Bulletin No. 1223
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Comparative Job Performance by Age:

Large Plants in the Men's Footwear and Household Furniture Industries

UNITED STATES DEPARTMENT OF LABOR
James P. Mitchell, Secretary
BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

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Preface

The difficulties faced by older workers in securing and retaining employment constitute a national problem which is becoming more pressing as the proportion of older workers in the total labor force rises. The U. S. Department of Labor, in response to this challenge, has been conducting a broad program to examine the problem and to find means for overcoming it. As one phase of this program, the present study attempts to furnish information on the relationships between age and work performance.

Much of the earlier research in this general area has shown quite clearly that many employers hold definite--and often unfavorable--attitudes toward employing older workers. However, objective means of determining the validity of these views have generally been lacking.

In other studies 1/ conducted by the Department of Labor, the status of the older worker has been examined from the standpoint of pension costs, insurance plans, counseling and placement services, and certain other specific aspects. The present study is directed toward a measurement of actual on-the-job performance of older production workers, as compared with the performance of those in the younger groups. It represents a continuation of earlier work in this field. A pilot study of relationships betwen job performance and age was undertaken by the Bureau of Labor Statistics during 1955-56, and the results were published as BLS Bulletin 1203, Job Performance and Age: A Study in Measurement, September 1956.

The pilot study was planned as a means of developing objective techniques which would be useful in comparing the performance of production workers in different age groups and was primarily methodological in nature. The present study has as its purpose the accumulation of more extensive data in this area which will permit the drawing of more definitive conclusions than were possible from the pilot work.

This study was conducted in the Bureau of Labor Statistics' Division of Productivity and Technological Developments under the direction of Jerome A. Mark, assisted by Bernard N. Rein, Stanley F. Miller, and Margaret L. Moeller.

The Bureau wishes to thank those firms whose cooperation made this work possible. They generously made their records available to the Bureau's representatives and furnished helpful suggestions.

1/ Older Workers Under Collective Bargaining: Part I: Hiring, Retention, Job Termination, BLS Bull. 1199-1; Older Workers Under Collective Bargaining: Part II: Health, Insurance, and Pension Plans, BLS Bull. 1199-2; 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, BES No. R. 151; Counseling and Placement Services for Older Workers, BES No. E. 152; How to Conduct an Earning-Opportunities Forum in Your Community.

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Summary of Findings

This survey of job performance and age represents one segment of the U. S. Department of Labor's program in the area of older worker studies and is an extension of the pilot work undertaken in 1955-56. Utilizing the methods developed during the pilot work, this survey centered on the measure of the relationships between age and output per man-hour, attendance, and continuity of service in large establishments manufacturing men's footwear and household furniture. Output data were included for over 5,100 production workers in 26 establishments--15 in the footwear industry and 11 in the furniture industry. Comparable output per man-hour data for workers in 4 footwear establishments included in the pilot investigation were incorporated with the data obtained in the current investigation in order to furnish a broader base for the findings. Attendance data were obtained for about 9,400 workers and continuity-of-service data for almost 10,000 in 22 establishments--11 in each industry.

Findings

With respect to output per man-hour this study reveals, in general, that for both men and women the indexes of output per man-hour are progressively higher from the under-25 group to the 25-34 age group; indexes for subsequent age groups show a gradual decline which is somewhat more marked for the 55-64 age group. Finally, at the 65-and-over level, a sharper decline occurs. However, the differences between age groups through the 55-64 group are generally small (with the exception of only 1 group of women in 1 industry, they are within 8 percentage points of the base, 35-44 age group) and the differences between average output per man-hour of adjacent groups (also with 1 exception) are particularly small.

At the same time, there is a wide range in output within each of the age groups, so that the output of any given individual is likely to differ sharply from the average of his age group. Variations in the output per man-hour of persons in the same age group are greater than differences between the average output of different age brackets. Consequently, substantial proportions of workers in older age groups perform better than the average for younger groups. As an illustration, in the 45-54 age group, 47 percent of the women workers (in both the footwear and furniture plants) have higher productivity than the average woman worker in the 35-44 age group. This wide variability within age groups coupled with the small differences between age group averages indicates that conclusions about individual performance cannot be based solely on chronological age.

Analysis of relationships between age and output per man-hour when the workers are classified and compared by type of operation and pay level--hand operators versus machine operators, higher versus lower paid occupations--reveals the same basic pattern as shown by the industry totals.

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The inference to be drawn from the findings concerning output per man-hour is that individual capabilities are the most important factors to be considered in selecting workers for specific jobs and that any attempt to establish formal age limits for various classes of jobs, even where the job content is clearly defined, fails to take into account the wide diversity of ability levels shown by persons of the same age.

Differences in attendance rates between one age group and another are extremely small. In the 11 footwear plants for which attendance data were compiled, the indexes of attendance among the 6 age groups vary by less than 1 percent for the men and by 1.2 percent for the women. In the furniture plants they vary by less than 4 percent for both men and women. The absence of any trend in relation to age and the apparently random manner in which the insignificant differences between age groups are distributed, suggest that age as a factor relating to a worker's attendance can be ignored.

No age attendance patterns emerge from the indexes of workers classified according to method of payment, length of service, and occupational pay level, although in a few cases the differences between age groups are somewhat larger than the differences for the industry totals.

In the two industries the women workers, regardless of age, show a slightly lower attendance rate than the men workers. At the same time, both men and women in the footwear plants have higher attendance rates than those in the furniture plants. For both industries hourly paid workers have lower attendance rates than incentive workers and workers with 2 or more years of service have higher rates than those with less than 2 years' service. Finally, for the most part, workers in higher paid jobs have a better attendance record than those in lower paid jobs.

In terms of continuity of service (the proportion of workers who remained on the job during a 1-year period), the study revealed that the percentage of workers who remain is highest for ages 45 through 64. As might be expected, both the youngest and oldest groups have the highest percentage of separations. Yet in the footwear plants the influence of retirement on the oldest groups is not as great as the influence of other factors causing separations among the youngest group.

Examination of the continuity indexes of workers grouped by industry, sex, and length of service reveals the same pattern indicated above except that among workers with less than 2 years' service, the declines in the rates for the oldest and youngest groups are greater than those for the corresponding groups of workers with 2 or more years of service.

It is apparent that the relationship between job performance and age is by no means simple. For each of the three aspects of job performance examined a different pattern emerges. For output per man-hour, although there are changes on the average associated with age, there is wide variability about the averages; in the case of attendance, no relationship is found; and for continuity of service, with the exception of the oldest age group where the influence of retirement is felt, as age increases the indexes generally increase.

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Scope

This study represents an outgrowth of a pilot survey of relationships between job performance and age. Whereas the earlier survey was methodological in approach, the present work concentrated on expanding the coverage so that more definitive conclusions could be drawn. The number of workers on which data were obtained was increased and the coverage was expanded geographically to include plants in the Middle West and Southeast regions as well as the Middle Atlantic and New England regions.

This report presents data for the industries producing wooden household furniture (upholstered and unupholstered) and men's footwear (except rubber). These industries were selected for study because they show a distribution of men and women workers throughout all age groups which is similar to manufacturing as a whole and because they involve wide use of incentive systems of payment. This latter characteristic is essential, for it furnishes a means to measure individual output. The fact that management and union sources in these two industries had expressed interest in the problem of job performance and age was a contributing factor in their selection for study.

Because of the necessity of making output per man-hour comparisons only among workers of the same sex engaged in the same occupation, it was important to select large establishments for this study to secure a sufficient number of observations. The sample was drawn from a roster of all large firms having incentive payment plans in the 2 industries--usually firms selected employed at least 300 workers paid on an incentive basis. The establishments may not necessarily be representative of all large firms in the industries, for some establishments were eventually excluded because of an unwillingness to cooperate or a lack of suitable records. In order to furnish a broader base for the findings, comparable output per man-hour data for workers in 4 footwear establishments included in the pilot investigation were incorporated with the data for output per man-hour.

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Concepts and Methods

As a result of the pilot investigation, three indicators were found to be suitable for representing an individual's job performance--output per man-hour, attendance, and continuity of service. They were selected because they afforded objective measures and were directly available from plant records.

Output Per Man-Hour

Probably the most important aspect of an individual's job performance is his productivity, for the rate at which a worker produces acceptable output is a key indication of how well he will be able to meet production requirements.

In this study, productivity was defined as the individual's physical volume of production per hour--his output per man-hour. For the most part, output per man-hour was measured by average straight-time hourly piecework earnings. As described in the report on the pilot study, 2/ this indicator was chosen as the best available measure of an individual's physical output. Although the limitations of this measure were recognized, it was found to be suitable for the purpose at hand.

To derive this measure, it was necessary that the earnings data exclude payments for other than production work. Thus, bonuses for length of service, makeup payments, 3/ and premium payments for overtime and holiday work were eliminated from the earnings figures for each worker. In addition, all time-work hours and earnings were removed from the figures on individuals who worked on both piecework and timework during the survey period.

In some cases, output per man-hour was measured in terms of the number of standard time units produced per hour worked. These data were maintained in certain plants for group incentive workers as well as those paid on an individual piece-rate basis, so that it was possible to expand the coverage to include these workers.

The observation period for output per man-hour data ranged from 4 to 12 weeks in the various plants. This was a compromise between a very long period which would tend to even out atypical influences of a temporary nature, and a very short period, which would permit the inclusion of a larger number of individuals. Only those employees who had worked during all, or nearly all, of the survey period, were included.

2/ Job Performance and Age, BLS Bull. 1203 (pp.8-9).

3/ The term "makeup payments" refers to the additional amounts paid to workers whose raw piecework earnings fall below some legal or guaranteed minimum.

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Eliminated from the productivity sample were pieceworkers in occupations for which management imposed production limits in order to maintain quality standards. Output measures based on earnings in these jobs would not have represented production rates determined by the individual worker. Beginners and employees who were paid according to group incentive plans (for whom no individual output data were available) were also excluded from the output per man-hour sample. Beginners were identified through discussions with foremen and by examining records of length of service in the particular job. In most occupations, employees with less than 3 months' service on the job were considered beginners.

Limitations of Comparing Employed Pieceworkers

Although this study includes data on the productivity of a small number of group incentive workers, the great majority of the individuals studied were paid according to piecework systems. Consequently, many of the limitations of any study which examines only pieceworkers are relevant to this survey.

The performance of pieceworkers, it is recognized, may not be entirely representative of all production workers. Skilled craftsmen are usually not paid according to production by the piece and most unskilled workers are paid on a time basis. However, the bulk of production workers are employed in the semiskilled type of jobs, many of which are covered by piecework plans.

It is quite possible that the factors determining productivity of pieceworkers may be different from those determining the productivity of industrial workers as a whole, and that these differences may not apply uniformly to all age groups. For example, piece-rate jobs may, on the average, place greater emphasis on speed, agility, and other physical attributes which are generally assumed to deteriorate with age. If this is so, then data based on the performance of pieceworkers would tend to show the older individuals in a less favorable light than would be the case if a variety of payment plans had been included. Nevertheless, there is justification for a study confined to pieceworkers, since in many establishments the piece-rate system is the dominant method of payment.

It may also be argued that because only employed persons were included in the study, the older workers who were still present in the occupations studied actually represented a selected group, since many workers originally in these occupations had left for other jobs 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 to some extent: the exceptionally superior workers may be assumed to have gone into better paying occupations; 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 comparable with those of the younger groups.

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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. Neither is there evidence of 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 to which these situations prevail in the plants surveyed. Since their effects tend to be offsetting, the net result is not believed to be very great.

Attendance

Although very important, an individual's rate of production is not the only aspect of his job performance. The amount of time he can be depended upon to be on the job and maintain his output--his attendance rate--is also significant.

For purposes of this study, the attendance rate was defined as the ratio of days worked to days scheduled. To compute this rate, an employee's absences were subtracted from the total number of days on which he was scheduled to work during the observation period, and this yielded the total days worked. This figure was then divided by the number of days scheduled. If a worker performed any work at all during a day, he was not considered absent that day. Days on which a worker was away because of layoffs, holidays, shutdowns, or regular vacations were excluded from both the days worked and days scheduled.

Attendance rather than absenteeism was selected because it is believed that the proportion of total scheduled time an employee is on the job is of greater importance as a performance indicator than the proportion of total time he is off. Small differences in absenteeism rates would tend to exaggerate the relative performance of different workers. For example, a worker who was absent 2 days in 100 scheduled workdays cannot realistically be considered twice as dependable as a worker absent 4 days in 100. It would seem more appropriate to relate the two workers in terms of their attendance rate, i.e., 98 days present out of 100 as compared with 96.

Unlike the output per man-hour measure, the attendance concept need not be restricted to workers paid according to any one specific arrangement. Data are presented for timeworkers and group bonus workers, as well as for piecework employees.

For attendance, as in the case of output per man-hour, the observation period must be long enough to avoid atypical situations. The period selected for obtaining attendance data in the various plants ranged from 12 weeks to 1 year, depending on the nature of the records. Parts of that period coincided with the observation period for output per man-hour.

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Continuity of Service

A third aspect of job performance examined in this survey was the rate of continuity of service--the proportion of total workers who remained on the job during a 1-year period. This indicator--the converse of the separation rate--was included as a measure of the relative stability of the various age groups.

The continuity rate was computed by dividing the number of workers in a given group who were still employed, i.e. did not quit, get discharged or retire, at the end of the observation period by the number in the group at the beginning of the period. Employees who were separated, as a result of production layoff were not considered as separations. Accessions during the period, were excluded from both the numerator and denominator. All workers for whom the necessary data could be obtained were included in this measure regardless of payment method.

As in the case of attendance, continuity of service rather than separations were used because small differences in the separations rates would tend to exaggerate differences between age groups.

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Statistical Procedures

The statistical methods applied in this study were designed, first, to isolate the influence of age from the many other factors which affect a person's job performance and second, to combine measures drawn from small groups of workers into larger aggregates. The initial measures drawn from small groups, could not furnish meaningful results, but their combination permitted the drawing of statistical conclusions.

Establishment of Direct Comparison Groups

Workers were first grouped according to factors, other than age, which might affect individual job performance, such as specific occupation, method of payment, and length of service. Within each of these groups, comparisons were made of the average performance of workers in various age groups. The non-age factors which determined these groups varied for each of the indicators (output per man-hour, attendance and continuity of service), although for all three indicators the groups were limited to workers of the same sex in the same plant. The purpose here was to insure that age-performance observations were made only among workers having in common those characteristics which would have an important bearing on the performance trait being measured. If this had not been done, any apparent differences in the performance of age groups might, in reality, be only a manifestation of the unequal distribution of these characteristics among the age groups. For example, it would be misleading to compare the average hourly earnings of two age groups composed of differing proportions of men and women, since this would introduce important factors other than age.

For output per man-hour, direct comparisons were limited to workers of the same sex who were regular operators (not beginners or part-time workers) performing the same job or series of operations in the same plant.

In the case of attendance, the basis for establishing the direct comparison groups was somewhat different. It was believed that the following non-age characteristics would influence attendance: Sex; plant; method of payment (time or incentive); length of service; and level of occupation (higher paid or lower paid).

Workers paid at an hourly rate are likely to have different attendance motivations from those under an incentive system. Similarly, employees with varying lengths of service may have different attendance motivations. Finally, it is probable that the factors influencing the attendance of workers in lower paid jobs differ from those affecting the attendance of workers in higher paid jobs. Attendance comparisons by age, ignoring these differences, might then reflect changes associated with these factors rather than with age. Therefore, the groups were established so that all of the above factors were constant within a given group.

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For the continuity-of-service measure, the groups were established according to the following characteristics: Sex; plant; and length of service.

The length-of-service classification divided workers into those who had been employed in the plant 2 years or more and those with less than 2 years' service. Most probably, separations are greater among relatively new employees than among a group of workers with extended service.

To classify each occupation as higher paid or lower paid, the following procedure was adopted: Specific average hourly earnings criteria were determined separately by region, sex, industry, and method of payment (incentive or timework), which were then used to distinguish between the two pay levels. These criteria were derived from data obtained in wage surveys conducted by the Bureau, and represented averages of all employees in each category, regardless of plant. The actual occupations found in the current study were then designated as higher paid if the average of the hourly earnings of workers in that category equaled or exceeded the predetermined criterion, and lower paid if it did not.

Each worker was then classified by age into 1 of 6 groups--under 25, 25-34, 35-44, 45-54, 55-64, and 65 and over.

For each indicator, the performance of age groups within the basic comparison groups was measured by calculating indexes for each age group average, using the average of the 35-44 age group as the base. Thus, a measure was derived for each age group reflecting the relative performance of that given age group as compared with the corresponding 35-44 age group. By transforming the average hourly earnings data of incentive workers into indexes for output per man-hour, the possibility of distortion from variations in absolute pay levels in different operations or in different plants was eliminated, and the indexes could be viewed as independent of the plant in which the individual worked.

Combinations of Direct Comparison Groups

To obtain results which would represent larger numbers of individuals than were available in the basic divisions mentioned above, these groups were combined into classes in which the effect of factors other than age was believed to be fairly uniform for all age groups. In the case of output per man-hour, the indexes for workers in specific occupations were grouped according to (1) sex, (2) higher or lower paid occupations, (3) hand or machine occupations, and (4) industry.

The basis for classifying occupations into higher or lower paid categories has already been described. The hand-machine distinction was drawn by defining a machine job as one which required the use of a powered device. Most of these designations were assigned after discussion with plant officials as to the particular equipment used in various occupations. The machine-hand distinction was made in order to separate jobs which place somewhat different requirements

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on workers. Machine jobs call for skills and talents different from those needed for hand operations, and the skills peculiar to machine operations or to hand operations may influence the productivity of various age groups differently. By making this distinction, the influence of these factors in age group comparisons was minimized.

In the case of attendance, the plant indexes for workers in higher and in lower paid jobs were combined across plants into larger groups of workers classified according to (1) sex, (2) higher or lower paid occupations, (3) incentive or timeworkers, (4) length of service, and (5) industry.

Similarly, for continuity of service, the plant indexes for workers with different lengths of service were combined across plant lines. Here, they were classified according to (1) sex, (2) length of service, and (3) industry.

To obtain these combinations, each of the age group indexes for a direct comparison group was combined with a weight which reflected its relative importance in the particular combination group. For example, the output per man-hour age group indexes for specific occupations were combined with weights reflecting the contribution of each specific occupation to the output per man-hour measure for an occupational group (e.g. higher paid machine jobs). The weight took into account the number of workers in the age group as well as the number of workers in the base group (age 35-44) for each occupation and took the form $N_aN_b/(N_a + N_b)$, where N_a was the number of workers in the age group and N_b the number in the base group. 4/

For attendance and continuity of service, the same form of weights was applied, except that the weight was multiplied by a constant for each plant in order to account for differences in the periods for which these data were collected. In the case of attendance, this constant was the number of scheduled workdays in the plant during the survey period. For continuity of service, the figure was the length of the observation period in the plant.

Additional Combinations

Besides the indexes for the basic comparisons and the initially combined groups, more generalized indications of the relative performance of the various age groups were derived. By combining the occupational group indexes for output per man-hour, a separate measure for workers in each industry by sex and occupational class (hand, machine, higher paid, lower paid) was obtained. Similarly, by subsequently combining these indexes, a separate measure for men and for women workers in each industry was derived. For attendance and continuity, similar combinations were made to obtain indexes for each industry by sex.

To derive these indexes, each of the component indexes was assigned a constant weight for all age groups. With this weighting system, the final

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4/ The derivation of this formula is shown in appendix II (pp. 54-56).

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index was not influenced by different proportions of the component groups in one age class as compared with another. Thus, the influence of factors other than age was constant for all age groups. The weight used in all cases was the total number of workers of all ages within the component group.

Individual Variation

In addition to presenting the indexes for an age group at the various stages of combination, the study also includes a measure of the extent of individual variation within each age group. This measure indicates whether an index derived for a particular age group reflects the performance of individuals whose scores show considerable uniformity or whether, on the other hand, their scores vary widely about the average for the group.

A dispersion measure was derived for the output per man-hour combinations only. Dispersion measures for attendance were not derived, since they have limited usefulness. The distribution of individual attendance rates is skewed, with most scores very close to the maximum score of 100. It was not feasible to derive a dispersion indicator for employment continuity because of the nature of the measure.

The dispersion measure employed was the coefficient of variation, which was expressed as a percent of the group score.

As with the age group indexes, the coefficients of variation for the specific occupations were combined to obtain a measure for the occupational group. These measures in turn were combined to obtain more general indications of the dispersion. In each combination, weights were used to reflect the relative importance of the component measure in the combination. In each case, the weight applied was the number of workers in the component group, less one.

Statistical Significance Testing

In the case of output per man-hour, procedures were employed for testing for statistical significance the difference 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 between the two indexes was obtained and its standard score computed. With few exceptions, it was found that these differences were statistically significant at the 5-percent level--that is, these indexes were significantly different from 100 in the sense that, if there were really no difference between an age group and base group, a difference as great as this would be obtained less than 1 time in 20 on repeated sampling. The indexes found to be not significant were those of the women employees aged 45-54 and the men aged 25-34 in the footwear plants and women aged 45-54 and under 25 and men under 25 and 25-34 in the furniture plants. The differences between these indexes and 100 were so small that even with the sizable samples they were not found to be statistically different from 100.

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Findings

The findings presented here reflect the experience of production workers in certain large establishments in the footwear and household furniture industries. Data on one or more of the performance indicators--productivity, attendance, or continuity of service--are presented for 13,350 workers employed in 26 establishments, 15 of which were in the men's footwear industry and 11 in the wood and upholstered furniture industry. (In the footwear industry, data on attendance and continuity of service were obtained from 11 plants.) The data were collected for substantially full-production periods during 1955-56.

Output Per Man-Hour

Direct comparisons of output per man-hour were limited to those workers whose individual contribution to total production could be measured, and who were performing the same operations. Consequently, it was not possible to collect productivity information for all workers in the establishments. However, output per man-hour measures were obtained for 5,147 production workers--1,651 in the furniture establishments and 3,496 in the footwear plants.

The majority of these workers, as mentioned above, were pieceworkers, but there were some workers for whom individual output data could be derived, even though they were paid according to a group incentive plan. It was not possible, however, to include any hourly rated workers in this group.

Separate results are presented for men and women employed in the 2 industries (tables 1 and 2), and the results are further subdivided into earnings level groups (tables 3, 4, 5, and 6), and according to hand and machine occupations (tables 7, 8, 9, and 10).

Industry Totals. From an examination of the combined indexes representing all occupational levels, two broad conclusions emerge. First, there is a consistent pattern of relationship between age and output--a rise in the indexes from the under 25 age group to the 25-34 group, followed by a gradual decline which is somewhat more marked for the 55-64 group. Finally, at the 65-and-over level, a sharper decline occurs. Second, it should be noted that differences between age groups are generally small. With only one exception, all of the output indexes, through the 55-64 year group are within 8 percentage points of the base group indexes. Differences between adjacent 10-year age groups are (also with one exception) relatively small.

These observations apply to both the footwear and furniture industries, and to both men and women workers. The one exception indicated above occurs in the case of women furniture workers aged 55-64, with the index declining to 85.6.

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Table 1. Indexes of output per man-hour for incentive workers in 15 men's footwear establishments, by sex and age group

(Age group 35-44=100)

Age group	Men			Women		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	98	93.8	17.9	111	94.4	17.1
25-34 . .	278	100.3	16.3	292	102.8	17.5
35-44 . .	484	100.0	13.8	589	100.0	15.2
45-54 . .	460	97.7	14.1	534	98.8	15.6
55-64 . .	322	92.5	14.5	219	94.1	13.1
65 and over	75	81.1	16.6	34	88.0	20.7

Table 2. Indexes of output per man-hour for incentive workers in 11 household furniture establishments, by sex and age group

(Age group 35-44=100)

Age group	Men			Women		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	214	98.5	16.3	22	101.4	18.8
25-34 . .	436	101.5	15.1	79	107.4	19.4
35-44 . .	372	100.0	11.8	97	100.0	17.8
45-54 . .	218	96.1	11.0	63	98.7	16.0
55-64 . .	96	94.5	11.8	33	85.6	18.6
65 and over	20	93.6	11.6	1	(1/)	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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In the footwear plants, the men show a slightly more pronounced tendency to decline in performance, with advancing age, than do the women. For age group 45-54, the index for the women is 98.8 whereas the men in this group record an index of 97.7. Similarly, at age 55-64, the 2 indexes are 94.1 and 92.5, respectively. In the furniture plants, a pattern of difference is not apparent. In the 45-54 age group, the women's output is slightly better than the men's (an index of 98.7 as compared with 96.1); the reverse is true for the 55-64 age group--an index of 94.5 for the men as against 85.6 for the women. It is possible that this latter age group is one in which the relatively heavier physical demands of occupations in the furniture industry, as compared with those in the footwear plants, place the older women in a less advantageous position. The jobs in which the women are commonly employed in the furniture industry are sewing covers, tacking upholstery, packing and wrapping chairs, and hand sanding. In comparison with the usual footwear occupations for women--stitching, pasting, cementing, skiving, folding, and dressing--the furniture occupations involve larger pieces on which to work and operations which necessitate strength in addition to skill. Even in the 55-64 age group of women furniture workers, however, performance is within 15 percentage points of the base group index (the 35-44 age group).

Although the 25-34 age group, in both the footwear and furniture plants, and for both men and women, constitutes the age group showing the peak performance index, the superiority of this group over those aged 35-44 is generally slight. In the case of women furniture workers, the index for this age group is 107.4, but in none of the other 3 categories does it exceed 102.8.

In the 65-and-over age group for which data are available, the indexes are all considerably lower than those of the base groups (35-44 years). In the footwear plants, output of the women workers age 65 and over holds up better than that of the men, with an index of 88.0 as compared with 81.1 for the men. Among the furniture workers, the number of women 65 and over was insufficient to permit the presentation of a meaningful index, but the men showed an index of 93.6.

The foregoing comments refer to the average indexes of the age groups. However, in an actual employment situation, there are always specific individual workers involved, so that information regarding the average performance levels of large groups is, by itself, of limited value. What is necessary is some measure of how closely the performance scores of the individual workers conform to this group average.

In this study, the measure used to provide this information is the coefficient of variation, which reflects the difference between the age group average and the individual scores. 5/

5/ The coefficient is calculated by dividing the standard deviation by the mean and indicates the relationship between the value of the mean and distance from the mean within which a specified proportion of the observations will be if the individual observations included in the mean are distributed in a normal frequency curve. For example, if the index of an age group were 90 and the coefficient of variation 10 percent, then about two-thirds of the individual indexes would be between 81.0 and 99.0 (these limits being the mean plus and minus 10 percent of the mean).

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With respect to the variability of individual age groups, there appears to be no consistent relationship between age and the coefficient of variation. Although for both sexes and in both the footwear and furniture industries, there is a slight tendency for the average coefficients of variation of the medium age groups (covering the ages 35-54) to be smaller than those in the younger and older groups, this pattern is not very marked and it is unlikely that any broad conclusions on this point would be justified.

Within the individual age groups, this variability is quite large and carries significant implications. As can be seen from chart 1, substantial proportions of the workers age 45-54 have output indexes which are higher than the average index of the 35-44 age group. This proportion varies from 47 percent for the women workers in both footwear and furniture plants to 39 percent in the case of men furniture workers. 6/

Even in the age group 55-64 there is a significant proportion of workers with output indexes higher than the average of the 35-44 age group. In the case of men workers, they comprise 30 percent of the employees in the footwear plants within this age group and 34 percent in the furniture plants. For women workers, the percentages are 35 and 21, respectively.

These results indicate that an evaluation of individual workers is far more important than any general ideas concerning the relationship between age and productivity. In view of the small differences in the averages of the age groups and the wide variability in individual performance rates found in this study, it is clear that an employer should emphasize the development of effective means for determining the individual capabilities of particular workers, rather than attempt to apply conclusions based on the chronological age of the workers involved.

It may be noted that the women workers show slightly higher average coefficients than the men. In the footwear plants, the average for men is 14.8 percent and for women, 15.6 percent. In the furniture plants, the men showed an average coefficient of variation of 13.9 percent, whereas the women averaged 17.9 percent. While the women show a higher variability in both industries, the difference between the men and women workers is greater in the furniture plants.

6/ These proportions were derived using the index and the average coefficient of variation with the assumption that the form of the distribution of the output per man-hour scores for individuals was normal. There is evidence supporting the view that this will be the case in output per man-hour scores. See Individual Productivity Differences Serial No. R. 1040, February 1940 (pp. 18 and 19). The actual proportions were computed and for the most part they were very close to those based on the normal distribution.

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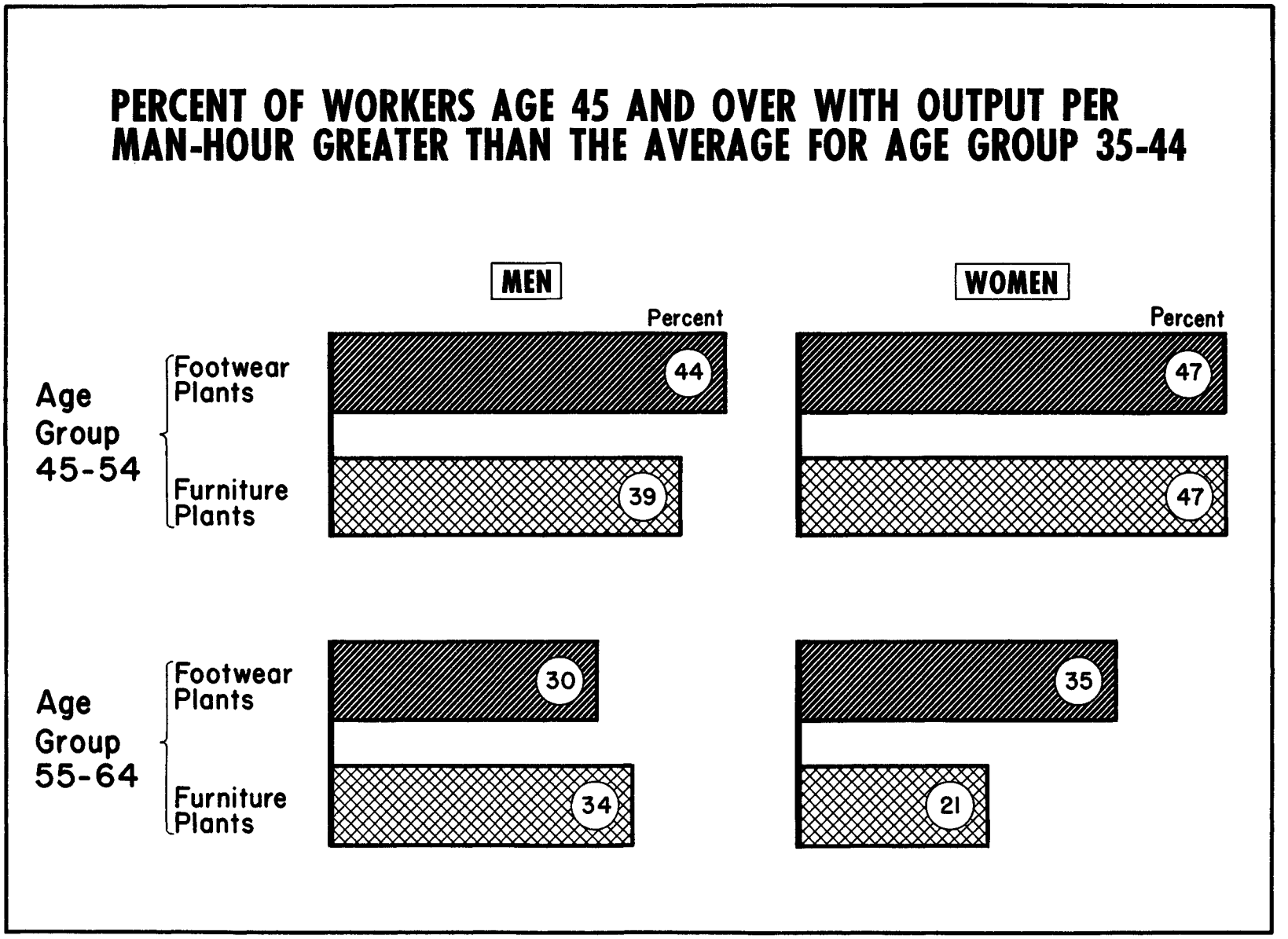
Chart 1.



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The basis for these differences is not clear. It is possible that the economic and domestic situation of women employees shows less uniformity than that of men, and that this, in turn, results in important differences in motivation. The ages of the children, for example, should have more effect on the mother's employment requirements than on the father's. In general, it should be pointed out that women tend to move in and out of the labor force more frequently than men. Their movement is in response to a wide range of influences--both economic and social.

As noted previously, the current study in deriving the productivity indexes did not consider any factors other than volume of output per man-hour. Characteristics such as perseverance, quality of output, and maturity of judgment are not reflected in the indexes. These are, of course, important yardsticks to be employed in determining the overall effectiveness of an employee. Although they are imprecise and subjectively evaluated characteristics, various other studies 7/ indicate that older workers would have the advantage in these respects. Therefore, bearing in mind the nature of the age-output relationship--small differences between the several age groups and great variation among the individuals within age groups--it would be appropriate for an employer to consider the advantages of dispensing with specific age limits in hiring, and thus provide himself with a much broader field from which to make individual selections.

Even the practice of setting age limits for jobs which are considered especially rigorous would appear to have doubtful merit, since the findings in the furniture plants, where physical capacity does appear to be an important factor, indicate that substantial percentages of workers age 55-64 performed better than the average of those age 35-44.

Higher and Lower Paid Occupations. As indicated in the section on statistical methods, the specific occupation indexes in this study are combined into broader groupings to furnish more general conclusions than are possible from the limited numbers of workers in individual occupations. Such groupings are based on characteristics other than age which are believed to influence the measure under consideration. In the case of output per man-hour, the groupings are determined by the average earnings levels of the occupations and by the distinction between hand and machine occupations.

7/ See, for example, Walter Gershenfeld, Job Specifications and Employment Policy (pp. 171-172) and James H. Mullen, The Costs of Retaining Older Workers in Industry (p. 197). (In Proceedings of the Second Conference on the Problems of Making a Living While Growing Old.) Commonwealth of Pennsylvania and Temple University, 1953. William H. Bowers, An Appraisal of Workers Characteristics as Related to Age (in Journal of Applied Psychology, October 1952, Vol. 36, No. 5, pp.296-300).

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The summarization of results separately for employees in higher and lower paid occupations is based on the assumption that these two groups may react differently, in terms of their output per man-hour, to the changes associated with age. It is generally assumed, for example, that higher paid jobs tend to include the more complex operations in which skill and experience are important factors in determining performance, whereas the lower paid jobs tend to be simpler and more repetitive, possibly placing a greater premium on physical abilities as contrasted with mental ones or where skill and experience requirements are lower.

The specific content of many jobs varies from plant to plant. Some of the common higher paid jobs in the furniture plants, for example, are upholsterers, assemblers, boring machine operators, and shaper operators. In the footwear plants, examples of higher paid jobs are the outside leather cutters, pullover operators, top stitchers, and goodyear stitchers. Lower paid jobs in the furniture plants include cusions fillers and glue clamp operators and in the footwear plants, cementers, heel trimmers, lining and leather closers, and folders.

As shown in tables 3 and 5, the same general pattern is followed by indexes for the higher and lower paid occupations in the footwear plants as is followed by the indexes representing the industry totals. For both the men and women workers, in both higher and lower paid occupations, indexes covering the age groups from 25-54 display only minor variation from one age group to another, and all are close to the base group index of 100. For most of the categories mentioned, the under 25 group, as well as the 2 oldest groups (55-64 and 65 and over), have lower indexes than the middle groups. This again is consistent with the industry total findings.

There is little evidence that the relationship between age and output per man-hour differs greatly between the higher and lower paid occupations in the footwear plants, except in two age groups. In the 65-and-over group, both men and women in the higher paid jobs show a much more pronounced decline than do those in lower paid jobs.

Comparison of the variability of output among footwear workers in higher and lower paid occupations reveals no difference of any sizable proportions. The average coefficient of variation (all age groups combined) is almost identical for the upper and lower paid occupations for workers of both sexes. Further, the pattern of variability-age relationships is irregular and unclear; the tendency for the coefficients of variation to be smallest among the medium age groups is less evident than is the case in the coefficients for the industry totals.

Among the workers in the furniture plants (tables 4 and 6), the indexes follow a somewhat different tendency. There is a significant decline in the performance of men workers in the higher paid jobs in the 45-and-over groups, whereas the corresponding decline among men in the lower paid jobs does not appear until the next higher age group (55-64). For women, on the other hand,

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Table 3. Indexes of output per man-hour for men incentive workers in higher and lower paid occupations in 15 men's footwear establishments, by age group

(Age group 35-44=100)

Age group	Higher paid			Lower paid		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	59	94.8	18.7	39	90.4	17.4
25-34 . .	212	100.5	16.5	66	99.5	15.6
35-44 . .	353	100.0	13.9	131	100.0	13.2
45-54 . .	386	97.4	13.9	74	98.8	15.3
55-64 . .	271	92.2	14.9	51	93.3	12.9
65 and over	50	79.1	17.6	25	97.9	15.2

Table 4. Indexes of output per man-hour for men incentive workers in higher and lower paid occupations in 11 household furniture establishments, by age group

(Age group 35-44=100)

Age group	Higher paid			Lower paid		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	182	99.1	16.8	32	96.5	11.7
25-34 . .	361	100.9	14.3	75	103.3	18.8
35-44 . .	279	100.0	12.8	93	100.0	7.3
45-54 . .	146	94.9	9.3	72	99.9	13.6
55-64 . .	60	94.7	8.7	36	93.9	14.0
65 and over	10	94.3	(1/)	10	91.5	11.6

1/ Data insufficient to derive measure.

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Table 5. Indexes of output per man-hour for women incentive workers in higher and lower paid occupations in 15 men's footwear establishments, by age group

(Age group 35-44=100)

Age group	Higher paid			Lower paid		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	72	92.7	17.2	39	97.6	15.3
25-34 . .	202	103.6	13.5	90	101.1	21.0
35-44 . .	377	100.0	17.8	212	100.0	16.6
45-54 . .	357	99.1	15.7	177	98.1	14.0
55-64 . .	131	93.3	16.4	88	95.5	13.9
65 and over	22	84.0	23.3	12	95.4	4.4

Table 6. Indexes of output per man-hour for women incentive workers in higher and lower paid occupations in 11 household furniture establishments, by age group

(Age group 35-44= 100)

Age group	Higher paid			Lower paid		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	16	106.8	18.0	6	92.5	20.4
25-34 . .	61	105.9	18.8	18	109.7	21.9
35-44 . .	55	100.0	18.0	42	100.0	16.6
45-54 . .	34	98.6	16.0	29	98.8	16.0
55-64 . .	13	84.1	14.4	20	88.1	20.3
65 and over	--	--	--	1	(1/)	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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there is no important difference between the patterns of the higher and lower paid occupations, except for the under 25 group. The index for this group is considerably higher than the base group (106.8) in higher paid occupations, while the reverse is true in the lower paid jobs. In this latter category, the under 25 group of women workers shows an average index of 92.5.

With regard to individual variability, the results in the furniture industry are similar to those seen in the footwear industry. Average coefficients of variation (all age groups combined) are virtually identical for higher and lower paid occupations. Also, coefficients for specific age groups show no discernible tendency to be related to age. In both industries, as may be seen from charts 2 and 3, the magnitude of the individual variations is substantial, indicating that in each of the occupational categories many workers will be found whose performance indexes are higher than the average of the base group.

Machine and Hand Occupations. Findings are presented separately for workers in machine and hand occupations in order to ascertain whether differences between the requirements imposed by the two types of jobs affect the various age groups dissimilarly. Machine occupations are defined as those in which a powered device is utilized. The distinction between the two types of jobs involves the notion that the physical demands of machine occupations are likely to be different from those of hand occupations.

Results of this analysis are shown in tables 7 through 10, from which no clear pattern emerges. For example, although the men footwear workers in the 2 oldest age groups (55-64 and 65 and over) do better in the machine jobs, relative to their respective base groups than in the hand occupations, the reverse is true in the case of women workers in this industry. Among the men furniture workers, the average index of the 55-64 age group is higher for those in hand occupations, while for those in the 65-and-over bracket the machine workers have a higher index.

Examination of the coefficients of variation reveals some limited differences between the hand and machine occupations. For example, the coefficients of variation (for all age groups combined) in both industries are higher for hand than for machine occupations among the men. For women workers the reverse is true, with employees in the machine occupations showing the greater variability. This suggests that no generalization is warranted concerning the equalizing effect of the machinery used by industrial workers. While this effect may be a significant factor in some occupations, it is evident from this study that it is by no means universal.

Comparisons of the age-variability patterns between the hand and machine occupations reveal no distinct trends. Although there appears to be a slight tendency for the coefficient of variation to be higher among the younger and older age groups than in the middle groups, the difference is rather small, as was noted in the comparison between higher and lower paid occupations.

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Chart 2.

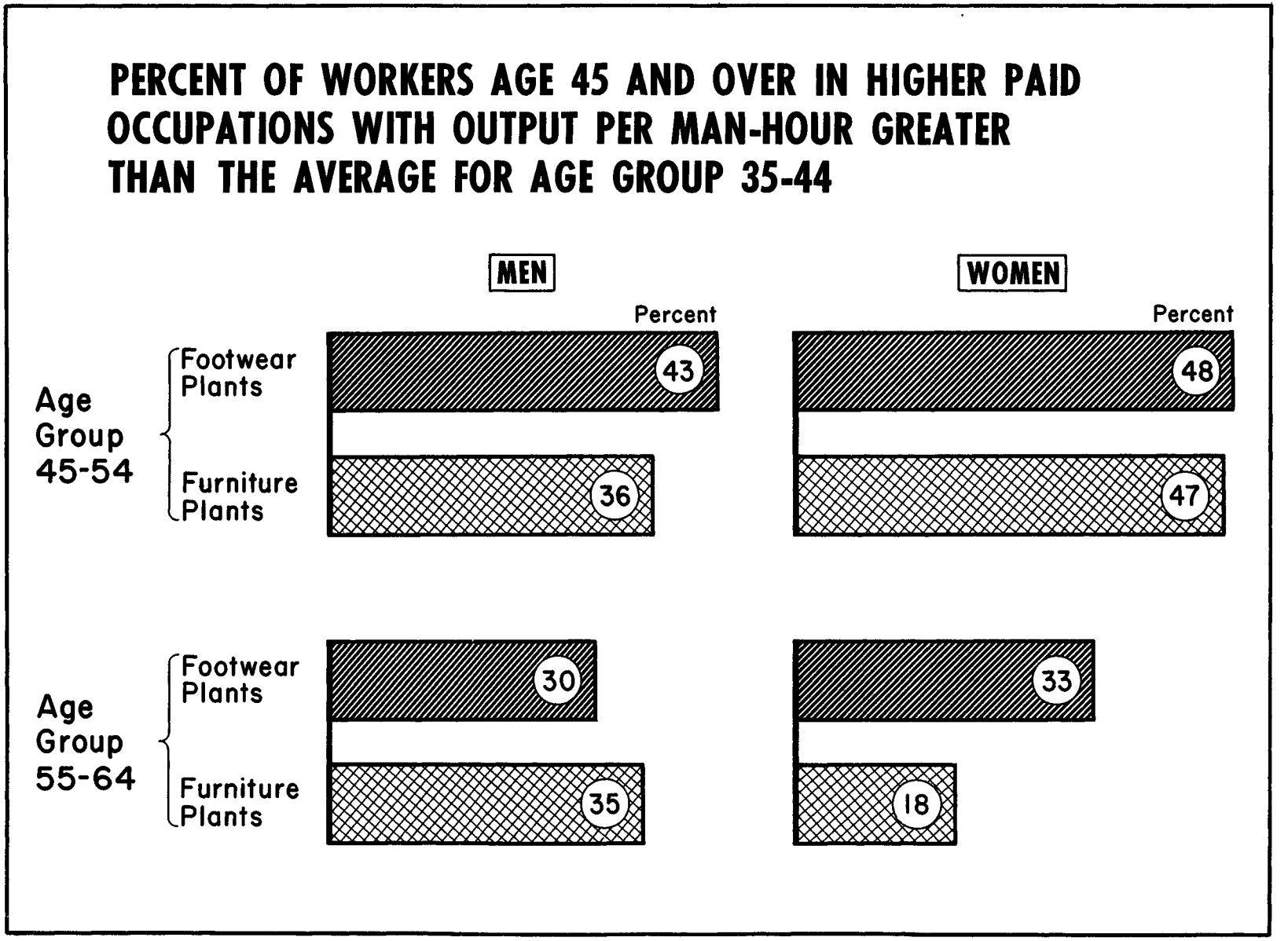

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Chart 3.

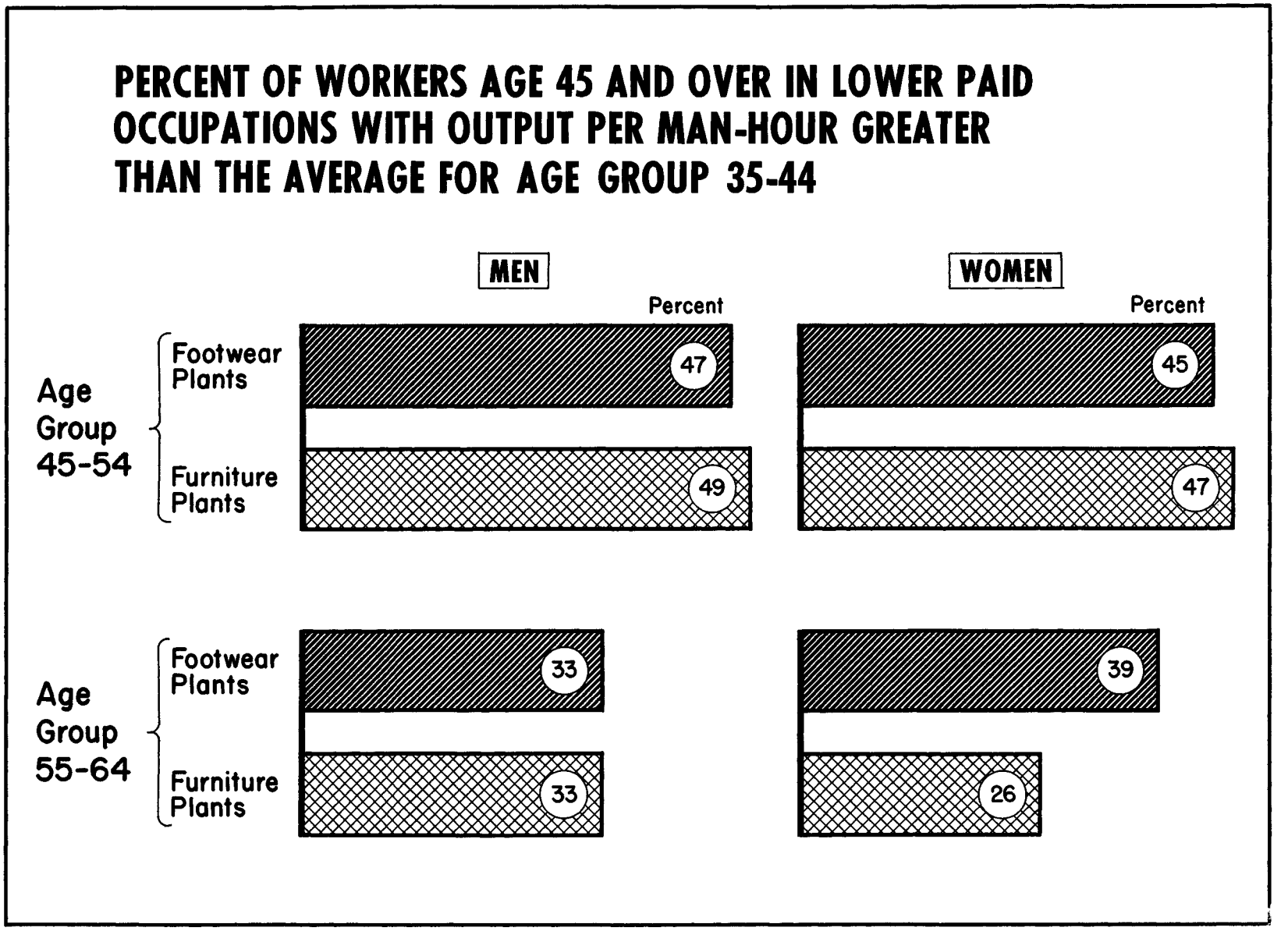

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Table 7. Indexes of output per man-hour for men incentive workers performing machine and hand operations in 15 men's footwear establishments, by age group

(Age group 35-44=100)

Age group	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	81	93.4	16.9	17	97.0	20.3
25-34 . .	228	99.6	16.2	50	105.4	16.5
35-44 . .	419	100.0	13.2	65	100.0	17.0
45-54 . .	424	97.4	14.0	36	99.8	16.0
55-64 . .	296	93.0	14.6	26	88.6	13.5
65 and over	63	81.8	16.6	12	75.8	16.6

Table 8. Indexes of output per man-hour for men incentive workers performing machine and hand operations in 11 household furniture establishments, by age group

(Age group 35-44=100)

Age group	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	82	97.0	11.0	132	100.5	18.4
25-34 . .	199	100.3	12.9	237	103.2	16.4
35-44 . .	242	100.0	8.9	130	100.0	15.5
45-54 . .	182	98.6	11.3	36	92.6	9.0
55-64 . .	72	94.4	11.2	24	94.7	13.3
65 and over	17	94.7	9.0	3	(1/)	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 9. Indexes of output per man-hour for women incentive workers performing machine and hand operations in 15 men's footwear establishments, by age group

(Age group 35-44=100)

Age group	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	76	95.7	17.8	35	91.1	14.2
25-34 . .	223	102.4	19.0	69	103.7	9.0
35-44 . .	398	100.0	15.9	191	100.0	13.2
45-54 . .	394	98.9	16.1	140	98.5	13.6
55-64 . .	167	93.6	13.8	52	95.2	9.5
65 and over	29	85.7	20.7	5	93.9	(1/)

1/ Data insufficient to derive measure.

Table 10. Indexes of output per man-hour for women incentive workers performing machine and hand operations in 11 household furniture establishments, by age group

(Age group 35-44=100)

Age group	Machine			Hand		
	Number of workers	Index	Coefficient of variation (percent)	Number of workers	Index	Coefficient of variation (percent)
Under 25 .	9	105.0	25.6	13	94.8	16.1
25-34 . .	27	109.3	22.7	52	104.2	17.8
35-44 . .	71	100.0	17.8	26	100.0	15.8
45-54 . .	46	97.3	17.7	17	101.0	6.8
55-64 . .	32	88.9	18.6	1	(1/)	(1/)
65 and over	1	(1/)	(1/)	--	--	--

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Even though they are somewhat irregular, the coefficients of variation in all age groups for both hand and machine occupations tend to be large. Individual variability is a factor of major significance among all the groups of workers studied, and the performance of an individual selected from one of these groups is likely to differ markedly from the average of his group.

As is evident from charts 4 and 5, substantial proportions of workers in the higher age brackets for both classifications perform better than the average for age group 35-44. There was no consistent difference in these proportions for machine operations as contrasted with those engaged in hand jobs.

This wide general variability combined with the small differences in the average indexes, as well as the absence of any consistent differences in the patterns for hand and machine occupations, would indicate that there is no valid basis for specifying definite age limitations for certain classes of jobs.

Attendance

Attendance data were collected for 9,440 workers of whom 4,780 were in 11 men's footwear plants and 4,660 were in 11 furniture plants. Depending on the plants' records, data were obtained for periods ranging from 3 months to 1 year. The sample for this indicator was larger than that for output per man-hour because here it was possible to include workers paid on an hourly basis as well as those paid according to an incentive system.

As can be seen in tables 11 and 12, which show the attendance findings for the industry totals separately by sex, the data refute current ideas that there are striking differences between age groups as to regularity of attendance at work. The differences between age groups, here, are extremely small. Among the footwear workers, these differences do not even exceed 1 percent for the men and 1.2 percent for the women. In the furniture plants, the indexes for all age groups fall within 98.6 and 102.4 percent of the base group (a range of 3.8 percent) for men and within 97.1 and 100 for women (2.9 percent). There is no consistent relationship between attendance and age.

With regard to individual variations, the differences in individuals' rates from the group average in all cases were insignificant.

The absence of any pattern of the indexes by age, as well as the extremely small variation between age groups, suggests that age as a factor relating to workers' attendance can be ignored.

Although there are no consistent differences in the pattern of the indexes by age for men or women in either industry, there are some differences in the overall measures for these groups. The men workers in both industries have slightly higher average attendance rates (number of days worked per 100 scheduled workdays) than do the women workers. In the footwear plants the rate for men is 98.3 and for women, 97.0. The rates in the furniture plants are 96.8 and 94.5, respectively. Also, as can be seen, both the men and women in the

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Chart 4.

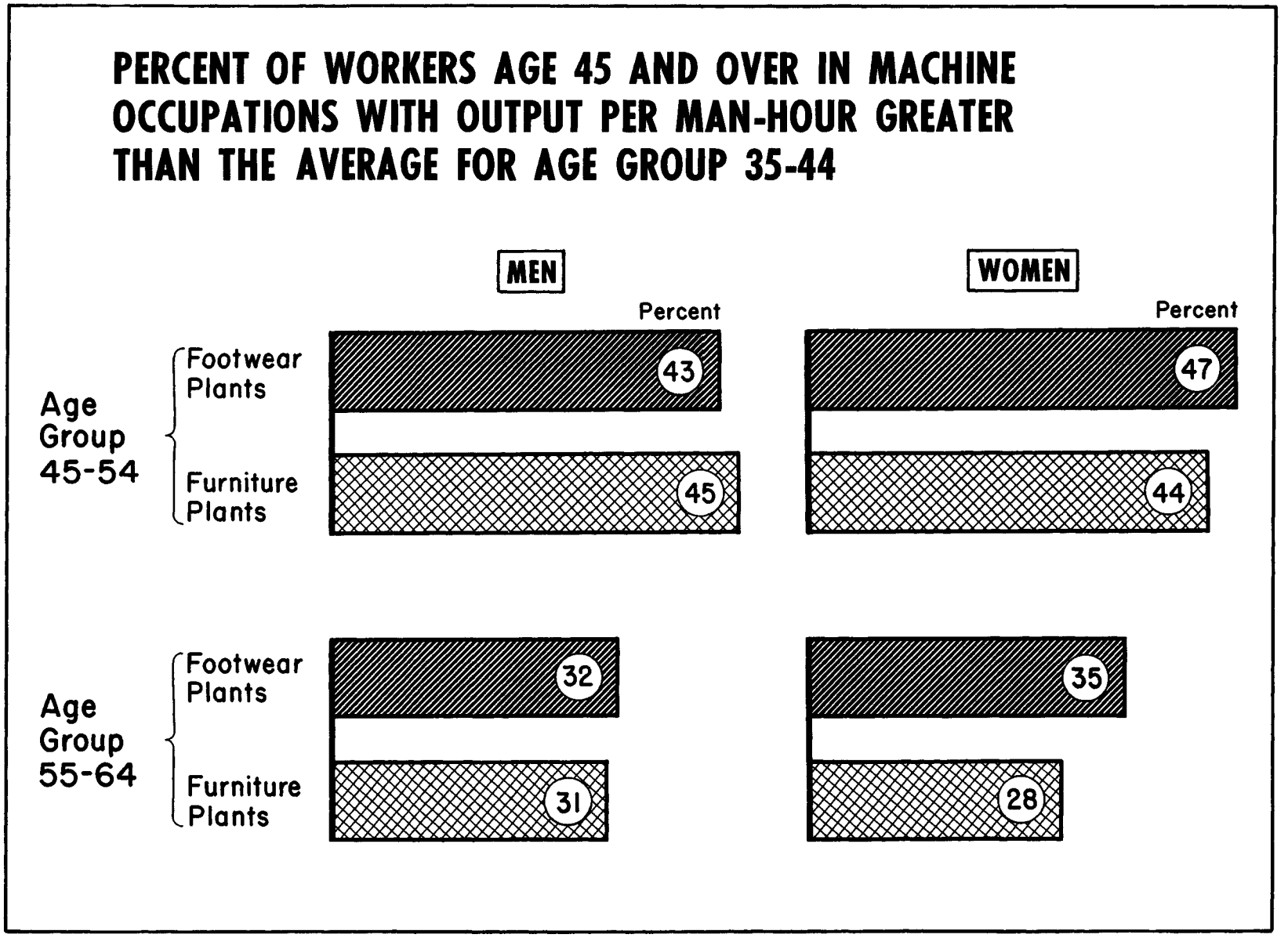

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Chart 5.

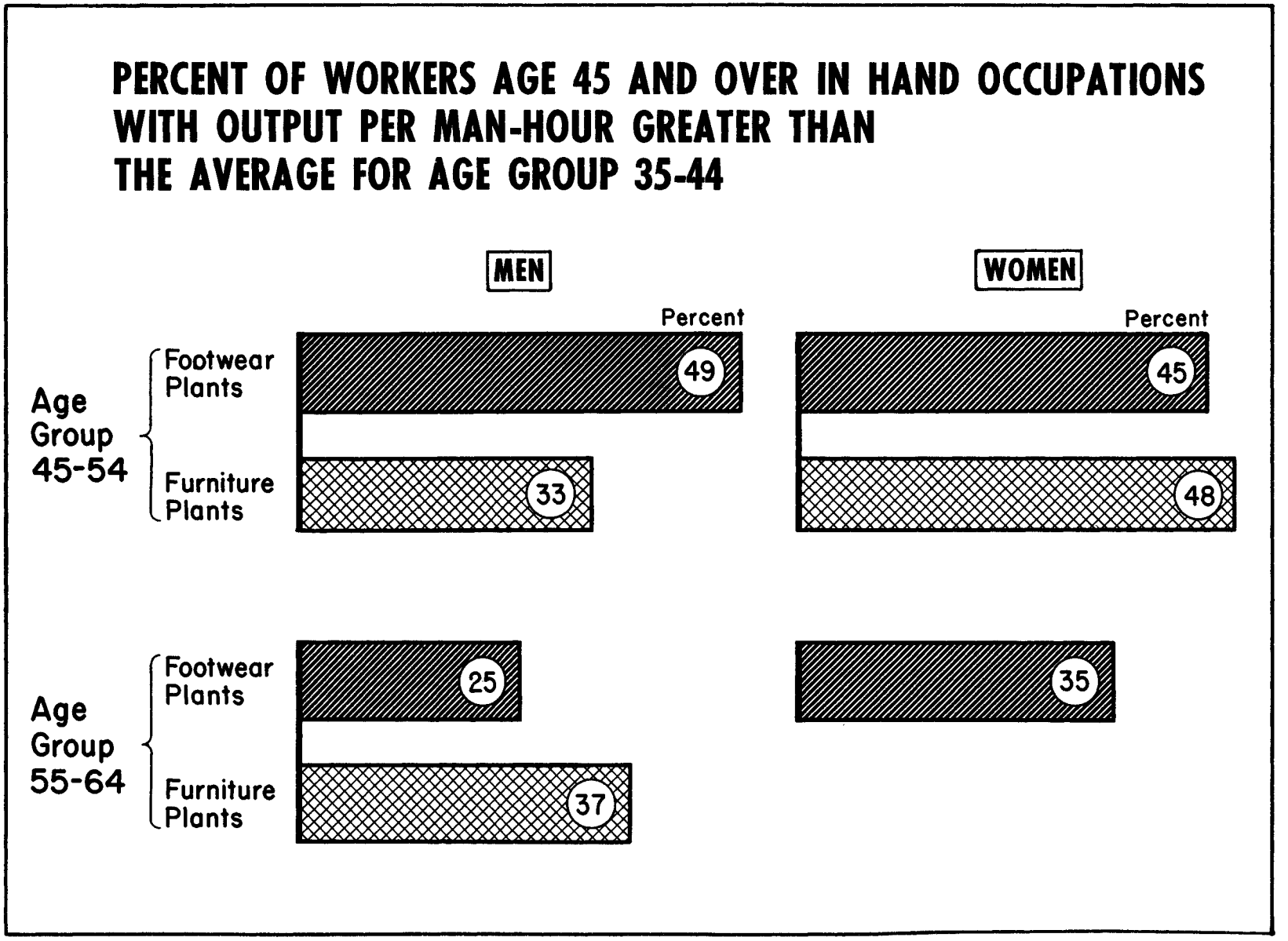

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Table 11. Indexes of attendance for production workers in 11 men's footwear establishments, by sex and age group

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	251	99.8	206	100.5
25-34	381	99.9	420	101.0
35-44	447	100.0	724	100.0
45-54	530	100.1	804	101.2
55-64	442	99.9	396	101.2
65 and over	125	99.7	54	101.2

Table 12. Indexes of attendance for production workers in 11 household furniture establishments, by sex and age group

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	562	101.3	54	99.9
25-34	1,122	102.4	140	98.9
35-44	1,010	100.0	197	100.0
45-54	770	100.9	148	99.8
55-64	433	101.5	71	97.6
65 and over	149	98.6	4	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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footwear industry show higher attendance rates than do the corresponding groups in the furniture industry. But all of these differences are small--in no case exceeding 2.5 days taken off per 100 days scheduled.

Because it was believed that the attendance motivations might differ for workers under various systems of payment, with varying length of service, or in higher or lower paid jobs, and that these might affect age groups differently, separate indexes for these classifications were derived. Tables 13 and 14 show age group indexes for incentive workers and for timeworkers; tables 15 and 16, for workers in higher paid jobs and in lower paid jobs; and tables 17 and 18, for workers with less than 2 years' service and with 2 years or more of service. The indexes for each of these groups show no tendency to vary consistently with age. Nor do the indexes show other than random differences in their patterns by age group. For the most part, the variations between age groups in these classifications, just as in the industry totals, are small, but there are a few groups which do show rather large differences. For example, the indexes for both men and women with less than 2 years' service in the furniture plants varied by 16.2 and 10.3 percentage points, respectively.

Although no age-attendance patterns emerge for the various classifications, some differences between the overall rates can be observed. As shown in table 19 both men and women incentive workers in the two industries have higher attendance rates than the hourly paid workers. Similarly, the workers with 2 years or more of service in all cases show higher rates than those with less than 2 years' service and, with one exception, workers in higher paid jobs in both industries have better attendance than those in lower paid jobs. The differences between the rates, while not large, are consistent and suggest that the attendance motivations for these various classifications do differ. The absence of any age-attendance pattern, however, indicates that while the effect of the classification on these motivations might vary, they do not affect age groups differently.

Continuity of Service

Data on continuity of service were recorded for a total of 9,898 workers--5,112 in the footwear plants and 4,786 in the furniture plants. This indicator, the converse of the separation rate, measures the relative proportions of workers in each age group who remained on the job during a survey period of 1 year. It is included to reflect the relative job stability of the various age groups. The number of workers who remained was determined by subtracting the number of workers who quit, retired, or were discharged (including military and medical separations but no layoffs) from the number of workers employed at the beginning of the observation period.

The results of the study show that the percentage of workers who remain on the job is highest for ages 45 through 64. (See tables 20 and 21.) Both the youngest and the oldest age groups have the highest percentage of separations. The decline in the indexes for the 65-and-over group largely reflects the influence of retirement. For the footwear plants, this influence apparently

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Table 13. Indexes of attendance for production workers in 11 footwear establishments, by sex, method of wage payment, and age group

(Age group 35-44=100)

Age group	Men			
	Incentive		Timework	
	Number of workers	Index	Number of workers	Index
Under 25	168	99.7	83	99.9
25-34	294	100.1	87	99.3
35-44	348	100.0	99	100.0
45-54	426	100.3	104	99.7
55-64	306	99.9	136	99.8
65 and over	64	99.8	61	99.5

Age group	Women			
	Incentive		Timework	
	Number of workers	Index	Number of workers	Index
Under 25	138	101.1	68	97.4
25-34	301	100.6	119	102.3
35-44	536	100.0	188	100.0
45-54	562	101.0	242	101.9
55-64	278	101.3	118	100.8
65 and over	39	101.2	15	101.1

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Table 14. Indexes of attendance for production workers in 11 household furniture establishments, by sex, method of payment, and age group

(Age group 35-44=100)

Age group	Men			
	Incentive		Timework	
	Number of workers	Index	Number of workers	Index
Under 25	425	101.4	137	101.2
25-34	852	102.8	270	101.8
35-44	741	100.0	269	100.0
45-54	509	101.7	261	99.4
55-64	229	102.0	204	100.5
65 and over	40	96.7	109	100.5

Age group	Women			
	Incentive		Timework	
	Number of workers	Index	Number of workers	Index
Under 25	35	97.5	19	103.9
25-34	96	98.6	44	99.5
35-44	142	100.0	55	100.0
45-54	103	99.4	45	100.6
55-64	46	95.9	25	100.0
65 and over	2	(1/)	2	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 15. Indexes of attendance for production workers in higher and lower paid occupations in 11 footwear establishments, by sex and age group

(Age group 35-44=100)

Age group	Men			
	Higher		Lower	
	Number of workers	Index	Number of workers	Index
Under 25	84	99.7	167	99.8
25-34	212	100.0	169	99.8
35-44	252	100.0	195	100.0
45-54	312	100.0	218	100.3
55-64	193	99.1	249	100.7
65 and over.	34	99.1	91	100.3

Age group	Women			
	Higher		Lower	
	Number of workers	Index	Number of workers	Index
Under 25	109	100.7	97	100.1
25-34	257	100.4	163	101.9
35-44	458	100.0	266	100.0
45-54	517	100.5	287	102.4
55-64	221	100.5	175	102.3
65 and over	32	100.4	22	103.1

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Table 16. Indexes of attendance for production workers in higher and lower paid occupations in 11 household furniture establishments, by sex and age group

(Age group 35-44=100)

Age group	Men			
	Higher		Lower	
	Number of workers	Index	Number of workers	Index
Under 25	301	100.3	261	102.7
25-34	651	100.6	471	105.1
35-44	583	100.0	427	100.0
45-54	434	100.3	336	101.9
55-64	206	99.8	227	104.0
65 and over	63	100.8	86	96.6

Age group	Women			
	Higher		Lower	
	Number of workers	Index	Number of workers	Index
Under 25	41	99.8	13	99.9
25-34	109	99.2	31	98.4
35-44	124	100.0	73	100.0
45-54	90	100.2	58	99.1
55-64	34	97.2	37	98.5
65 and over	2	(1/)	2	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 17. Indexes of attendance for production workers in 11 footwear establishments, by sex, years of service, and age group

(Age group 35-44=100)

Age group	Men			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	108	99.6	143	100.9
25-34	330	99.8	51	101.1
35-44	410	100.0	37	100.0
45-54	500	100.0	30	102.1
55-64	411	99.6	31	102.8
65 and over	118	99.8	7	97.5

Age group	Women			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	97	100.4	109	101.3
25-34	337	101.3	83	98.7
35-44	627	100.0	97	100.0
45-54	729	101.1	75	101.8
55-64	363	101.0	33	103.3
65 and over	51	101.0	3	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 18. Indexes of attendance for production workers in 11 household furniture establishments, by sex, years of service, and age group

(Age group 35-44=100)

Age group	Men			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	235	99.5	327	107.4
25-34	851	100.3	271	110.1
35-44	870	100.0	140	100.0
45-54	693	99.8	77	106.5
55-64	404	99.0	29	116.2
65 and over	144	97.8	5	114.2

Age group	Women			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	22	101.0	32	96.0
25-34	98	101.1	42	90.9
35-44	150	100.0	47	100.0
45-54	136	99.6	12	101.2
55-64	67	97.3	4	(1/)
65 and over	4	(1/)	—	—

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 19. Attendance rates 1/ for production workers in 11 men's footwear and 11 furniture establishments, by sex, method of payment, length of service, and occupational pay level

Classification	Industry			
	Men's footwear		Furniture	
	Men	Women	Men	Women
Total	98.3	97.0	96.8	94.5
Method of payment				
Incentive	98.4	97.2	96.9	95.4
Time.	98.0	96.4	96.7	93.0
Length of service				
Less than 2 years	97.4	95.5	95.3	94.0
2 years and more	98.4	97.3	97.3	94.6
Occupational pay level				
Higher paid	98.5	97.4	97.1	94.2
Lower paid	98.1	96.4	96.5	95.2

1/ Number of days worked per 100 days scheduled.

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is not as great as the influence on the youngest age group of other factors causing separations. The indexes for the youngest age group are markedly lower than those for the oldest age group.

Although the continuity-of-service rates for age group 55-64 are generally higher than those for the 65-and-over group, there is a rather sharp decline in the number of workers in the latter group. If the distributions of workers by age shown in tables 20 and 21 are generally representative of the actual situation over a period of years, then the decline in the number of workers in the oldest age group reflects in part the continuing influence of separations in the 55-64 age group without replacement by workers in the same age group. Even though the separation rate is lowest for this age group, the fewer accessions (resulting from fewer people in this age group reentering the labor force once they leave as well as a failure on the part of employers to hire workers in this age group) leads to the sharp decline in the number on the job at 65.

In addition to the findings by sex and industry, results are shown separately for those employees with less than 2 years' service and for those with 2 or more years of service. This last distinction was made on the assumption that a relatively newly hired group of workers may show a continuity-of-service pattern different from a group which had worked in the plant a longer period, and that this difference, if not taken into account, might influence the actual age-performance relationships.

Examination of tables 22 and 23, which present continuity indexes by length of service, reveals for the most part the same pattern as the industry totals. The highest indexes were generally recorded for age groups 45 through 64, and the lowest for the youngest and oldest age groups. However, the differences in the rates between age groups are generally larger for workers with less than 2 years' service.

Although the age-performance patterns for the workers classified by length of service are similar, the average continuity-of-service rates do show wide differences. Table 24 shows the continuity-of-service rates for all workers studied, grouped by sex, industry, and length of service. (Note that these are actual rates rather than indexes.) In general, the workers with 2 or more years of service show considerably higher rates than those with less than 2 years' service. Also, the difference between these two groups is more pronounced for men than it is for women. Among the women furniture workers, the rates for the two groups are very close.

On the other hand, the results show that the continuity-of-service rates for both men and women (over all age groups) in the two industries do not differ appreciably. The rates are identical in footwear plants and show a difference of slightly over 1 percent for the furniture plants.

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Table 20. Indexes of continuity of service for production workers in 11 footwear establishments, by sex and age group

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	245	83.9	238	88.2
25-34	418	96.7	438	97.6
35-44	478	100.0	749	100.0
45-54	589	101.5	838	102.1
55-64	509	100.4	393	101.4
65 and over	158	90.4	59	1/ 97.5

1/ Includes only employees with more than 2 years' service.

Table 21. Indexes of continuity of service for production workers in 11 household furniture establishments, by sex and age group

(Age group 35-44=100)

Age group	Men		Women	
	Number of workers	Index	Number of workers	Index
Under 25	561	87.7	58	61.1
25-34	1,179	94.1	141	93.0
35-44	1,017	100.0	206	100.0
45-54	783	101.3	152	102.3
55-64	440	103.7	75	1/ 105.1
65 and over	168	87.6	6	1/ 47.7

1/ Includes only employees with more than 2 years' service.

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Table 22. Indexes of continuity of service for production workers in 11 footwear establishments, by sex, years of service, and age group

(Age group 35-44=100)

Age group	Men			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	120	84.0	125	83.0
25-34	364	98.8	54	80.3
35-44	447	100.0	31	100.0
45-54	560	101.2	29	103.9
55-64	483	100.0	26	103.9
65 and over . . .	148	95.1	10	54.1

Age group	Women			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	110	87.7	128	91.3
25-34	353	96.3	85	104.3
35-44	642	100.0	107	100.0
45-54	761	100.0	77	113.0
55-64	363	100.0	30	108.6
65 and over . . .	55	97.5	4	(1/)

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 23. Indexes of continuity of service for production workers in 11 household furniture establishments, by sex, years of service, and age group

(Age group 35-44=100)

Age group	Men			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	258	88.8	303	82.7
25-34	923	95.0	256	89.9
35-44	900	100.0	117	100.0
45-54	717	101.2	66	101.4
55-64	417	101.2	23	114.4
65 and over . .	162	95.0	6	55.3

Age group	Women			
	2 years' service or more		Less than 2 years' service	
	Number of workers	Index	Number of workers	Index
Under 25	33	59.1	25	70.0
25-34	108	93.6	33	90.4
35-44	161	100.0	45	100.0
45-54	140	105.1	12	102.3
55-64	71	105.1	4	(1/)
65 and over . .	6	47.7	—	—

1/ Fewer than 5 observations were considered insufficient for deriving the indexes.

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Table 24. Continuity-of-service rates 1/ for production workers in 11 men's footwear and 11 furniture establishments, by sex and length of service

Length of service	Industry			
	Men's Footwear		Furniture	
	Men	Women	Men	Women
Total	95.2	95.2	90.4	91.6
Less than 2 years' service	80.8	84.4	74.8	90.4
2 years' service and more	96.4	96.4	94.0	91.6

1/ Number of workers per 100 who remained on the job during a survey period of 1 year.

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APPENDIX I: Questionnaire and Worksheets

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

Job Performance and Age

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 (a) how many production workers are employed? _____, (b) how many of these workers are paid according to individual incentive rates? _____.

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THE FOLLOWING QUESTIONS REFER TO PRODUCTION WORKERS ONLY

B. Plant Records

3. For what periods (during the first half of 1956) 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? (As measured by incentive earnings or physical units)

_____

5. Briefly describe these records _____

_____

6. Which of the following are utilized in determining piece rates or other individual incentive rates:

   a. Time studies Yes ☐ No ☐

   b. Employee-management conference Yes ☐ No ☐

   c. Other (specify) _____

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

_____

_____

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

9. If yes, describe _____

10. 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 ☐

11. Are employees on leave of absence because of illness or other reasons marked on your records as separated? Yes ☐ No ☐ If no, describe how they are marked _____

_____

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C. Placement Procedures

Do your procedures for placing production workers include the following:

12. Initial physical examination Yes ☐ No ☐

13. Periodic physical examination Yes ☐ No ☐

If yes, give time interval between physical checkups _____

14. Aptitude testing Yes ☐ No ☐

15. 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 ☐

16. Other, specify _____

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

18. Have there been instances of retraining or reassignment of older workers? Yes ☐ No ☐ If yes, give examples, including reasons for these steps.

_____

_____

D. Earnings Adjustments

19. Do you compute, for individual workers, their average hourly piecework earnings over certain periods? Yes ☐ No ☐ If yes, indicate periods.

_____

20. How is the vacation pay for incentive workers determined? _____

_____

_____

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

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

23. If these rates of extra pay do not apply to piecework, specify the premium rates on piecework for overtime ___ and holidays _____

24. Dates of vacation periods of plant _____

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Job Performance and Age

General Instructions for Completing Questionnaire

The questionnaire and worksheet on Job Performance and Age are to be used to collect data pertaining to productivity, absenteeism, and separations of individual production workers in the plants studied. These data are to be collected together with employees' ages and other pertinent personal information. The questionnaire relates to general information, plant records, placement procedures, and earnings adjustments (sections A through D). The worksheet is used for recording personnel information and data on output, attendance, and separations of an employee.

The recommended procedure is to fill out the questionnaire through section D during the initial interview with the plant official, 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, wooden chairs. Designate price range at retail prices for an indication of general quality range of the plant's production.

2. Employment -- a. 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, janitoral, watchman services, product development, auxiliary production for plant's own use, recordkeeping and other services closely associated with these production operations.
   b. Number of workers on individual (not group) incentive pay.

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 in given numbers of hours worked by individual workers.

   In other cases, output data may be available in terms of time standards.

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

6. Incentive Pay Rates -- The purpose of this question is to ascertain whether incentive rates reflect 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.

8,9. 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 time-cards directly. Determine whether time cards are available for full production periods of at least 8 weeks, preferably during the first half of 1956.

10. Describe nature and location of such records.

11. If ill or absent employees are not marked as "separated," determine what entry is used, for instance "temporary termination" or no entry.

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

20. Vacation Pay -- Record how the hourly rate during paid vacations is determined for piece-rate and other individual incentive workers.

21,22. Premium Rates -- If the premium rates vary by job classification, list them on back of the sheet.

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

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CLOCK NUMBER	PLANT	PLANT CODE	DEPARTMENT	DEPT CODE	NAME OF EMPLOYEE	M=1 F=2	DATE BORN	AGE	AS	PS	PPS

OCCUPATION TITLE		MACHINERY USED				
PRELIM.	FINAL					
OCCUPATION CODES	OPERATION DESCRIPTION	AVERAGE HOURLY EARNINGS	U=1 L=2	H=1 M=2	P=1 T=2	SEP. SAMPLE

PERIOD ENDING	PIECEWORK EARNINGS		HOURS		CP DATE	YEARS' SERVICE	YEARS' EXPER	BEGINNER
	STRAIGHT TIME	OVERTIME	TOTAL	TIMEWORK				
1								
2					REMARKS:			
3								TIME WORK RATE
4								
5								
6								
7								
8								
TOTAL								
ADJUSTMENT								LEARN TIME
ADJUSTED TOTAL								

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ABSENTEEISM

CLOCK NO.

DAYS SCHED.

DAYS ABSENT

ATTEND RATE

DAY OF WEEK	WEEK OF YEAR																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
MONDAY																										
TUESDAY																										
WEDNESDAY																										
THURSDAY																										
FRIDAY																										
	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
MONDAY																										
TUESDAY																										
WEDNESDAY																										
THURSDAY																										
FRIDAY																										

DATES HIRED	DATES SEPARATED	REASON	REMARKS →
			DATE FIRST HIRED
			SEPARATED

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Job Performance and Age

Instructions for the Worksheet

Clock Number -- Record clock number listed on the payroll or the worker's timecard. If this number differs from the number on the personnel records, note this in "Remarks" space.

Plant Code -- Record plant code from questionnaire.

Dept. Code -- 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.

M = 1, F = 2 -- Indicate sex by this code.

Date Born -- Record last two digits of year of birth.

Age -- Do not fill in at plant unless convenient.

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 at least two incentive workers of the same sex performing the same operations. For groups which fail to fulfill this condition, do not take down productivity information.

Occupation Title -- List occupation title (and grade, if used) of the worker (e.g., "chair assembler").

Preliminary Occupation Code -- Where available, record occupation number as used by establishment. Otherwise, leave blank.

Final Occupation Code -- Do not fill in at plant.

Operation Description -- Describe the specific operation or operations performed, including where relevant the names of the products turned out. This should be in sufficient detail to determine whether the employee's activity is comparable with that of others. If standard operation numbers are available, list them in this space. This information may be obtained from production records (particularly operation numbers) and from the foreman. In doubtful cases, confirm from the appropriate plant official that all workers in an occupation actually perform the same types of operations.

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Machinery Used -- List the type of machines or tools used. Write in "automatic feed" if the machine employs an automatic feed and discharge mechanism for the work pieces, so that the individual work pieces do not have to be inserted and removed by hand.

AHE -- Average Hourly Earnings of incentive workers only. If average hourly piece-rate earnings for the productivity period have already been computed by the company, record in this cell. Otherwise, leave blank.

U = 1, L = 2 -- Do not fill in at plant.

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

P = 1, T = 2 -- 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 piece and time work during the reporting period, indicate by "1" (i.e., list as piece-rate worker).

Sep. Sample -- Do not fill in at plant.

Periods Ending, Piecework Earnings, Hours -- Do not fill in if the plant calculates average hourly piecework earnings for a full production period of 4 weeks or more.

For the reporting period on productivity, select, with the aid of the appropriate company official, a full production period totaling 8 weeks, preferably during the first half of 1956 (not necessarily consecutive). If this is not available, use a minimum of 4 weeks for the period studied.

Period Ending -- Record in spaces 1 to 8 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 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.

Straight-Time Piecework Earnings -- Record straight-time piecework earnings. Include dollars and cents with .00 if no cents.

Overtime -- Record overtime piecework 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.

Total Hours -- Record the total number of hours worked during the time period studied to nearest quarter hour. Mark quarter hours as decimals, i.e., .25 or .50. If total piecework hours are available, record in this space and indicate this fact in the "Remarks" space.

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Timework -- Record the total number of hours for which the worker was paid on a time basis (hourly rate) during the period studied. If total piecework hours are recorded in the total hours column, leave this column blank.

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. This information is not needed if complete data on separations are conveniently available.

Years' Service -- Do not fill in at the plant.

Years' Experience -- Determine whether information is available on experience on similar jobs in the same company, or in previous employment and record.

Beginner -- Do not fill in if years of experience are obtained. If years of experience are not available, obtain identity of beginners from the foreman.

Learning Time -- Obtain from production manager or foreman information on average learning period required for an inexperienced employee to attain average efficiency in his occupation. For each group of employees working at the same occupation, this information needs to be entered on one card only. Indicate whether time is stated in months or years, e.g., "6 mo." or "4 years."

Timework Rate -- Record here the wage rate paid to employees on timework. This includes workers partly on incentive work and partly on timework. For incentive workers for whom a wage rate is not available, determine whether the plant maintains a record of their rate of pay per minute (or hour) of standard time and enter in this space.

Absenteeism Calendar -- If a convenient absenteeism record is maintained in the plant for each employee, record absenteeism for the year 1956 up to the time of plant visit, if available. If absenteeism has to be reconstructed from timecards, record absenteeism for a period of 8 to 12 weeks, covering the 8-week full production period used for the measurement of productivity.

Indicate by "A" on a master card the first and last dates of the absenteeism survey period. Also indicate on this card, by marking "-" in the appropriate cell, the holidays and weekdays which the entire plant was shut down.

On the calendar, for each employee mark by "O" each workday missed by the employee. Do not mark an employee as missing ("O") on days on which you know that the entire plant was shut down.

Clock No. -- Repeat clock number from other side of card.

Days Scheduled, Days Absent, Attend. Rate -- Do not fill in at plant.

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Dates 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.

Dates Separated — Record all separation dates (by day, month, and year) from beginning of absenteeism period to time of plant visit.

Reason -- 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		

Date First Hired and Separated Code — Do not fill in at the plant.

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APPENDIX II. Derivation of Formulas

1. First Stage of Aggretation

The basic index for each indicator takes the form:

$$\frac{\bar{X}_{ci}}{\bar{X}_{bi}}$$

Where $\bar{X}_{ci}$ is the average performance rate of workers of a specific 10-year age group (c) within the basic comparison group (i), and $\bar{X}_{bi}$ is the average performance rate of workers in the base age group (35-44) within the same basic comparison group.

The performance rate may be average hourly earnings, attendance rate, or continuity-of-service rate, and, as indicated elsewhere, the basic comparison group is different for each of the three measures.

In aggregating these original indexes so that they will represent larger groupings, it is desirable that the aggregate indexes should have the minimum possible variance. Therefore, each component index is weighted according to its reliability, i.e., according to the reciprocal of its squared standard error.

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

$$V^2(I_{ci}) = \frac{V_c^2}{N_{ci}} + \frac{V_b^2}{N_{bi}} \quad \underline{8}/$$

where V_c^2 and V_b^2 are the population rel-variances of the individual scores and N_{ci} and N_{bi} are number of individuals in the age group and base group, respectively. Another form of $V^2(I_{ci})$ is

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

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

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

8/ In the cases of attendance and of continuity of service, the rel-variance of the plant indexes is dependent not only on the number of individuals in the sample but also on the length of the observation period. This is because the unit of observation for attendance is a man-day and for continuity of service, a man-month. The only modification in the derivation which is entailed by this is that

$$V^2(I_{ci}) = \frac{V_c^2}{N_{ci} S_k} + \frac{V_b^2}{N_{bi} S_k}$$ where S_k = the number of days scheduled in the attendance period in the Kth establishment, or the number of months in the observation period for continuity of service.

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Using the reciprocal of the variance of each direct comparison group sample index as the weight, then the aggregate index 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,

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

If the assumption is made that the rel-variance of the age groups are the same, i.e. $V_b^2 = V_c^2$ 9/

then, $W_i = \frac{N_{bi} N_{ci}}{N_{bi} + N_{ci}}$ 10/

9/ There is little evidence in the findings to challenge the assumption that $V_c^2 = V_b^2$. The differences between the age group coefficient of variation were not consistent nor, for the most part, sizable.

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

10/ For attendance and employment continuity W_i becomes

$$\frac{N_{bi} N_{ci} S_k}{N_{bi} + N_{ci}}$$

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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

$$\sigma^2(\bar{I}_c) = \sum \left(\frac{W_i}{\sum W_i} \right)^2 \sigma^2(I_{ci}) \text{ . } \underline{11}/$$

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

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

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

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

11/ 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.

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3. Combining Indexes for Final Aggregates

The indexes for the initial aggregations (occupational groups, higher and lower paid jobs and length of service classes) were in turn combined to derive indexes for final aggregations (men and women). These indexes were combined with weights equal to the total number of workers of all ages in a particular group, i.e.,

$$\bar{\bar{I}}_c = \frac{\sum M_i \bar{I}_c}{\sum M_i}$$

where $\bar{I}$ is equal to a major grouping index (hand, machine, etc.) for age group c, M is equal to the number of workers of all ages in the initial aggregate group.

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

$$\sigma^2(\bar{\bar{I}}_c) = \sum \left(\frac{M_i}{\sum M_i}\right)^2 \sigma^2(\bar{I}_c)$$

$$= \frac{\sum M_i^2 \, \sigma^2(\bar{I}_c)}{(\sum M_i)^2}$$

$$= \frac{\sum \left(M_i^2 V_c^2 I_c^2 \Big/ \sum W_i \right)}{(\sum M_i)^2}$$

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4. Coefficient of Variation for Output per Man-Hour 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

$V_i^2 = S_i^2 \Big/ \bar{X}_i^2$, the rel-variance of the sample, an estimate of the population rel-variance V^2

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

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 $\frac{\sigma_i^2}{N_i} \Big/ \bar{\bar{X}}_i^2 = \frac{V^2}{N_i}$.

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

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

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

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

$$\cong \frac{2(1 + 2V^2)}{N_i-1},$$ 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

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

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

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