performance by age group only for the plants surveyed, and generalizations should not be drawn with respect to the two industries included in the samples. In addition to the smallness of the sample, the method of plant selection did not attempt to achieve industry representativeness. It was not the purpose of this investigation to compile statistics which would provide definitive results for the two industries, although certain limited findings were anticipated. As indicated elsewhere in this report, the main emphasis was on developing performance indicators and testing measurement techniques.

The findings presented here reflect the experience of piece-rate production workers employed in 4 plants in the men's clothing industry and 4 plants in the footwear industry. All plants were located in the New England and Middle Atlantic regions and ranged in size from 500 production workers to more than 2,500. Data for selected periods in 1955 were collected. The periods chosen were those of substantially full production in the plants studied.

Output Per Man-Hour

Output per man-hour data were obtained for 2,217 production workers--933 in the footwear plants and 1,284 in the clothing plants. Separate results are shown for men and women employed in the two groups of plants (tables 1 and 2). They are further broken down into earnings level groups (tables 3, 4, 5, and 6) and according to hand and machine occupations (tables 7, 8, 9, and 10).

The age span surveyed ranges from under 25 years of age to 65 years and over for the detailed job classifications. For the combined groups, this range was narrowed to the age groups 25 to 65 only, because of the inadequate number of observations which could be obtained in the youngest and oldest age groups in some of the detailed job categories.

Men and Women. The productivity of both male and female pieceworkers in the footwear and clothing plants studied did not vary with age until after age 54 (tables 1 and 2). The small differences between the indexes for age groups under 55 were not statistically significant. After that age the figures for most groups show a decline which, although statistically significant, was not of serious proportions. In no case did the performance of any 55-64 year group fall below 90 percent of the base group index. And one group of older workers (women aged 55-64 in the footwear plants) in fact performed as well as any younger group of women.

The output indexes for men in both the footwear and clothing plants show slight increases between the youngest groups (25-34) and the base groups. These apparent increases, however, are not statistically significant. Similarly, the small differences observed between the base groups and the corresponding 45-54 year groups are not significant. After age 54, the decline noted above occurs.

Table 1.--Indexes of output per man-hour for pieceworkers in four footwear establishments, by sex and age group

(Age group 35-44=100)

Age group 1/	Men			Women		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34.....	94	97.3	18.8	97	100.8	18.2
35-44.....	163	100.0	14.0	164	100.0	14.6
45-54.....	123	97.8	14.0	129	99.0	13.4
55-64.....	98	2/ 92.1	13.3	60	99.6	11.4

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. Cf. table 11.

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 2.--Indexes of output per man-hour for pieceworkers in four clothing establishments, by sex and age group

(Age group 35-44=100)

Age group 1/	Men			Women		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34.....	52	98.6	7.1	100	99.3	22.2
35-44.....	82	100.0	15.0	220	100.0	19.8
45-54.....	51	100.5	14.1	387	98.4	18.2
55-64.....	110	2/ 91.8	20.8	279	2/ 90.2	19.2

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. Cf. table 12.

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Although the output pattern for men is similar in both industries, the patterns for women differ. The indexes for women in the footwear plants show insignificant variation between the age groups. In the clothing plants, however, the indexes for women exhibit a pattern similar to that of the indexes for men--stable output until age 54, after which there is a decline.

In addition to comparing the average productivity of age groups, it is useful to examine the variation in performance among individuals within each age group. The measure of this variation is provided by the coefficient of variation. 17/ As shown in the tables, the coefficients of variation exhibit no pronounced tendency to vary consistently with age. Although the measures for both men and women in the footwear plants decline slightly with age, these differences are small. For the clothing plants, the dispersion measures appear to increase for men after age 34 and again after age 54. They show a slight decline for women after age 34, remaining stable thereafter.

The coefficients do, however, indicate considerable individual variability within age groups. Also, individual dispersion appears to be somewhat greater in the clothing plants than in the shoe plants. The average coefficient of variation for men of all ages in the footwear plants was the same as for women--15 percent. In the clothing plants the average coefficient for all men was 17 percent and for women 19 percent.

When the dispersion measures for the age groups are examined together with the output per man-hour indexes, it is evident that the differences in performance among individuals within age groups are usually more important than differences between age groups. For example, men between the ages of 55 and 64 in the footwear plants had an index of 92 and a dispersion measure of 13 percent, indicating that roughly one-third of the individual scores can be expected to be outside the index values of 104 and 80. More interesting, perhaps, is the inference that approximately 25 percent of the men, aged 55-64

17/ The coefficient of variation is used to express the relative variability of groups of data. It is calculated by dividing the standard deviation by the mean, and indicates the relationship between the value of the mean and the distance from the mean within which a specified proportion of the observationswill lie, if the distribution is approximately normal. For example, if the average index of an age group were 90, and the coefficient of variation 10 percent, then about two-thirds of the indexes would lie between 81.0 and 99.0 (these limits being the mean plus and minus 10 percent of the mean). This assumes, again, that the form of the distribution is not far from normal. There is evidence supporting the view that this will be the case in output per man-hour scores. See Individual Productivity Differences, BLS Serial No. R. 1040, February 1940, (pp. 18 and 19).

in the footwear plants would be expected to produce more than the average produced by the 35-44 year group--the peak performance group. Thus, although in most cases the indexes for the 55-64 year groups are somewhat lower than those for other age groups, the sizable variation observed within all age groups implies that too much emphasis should not be placed on the group indexes as indicators of individual performance.

Insofar as practical implications are concerned, these data suggest that an employer, in considering an applicant for employment, should evaluate the person as an individual rather than attempt to draw conclusions from his chronological age.

Higher and Lower Paid Occupations. The manner in which age is associated with the performance of workers in higher and lower paid jobs is indicated in tables 3, 4, 5, and 6. Since the earnings level of a job often reflects its skill level, differences in the performance of age groups in the two classes of jobs would imply differences in the relationship of age with performance for workers in various skill levels.

Comparisons of workers in higher and lower paid occupations can thus furnish some information regarding the prevailing notion that the performance of skilled workers is less affected by advancing age than is the performance of unskilled workers.

Tables 3 and 4 show that the output indexes for female workers in both higher and lower paid jobs and for male workers in lower paid jobs in the footwear plants were substantially the same for all age groups. None of the indexes shown for these groups were significantly different from 100, according to statistical tests which were applied. In contrast, male workers in higher paid jobs showed declines in the 45-54 and 55-64 year groups which were statistically significant.

Tables 5 and 6 indicate that the index patterns for workers in both higher and lower paid jobs were identical in the clothing plants surveyed. This pattern--performance by the groups 25-54 years which were not significantly different from 100 and somewhat reduced performance by the 55-64 year group--follows the general pattern for men and women described above.

There appears to be no consistent difference in the pattern of the age-productivity relationships between workers in higher and in lower paid occupations. In fact, for all workers in the clothing plants and for women in the shoe plants, age did not affect the productivity of workers in higher paid jobs differently from those in lower paid jobs.

It might be noted that the individual variation within age groups in these classifications did not change consistently with age. For example, the coefficients of variation for male workers in the higher paid jobs in the footwear plants declined with successive age groups, whereas the corresponding coefficients in the clothing plants increased.

Table 3.--Indexes of output per man-hour for men pieceworkers in higher and lower paid occupations in four footwear establishments, by age group

(Age group 35-44=100)

Age group 1/	Higher			Lower		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34 .	61	97.4	17.8	33	96.8	21.9
35-44 .	127	100.0	13.9	36	100.0	14.8
45-54 .	101	2/ 95.6	13.5	3/ 22	3/ 105.7	17.5
55-64 .	77	2/ 90.5	12.9	3/ 21	3/ 97.8	15.2

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. (See table 11.)

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

3/ Includes lower paid machine operations only.

Table 4.--Indexes of output per man-hour for women pieceworkers in higher and lower paid occupations in four footwear establishments, by age group

(Age group 35-44=100)

Age group 1/	Higher			Lower		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34 .	44	100.3	16.7	53	101.1	19.0
35-44 .	62	100.0	11.1	102	100.0	16.4
45-54 .	46	100.0	11.2	83	98.3	14.2
55-64 .	24	96.0	7.6	36	101.9	12.7

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. (See table 11.)

Table 5.--Indexes of output per man-hour for men pieceworkers in higher and lower paid occupations in four clothing establishments, by age group

(Age group 35-44=100)

Age group 1/	Higher			Lower		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34.....	2/27	2/100.6	5.8	25	96.6	8.9
35-44.....	49	100.0	14.6	33	100.0	15.7
45-54.....	35	96.2	14.5	16	105.4	12.5
55-64.....	45	3/ 93.0	18.5	65	3/ 90.3	21.7

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. (See table 12.)
2/ Includes higher paid machine operations only.
3/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 6.--Indexes of output per man-hour for women pieceworkers in higher and lower paid occupations in four clothing establishments, by age group

(Age group 35-44=100)

Age group 1/	Higher			Lower		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34.....	20	95.5	15.4	80	100.8	22.8
35-44.....	67	100.0	12.3	153	100.0	21.8
45-54.....	119	96.1	15.7	268	99.2	19.2
55-64.....	67	2/ 89.9	15.3	212	2/ 90.3	20.2

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient. (See table 12.)
2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Consequently, variation within age groups again must be viewed in terms of its magnitude rather than in terms of its relationship to age. As noted earlier, the considerable degree of variation evidenced means that even though a decline in average performance after age 54 was observed, there are many workers aged 55-64 whose performance equaled or even surpassed the average performance of younger groups.

One difference between the variation within age groups for workers in higher paid jobs and for workers in lower paid jobs is apparent. The variation was, on the average, slightly greater among workers in lower paid jobs than among those in higher paid jobs, indicating more individual differences in productivity in less skilled occupations.

Machine and Hand Occupations. Because the nature of machine work differs substantially from that of handwork, data are presented to shed light on the question of whether age affects the performance of workers in the one type of operation more than in the other.

The same general picture of stability until age 54 and some decline thereafter is evident in the machine-hand comparisions (tables 7, 8, 9, and 10). There were exceptions, however. The indexes for male handworkers aged 55-64, although apparently lower in both industries, were found not to be significantly different from the indexes for other age groups. At the same time, the apparent increase in the index for female machine operators in the shoe plants was also found not to be statistically significant (table 8).

One interesting difference between hand and machine operators in the footwear plants should be noted; the index for male machine operators aged 25-34 is significantly lower than that for the 35-44 year group. The indexes for both male and female handworkers aged 25-34 are significantly higher than those for the corresponding handworkers aged 35-44. The indexes for the clothing workers in these age groups were not significantly different from the corresponding base group index (according to statistical tests) for either machine or hand operations.

Again no consistent pattern evolved and no general conclusion about differences in the age-productivity relationships of machine operators as contrasted with handworkers can be drawn.

The age group performance indexes should, once again, be interpreted in the light of the variation measures. Again, the range of individual variability was sizable.

Initial Occupational Groups. Tables 11 and 12 show output per man-hour indexes by industry, sex, level of pay, and type of operation (hand or machine).

These are the indexes obtained in the initial aggregation of the specific occupation indexes, and, in many cases, represent only a small number of workers. Results are not shown for those groups containing fewer than five

Table 7.--Indexes of output per man-hour of men pieceworkers performing machine and hand operations in four footwear establishments, by age group

(Age group 35-44=100)

Age group 1/	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34...	64	2/ 95.0	17.6	30	2/ 109.6	19.9
35-44...	139	100.0	12.0	24	100.0	21.0
45-54...	113	97.5	13.8	3/ 10	3/ 100.2	15.3
55-64...	93	2/ 91.2	13.7	3/ 5	3/ 98.6	6.4

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient.

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

3/ Includes higher paid hand operations only.

Table 8.--Indexes of output per man-hour of women pieceworkers performing machine and hand operations in four footwear establishments, by age group

(Age group 35-44=100)

Age group 1/	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34...	64	98.8	20.4	33	2/ 105.0	9.9
35-44...	100	100.0	17.0	64	100.0	9.6
45-54...	97	98.0	13.9	32	101.0	9.3
55-64...	42	103.0	11.0	18	2/ 92.6	12.5

1/ Two age groups, under 25 and over 65 and over, are excluded because the number of observations was considered insufficient.

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 9.--Indexes of output per man-hour of men pieceworkers performing machine and hand operations in four clothing establishments, by age group

(Age group 35-44=100)

Age group 1/	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34 . .	43	96.6	6.5	2/ 9	2/ 104.4	9.5
35-44 . .	56	100.0	15.2	26	100.0	14.6
45-54 . .	34	100.0	15.5	17	101.6	10.2
55-64 . .	70	3/ 90.8	18.4	40	93.9	23.0

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient.

2/ Includes lower paid hand operations only.

3/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 10.--Indexes of output per man-hour of women pieceworkers performing machine and hand operations in four clothing establishments, by age group

(Age group 35-44=100)

Age group 1/	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
25-34 . .	54	100.3	22.7	46	98.3	21.9
35-44 . .	129	100.0	18.7	91	100.0	20.7
45-54 . .	203	100.4	17.6	184	96.3	18.7
55-64 . .	106	2/ 91.2	18.1	173	2/ 89.2	19.6

1/ Two age groups, under 25 and 65 and over, are excluded because the number of observations was considered insufficient.

2/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 11.--Indexes of output per man-hour of pieceworkers in four footwear establishments, by sex, age group, and type of occupation 1/

(Age group 35-44=100)

Age group	Men				Women			
	Hand		Machine		Hand		Machine	
	Number of workers	Index	Number of workers	Index	Number of workers	Index	Number of workers	Index
Higher paid occupations								
Under 25	2	(2/)	6	92.5	3	(2/)	4	(2/)
25-34	22	114.1	39	3/94.4	15	104.8	29	97.6
35-44	19	100.0	108	100.0	33	100.0	29	100.0
45-54	10	100.2	91	94.8	12	101.3	34	99.3
55-64	5	98.6	72	3/89.1	6	3/78.7	18	106.4
65 and over .	2	(2/)	12	3/78.9	0	--	7	3/72.0
Lower paid occupations								
Under 25	6	85.6	13	3/79.9	9	91.3	13	3/110.4
25-34	8	95.8	25	97.0	18	105.1	35	99.5
35-44	5	100.0	31	100.0	31	100.0	71	100.0
45-54	2	(2/)	22	105.7	20	100.7	63	97.2
55-64	3	(2/)	21	97.8	12	104.0	24	101.0
65 and over .	0	--	17	97.6	1	(2/)	4	(2/)

1/ Indexes refer to workers' output per man-hour during selected periods of 1955.

2/ Less than 5 observations were considered insufficient for comparable indexes.

3/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

Table 12.--Indexes of output per man-hour of pieceworkers in four clothing establishments, by sex, age group, and type of occupation 1/

(Age group 35-44=100)

Age group	Men				Women			
	Hand		Machine		Hand		Machine	
	Number of workers	Index	Number of workers	Index	Number of workers	Index	Number of workers	Index
Higher paid occupations								
Under 25	0	--	0	--	1	(2/)	1	(2/)
25-34	3	(2/)	27	100.6	7	89.2	13	98.0
35-44	11	100.0	38	100.0	12	100.0	55	100.0
45-54	6	95.4	29	96.4	33	3/86.3	86	100.0
55-64	8	97.6	37	3/92.0	25	3/81.1	42	93.3
65 and over .	2	(2/)	16	3/80.1	0	--	2	(2/)
Lower paid occupations								
Under 25	0	--	2	(2/)	5	100.6	10	96.4
25-34	9	104.4	16	3/89.4	39	100.0	41	101.9
35-44	15	100.0	18	100.0	79	100.0	74	100.0
45-54	11	104.3	5	106.5	151	98.1	117	100.7
55-64	32	92.4	33	3/88.4	148	3/90.7	64	3/89.8
65 and over .	7	89.7	6	75.6	5	3/71.3	3	(2/)

1/ Indexes refer to workers' output per man-hour during selected periods of 1955.

2/ Less than 5 observations were considered insufficient for comparable indexes.

3/ This index is significantly different from 100 in the sense that, if there were really no difference between the age group and the base group, a difference as great as this would be obtained less than one time in twenty on repeated sampling.

individuals, since it was felt that data based on such a limited number of observations would not be sufficiently reliable to be compared with indexes based on greater numbers.

These tables illustrate the need for a large number of observations for each age group in specific occupations.

The indexes shown in the tables reveal greater fluctuation than was evident in the combined indexes. 18/ This greater fluctuation is attributable, for the most part, to the small number of workers underlying each index, resulting in a greater influence on the group average of individual scores which are extreme.

It should be recalled that the number of workers in any age group in each of the classifications shown in the tables (e.g., men, aged 25-34, in higher paid hand occupations) already is an aggregation of workers in various specific occupations in several plants.

Although the initial indexes for occupational groups appear to fluctuate more than those for the combined occupational groups, they nevertheless exhibit similar patterns. For the most part, there were no significant differences between the indexes for the age groups 25-54; after age 54, a small decline, statistically significant, occurred. While the varying composition of these combined groups will not impair the comparability of the different age groups within a series (since the same weights were applied in combining each of the age groups in the series), it will affect the comparability of one series with another. To whatever extent the relationships between age and work performance differ among the occupational groups, the comparability of indexes representing combinations of these groups will be impaired.

Attendance

Data on attendance were collected for 4,009 production workers of which 1,758 were in the footwear plants and 2,251 were in the clothing plants.

Although the attendance indexes show minor differences between age groups, as indicated in tables 13 and 14, these differences are of such limited magnitude as to justify the conclusion that attendance rates in the plants surveyed show no appreciable relationship with age. In the clothing plants, the indexes of all age groups fell within 95.5 and 102.3 percent of base group average. In the footwear plants, the range was even smaller--98.7 to 101.6.

With regard to individual differences, the individual attendance rates within comparison groups showed remarkable consistency and it became evident, at an early stage, that no purpose could be served by calculating the coefficients of variation of these rates. The individual differences about the average indexes were so small that they played no role in the comparisons.

18/ Cf. tables 1 through 10.

Table 13.--Indexes of attendance of pieceworkers in four footwear establishments, by sex and age group 1/

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	104	101.2	65	99.7
25-34	129	101.6	159	100.2
35-44	197	100.0	259	100.0
45-54	190	101.3	230	100.3
55-64	183	100.8	127	100.9
65 and over	83	98.7	32	100.5

1/ Indexes refer to workers' attendance during selected periods of 1955.

Table 14.--Indexes of attendance of pieceworkers in four clothing establishments, by sex and age group 1/

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	2/ 22	2/ 100.8	65	102.3
25-34	127	99.7	141	100.6
35-44	153	100.0	305	100.0
45-54	112	100.4	560	99.2
55-64	263	98.5	425	99.5
65 and over	59	101.1	2/ 15	2/ 95.5

1/ Indexes refer to workers' attendance during selected periods of 1955.
2/ Includes lower paid occupations only.

Table 15.--Indexes of attendance for pieceworkers in higher and lower paid occupations in four footwear establishments, by sex and age group 1/

(Age group 35-44=100)

Age group	Men				Women			
	Higher		Lower		Higher		Lower	
	Number of workers	Index	Number of workers	Index	Number of workers	Index	Number of workers	Index
Under 25...	21	100.5	83	102.0	13	103.6	52	98.0
25-34.....	68	100.3	61	103.0	63	100.6	96	100.0
35-44.....	135	100.0	62	100.0	84	100.0	175	100.0
45-54.....	119	100.5	71	102.1	73	101.1	157	99.9
55-64.....	97	99.7	86	101.9	34	101.7	93	100.6
65 and over	20	97.5	63	99.9	5	102.6	27	99.6

1/ Indexes refer to workers' attendance during selected periods of 1955.

Table 16.--Indexes of attendance for pieceworkers in higher and lower paid occupations in four clothing establishments, by sex and age group 1/

(Age group 35-44=100)

Age group	Men				Women			
	Higher		Lower		Higher		Lower	
	Number of workers	Index	Number of workers	Index	Number of workers	Index	Number of workers	Index
Under 25...	2	(2/)	22	100.8	16	102.9	49	102.0
25-34.....	63	100.0	64	99.4	38	101.7	103	100.1
35-44.....	93	100.0	60	100.0	103	100.0	202	100.0
45-54.....	67	100.2	45	100.6	203	101.0	357	98.4
55-64.....	131	98.7	132	98.2	114	101.0	311	98.8
65 and over	27	101.5	32	100.6	2	(2/)	15	95.5

1/ Indexes refer to workers' attendance during selected periods of 1955.
2/ Less than 5 observations were considered insufficiently reliable for comparison of indexes.

As can be noted in tables 15 and 16, no consistent differences in the patterns of the age group indexes can be observed for higher and lower paid occupations.

Industrial Injuries

Data on industrial injuries were collected for 2,637 workers, of whom 729 were in footwear plants and 1,908 in clothing plants. Tables 17, 18, and 19 illustrate the nature of the plant data which could be obtained in the survey. In many age groups, no injuries were recorded. It is evident that a larger number of individuals, or a longer period of observation, is required to derive any meaningful data on injuries.

As noted previously, the index method was not used here. In several categories, no base group was available (since no injuries were recorded in the base group).

A word of caution is appropriate concerning even the limited data shown in tables 17, 18, and 19. Due to the variability of reporting practices among the plants, particularly as regards nondisabling injuries, the injury experience of any one plant will not be comparable with that of another. Note, for example, that plant B reported 545 nondisabling injuries, whereas plant C, which was of approximately the same size, reported only 47. This difference undoubtedly reflects the absence of uniform recordkeeping practices.

Separations

The separations data shown in tables 20 and 21 are illustrative of the type of information that can be obtained in a small-scale survey, and indicate some of the difficulties involved in the collection of separations rates. Records of separations were kept in detail at only 4 plants providing figures for 2,734 workers over the period of a year or more. Although actual conclusions relating to the separation rates of various age groups are difficult to derive from the findings, certain aspects of the technical problems encountered in this field are pointed up quite clearly.

There are two noteworthy characteristics in the data shown in these tables. First, the indexes cover a remarkably wide range--from 0 to 879.2. Secondly, the number of separations occurring in each age group is extremely small, with many groups showing no separations at all.

It is evident that these data are of limited value, insofar as any possible generalizations are concerned. The problem here is somewhat similar to that with respect to the industrial injury findings, in that a longer observation period, or a larger number of individuals, would be necessary to produce any definitive results.

Within these limitations, however, the indexes appear to show tendencies which correspond to those which might be expected. In the clothing plants,

Table 17.--Industrial injuries of pieceworkers in selected shoe plant A by sex, occupation, and age group, during 1-year period ending December 31, 1955

Occupation and age group	Men				Women			
	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries
Hand occupations								
Under 25	10	17,634	3	0	6	10,584	1	0
25-34	3	5,503	3	0	25	44,818	2	0
35-44	5	8,267	0	0	55	103,917	6	1
45-54	2	3,845	0	0	35	65,766	2	0
55-64	9	15,138	0	0	12	23,042	0	0
65 and over	--	--	--	--	1	2,159	0	0
Machine occupations								
Under 25	14	23,924	2	1	10	17,583	0	0
25-34	27	49,792	2	1	48	87,910	2	0
35-44	82	148,154	8	0	83	151,457	11	1
45-54.....	97	175,037	2	1	101	186,955	6	0
55-64	59	110,254	6	2	39	72,077	3	0
65 and over	4	7,204	0	0	2	3,695	0	0

Table 18.--Industrial injuries of pieceworkers in selected clothing plant B by sex, occupation, and age group, during 2-year period ending December 31, 1955

Occupation and age group	Men				Women			
	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries
Hand occupations								
Under 25	4	11,532	11	0	10	26,368	7	1
25-34	5	17,306	2	0	24	71,012	6	0
35-44	15	45,274	11	0	57	173,009	32	0
45-54	16	48,242	7	1	118	358,513	43	3
55-64	41	132,675	9	1	127	396,052	36	4
65 and over	3	8,620	0	0	3	10,468	0	0
Machine occupations								
Under 25	6	16,479	7	0	10	26,751	21	0
25-34	22	67,882	14	0	15	44,267	14	0
35-44	26	91,803	16	0	74	226,860	52	0
45-54	24	81,951	17	1	188	567,817	153	8
55-64	36	116,902	20	2	110	326,029	66	3
65 and over	7	21,311	1	0	2	5,567	0	0

Table 19.--Industrial injuries of pieceworkers, in selected clothing plant C by sex, occupation, and age group, during 2-year period ending December 31, 1955

Occupation and age group	Men				Women			
	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries	Number of workers	Exposure hours	Number of non-disabling injuries	Number of disabling injuries
Hand occupations								
Under 25	2	8,000	0	0	10	28,400	0	0
25-34	22	78,500	0	0	21	64,600	1	3
35-44	22	82,600	1	1	66	185,600	4	3
45-54	20	75,400	0	1	108	327,400	6	3
55-64	41	157,300	2	3	122	389,800	6	4
65 and over	6	23,200	0	0	7	17,300	2	0
Machine occupations								
Under 25	13	35,700	0	0	15	36,600	0	0
25-34	36	122,200	2	1	44	134,700	3	1
35-44	41	147,800	1	0	91	285,800	6	2
45-54	41	149,000	1	1	134	427,700	9	7
55-64	29	108,000	0	0	60	190,500	3	1
65 and over	5	17,700	0	0	9	29,000	0	0

the under 25 age group shows a very high rate of separations, as does the 65 and over group, whereas the 45-54 and 55-64 year groups show an extremely low rate of separations reflecting the relative stability of these groups. The youngest age group is generally recognized to be one of greater mobility, while the 65 and over class reflects the high incidence of retirements.

The intermediate groups show rates that vary considerably. These rates are, in general, lower than the rates for the youngest and the oldest groups.

In view of the inadequate data, it is not possible to identify any significant differences in the age-separations patterns shown by the various groups. In a larger scale survey, however, it would probably be important to retain the categories used here, in which distinctions are made according to sex, industry, and length of service.

Table 20.--Indexes of separation rates of pieceworkers in two footwear plants by sex, length of service, and age group

(Age group 35-44=100)

Length of service and age group	Men				Women			
	Number of workers	Number of man-months	Number of separations	Index	Number of workers	Number of man-months	Number of separations	Index
Less than 2 years' service								
Under 25	52	509	18	(1/)	23	241	8	636.0
25-34	8	81	3	(1/)	27	269	5	387.8
35-44	5	40	2	(1/)	38	396	2	100.0
45-54	4	33	1	(1/)	17	158	0	0
55-64	1	7	0	(1/)	2	14	0	(1/)
65 and over	--	--	--	--	--	--	--	--
More than 2 years' service								
Under 25	32	309	5	704.0	35	365	8	879.2
25-34	79	708	4	342.1	116	1,202	7	246.2
35-44	134	1,388	3	100.0	180	1,975	5	100.0
45-54	110	1,270	4	163.6	173	1,916	4	81.4
55-64	95	1,030	4	183.5	73	806	6	285.4
65 and over	10	90	1	693.9	5	50	0	0

1/ Less than 5 workers or less than 50 man-months in the base group or age group were considered insufficient to permit reliable indexes. Also, indexes were not calculated for those series in which the base group showed no separations.

Table 21.--Indexes of separation rates of pieceworkers in two men's clothing plants by sex, length of service, and age group

(Age group 35-44=100)

Length of service and age group	Men				Women			
	Number of workers	Number of man-months	Number of separations	Index	Number of workers	Number of man-months	Number of separations	Index
Less than 2 years' service								
Under 25	20	200	7	(1/)	24	324	6	89.7
25-34	14	140	2	(1/)	26	288	15	121.5
35-44	8	80	0	(1/)	45	506	13	100.0
45-54	6	60	0	(1/)	27	284	9	108.7
55-64	2	34	0	(1/)	13	130	4	109.2
65 and over	1	24	0	(1/)	1	10	0	(1/)
More than 2 years' service								
Under 25	13	186	2	262.2	19	316	9	615.7
25-34	44	496	5	147.5	73	1,290	14	244.6
35-44	66	758	5	100.0	157	2,298	10	100.0
45-54	82	988	2	33.7	369	4,768	16	63.4
55-64	166	1,758	7	44.5	280	3,276	16	89.7
65 and over	35	350	9	303.4	24	380	15	835.8

1/ Less than 5 workers or less than 50 man-months in the base group or age group were considered insufficient to permit reliable indexes. Also, indexes were not calculated for those series in which the base group showed no separations.

Appendix

I. Further Notes on Statistical Methods

This section is included in order to clarify the assumptions underlying the statistical methods adopted, and to describe more fully the steps followed in deriving the measures of work performance. It is not included in the body of the report, since it is believed to be of limited interest to many readers.

As indicated throughout this report, there were two basic problems to be resolved by the statistical methods applied in this investigation. First, it was necessary to derive comparisons which isolated the influence of age from the many other (and often more important) factors which act upon a person's work performance. Second, there was the problem of combining the measures drawn from small groups of persons, which alone could not furnish meaningful results, into larger aggregates from which statistical conclusions might be drawn.

The first problem was resolved in two ways--classification of workers and the use of relative scores. The second problem was resolved, to a certain extent, by applying the appropriate weights to the groups to be combined. For each of the performance indicators the specific classification scheme varied, as did the weights applied to the measure, but the fundamental approach was similar.

Before discussing the bases for the statistical methods applied, it would perhaps be useful to indicate briefly the definition of the universe which is being measured by this investigation.

Definition of Universe

As noted previously, the findings resulting from this study are applicable only to the particular plants included, and do not necessarily reflect conditions throughout the two industries. In another sense, however, the individual employees for whom data were collected constitute a sample drawn from a larger population. If a different survey period had been selected, or if the eight companies had employed individuals other than those whose characteristics were recorded in this study, the results would, of course, have been somewhat different from those reported here.

The data presented in this study are, with respect to the particular individuals concerned, actual measurements rather than estimates. However, these individuals may be regarded as a sample, drawn from a universe which includes all possible employees who might be found, at any time, to be working in plants which are identical to the ones studied in matters affecting employment practices and working conditions. If this broader applicability is ascribed to the findings, then they must be regarded as merely estimates, and subject to certain errors.

Methods for evaluating the reliability of these estimates--that is, of determining the probability that the estimates will fall within a specified percentage of the results that would have been obtained if the entire universe had been used rather than a sample--are available through the application of appropriate statistical techniques. It was this interpretation of the population which led to the use of reliability weights which are discussed later.

Occupational Classification

Direct comparisons of output per man-hour scores were made only among individuals in the same specific occupation. The occupations were, in turn, classified into several occupational groups according to the following characteristics: hand operations, machine operations, higher paying jobs, and lower paying jobs. For attendance, direct comparisons were made among individuals whose occupations were in the same earnings classification.

Earnings Classifications. The idea behind the classification of workers according to the average earnings of their occupations is that earnings, on the whole, can be regarded as indicative of the relative degree of skill and experience required for the job. Special exceptions, of course, have to be made for jobs in which the level of pay is relatively high for other reasons, such as less desirable working conditions.

Initially, an attempt was made to classify jobs into skilled, semiskilled, and unskilled occupations according to classifications given by the Dictionary of Occupational Titles. 19/ After this had been done, it was found that many skill level classifications thus derived were inconsistent with the average earnings of persons on the job. Some "unskilled" jobs were among the highest paid occupations, while some "skilled" jobs were in the lowest paid group. This was probably because of the great variation in the nature of jobs which carry the same title in different plants. Because of these inconsistencies, it was decided that average hourly earnings for jobs would provide a better basis for classification.

There are several alternatives which could have been used for establishing the limit to divide jobs into higher and lower paid groups. One is to draw a dividing line for each plant surveyed; another is to establish a regional limit. The use of plant averages would reflect special differences in conditions which affect earnings in particular plants, such as plant efficiency, degree of unionization, and local bargaining power of particular groups of workers. For purposes of this study, however, some criterion was desired which would be sensitive to the actual skill levels of workers, rather than their status in relation to the rest of the workers in the plant. Such a criterion

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19/ Dictionary of Occupational Titles, Federal Security Agency, U. S. Employment Service, Division of Occupational Analysis, March 1949.

was necessary in order to arrive at some grouping of skill levels which would be consistent from plant to plant, and would thus permit the aggregation of indexes from various plants according to a skill level classification.

A specific dollar figure was established, therefore, for each industry within a given region, and was used to distinguish between higher and lower paid occupations. This figure was derived from the average hourly earnings for the specific industry and region (as determined through wage surveys conducted by the Bureau 20/) adjusted for changes in wage levels since the date of the most recent survey.

This figure was then used to classify each of the occupations found in the present survey. Those occupations in which the average hourly earnings (within a given plant) exceeded the regional average for the industry were considered higher paid, whereas those in which average earnings fell below this figure were considered lower paid. This was done separately for male and female workers.

In this way, the skill level classification which was assigned to each occupation depended on the relationship of the average earnings in that occupation to the overall regional average for the industry, rather than to the average for the one plant alone. It was believed that the use of regional industry averages as cutoff points would provide more reliable indications of actual skill requirements than would the use of individual plant averages.

Machine-Hand Classifications. The machine-hand distinctions were made in order to separate jobs which place somewhat different requirements on workers. Machine jobs, it is believed, call for many skills and talents different from those needed for hand operations, and the skills peculiar to machine operations or to hand operations influence the productivity of various age groups differently. By making this distinction, the influence of these factors in the age group comparisons was minimized.

A machine job was somewhat arbitrarily designated as one which required the use of a powered device. Most of the designations were arrived at after a discussion with plant officials as to the particular equipment used in the various occupations. In some cases, where it was difficult to classify the job, the judgment of the plant official who was aware of the physical requirements of the job was used.

20/ Wage Structure - Footwear March 1953, BLS Report 46, December 1953. Men's and Boys' Suit and Coat Industry: Earnings March 1951, Monthly Labor Review, November 1951 (pp. 573-575).

Transforming Absolute Scores into Indexes

As stated earlier, in the case of output per man-hour, the average hourly earnings of the age groups in a specific occupation were related to the average hourly earnings for the 35-44 year group, which was used as a base. In the actual derivation, 2 different 10-year age groups were chosen as bases of comparison, the group 35-44 designated base group "A" and the group 25-34 called base group "B".

Indexes could be constructed only for those operations where workers of base group age were present. The use of 2 base groups instead of 1 permitted the inclusion of additional occupations in the productivity comparisons. In this way a greater proportion of the raw data collected during the plant visits could be utilized. 21/ In those occupations which included persons in both base groups, two productivity indexes were derived for each age group.

A single 20-year base group, ages 25-44, was considered and rejected because, on aggregating over occupations, the results might reflect differences in performance associated with the average age of members of the base group, rather than differences in the performance of the age groups compared.

Combining Occupation Indexes

The occupation indexes of an age group using age group 35-44 as a base (base group A) were combined with appropriate weights to furnish an occupational group index for that age group. The specific occupations are viewed as samples yielding estimates of the index for the occupational group. They should, therefore, be combined, using weights which take proper account of their reliability.

The occupation indexes were usually based on different numbers of people in the age group and different numbers of people in the base group. Accordingly, they are more reliable the greater the number of individuals in the age group and the greater number of individuals in the base group. The formula for the weights was $N_a N_b / N_a + N_b$ where N_a is the number of individuals in the age group and N_b is the number of individuals in the base group. 22/ 23/

21/ Because of the limited data available--in some cases there were no individuals in some age groups--statistical techniques such as pairing or standardization procedures could not be applied to productivity comparisons by age groups. These techniques require equalizing the occupational composition of each group or giving results from each occupation the same weight in order to make the age groups comparable. To apply these procedures, at least 1 person from each of the 6 age groups must be present in each occupation.

22/ The derivation of this formula was worked out with the assistance of the Bureau's Office of Statistical Standards. Each weight should be inversely proportional to the variance of the index to which it applies.

23/ For attendance the same form of weights was applied in combining the earnings level classifications in each plant. One modification was that the weight had to be multiplied by the number of scheduled workdays in the plant during the survey period.

A similar procedure was employed in combining the occupation indexes based on age group B. Thus, for each age group, two indexes were derived for the same occupational group.

The final step in deriving the index for the occupational grouping is to combine the indexes based on groups A and B. To do this, the B indexes for all age groups were shifted to group A through dividing them by the B index for age group A (35-44). This converted all indexes into series based on a score of 100 for base group A. The two series were then averaged by means of weights expressing the reliability of each index.

Measures of Dispersion

The basic measure of dispersion in an age group was the coefficient of variation for the specific occupation. It did not matter whether the coefficient was determined from the raw scores or the indexes for the individuals, because, within an occupation and age group, each raw score is divided by a constant to derive the index for the occupation.

The dispersion measures for the occupational groupings were derived by combining the measures for the occupations. These were actually derived by combining the squares of the coefficients of variation with appropriate weights and then taking the square root. In this case, also, the number of independent observations in each age group determined the reliability and was used as the weight. The number of observations in the base group has no influence since it does not affect the value of the coefficient of variation within an occupation. 24/

Measures of relative dispersion for individual attendance rates in the age groups are not presented in this report. It was felt that the measures would possibly be misleading, should inferences be drawn. The distributions of individual attendance rates are highly skewed with the mode very close to the maximum score of 100, a very short tail to the right of the mode, and a long tail dropping sharply to the left of the mode.

Statistical Significance Testing

Procedures were employed for testing for statistical significance the differences between the age group indexes. Each age group index for an occupational group and combinations of these groups was compared with the corresponding base group index of 100. The standard error of the difference

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24/ The number of independent observations is one less than the number of persons in the occupation.

between the two indexes was obtained and its standard score computed. If the probability is less than 5 percent that the difference of a given size or larger would occur by chance, assuming the two indexes are the same, the difference was considered significant. 25/

It was similarly possible to test the significance of the difference between any two age group indexes within an occupational group or between such groups. 26/

25/ It might be noted that, since the base group index of 100 is an exact number and not an estimate, it has no standard error and the standard error of the difference between the two indexes is the standard error of the age group index alone.

26/ In this case the variance of the difference between the indexes is the sum of the variances of the two indexes assuming no correlation between the observations making up the two indexes and the standard error is the square root of that variance. This assumption is not correct for age group indexes in the same occupational grouping. These indexes are in part composed of the same base groups and are, therefore, partially correlated. Wherever this is true the assumption makes the computed standard error larger than the correct one. Here, a difference which is found significant at the 5-percent level, on the basis of its computed standard error, will actually be significant at a level of less than 5 percent.

II. Derivation of Formulas

1. Weights for Combining Indexes for Specific Occupations

The output per man-hour indexes were combined to furnish an index for an occupational group. Here, there are a series of indexes of the form $\bar{X}_{ci}/\bar{X}_{bi}$; where $\bar{X}_{ci}$ and $\bar{X}_{bi}$ are the average hourly earnings of a sample of N_{ci} individuals in age group C and N_{bi} in the base group for occupation i, respectively. In order to obtain from the specific occupation samples an occupational group index having the minimum variance, each sample index should be weighted according to its reliability, i.e. according to the reciprocal of the squared standard error of the sample index.

If the numerator and denominator samples are uncorrelated, then the rel-variance of each age group index for a specific occupation is

$$V^2(I_{ci}) \cong \frac{V_c^2}{N_{ci}} + \frac{V_b^2}{N_{bi}}$$

where V_c^2 and V_b^2 are the population rel-variances of the individual scores in the age and base groups respectively. Another form of $V^2(I_{ci})$ is:

$$V^2(I_{ci}) \cong \frac{V_c^2\left(\frac{V_b^2}{V_c^2} N_{ci} + N_{bi}\right)}{N_{bi}N_{ci}} .$$

$$\text{Setting } W_i = \frac{N_{bi}\, N_{ci}}{\frac{V_b^2}{V_c^2} N_{ci} + N_{bi}} ,$$

then $$V^2(I_{ci}) = \frac{V_c^2}{W_i} ;$$

but $V^2(I_{ci}) = \frac{\sigma^{-2}(I_{ci})}{I_c^2}$, where I_c is the population index for age group c and $\sigma^{-2}(I_{ci})$ is the variance of the sample index.

Using the reciprocal of the variance of each occupation sample index as the weight, then the index for an occupational group is:

$$\bar{I}_c = \frac{\sum \frac{1}{\sigma^{-2}(I_{ci})} I_{ci}}{\sum \frac{1}{\sigma^{-2}(I_{ci})}} = \frac{\sum \frac{W_i}{V_c^2 I_c^2} I_{ci}}{\sum \frac{W_i}{V_c^2 I_c^2}}$$

Since V_c^2 and I_c^2 are constant with respect to the summation

$$\bar{I}_c = \frac{\sum W_i I_{ci}}{\sum W_i} = \frac{\sum \frac{N_{bi} N_{ci} I_{ci}}{\frac{V_b^2}{V_c^2} N_{ci} + N_{bi}}}{\sum \frac{N_{bi} N_{ci}}{\frac{V_b^2}{V_c^2} N_{ci} + N_{bi}}}$$

If the assumption is made that the rel-variances of the age groups are the same, i.e. $V_b^2 = V_c^2$, then $W_i = \frac{N_{bi} N_{ci}}{N_{bi} + N_{ci}}$. 27/

27/ There was little evidence in the findings to challenge the assumption that $V_c^2 = V_b^2$. The differences between the age group coefficients of variation were not consistent nor, for the most part, sizeable. In fact, age groups which had the largest number of observations (and hence the most reliable estimates) had almost the same coefficients.

It should also be noted that any difference between V_b^2 and V_c^2 would have little effect on the relative weights used for averaging the occupation indexes.

2. Variance of an Age Group Index for an Occupational Group

The occupational group index $\bar{I}_c$ for age group C is

$$\bar{I}_c = \frac{\sum W_i I_{ci}}{\sum W_i} = \sum \left(\frac{W_i}{\sum W_i} \right) I_{ci}$$

and the variance of $\bar{I}_c$ is

$$\sigma^2(\bar{I}_c) = \sum \left(\frac{W_i}{\sum W_i} \right)^2 \sigma^2(I_{ci}). \quad 28/$$

As shown above, $\sigma^2(I_{ci}) = \frac{V_c^2 I_c^2}{W_i}$

Therefore, $\sigma^2(\bar{I}_c) = \frac{1}{(\sum W_i)^2} \sum \frac{W_i^2 V_c^2 I_c^2}{W_i}$

$$= \frac{V_c^2 I_c^2}{(\sum W_i)^2} \sum W_i$$

$$= \frac{V_c^2 I_c^2}{\sum W_i} .$$

3. Weights for Combining Indexes to base A with Indexes to base B

As noted above, 2 series of indexes were computed from occupational data, 1 to base group A (35-44) and another to base group B (25-34). Each series of indexes was averaged separately into an occupational group index. The series of age group indexes to base B was

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28/ In this derivation, use is made of the principles that (a) the variance of a sum of uncorrelated variables is the sum of the variances of the variables, and (b) the variance of a variable times a constant is the square of the constant times the variance of the variable.

converted to base A by dividing each B index by the index of age group A based on group B. This led to a series of converted indexes of the form

$_{a'}I_c = \frac{_bI_c}{_bI_a}$ where the left hand subscript denotes the base used and a' represents the converted B base index.

For each age group, the index $_aI_c$ was then averaged with the converted index $_{a'}I_c$ by means of reliability weights.

i.e.

$$_{a,a'}I_c = \frac{_aI_c\left[\frac{1}{\sigma^2(_aI_c)}\right] + _{a'}I_c\left[\frac{1}{\sigma^2(_{a'}I_c)}\right]}{\frac{1}{\sigma^2(_aI_c)} + \frac{1}{\sigma^2(_{a'}I_c)}} .$$

From above, $\sigma^{-2}(_aI_c) = \frac{V_c^2\ _aI_c^2}{\Sigma\ _aW_{ci}}$.

$\sigma^{-2}(_{a'}I_c)$ is derived as follows:

$$V^2(_{a'}I_c) \cong V^2(_bI_c) + V^2(_bI_a) - 2\rho V(_bI_c)V(_bI_a)$$

$$\approx V^2(_bI_c) + V^2(_bI_a) . \quad 29/$$

From the formula for the variance of an occupational group index, it is known that

$$V^2(_bI_c) = \frac{V_c^2}{\Sigma\ _bW_{ci}}, \text{ and } V^2(_bI_a) = \frac{V_a^2}{\Sigma\ _bW_{ai}} ;$$

therefore $V^2(_{a'}I_c) \cong \frac{V_c^2}{\Sigma\ _bW_{ci}} + \frac{V_a^2}{\Sigma\ _bW_{ai}}$.

29/ Although there is some correlation between indexes $_bI_c$ and $_bI_a$, the influence on the relative weights is very small when the correlation term is dropped.

Again assuming that $V_c^2 = V_a^2$,

$$V^2({}_{a'}I_c) \cong V_c^2 \left(\frac{1}{\Sigma_b W_c} + \frac{1}{\Sigma_b W_a}\right) = V_c^2 \left(\frac{\Sigma_b W_a + \Sigma_b W_c}{\Sigma_b W_a \; \Sigma_b W_c}\right).$$

Setting $\Sigma_{a'} W_c = \frac{\Sigma_b W_a \, \Sigma_b W_c}{\Sigma_b W_a + \Sigma_b W_c}$,

$$V^2({}_{a'}I_c) = \frac{V_c^2}{\Sigma_{a'} W_c} = \frac{\sigma^{-2}({}_{a'}I_c)}{{}_{a}I_c^2}, \text{ whence}$$

$$\sigma^{-2}({}_{a'}I_c) = \frac{V_c^2 \; {}_{a}I_c^2}{\Sigma_{a'} W_c}.$$

The average index combining the two estimates for each age group is

$${}_{a,a'}\bar{I}_c = \frac{{}_{a}I_c \left(\frac{\Sigma_a W_c}{V_c^2 \; {}_{a}I_c^2}\right) + {}_{a'}I_c \left(\frac{\Sigma_{a'} W_c}{V_c^2 \; {}_{a}I_c^2}\right)}{\left(\frac{\Sigma_a W_c}{V_c^2 \; {}_{a}I_c^2} + \frac{\Sigma_{a'} W_c}{V_c^2 \; {}_{a}I_c^2}\right)}$$

$$= \frac{{}_{a}I_c \, \Sigma_a W_c + {}_{a'}I_c \, \Sigma_{a'} W_c}{\Sigma_a W_c + \Sigma_{a'} W_c}.$$

4. Variance of the Combined Index

The variance of the combined index $({}_{a,a'}I_c)$ can be found by the same procedure as described in (2) above. The variance of this index is needed to conduct tests of significance on the differences between the age group indexes.

The variance for an occupational group index as derived in (2) involved no correlation between the indexes for the specific occupations. In this case, however, some correlation exists between the two indexes for each age group—the A based index and the converted B based index. Both indexes for an age group are derived in part from the same specific occupation sample. For these particular occupations, though the base group components involved different individuals, the age group components are based on the average hourly earnings for the same individuals. Because of the complicated form involved when this possible correlation is introduced, an approximation procedure was employed.

The combined index should be at least as reliable as one of its component indexes. If the correlation were perfect then no reliability would be gained by combining ${}_aI_c$ and ${}_{a'}I_c$. As a limiting case, therefore, the reliability of the combined index is equal to the more reliable of its component indexes.

Accordingly, the variance computed for the occupational group index to base A, ${}_aI_c$, was used to approximate the variance of the combined index, ${}_{a,'}I_c$. The variance was $= \frac{V_c^2 \; {}_aI_c^2}{\Sigma \; {}_aW_{ci}}$

The standard error computed on this basis is generally larger than the true standard error of the combined index. Thus, any difference in age group indexes which are found significant at a given probability level through this procedure would actually be significant with even greater probability.

5. Coefficient of Variation for an Occupational Group

The age group coefficient of variation for an occupation group was derived by combining the rel-variances of specific occupation samples and taking the square root of this average rel-variance. This section explains how the weights were applied to obtain the average rel-variance.

For an age group in a specific occupation let

N_i = the number of individuals in occupation i (must be ≥ 2)

$\bar{X}_i$ = mean of the sample

$\bar{\bar{X}}_i$ = mean of the population in the specific occupation. This value is estimated by the sample mean $\bar{X}_i$

$s_i^2 = \frac{1}{N_i - 1}\sum(X_{ij} - \bar{X}_i)^2$ which is an estimate of the population variance σ_i^2

$v_i^2 = s_i^2/\bar{X}_i^2$, the rel-variance of the sample, an estimate of the population rel-variance v^2

$v^2 = \sigma_i^2/\bar{\bar{X}}_i^2$.

Assuming a normal distribution in the specific occupation, the rel-variance of S_i^2 is $\frac{2}{N_i - 1}$ and the rel-variance of $\bar{X}_i$ is $\frac{\sigma_i^2}{N_i}\Big/\bar{\bar{X}}_i^2 = \frac{v^2}{N_i}$.

$v^2(\bar{X}_i^2) \cong \frac{4v^2}{N_i}$, according to a general rule for the rel-variance of a square.

If S_i^2 and $\bar{X}_i^2$ are uncorrelated, the rel-variance of V_i^2 is approximately

$$V^2(S_i^2)+V^2(\bar{X}_i^2) \cong \frac{2}{N_i-1} + \frac{4V^2}{N_i}$$

$$= \frac{2(1+2V^2)}{N_i-1}\left[1-\frac{2V^2}{N_i(1+2V^2)}\right]$$

$$\cong \frac{2(1+2V^2)}{N_i-1}, \text{ since the second term of the bracketed}$$

expression will be less than 0.08 provided $V < 0.3$ and $n \geq 2$ and less than 0.12 provided $V < 0.4$ and $n \geq 2$.

So the variance of V_i^2 is approximately $\frac{2V^4(1+2V^2)}{W_i}$, where $W_i = N_i-1$.

The estimate of the rel-variance for an occupational group is therefore

$$\frac{\Sigma W_i V_i^2}{\Sigma W_i} = \frac{1}{\Sigma(N_i-1)}\sum\sum\left(\frac{X_{ij}}{\bar{X}_i}-1\right)^2, \text{ and its estimated variance is}$$

$$\Sigma\left(\frac{W_i}{\Sigma W_i}\right)^2 \text{Variance } V_i^2 = \frac{2V^4(1+2V^2)}{\Sigma W_i}.$$

6. Combining Occupational Group Indexes

As noted above, occupational group indexes for an age group were combined with weights equal to the total number of workers of all ages in the particular occupational group, i.e.

$$I_c = \frac{\Sigma(M_i)\ a,a' I_c}{\Sigma M_i}$$

Where I_c = major grouping index (hand, machine, etc.) for age group C

M_i = number of workers of all ages in occupational group i.

The variance of this index, following the same procedure outlined in (2) is

$$\sigma^2(I_c) = \sum \left(\frac{M_i}{\Sigma M_i}\right)^2 \sigma^2_{(a,a',I_c)}$$

$$= \frac{\Sigma M_i^2 \, \sigma^2_{(a,a',I_c)}}{(\Sigma M_i)^2}$$

where $\sigma^2_{(a,a',I_c)} = \frac{V_c^2 \, I_c^2}{\Sigma_{a,a'} W_i}$

UNITED STATES DEPARTMENT OF LABOR
Bureau of Labor Statistics
Washington 25, D. C.

CONFIDENTIAL

Age and Work Performance

Industry_____

Plant_____ Address_____

Parent Company_____ Address_____

Officials interviewed: (Cross out, "Co." or "Plant")

Name_____ Title_____ (Co.) (Plant)

Name_____ Title_____ (Co.) (Plant)

Survey made by_____ Dates_____

_____ Dates_____

The data submitted on this schedule will be seen only by sworn employees of the Bureau of Labor Statistics. The data will not be released in any form which permits identification with any specific company, without written permission.

A. General Information

1. What are the principal products manufactured in this plant and their price range?_____

_____

2. During normal production periods approximately how many production workers are employed?_____

THE FOLLOWING QUESTIONS REFER TO PRODUCTION WORKERS ONLY

B. Plant Records

3. For what periods during the first half of 1955 was this plant operating on a full production schedule? (If these periods vary by department, specify)_____

_____

4. For what departments do you maintain records which will yield data on output per man?_____

5. Briefly describe these records_____

_____

6. Which of the following are factors in determining piece rates:

   a. Time studies Yes ☐ No ☐

   b. Employee - management conference Yes ☐ No ☐

   c. Other (specify)_____

7. Are time standards available for piece rate jobs Yes ☐ No ☐, and other jobs (specify)?_____

8. When were the piece rates last reviewed?_____

   And approximately what percentage of piece rate jobs was covered by this review?_____

9. For what piece rate jobs have maximum production limits been established (limits such as maximum number of units paid for per hour)?

_____

_____

10. Do you maintain records of work injuries on workmen's compensation forms ☐ or other forms? Specify_____

11. Do you maintain a record of total working hours for each employee by quarter ☐, year ☐, or other period?_____

12. During slack periods, is seniority a factor in determining the order of employee production layoffs? Yes ☐ No ☐

13. Do you maintain special records of employee absences? Yes ☐ No ☐

14. If yes, describe_____

15. For employees who have left during the past year, do you record the date on which they left Yes ☐ No ☐, and the reason (quit, lack of work, etc.)? Yes ☐ No ☐

16. After how many weeks of absence will an employee be marked as separated on your records?_____

17. Do your records contain any information on the quality of work turned out by individual workers (such as number of rejects, quality warnings, etc.)? Yes ☐ No ☐ If yes, describe _____

_____

C. Placement Procedures

Do your procedures for placing production workers include the following:

18. Initial physical examination Yes ☐ No ☐

19. Periodic physical examination Yes ☐ No ☐

If yes, give time interval between physical checkups _____

20. Aptitude testing Yes ☐ No ☐

21. Analysis of physical job requirements:

a. Written description of physical requirements (such as working position, physical exertion, vision, etc.) Yes ☐ No ☐

b. Informal evaluation Yes ☐ No ☐

22. Other, specify _____

23. What program is there for the retraining and reassignment of production workers? _____

_____

24. What has been done to retrain and reassign older workers? _____

_____

25. Have any measures been taken to review and redesign jobs held by older workers? Yes ☐ No ☐. If yes, give example, and if possible indicate reasons for initiating these measures _____

_____

D. Data for Adjusting Performance Measures

26. Overtime rates become effective after __ hours per day, ___ hours per week.

27. What is the premium rate for overtime work ___, Sunday or holiday work ___

28. If these rates of extra pay do not apply to piece work, specify the premium rates on piece work for overtime ____ and holidays _____

29. Dates of vacation periods of plant _____

Age and Work Performance

General Instructions for Completing Questionnaire

The questionnaire and worksheets on "Age and Work Performance" are to be used to collect data pertaining to productivity, absenteeism, and work injuries of individual production workers in the plants studied. These data are to be collected together with employee's ages and other pertinent personal information. The questionnaire relates to general information, plant records, placement procedures and data-adjustments (sections A through D). Worksheet 1 is used for recording personal information, data on production, absenteeism and injury for each worker; a supplementary worksheet 2 is to record detailed productivity information where necessary.

The recommended procedure is to fill out the questionnaire during the initial interview with the plant official, and then to record the individual employee data on the worksheets.

Questionnaire

Instructions are included only for those items not considered self-explanatory.

If additional space is needed for answers, use back of sheets.

1. Principal products -- Indicate principal products manufactured in terms of broad product classes, such as Men's Goodyear Welt Shoes, Men's Suits. Designate price range at retail prices for an indication of general quality range of the plant's production.

2. Employment -- Enter approximate number of production and related workers in this plant. These include workers (up through the working foreman level) engaged in fabricating, processing, assembling, inspection, receiving, storage, handling, packing, warehousing, shipping (but not delivery), maintenance, repair, janitorial, watchman services, product development, auxiliary production for plant's own use, recordkeeping and other services closely associated with these production operations. If the plant has less than 500 workers, record this information and terminate the interview.

3. Production Period -- Obtain dates for 8 weeks (not necessarily consecutive) when plant was operating at full production.

4,5. Output Per Man Records -- Payroll records which yield straight piecework earnings of production workers separate from timework earnings will furnish output per man figures.

If such payroll records are not available, production records from which individual straight-time piecework earnings can be derived are satisfactory. Straight-time piecework earnings can be computed from records which show the quantities produced at given piece rates by individual workers.

In some cases output data may be recorded also for timeworkers. Inquire whether these data are available.

6, 7, 8. Piece Rates -- The purpose of these questions is to ascertain whether piece rates reflect accurately differences in the time required to perform the same operation on different models. If they do, workers performing the same operation can be compared regardless of differences in their product mix.

13, 14. Absenteeism Records -- Indicate whether any special records maintained by the establishment will furnish information on time scheduled and time worked. Scheduled days and days worked may have to be obtained from timecards directly. Determine whether timecards of piece-rate workers are available for full production periods of at least 8 weeks, preferably during the first half of 1955.

16. Ascertain what the plant practice is.

17. Describe nature and location of such records.

22. Other Placement Procedures -- Indicate any steps not mentioned above which are employed in placing production workers.

23. Retraining and Reassignment -- Use retraining as teaching the worker to perform a new set of operations, or to modify his present set of operations. Use reassignment as the transfer of the worker to another occupation (set of operations). Reassignment does not necessarily involve retraining.

26, 27. Premium Rates -- If the premium rates vary by job classification, list them on back of the sheet.

29. Vacation Periods -- If vacation periods vary by department, list the departments and relevant periods.

A

Clock No.	Plant No.	Name of Plant	Dept No.	Name of Employee	Prod. Int.	M 1 F 2	Date Born	Age	IS	AS	PS	PPS

Prelim. Operation Code / Occupation Code	Occupation Description:	P 1 T 2	Hourly Rate	C P Date	H 1 M 2	Q S

B

Period Ending	SPE	OPE	TH	HTW	W	R	M 1	T 2	W 3	TH 4	F 5	DW	DM	DWS

Period Ending	M	T	W	TH	F	DW	DM	DWS

Date Hired	Date Left	R
Years Service		

C

Date Injured	Date Disabled	Date Returned	Days Disabled

Remarks

D

Expos. Hours							

WORKSHEET 1

A

Clock No.	Plant No.	Dept. No.	Prelim. Oper. Code	Sex	Age

Date	SPE	OPE	TH	HTW
Totals				

Remarks:

Worksheet 2

B

Operation Description	Model No.	Piece Rate	STU	Dates					Totals
				Quantity (Units:)					
Totals									

Total Units		Total PW Earnings		Avg. Pc. Rate Per Unit	

Instructions for Worksheets

Worksheet 1

Section A. Clock Number -- Record clock number listed on the worker's time-card. If this number differs from the number on the personnel records, note this in "Remarks" space.

Plant -- Record plant code from questionnaire.

Dept. No.-- Record department number as listed by the plant. If plant does not number departments use arbitrary code, and record code on plant questionnaire.

Name of Employee -- Record first and last name.

Production Interval -- Using the following code record time period for which production is measured.

1. - Week 2. - Two weeks 3. - Month

Sex -- Indicate by 1 or 2 whether male or female.

Date Born -- Record number of month and last two digits of year of birth.

Age -- Do not fill in at plant unless convenient as a means of selecting sample.

IS)
)
AS) Do not fill in at plant.
)
PS)

PPS -- Prelim. Prod. Sample - Check if workers belong to a preliminary productivity sample group. Such a group consists of all piece-rate workers of the same sex performing the same operations including at least one worker over 45 and one worker under 45 years of age. For groups which fail to fulfill this condition do not take down productivity information.

Preliminary Operation Code -- Where available, record operation number (s) as used by establishment. Otherwise, leave blank.

Occupation Code -- Do not fill in at plant.

Occupation Description -- From company personnel or production records list worker's occupation during the period studied. Describe the occupation briefly in terms of specific operations performed. For persons whose productivity is to be compared, confirm from the appropriate plant official that all workers in an occupation actually perform the same operations. Also ascertain who is not a fully qualified operator, such as a beginner, or a recently transferred employee.

P or T--Piece or Time Work - Indicate by "1" if worker is paid by piece rate and "2" if worker is paid on a time basis (hourly rate). If a worker is on both piecework and timework during the reporting period, indicate by "1" (i.e., list as piece rate worker).

Hourly Rate -- Record hourly wage rate for all timeworkers for whom personnel information is collected. In the case of piece-rate workers, if average hourly piece rate earnings for the 4 busiest weeks of the year have already been computed by the company (as in the clothing industry), record in this cell. Otherwise, leave blank for piece rate workers.

C. P. Date -- Current Payroll- Record the month and day of the pay period nearest to the time of the plant visit, if the employee was on the payroll. If the employee was not on the payroll, leave blank.

H or M --Hand or Machine - Indicate by "1" or "2" whether worker is primarily a hand or a powered machine operator.

QS -- Do not fill in at plant.

Section B. For the reporting period on productivity, select, with the aid of the appropriate company official, a full production period totalling 8 weeks, preferably during the first half of 1955, (not necessarily consecutive). If this is not available, use a minimum of 4 weeks for the period studied.

Period Ending -- Record number of the month and day and only the last digit of the year for the ending dates of the relevant period. If productivity information (second column through fourth) is available on the basis of a 2-week pay period record productivity information in every other row; if it is monthly record on every fourth row.

SPE -- Refers to straight time piece work earnings. Include dollars and cents with .00 if no cents.

OPE -- Refers to overtime piece work earnings. Do not adjust to straight time levels. Where records have overtime earnings already adjusted to straight time rates, indicate in "Remarks" space. Record both dollars and cents.

TH -- Refers to the total number of hours worked during the time period studied.

HTW -- Hours on Time Work - Refers to the total number of hours for which the worker was paid on a time basis (hourly rate) during the period studied.

W and R -- In plants which have, for individual workers, measures of the quality of output indicate in the appropriate column the number of quality warnings (W) received and the number of rejects (R) charged to the worker. If another form of quality measure is kept by the plant indicate in "Remarks" space, and if the information is quantitative, record it in the W and R columns adjusting the titles.

Absenteeism -- The remaining columns in section B relate to absenteeism. Using the same 8-week full production period as used for productivity, record the weekday missed in the appropriate cell. In most cases, these data will have to be obtained from individual employee timecard.

In addition to the 8-week full production period, select, with the aid of the appropriate company official, four other weeks (not necessarily consecutive) in which the plant was on a less than full production schedule.

M, T, W, Th, F -- Refer to the specific weekday missed by the worker during the specified period. Record the code number of the day of the week the worker did not punch in. Note any day for which there is no entry on the timecard. If an individual punched in on Saturday of any week, note this information in the "Remarks" space with the appropriate ending date of the period.

DW -- Refers to the number of days the employee worked or was present during the specified period.

DM)
) Do not fill in at the plant.
DWS)

Date Hired -- Record original date hired and subsequent dates rehired from beginning of absentee period to time of plant visit. Include day, month, and year if available.

Date Left -- Record all dates left (by day, month, and year), from beginning of absenteeism period to time of plant visit.

R -- Refers to reason the worker left. Try to obtain reason for each incident and indicate by the following coding:

Layoff	- 1	Retired	- 4
Quit	- 2	Other	- 5
Discharge	- 3		

Years Service -- Do not fill in at plant.

Section C. Record only work-connected injuries. Data should be obtained from workmen's compensation records, if possible. If these records are not available either at the plant or at an insurance company consult the records of the plant's first-aid station.

If possible, data on injuries and exposure hours should be obtained for a maximum period of 2 years beginning 27 months prior to the date of the plant visit. Enter beginning and ending dates of time period for which exposure hours are recorded in the first and last cells of the exposure hour space.

Note: All dates should be recorded in numerical form, e.g.: 9-22-5. Do not write out the month, and record only the final digit of the year.

Date Disabled -- Record date of beginning of disability. If same as date of injury, enter "same."

Date Returned -- Record first date worked following disablement. If there is more than one continuous period of disablement resulting from a single injury, enter starting and ending dates for each such period under "Date Disabled", and "Date Returned".

No. Days Disabled -- Leave blank.

Section D. This section is arranged to accomodate various methods plants employ to record individual employee's hours worked for long periods. From appropriate plant records the data may be directly available in annual, quarterly, monthly, or weekly totals.

If data are available in annual totals, record figures in first and second cells of the bottom row;

in quarterly total, record figures in cells of bottom row;

in monthly totals, record figures in adjacent six cells in each column leaving the bottom row blank;

in weekly totals, record figures in all cells with exception of those in bottom row.

For additional entries of weekly totals, use another worksheet recording individual's clock number, plant number, and department number as well.

Worksheet No. 2

Section A of this worksheet should be used in place of worksheet 1 (Row B) for recording information on piece-rate earnings where individual production records are available on a daily basis rather than by pay period. Refer to instructions for Section B of worksheet 1.

Section B is to be used in those plants where there is reason to believe that the product mix for individual workers performing the same operations varies considerably. Record information for one week of the 4-week production period during which earnings data are collected.

Operation Description and Model No.-- Record specific operations performed and enter the model numbers assigned to each product worked upon. These numbers are usually available from production records or from individual piece tickets.

Piece Rate and Standard Time -- Where piece rates are available, record the rates corresponding to the operations and models. In addition to piece rates, record time standards, if available, for all jobs for which product mix data are obtained. Time standards may be expressed, for instance, as standard minutes per unit or standard units per minute. Enter time standards in column headed STU, and enter definition of time standards in remarks space.

Quantity Produced -- For corresponding model numbers record the number of units produced during the production time period. Indicate the unit of measure in the cap after the word "unit." If unit of measure is not uniform throughout the worksheet, record units of measure in "Remarks."

Dates refer to one day.

Total Units)
Total PW Earnings) Record only if directly available. Do not compute at the plant.

Average Piece Rate -- Do not fill in during plant visit.

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