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THE CONSTRUCTION AND DEVELOPMENT OF
AN OBJECTIVE CARPENTER'S TRADE TEST

by

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THE FIRST RECORDED OBJECTIVE
TEST.

"When these Ephramites which were escaped said, let me go over; that the men of Gilead said unto him, art thou an Ephramite? If he said, nay; then they said unto him, say now Shibboleth; and he said Sibboleth: for he could not frame to pronounce it right. Then they took him and slew him."

Judges 12; 5,6.

THE CONSTRUCTION AND DEVELOPMENT OF AN OBJECTIVE
CARPENTERS TRADE TEST.
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ABSTRACT

The purpose of this study was the construction and development of an objective written carpenter's trade test which would represent an economy in the screening of trade applicants. A brief survey was made of the major developments and current trends in the trade testing movement and available pertinent statistics regarding other reported studies was presented.

A trade test consisting of two hundred and four items was then constructed. They were multiple choice items and an effort was made to make as many of the items pictorial as was possible. The Canadian Army trade specifications for the trade of carpenter was selected as the subject area which was to be sampled by the test. Material was chosen from existing carpentry tests, technical journals and technical books and incorporated into acceptable items. Each item was reviewed by at least three competent carpenters and evaluated in accordance with the criteria of a good test item before inclusion in the test.

The test was then administered to 240 subjects; 96 novices, 81 apprentices and 63 carpenters. The Wonderlic Personnel Test was administered at the same time in order to obtain an indication of the subject's intelligence. The 204 item test was then scored.

The number of items correctly answered by each individual and the percentage of each group answering each item correctly were computed. For each individual item the standard errors of the percentage for each group, the standard error of the difference between the adjacent groups and the "t" ratios were determined. Items for the final test were then selected upon a twofold criteria; these were that a "t" ratio of at least three be obtained between two of the adjacent groups and that not less than fifty percent of the carpenters correctly answered the item and that not more than fifty percent of the novices correctly answered it. One hundred items were selected for the final test. The average "t" ratio between carpenters and apprentices and between novices and apprentices was 3.61. These items were then rescored for each individual. The standard errors of the means for each group, the standard errors of the differences between the means of the adjacent groups and "t" ratios were computed. The resultant "t" ratios were 13.61 between the carpenters and the apprentices groups, 13.55 between apprentices and novices groups and 35.18 between novices and carpenters group. These would indicate very significant differences between the three groups.

The reliabilities of the test for each group was determined by the split-half method increased by the Spearman-Brown formula. Reliabilities of .79, .88, .73 and .96 were obtained for the carpenters' apprentices' novices' and total groups respectively. The relationship between trade test scores and other variables was determined. The test showed a statistically significantly reliable, but low, correlation co-efficient with intelligence as measured by the Wonderlic Personnel Test but education, age and experience had a negligible relationship to trade test scores. A reasonable degree of validity was exhibited.

The conclusion was drawn that the test would serve a useful adjunct in the screening of trade applicants and that the method followed in its construction could be extended to the development of similar tests for other occupations.

TABLE OF CONTENTS

CHAPTER 1. Introduction

CHAPTER 2. Statement of the problem

CHAPTER 3. Major developments in trade testing

(a) World War I

(b) United States Employment Services

(c) World War II

i. U.S. Navy

ii. U.S. Army

(d) United States Bureau of Prisons

(e) Private industry

(f) In England

(g) In Germany

(h) Vocational Schools

(i) Commercial tests

(j) Summary

CHAPTER 4. Previous studies pertaining to the relationship between trade tests scores and other variables.

(a) Reported reliabilities

(b) Age, education and intelligence

(c) Validity

(d) Summary

CHAPTER 5. Construction of the carpenter's trade test

(a) Determination of area of knowledge to be tested

- (b) Form of the items
- (c) Considerations in the selection and construction of items
- (d) Sources of material for item construction
- (e) Arrangement of answers and distractors in the item

CHAPTER 6. The Wonderlic Personnel Test

CHAPTER 7. Description of the sample

- (a) definitions used
- (b) "novice" sample
- (c) "apprentice" sample
- (d) "carpenters" sample

CHAPTER 8. Administration of tests

CHAPTER 9. Raw test analysis

CHAPTER 10. Item analysis of raw test

CHAPTER 11. Analysis of test scores based upon the selected items

CHAPTER 12. Reliability of test

- (a) Meaning of reliability
- (b) Reliability co-efficients
- (c) Standard error of measurement

CHAPTER 13. Relationship between test scores and other variables

- (a) Intelligence
- (b) Experience
- (c) Age
- (d) Education

CHAPTER 14. Validity

CHAPTER 15. Norms, interpretative data and critical scores

CHAPTER 16. Conclusions.

CHAPTER 17. Suggestions for further research.

INTRODUCTION

With the outbreak of war in 1939, Canada was faced with the tremendous task of creating and maintaining, from a civilian population, an efficient war machine. To accomplish this feat required the utilization of every possible resource. The importance of the physical resources were recognized early in the struggle. As the war progressed the importance of utilizing every available human capacity became more apparent. Intensive programs of psychological research were inaugurated in all three of the armed services and in the rapidly expanding war industry. Tests of aptitude, interest, intelligence and of nearly every human characteristic were devised in order to select individuals who would best perform specific jobs. In the majority of cases these tests were indicative of the potential worth of the individual rather than an accurate assessment of his present ability to do a specific job. Under these circumstances, expediency motivated the direction of the effort. The immediate demand had been for highly skilled operators peculiar to the military situation and generally not available in the civilian population. The main trend of psychometric research was thus aimed at uncovering aptitudes needed for successful operation in these fields. As aspect of the selection program which remained vague and ill-defined was the selection of trained tradesmen.

The magnitude of the change-over of effort

involved in gearing the nation to maximum war time efficiency can best be realized by a survey of the statistics for Canada (53, p.3). At one period during the war, 1,166,000 persons (13.3 percent of the total population) were employed either directly or indirectly in industries associated with war work. 1,031,000 persons (11 percent of the total population) were simultaneously in the armed forces. Bloomfield (4, P.207) states that approximately twenty-five percent of the enlisted men in the First World War were employed by the army upon skilled trades. Burt (6, p.163) estimates that over thirty percent of the army applicants for skilled trades lacked even an elementary knowledge of the trade for which they claimed trade proficiency. This would indicate that a tremendous task of allocating men to jobs in which they would operate effectively was involved. Objective measures of trade proficiency would be an invaluable asset in these circumstances. The need for such measures is not restricted to the armed forces. Vocational trade schools and industry have a keen interest in the accurate measurement of an individual's trade skills. With the increased mobility of the present day population, industry is finding it increasingly difficult to evaluate a tradesman's proficiency upon the basis of references and statements of training. The main alternative has usually consisted of the costly and time consuming procedure of placing the man on the job and then making a subjective evaluation based upon his performance.

Trade schools similarly must assess the individual's trade proficiency. Usually this is done upon the basis of tests constructed within the school and upon the instructor's ratings. Such estimates give no indication of the degree of trade proficiency exhibited by either the individual in relation to other individuals, or of the group in relation to other groups.

It is interesting to note that even in trade unions, where the incentive to maintain adequate standards should be apparent, no objective measure of trade competency is obtained. In discussing this matter with union officials, the author was informed that admittance to the union was based upon the recommendations of two union members. The proof of whether the individual was competent or not was dependent upon whether he remained upon the job to which he was assigned. If he was dismissed because of inability to perform the required work, the union assumed that he was not a tradesman. This would appear to be a costly procedure for both the union and the industry involved.

A similar need has long been realized in the academic educational fields. In contrast however, standardized objective achievement measures are available for nearly every academic subject and have been used even in the determination of an individual's professional proficiency (5, p.110). Much of this need is being met by nation-wide testing programs such as those conducted by the Co-operative Test Service (14)

In 1942, this service reported testing 30,000 students throughout 170 institutions in that year's Sophomore Testing Programme alone. This and other test services have met a major need by offering reliable comparative standards to the educational fields. The vocational world of skilled trades would benefit from a similar service.

2. STATEMENT OF THE PROBLEM

The stimulus for this study was given in the Fall of 1947 when the Defence Research Board made a grant^x available for research in the field of aptitude testing within the armed forces. The author was assigned as a research assistant to investigate the value of measures of achievement as predictors of aptitude.

In order to clarify the terms used in this study it would be advisable to define the meaning of aptitude and achievement. Warren (44, p.281) defines aptitude as a condition or set of characteristics regarded as symptomatic of an individual's ability to acquire with training some specified knowledge, skill or set of responses. The common assumption held by many is that aptitudes represent inborn characteristics. Achievement may be defined as an individual's attained skill or knowledge in a specified field. In this respect it is viewed as a resultant. In test construction practice, the two have been dichotomized. However, as Hull (18, p.52) suggests, while the purpose of achievement and aptitude tests differ, what is accomplished by them is not so clearly differentiated. By this he expresses the fact that two tests of type do not entirely distinguish between the results of training and the

^xThe grant was made to the University of British Columbia and was initially under the direction of J. E. Morsh. Upon Dr. Morsh's resignation in September 1949 supervision was transferred to E.S.W. Belyea.

results of natural aptitude. Thus if two men of equal aptitude differ in the amount of training, then the individual with training will excel the one without training in aptitude scores. If, on the other hand, two individuals have the same amount of training and differ in natural aptitude, then wide differences will exist upon achievement measures. In this way it seems possible that a well devised achievement test can also be a measure of aptitude. Traxler (42) draws attention to this fact when he states that an individual's high school record, which represents achievement, is the best indication of his college success. Thus he sees aptitude and achievement as simply representing different emphasis upon native ability and training.

The initial requirement for the satisfactory investigation of the suggested problem was to obtain an achievement test pertaining to skills widely used in the armed forces and for which suitable personnel were obtainable as subjects. The validity of the study would depend to a large extent upon the validity of the achievement measure. The existing measures of trade achievement used by the Canadian Army were for the most part of a purely local nature, designed by camp instructors within the individual unit. Little statistical data regarding their validity, reliability and other pertinent information was available. The achievement measures developed outside the armed forces did not appear applicable since the area of knowledge sampled could not be considered equivalent

to that of the armed forces. Thus no adequate achievement test, suitable to the individuals obtainable or to the subject area desired, could be found. Owing to these considerations the above mentioned project did not seem to indicate the most productive approach.

The inquiry did, however, tend to emphasize the shortcomings of the existing trade tests used in the Canadian Army. These consisted of tests for individual trades (52) and were in two sections; a practical and a theoretical section. The practical section involved the applicant performing a task which was representative of the trade skill for which he claimed proficiency. The theoretical section consisted of a series of questions regarding trade information. The average time required to administer the complete test was between six and eight hours. Trained tradesmen were required as examiners. Scoring on the practical section was in a dichotomy. All the operations involved had to be successfully completed for the candidate to receive a passing mark. A wider range was allowed on the theoretical section. A passing mark was indicated by correctly answering seventy percent of the questions. No norms were available to indicate the degree of trade proficiency exhibited by a particular score.

From the observation of the present trade tests, it seemed possible that a measure of trade proficiency could be devised which would have a greater economy in terms of time and trained personnel required to administer it. Such a test

would also be useful in the previously mentioned investigation. Because of the availability of subjects the trade of carpenter was selected as the trade for which a test was to be developed. The intention was that if a satisfactory method of devising trade tests for the selection of applicants professing trade proficiency of carpentry was developed, in terms of function and economy of time and administration, then similar tests could be constructed to cover the basic trades required by the armed forces. The development of tests of this nature would also facilitate the investigation of the relationship of measures of achievement as predictors of aptitude.

A trade test may be defined as a measure of an individual's ability to perform trade abilities. In this respect it is an achievement test since it measures present status or attainment. Chapman (8, p.12) defines trade ability as consisting of a "set of co-ordinations which are acquired in a fairly definite order and which characterize all men skilled in a given trade." It appears highly probable that in the process of acquiring this co-ordination that there would be an accompanying increase in the amount of trade information acquired. Thus two principles would be involved; skill and information, and it would seem possible that they increase uniformly. While the possession of the latter would not necessarily imply the former, it seems highly unlikely that the skill could be acquired without the acquisition of information. Therefore, it would seem possible that a trade information test

would give an indication of the individual's level of trade proficiency.

The immediate project was then the development of an objective, written carpenter's trade test which would measure the extent of the individual's trade information.

MAJOR DEVELOPMENTS IN TRADE TESTING

No attempt is made to provide a complete historical background to the trade testing movement. The intention is primarily to acquaint the reader with the most significant developments and current trends.

(a) World War 1

The main impetus to trade testing was received during the first World War. Prior to this no objective and standardized methods had been developed. The most common method of determining an individual's skill in a trade consisted of subjective evaluations by men who were themselves trained tradesmen. These methods could be classified as;

1. a series of questions relative to the trade but not having any diagnostic value beyond the examiners subjective interpretation.
2. the performance by the candidate of a task representative of the skill for which he professed ability.
3. a personal interview.
4. actually placing the candidate upon the job and observing his trade skills.

All of these methods were based upon subjective evaluations of the observer and gave little indication of the degree of familiarity that the workman had with the skilled trade in question and the personal bias of the individual examiner was often the determining factor.

With the outbreak of the war, the rapid mobilization of the armed forces and the ever increasing labour requirements in industry demanded the utmost utilization of the available skilled manpower. Methods of evaluating individual's acquired skill and knowledge in professed trades which were suitable to the army situation were required. Owing to the large numbers involved, it was necessary that any such method developed be rapid and not require the expenditure of too great a number of trained men. In endeavouring to meet this need, much of the methodology of the already developing and related field of educational achievement measurement was borrowed.

The main development occurred within the United States Army.(8). The first attempt at a controlled method was in the form of "Aids to Interviewers". These consisted of a series of questions to which the examiner had a list of possible replies. Scoring was done upon the basis of the number of questions that men possessing various levels of trade ability should answer correctly. The heavy emphasis upon subjective interpretation and the need therefore, for trained tradesmen for purposes of administration made this method unsatisfactory. From this form, however, the four fundamental types of trade tests used by the U. S. Army in World War 1 were developed which more adequately met the required demands. These are the basic methods still predominant in many trade test situations today. They were the single answer oral question, the picture trade test, the performance test and the

written group test.

The oral trade test consisted of twenty trade questions to which a single answer response was required. Picture trade tests utilized photographs or drawings of tools, parts or materials in which the subject was asked to identify various parts. The performance trade test involved the candidate combining the use of various explicit skills required in the trade. Scoring was done on the basis of process (how the individual did the task), and product (the excellence of the finished task). The written trade test was never utilized in the military situation and only a single experimental form was designed. This was a multiple choice type questionnaire.

The development of these tests were for the first time accompanied by a statistical analysis of the responses of the various groups. The preliminary test, based upon a survey of the requirements of the trade in question, was administered to groups representing various levels of trade proficiency. The percentage of correct answers obtained from each group for each item was then computed and a graphic comparison was made. Items showing the greatest discrimination were selected for inclusion in the final test. Critical scores were arbitrarily drawn at discriminating points.

(b) United States Employment Service

During the period of demobilization following the war, a special department of the United States Employment Services was created to handle skilled labour only. In order

to differentiate men of various trade abilities some form of assessment was necessary. The selective trade interview was developed for this purpose. This consisted of a series of ten questions, carefully selected upon a subjective basis. Six of these were chosen at random to be used during the interview with the candidate. No norms were available, but the interviewer judged the subject's familiarity with the trade by the ease or fluency with which he replied to the question.

Little development was made in trade testing until the publication of Thompson's trade questions. These were constructed at the Cincinnati Employment Service in order to facilitate public placement. They consisted of trade questions for 131 trades and were published in book form (40). Each test contained fifteen to twenty questions which were asked orally during the interview. Their use was limited owing to the local nature of the questions and the inadequate validation. (39, p. 159)

During the depression of the 1930's, the United States Employment Services, faced with an increasing number of unemployed applicants claiming trade skills, required some objective measure to assess the individual tradesman. Initially they tried to utilize the existing World War I trade tests by revising and adapting them to the civilian situation. This did not yield adequate results and fresh tests were developed. These were of the oral type and consisted of from twelve to twenty questions, each of which could be answered by a single response. The tests were not restricted to the area of the skilled trades but also included questions pertaining to

semi-skilled and manual occupations. The procedure employed by the United States Army trade test constructors was followed. The questions were selected by an analysis of the differential replies obtained from a sample group consisting of 100, fifty experts and tradesmen, twenty-five apprentices and twenty-five novices. In the 1940 volume of oral trade questions, published by the Federal Security Board (56), trade questions are given for seven hundred and ninety-three trades and occupations. In February, 1942, Supplement A was issued containing questions for seventy-seven additional trades and occupations (57). Later in the same year, Supplement B containing fifty-two sets of trade questions was published by the War Manpower Commission (58). In April, 1944, Supplement C with an additional forty-four sets of questions was issued (59). Picture trade tests were devised for five occupations and blueprint reading questions were developed for three trades (34).

The original trade questions developed by the United States Employment Services were constructed upon the following basis.(33). Questions were developed in connection with a thorough job analysis. These questions were then reviewed in compliance with the criterion of good test items and were given to a preliminary group of experts. Items upon which the experts agreed were then selected and administered to a sample consisting of experts, apprentices and novices. The responses were then analyzed for items which discriminated the three groups. It was found necessary to eliminate the initial

administration to an expert group since difficulty was encountered in obtaining unanimity between them. In 1943, only two steps were retained in construction. These were an occupational survey to determine knowledge and skill factors required to do the task and the formulation of trade questions by cooperative discussion between trade experts and test technicians. Simultaneously the tests were constructed upon the basis of local labour markets and needs and thus reflected a much more specific outlook (34).

The trade questions were constructed to be supplementary to the interview and were considered an integral part of it. No formal testing situation was created and the questions were introduced in an informal manner during the course of the interview. Interpretation was on the basis of a trichotomy; well informed, some information, and little information.

These tests were restricted to the United States Employment Offices and were not generally available. A much wider concept of their functional value was obtained. Stead and Shartle (32,p.139) summarize their main use as follows;

1. to bring out information of workers past experience when used during an interview.
2. to substantiate claimed work experience.
3. to clarify workers qualifications where these are doubtful.
4. to verify trade knowledge before transferring.
5. to facilitate the handling of mass interviewing

of job applicants.

6. to measure the extent of improvement resulting from supplementary training or work experience.
7. to facilitate the most effective utilization of worker's ability.
8. to allow individual indications regarding suitable training courses.

(c) World War II

As in World War I, the second World War saw a fresh emphasis being placed upon the trade testing movement within the American Armed Forces.

U.S. Navy.

Prior to 1944, achievement testing in the skilled trades, by the U.S. Navy, was conducted upon a purely local basis and reflected the curricula or bias of the individual schools or unit (62). The development of standardized trade tests was in a large part due to the need to standardize instruction in the trade schools and to improve the basis for comparing personnel from different schools. An accompanying impetus was derived from the rapidly expanding aptitude testing program. The effective use of aptitude tests was entirely dependent upon the adequacy of the criterion used in their development. The use of instructor's ratings or school marks was found to be unreliable, often being more influenced by the subject's personal qualifications than by his trade proficiency (38,p.377).

The main types of achievement tests developed were paper and pencil tests, performance tests, identification tests and product gage ratings.

The identification tests consisted of multiple choice items and usually contained seventy-five to two hundred items. These were developed from a thorough analysis of the trade and the school curricula. In their construction, greater attention was paid to measuring the understanding of function rather than the ability to memorize.

In the development of the performance tests, many of the causes of the objections formerly directed at this type of test were overcome. By breaking down the task into its component elements, sub-assemblies and multiple equipment were set up. Objectivity of scoring was obtained by providing the examiner with a check list which was specific and merely required that he check the actions of the subject as he performed them and record the times.

The identification tests comprised of the subject viewing a disassembled part attached to which was a tag bearing four or five possible names. The subject selected the name which applied to that particular part. Again the time element was improved by having a multiplicity of parts. The number of subjects who could be tested simultaneously was then determined only by the number of parts in the test. Product rating gages involved the subject making a product representative of his trade. Certain specifications were given and the subject's

product was then evaluated in terms of its proximity to these. In all types of trade tests, a thorough job or course analysis was conducted prior to the construction of the test. Where applicable, a full item analysis was conducted upon the initial items. In the case of multiple choice items, consideration was given to the effectiveness of the individual distractors (38).

The main contribution of the United States Navy achievement testing program was to stress the importance of reliable and valid achievement measures within the trade training schools. Not only were they found to give more adequate basis for comparing schools and allowing a better standard to be maintained throughout the schools, but also they were found to be highly motivating to both the students and instructors alike. A constant score increase was observed with each successive class to which the tests were administered despite adequate precautions to protect the secrecy of the test material. The increases could only be attributed to the increased motivation and effort of all those participating.

United States Army.

Considerable development was also done on trade tests within the United States Army during the recent war. These (48) followed the standard type of multiple choice objective information tests. Considerable emphasis was directed towards the pictorial type of item in order to reduce the influence of education and reading skill. A feature of these tests was the addition of an experience check list upon which

the subject checked, from a series of job operations and tools, those items upon which he had experience. These were not quantitatively scored but were used as subjective aids in order to help the examiner interpret a test performance. By comparing the individual's check list with that of a typical army school graduate's check list in the specific trade, an indication could be obtained of areas in which the experience of the testee was inadequate. Critical scores were used to evaluate the individual's score. Later tests (49) gave graphic distribution of test scores for various levels of trade proficiency. In a few cases standardized performance tests were developed (50). These were objectively scored upon the basis of the number of operations, precision and time.

The main use of the tests (51), as stated by the manual, is to differentiate between those men that need training in order to work at a specific occupation and those men who are capable of pursuing the work without further training. Subjects that achieve the critical score or a higher score are considered not to need additional training. In the cases of those subjects whose scores are below the critical score, an evaluation from the test scores and the experience check list is made of the training required. In many cases where a score below the critical score is obtained, a high degree of specialization which could be directly utilized without further training may be indicated. This can often be determined by a closer inspection of the experience check list and other personal data.

(d) United States Bureau of Prisons

The United States Bureau of Prisons has developed performance trade tests covering thirty-five skilled trades required in the operation of the federal prison system. These are based upon the job descriptions as given in the Dictionary of Occupational Titles, and are thus applicable to a non-restricted testing area. The tests require the presence of a trained tradesman who rates the individual descriptively upon six factors related to his performance. These include his skill in the application of techniques and procedures, the presentability of the work sample, his attention to pertinent detail, the accuracy of the final product, his rate of progress and his initiative. As yet they have not been widely utilized but present indications (29) would suggest that they have a functional value.

(e) Private Industries.

Trade tests have also been utilized in private industries, but for the most part they have remained upon a purely local basis and have been constructed to satisfy the demands of the particular industry. Irwin (19) cites an example of their use by the Lockheed Aircraft Company. With the increased industrial expansion owing to defence orders, the company was faced with a shortage of trained tradesmen. Twelve trade tests were developed. These were used selectively and diagnostically; the emphasis being upon the latter. The shortage of competent tradesmen made it necessary to utilize skilled workers in

related types of work. The minimum necessary training required by a tradesman from a related trade could be determined by an analysis of his test performance in relation to the specific job requirements.

The extent of their use in private industry, however, would not seem to have been extensive. It is interesting to note that, in a special issue of the Personnel Journal (37) designed to facilitate the hiring of skilled workers during the recent war emergency, none of the industries reporting indicated the standardized objective trade test as a method of selecting or developing skilled tradesmen. It would suggest that industry is still relying heavily upon such methods as the interviewer's judgments, past experience and on the job performances.

(f) In England.

Objective written trade testing in England during the recent war did not appear to reach the same degree of development within the armed forces that was apparent in America. Vernon, referring to the Personnel Selection Officer's techniques in 1944 states "PSOs did not use any standardized trade tests or tests of trade knowledge" (43, p. 121). Oral trade questions were used fairly extensively, but their administration was not standardized. They were applied informally during the interview with the trade candidate and their use was directed more at uncovering work attitudes or in gaining rapport than they were to assess comparatively the individual's trade

knowledge. In a list of the main tests used throughout the war for purposes of personnel selection, Vernon (43, App A) mentions only one objective written test that was used to determine trade knowledge. This was an untimed, ten item test of electrical trade knowledge. Two general information tests are listed; a mechanical and an electrical information test. These were used more as aptitude tests since they were administered to incoming recruits in order to select potential tradesmen and thus cannot be viewed as trade tests.

(g) In Germany.

Objective tests of trade knowledge and trade information suitable to group administration have also been used in Germany. The full extent of their use and development has not as yet been fully determined. Ansbacher (2) reports that considerable use was made of them during the recent war in the industrial classification of foreign workers. No statistical or descriptive information is available regarding these tests, but Futts (15) indicates that a heavy emphasis was placed upon subjective evaluation rather than objective statistical analysis. Written trade tests were also used by the Reich Manpower Engineers (1) in an effort to obtain the most economical manpower utilization. These were further supplemented by job performance tests.

(h) Vocational Schools.

Considerable development has been made in the field

of objective tests for industrial arts subjects as applicable to vocational schools. The main emphasis has been upon adequate construction of tests within the individual school rather than the development of specific tests. Industrial education magazines such as the "Industrial Arts and Vocational Education" (55) print frequent articles upon the correct methodology for objective test construction and thus strive to increase the reliability of the individual school's assessment of the student's vocational fitness. Developed trade tests for specific trade school courses are also published periodically but owing to the restricted nature of the standardizing samples are not applicable to general trade testing (11,46). They are based upon the objective test item and include alternate response, multiple choice, matching, free response and completion items.

(i) Tests available commercially.

Few objective trade tests have been developed commercially. From an exhaustive search of the literature and of test catalogues only three sources were available. Science Research Associates (60) publish the Purdue Vocational Tests developed by Tiffin. These consist of two trade information tests, technical information in electricity and machine shop and machine operation. These are a multiple choice type of test containing 149 and 133 items respectively. Link and Keeler publish a series of trade tests for the machinist trade through C. H. Stoetling and Company (61). These include tests of machinist's information, association test, designer's test,

toolmakers vocabulary test and a context test. Thompson's previously mentioned book of oral trade tests is still available commercially although its usefulness has been restricted because of occupational changes since its publication and because of the somewhat local nature of the questions.

Summary

The general conclusion that could be drawn from the review is that the majority of trade tests have been locally constructed with the view to filling the needs of specific situations. Thus, their use is restricted and they are not generally applicable to a wider testing range. For the most part these have not been reported in the literature.

4. Previous Studies Pertaining to the Relationship
Between Tests Scores and Other Variables.

The majority of the studies pertaining to job information tests have been conducted by the armed forces during the recent war and, for the most part, quantitative data regarding them have not as yet been released. The following is a short summary of the available and pertinent studies to date.

(a) Reliability.

Reliability has been investigated by Feder and Lefever. Feder (13) in an analysis of six multiple choice type of trade information tests found reliability co-efficients, computed by the Kuder-Richardson formula, ranging from $r=.84$ to $r=.87$ with a median co-efficient of $r=.85$. Lefever (23) from an investigation of ninety-seven similar tests used at an air technical school reports reliability co-efficients, derived from the split-half method and increased by the Spearman-Brown formula, ranging from $r=.62$ to $r=.95$ with a median co-efficient of $r=.87$. The reliability co-efficients computed by the Kuder-Richardson formula, derived from the Navy's achievement testing program as reported by Stuit (38) range from $r=.84$ to $r=.87$ with a mean co-efficient of $r=.86$. The United States Army tests are reported to yield reliability co-efficients ranging from $r=.73$ to $r=.90$. (51). Stead and Shartle (32) report reliability co-efficients of between $r=.79$ to $r=.93$ for the later United States Employment Tests. The methods of computing the two latter co-efficients are not reported.

(b) Age, Education and Intelligence.

The criticism is often made that written tests discriminate against the older and less educated individuals. Lefever (23) reports a correlation between test scores and age in groups ranging from sixteen to sixty to be $r=.06$. When the over fifty age group were removed from the sample a correlation of $r=.08$ was obtained. On the same study a median correlation of $r=.29$ was reported between education and test scores on twenty-two tests. When a partial co-efficient between age and test scores, holding education constant, was computed a correlation of $r=.3^{.00}$ was obtained. In another more recent study (24) a correlation of $r=.25$ was obtained between education and test scores. These studies would indicate that education was a more influential factor than age. Age and education, however, were negatively correlated yielding a co-efficient of $r=.35$. This would suggest that the older tradesmen would have less education. In general he found that education was not a determining factor except in those cases in which it was less than grade eight. He concludes that special consideration should be allowed for those subjects with less than a grade six education. If the purpose of the trade test is to measure trade proficiency, and the trade test has validity, then any such consideration would seem unwarranted, until at least more evidence is available regarding the relationship of education to job performance.

Lefever (24) found a correlation co-efficient of $r=.41$ between intelligence test scores and trade test scores.

Trade training and trade experience yielded median correlations of $r = .25$ with test scores. Slocombe reports a correlation of $r = .023$ between experience and a particular test of electrical knowledge in a group of electricians (37).

(c) Validity.

The earlier studies of Chapman, the United States Employment Services and others have clearly indicated the validity of trade information tests for the purpose of discriminating groups into coarse levels of trade skills by the use of critical scores. Little statistical data is available regarding the relationship between increased trade test scores and increased trade proficiency within these levels. The main difficulty encountered has been the unreliability of the criterion against which they have been evaluated. Ratings by supervisors or instructors have been widely utilized. Stuit (38) rejects these upon the basis of unreliability, lack of validity and lack of discrimination. Lefever (24) in a follow up study of testees found that there was a tendency for more promotions to accompany higher scores, and for resignations and discharges to accompany lower scores. This was ascertained by the use of a chi-squared formula after a six month period. A "P" value of .06 was obtained. A similar study upon the same subjects after a nine month period yielded a P value of .01. This would indicate that there is only one chance in a hundred that these results could occur by chance.

(d) Summary.

The preceding summary would indicate that previously developed objective trade tests have demonstrated a satisfactory degree of reliability. Scores upon them have had a negligible relationship with age and education, except where less than grade eight, but intelligence would be an influential factor in determining trade test scores. Validity has been adequately demonstrated for differentiating coarse levels of trade proficiency. Few studies are available regarding their validity for differentiating degrees of skill within the coarse levels, but these reported would be suggestive.

5. Construction of the Carpenter's Trade Test

The ensuing chapter deals with the construction of the carpenter's trade test, and attempts to outline some of the considerations and the general method followed.

Determination of area of knowledge to be tested.

The first requirement in the construction of a valid trade test is the definition of the occupational area which is to be sampled and the determination of its pertinence to the proficiency of the individual's trade ability. The latter could be determined by a statistical analysis, but the validity of the test would depend to a large extent upon the adequate sampling of the pertinent area. Since this test was being designed for use in the army situation, the job descriptions as defined by the Canadian Army for the trade of carpenter were utilized and accepted as those areas of which a knowledge is required for successful trade conduct. These included both required trade duties and expected theoretical and practical trade knowledge. Appendix A indicates the area of knowledge with which the test is attempting to measure familiarity.

Form of Items.

Owing to the use to which the test was to be put, certain conditions had to be met in the form of the items. Among these were objectivity of scoring. It was felt that the test would be administered by personnel differing widely in their degrees of trade knowledge. Many of the existing trade

tests consist of a single free response item. This requires that the administrator be a highly trained tradesman in the area which is being tested since interpretation of replies would be necessary. Another consideration in the form of the questions was its applicability to the subjects for which the test was to be designed. It seemed feasible that the subjects would be in the mid to lower part of the population in intelligence, education and test sophistication (3,p.50). The aim of the test was to measure trade knowledge and to reduce the influence of other variables. Thus the form of the test item must be such that it minimize these factors. Cronbach (10) has indicated that the personal characteristics of the individual will be instrumental in the manner in which he answers various forms of tests. He found that variations due to these were least in the multiple choice type of item.

Beacuse of these considerations, the most direct method of phrasing the question was sought. The multiple choice form seemed to minimize the verbal element and rely strongly upon associations which could be so presented that they represented problems met upon the job situation. They also have the advantage of speed of scoring and administration (36).

Considerable literature upon the comparability of various forms of achievement tests exists. Eurich (12) found that the essay, multiple choice, completion and true-false forms of tests have equal validity. Other investigators

(30,9,25) have compared the various forms and the general conclusions would be that there is no significant difference between the reliabilities and validities of them. Copeland and Gilliland (9) in a well controlled experiment, found that while differences existed, they were not large enough to be considered in the practical test situation, provided that the tests had been carefully constructed. Other advantages of the multiple choice type of item is the greater opportunity allowed to sample the area of knowledge being tested. Thorndyke (41) states that they also allow finer discrimination of response than does the true-false or recall type of item. With these considerations in mind, it seemed that the multiple choice type of question best suited the present requirements.

Considerations in the selection and construction of items.

The individual items were constructed in accordance with the recognized characteristics of a good test item. These characteristics were adapted from discussions by authors (54, 4, 8,) who have had considerable experience in the field of trade test construction. Every item was examined in order to determine whether an affirmative answer could be given to the following questions:-

1. Does the item call for a knowledge that the candidate must use or present a problem that he may have to face on the job? Furthermore, is it a question that the more highly trained man would be expected to be familiar with? This characteristic was determined with reference to the Canadian Army trade

specifications as indicated in App. A.

2. Does the item have "face validity"? This particular requirement has been heavily emphasized by the United States War Department test construction staff. It lays an emphasis upon the necessity of the question appearing practical to the testee in view to the job for which he claims qualifications.
3. Is the question phrased in the language of the trade? This was included to ensure that the testee's vocabulary, rather than his trade knowledge, would not limit his understanding of the question.
4. Is the item such that it could not be answered upon the basis of general intelligence and general knowledge, but would require specific trade knowledge?
5. Is each item independent; i.e. not dependent upon or revealing the answer to another item?
6. Are the "distractors" plausible and likely to be taken for the right answer by persons without a detailed knowledge of the Trade? They should be important, plausible answers and present common misconceptions rather than trivial and implausible alternatives. Ideally, the most satisfactory method would have been to administer the test as a free response test to various levels of ability and then to select the most commonly occurring incorrect answers as the distractors. Owing to the lack of subjects, this was not feasible in this study.
7. Is the question free from any "specific determiners" that would suggest the answer sought?

8. Does the question elicit a response that is common throughout the trade rather than a response that is purely local or regional in nature?
9. Is the problem stated clearly and precisely so that only one interpretation could be placed upon it by a subject that had been trained in carpentry?
10. Does the answer to the question reflect a good trade practice?

Every item was constructed with respect to, and later examined in regard to these qualifications, and any item which did not yield an affirmative answer to these requirements was rejected.

Sources of material for item construction.

Two hundred and four items were constructed of a four multiple choice nature. The author was initially handicapped by a lack of familiarity with the carpentering field. Considerable reading was done regarding technical carpentry subjects in order to partially overcome this defect. All items constructed were devised in relation to the Canadian Army trade description for Carpenters and indirectly provided a source of possible test items. By breaking down the job description into finer units and descriptions various items were suggested. This was supplemented by discussions with Major Young, officer in charge of trades training, Royal Canadian Engineers.

One of the most useful sources of information upon

which to devise questions was found to be technical trade journals and technical carpentry books. A list of these sources is given in Appendix B. Another source of material from which to develop questions were the already existing trade tests. These included tests developed by the United States Army, the United States Employment Services and the Canadian Army Trade tests. Many of these questions were in oral form and required a single free response answer, but were readily adapted to the multiple choice form.

In many cases subject materials were suggested in conferences with skilled tradesmen, and these were incorporated into question form. It was found that better results could be obtained by direct questioning of carpenters rather than asking them to construct a complete question. The carpenters seldom grasped the general form in which the question was to be phrased, but they were invaluable in suggesting common errors found in the less skilled and upon which subject material they were most apt to have the least knowledge.

An attempt was made to make as many of the items as descriptive as possible. Since the test was to be a measure of trade knowledge, the test should be a sampling of the individual's ability or information in this field only. In order to do this, the verbal element was kept at a minimum since a wide range of verbal facility would likely be encountered in the groups for which the test was being designed. Of the two hundred and four items originally compiled, eighty-four items were pictorial.

When these had been constructed, each item was reviewed by the Foremen of Carpenters^x at the University of British Columbia, and two other skilled carpenters of twenty-five years experience. In many cases questions were modified or replaced by fresh items at their suggestion. Before the printing of the initial copy of the test, agreement was obtained amongst these skilled carpenters as to the correctness of the selected answer and the suitability of the distractors.

The initial copy of the test, consisting of 204 items, is given in App. C.

Arrangement of answers and distractors in the item.

In the majority of four multiple choice type examinations, the assumption is held that completely naive subjects will score twenty-five percent and that the correct choices need only be scattered in such a way that the subject will not discern any particular pattern. However, Weitzman and McNamara (45), in a well controlled experiment found that a position factor existed. The difficulty of the item was significantly different according to the placement of the correct answer. When the order of the choices is left to the whim of the test constructor, a personal position preference is likely to result in a preponderance of the correct answers falling in one position. Moreover, the distractors, tending to be written in order of plausibility, will assume a particular pattern.

^xAppreciation is expressed to Mr. G. Rogers and members of his staff for their time and many helpful suggestions offered in the construction of many of the items.

Mosier and Rice (26) suggest a method of randomizing not only the **correct choice** but also the **distractors** in a five **choice** question. The present method used is a slight modification to make it applicable to four multiple **choice** questions.

While **constructing** the question, the **correct choice** was always placed first with the **distractors** following. The permutations for one, two, three and four, which have twenty-four possible arrangements, were written in a systematic and **cyclic** order. Each permutation was then assigned a sequence number of from one to twenty-four. Each permutation was then assigned as its final position in the table the order in which its sequence number occurred among the last two figures of a six place logarithm table (7). Since two hundred and four questions were initially used, nine sets of permutations were made. To avoid duplication of sequence, the following set was begun where the preceding one was left off. This method showed various advantages. There were no repetitions or omissions of **choice** numbers for any item and every possible position of both **choice** and **distractors** were used before a duplication occurred. Furthermore, considerable time is saved by the order of all four **choices** being given simultaneously. Table 1 gives the order of the **correct** answer and the **distractors**. In each case "1" represents the **correct** answer and "2", "3" and "4" the **distractors**.

(Table 1)

This method therefore ensured adequate randomization of answers and **distractors**.

TABLE 1

Arrangement of Correct Answers and Distractors

1.	4132	52.	4231	103.	1234	154.	3421
2.	4321	53.	1324	104.	1324	155.	1324
3.	4231	54.	3241	105.	2134	156.	4132
4.	4123	55.	1234	106.	2431	157.	2413
5.	2134	56.	4123	107.	4312	158.	4213
6.	3421	57.	3124	108.	2314	159.	3124
7.	1243	58.	2134	109.	3421	160.	3214
8.	1432	59.	1423	110.	4132	161.	2143
9.	3241	60.	4132	111.	3214	162.	4312
10.	2143	61.	1432	112.	1432	163.	4213
11.	4213	62.	4312	113.	2341	164.	1342
12.	1324	63.	3421	114.	4213	165.	2431
13.	3214	64.	2341	115.	3124	166.	2134
14.	1234	65.	3412	116.	3241	167.	1243
15.	4312	66.	1243	117.	4123	168.	3142
16.	2413	67.	1342	118.	2143	169.	4123
17.	1423	68.	2431	119.	4321	170.	3142
18.	3142	69.	2314	120.	1342	171.	2413
19.	3124	70.	4321	121.	1423	172.	1234
20.	2431	71.	3412	122.	3412	173.	1243
21.	3412	72.	2413	123.	1243	174.	4213
22.	1342	73.	4321	124.	2413	175.	2431
23.	2341	74.	3412	125.	3412	176.	3124
24.	2314	75.	4132	126.	3214	177.	1342
25.	2413	76.	4213	127.	4321	178.	1324
26.	4312	77.	1324	128.	4132	179.	3142
27.	1423	78.	1243	129.	3421	180.	1423
28.	2431	79.	1423	130.	2143	181.	2314
29.	3241	80.	2431	131.	4312	182.	4321
30.	4312	81.	2314	132.	2431	183.	3241
31.	1432	82.	4231	133.	3241	184.	2134
32.	2431	83.	3412	134.	4213	185.	4132
33.	3214	84.	4123	135.	4231	186.	4321
34.	3124	85.	3124	136.	3124	187.	1432
35.	4132	86.	3421	137.	4123	188.	3214
36.	2341	87.	2134	138.	2314	189.	3421
37.	4321	88.	2341	139.	1324	190.	2341
38.	2143	89.	1432	140.	2134	191.	2143
39.	1234	90.	1234	141.	1342	192.	4231
40.	1234	91.	3124	142.	1432	193.	2413
41.	1432	92.	2143	143.	1234	194.	2143
42.	2314	93.	3241	144.	2341	195.	2341
43.	4123	94.	4312	145.	2341	196.	1243
44.	3421	95.	2413	146.	4321	197.	4312
45.	3142	96.	1342	147.	1432	198.	3412
46.	4213	97.	1423	148.	1234	199.	3124
47.	4231	98.	3142	149.	2314	200.	1324

TABLE 1 (cont'd)

48. 1324	99. 1243	150. 3241	201. 4213
49. 2143	100. 4231	151. 1423	202. 4123
50. 3214	101. 2413	152. 4123	203. 4231
51. 4213	102. 3412	153. 3421	204. 1342.

6. The Wonderlic Personnel Test.

One of the major considerations in standardizing the trade test was to determine to what extent intelligence, independent of experience, would effect an individual's score. Without this knowledge, the trade test could become an intelligence test disguised in carpentering terminology. The Wonderlic Personnel Test(App. D) was used to ascertain the intelligence of the subjects used in the standardization sample. It was selected because, besides being economical in the time required to administer, it has been standardized upon a large number of adults in business and industry. The majority of intelligence tests are developed in educational situations and may lack applicability to adult industrial circumstances.

The Wonderlic Personnel Test (64) is an abridgement of the Otis Self Administering Test of Mental Ability, Higher Form. By an analysis of eight thousand Otis Tests, the authors reduced the number of items and the administration time. The items were selected from the existing Otis examinations on a three fold criterion. These were those items which 1. differentiated successful and unsuccessful industrial employees, 2. differentiate good and poor school records as indicated by statistically significant differences between the upper and lower twenty-five percent with respect to academic achievement and 3. yielded satisfactory bi-serial co-efficients between final total scores and pass or fail on the individual item.

The authors report (47) reliability co-efficients of between $r = .82$ and $r = .94$ by the test retest method and of $r = .88$ to $r = .94$ by the split half method. The correlation between the Wonderlic Personnel Test and the Otis S.A. Higher Form is reported to be between $r = .81$ and $r = .87$. While these correlations are spuriously high, since the items contained in the Wonderlic Personnel Test are part of the validating criterion, the remaining two criterion would seem to represent adequate safeguards.

The test requires twelve minutes to administer and contains fifty questions. Scores are interpreted in terms of the total number of questions correctly answered. A correction is allowed on the scoring for the older age groups. An extra three points are added, beginning at twenty-nine and increasing by regular increments to the age of sixty-nine.

The Wonderlic Personnel Test was administered to the subjects used as the sample and the scores obtained were viewed as a measure of the intelligence of the subjects.

7. Description of the Sample.

The test was standardized upon a criterion of three groups. These were selected in order to represent varying degrees of trade proficiency in carpentering. They were designated as "novice", "apprentice" and "carpenter" groups. The following definitions were used;

"novice"

a novice was defined as an individual who had no specific carpentry training although he may have worked as a helper or an unskilled labourer in carpentry.

"apprentice"

an apprentice was considered to be someone who had received training courses in carpentry or who had worked at the trade in a learner's capacity for a period of not more than three years. The British Columbia Department of Labour considers four years on-the-job-training as the required training period for qualification as a journeyman carpenter. Some modification is allowed, however, in the required apprenticeship time for formal training courses taken. Students who have completed grade twelve in woodworking and carpentry at a technical school or who have completed a six months woodworking course at the Dominion sponsored Vocational Training Institute are

allowed up to one and one half years credit on their apprenticeship time (63)

"carpenters"

a carpenter was defined as a man having three years or more carpentry experience and at present engaged upon the work of a carpentering nature. Satisfaction of the second qualification was taken to indicate that the man had in fact achieved the status of a skilled carpenter.

(b) "novice" sample

The novice sample consisted of one hundred navy enlisted personnel stationed at H.M.C.S.Naden. When tested they were waiting to receive training courses of assorted natures. They represented a heterogeneous group in so far as interests and work experience were concerned. Twenty-two had no previous work experience; sixteen had worked as trainees or helpers in skilled mechanical trades; seven had been employed in a clerical or sales capacity and fifty-five had been engaged in semi-skilled or unskilled work. Ages, at last birthday, ranged from seventeen to twenty-eight with a mean age of twenty and a median of nineteen (ages at last birthday were rounded to the nearest whole number of years).

(c) "apprentice" sample

Difficulty was encountered in obtaining the apprentice group and it was necessary to draw subjects from various sources. Eighty-one subjects were used in this category.

Eighteen were enrolled in grade twelve at the Vancouver Technical School. They had all specialized in woodworking and carpentry besides taking an active participation in the construction of housing. Twenty-nine were enrolled at Trapp Technical School, New Westminster, and had all likewise specialized in woodworking and carpentry. Fifteen were recent graduates from the Royal Canadian (Army) Engineers course in carpentry at Chilliwack. The remaining nineteen were engaged upon, and held trade groupings as carpenters with the Canadian Armed Forces but had less than three years experience at the trade. The ages of the total apprentice group ranged from fifteen to forty-seven with a mean of twenty and a median of eighteen.

(d) "carpenter" sample

The carpenter's group consisted of sixty-one enlisted personnel in the armed forces holding trade groupings as carpenters, having more than three years experience at the trade and currently engaged at the trade. The ages of the carpenter's group ranged from twenty to forty-five with a mean and median age of thirty-one. Their experience at the trade ranged from three years to twenty-five years with a mean of nine years and a standard deviation of 4.97 years.

8. Administration of the Tests.

The tests were administered in a similar manner to the various groups. The novice group, obtained through the co-operation of the Royal Canadian Navy, were tested on May 16th, 1949. Adequate physical surroundings were obtained by the use of a class room at H.M.C.S. Naden. Testing took place in two sessions; fifty subjects being tested in the morning commencing at nine o'clock and fifty subjects being tested in the afternoon commencing at two o'clock. Since many of the subjects had been tested on a previous occasion by the examiners, it was felt that a fairly high degree of rapport and motivation had been established. It is possible that this was further facilitated by the fact that the testing represented an excuse from more arduous training duties.

The purpose of the test was explained to them and the part that they would take was indicated. The Wonderlic Personnel Test was then administered on a twelve minute time limit, and according to the instructions upon the title page. The directions on the trade test were then read to the group and they were asked to complete the personal data sheet (App. E) prepared for novices and civilian apprentices. A special emphasis was placed upon answering all the questions since an item analysis was intended. The subjects then proceeded to answer the trade test. The earliest recorded time required to complete the test was one hour and ten minutes and the longest time was two hours and fifty minutes. This procedure was

repeated for the afternoon group.

The same procedure was followed for the apprentice group tested by the author. Testing with the technical school subjects was conducted in the class rooms of the respective school and with the co-operation of the school woodworking and carpentry instructor.

Owing to the inability to obtain carpenters locally, arrangements were made for the Defence Research Board to receive the test forms and to distribute them to the various units in which carpenters were engaged. Appendix E indicates the personal data sheet attached to tests which were to be completed by carpenter subjects. Because of the diversity of testing situations and the variety of examiners who would be administering the tests an "instruction to the examiners" sheet was mailed with each group of tests (App.G) for the guidance of examining officers in each unit.

While it is likely that the uniformity of testing procedures may have suffered by this method of "farming" out the tests, it seemed to have the advantage of avoiding answers that would be purely local in nature and thus reflect a regional bias.

9. Raw Test Analysis.

The personal data sheets attached to the front of each test was surveyed to ensure that each subject was adequately placed regarding carpentering experience. Four cases in the novice group were removed because they had at one time been either carpenter's apprentices or received training in the occupation. This resulted in the novice group consisting of ninety-six subjects. The sixty-three carpenters and eighty-one apprentices were satisfactory from a definition standpoint. The total sample consisted of two hundred and forty subjects.

The tests were then scored upon the basis of the total number of correct responses. The total number of correct responses for each subject for the complete test was then computed along with the percentage of each group correctly answering each item. Items upon which the percentage of carpenters successfully answering did not exceed the number of novices correctly answering were more closely analyzed for errors in scoring. Upon these items the individual responses were determined in order to ascertain whether the groups differed significantly in their choices of alternate responses. Distributions based upon the total scores of individuals were then compared. Fig. 1 gives a graphical representation and Table 11 indicates the pertinent information regarding them.

(Table 11.)

In order to determine the reliability of the means for the three groups, the standard errors of the means were

FREQUENCY

..... novices
 ---- apprentices
 ————— carpenters

25

20

15

10

5

0

12.0 17.0 22.0 27.0 32.0 37.0 42.0 47.0 52.0 57.0 62.0 67.0 72.0 77.0 82.0 87.0 92.0 97.0 102.0 107.0 112.0 117.0 122.0 127.0 132.0 137.0 142.0 147.0 152.0 157.0 162.0

TEST SCORES ON 204 ITEMS

Fig. 1 Percentage distribution of carpenters, apprentices and novices on trade test of 204 items

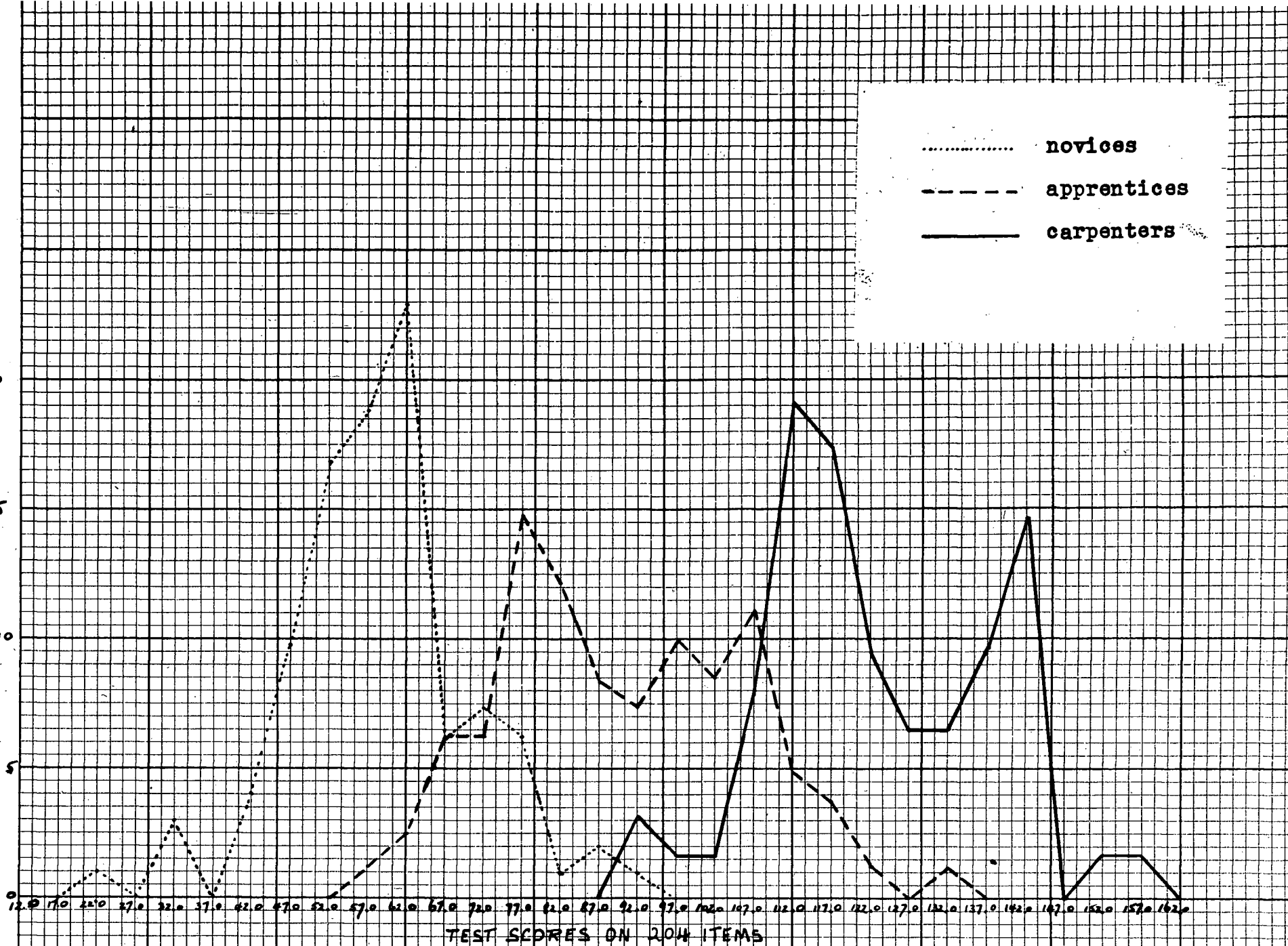


TABLE 11.

Distributions and pertinent data derived from administration of 204 item test to novices, apprentices and carpenters.

Score int.	Carpenters	Apprentices	Novices.	Comb.
159-155	1			1
154-150	1			1
149-145	0			0
144-140	9			9
139-135	6			6
134-130	4	1		5
129-125	4	0		4
124-120	6	1		7
119-115	11	3		14
114-110	12	4		16
109-105	5	9		14
104-100	1	7		8
99-95	1	8		9
94-90	2	6	1	9
89-85		7	2	9
84-80		10	1	11
79-75		12	6	18
74-70		5	7	12
69-65		5	6	11
64-60		2	22	24
59-55		1	18	19
54-50			16	16
49-45			9	9
44-40			4	4
39-35			0	0
34-30			3	3
29-25			0	0
24-20			1	1
19-15				
14-10				
N =	63	81	96	240
Mean	123.1	90.5	59.3	
Standard Deviation	14.2	15.7	11.7	
Standard error of mean =	1.81	1.75	1.20	
Fiducial limits .05=	119.5-126.7	87.0-94.0	56.9-61.7	
Fiducial limits .01	118.3-127.9	85.9-95.1	56.1-62.5	

computed using the formula

$$\sigma_M = \frac{\sigma}{\sqrt{N - 1}} \quad (16, p. 189)$$

The standard error of the differences between the means for the three groups were also computed using the formula suggested by Garrett for use when dealing with different groups

$$\sigma_D = \sqrt{\sigma_{M1}^2 + \sigma_{M2}^2} \quad (216, P. 29)$$

Critical ratios were determined by dividing the differences between the respective means of the groups by the standard error of the differences between the means. The results are tabulated in Table III.

Table III
=

These "t" values indicate the probability that obtained mean values for the three groups could occur on the basis of chance variations in the selection of the samples. In all cases, by reference to probability table, they indicated that a significant difference did exist well beyond the point at which chance factors would account for the obtained distributions. From these data the test seemed to indicate enough discriminatory power to warrant further investigation.

10. Item analysis of raw test.

The main purpose of the item analysis was to reject

Table III

Determination of "t" values

	σ_M		σ_{DM}	Diff. "t" (Diff)	F_{DM}
carpenters	1.81	carpenters-apprentice	2.52	32.6	12.94
apprentices	1.75	apprentices-novice	2.12	30.7	14.48
novices	1.20	carpenters-novices	2.17	63.8	29.40

those items that failed to differentiate between various levels of trade proficiency and in this way increase the discriminatory power of the test. A practical advantage is the reduction in length of the exam without loss of efficacy.

The most common methods of item analysis express a relationship between a dichotomous item variable (eg pass-fail) and multiple categories or a continuous criterion. This usually takes the form of a correlation co-efficient. The criterion may be either internal, that is the test scores themselves, or an externally determined criterion. The former method can seldom be defended if some external criterion is obtainable: its use tends to select items which measure what the test measures as a whole and while it may increase the internal consistency of the test, it does not necessarily increase the test validity. It may, on the contrary, decrease the test validity. The most common forms of item analysis against an external criterion are biserial r , point biserial r and tetrachoric r . In all of these measures the assumption is made that either the criterion or the test variable, although it may be arbitrarily categorized, is fundamentally a continuum normally distributed. In the case of the present data such an assumption appears untenable.

Item analysis is primarily dependent upon two factors; item difficulty and item discrimination. The method of item analysis employed in this study, while not demonstrating the statistical refinements of more elaborate devices, recognizes both these elements. It also has the advantage of

economy of time; a necessary practical consideration in any proposed wide-range testing situation.

Using the data available from Table IV , which gives the percentage of correct responses for each item by groups, the standard errors of the percentages,

$$\sigma\% = \sqrt{\frac{pq}{n}} \quad (16 \text{ p.227})$$

the standard errors of the differences between the percentages for each group

$$\sigma D\% = \sqrt{\sigma^2\%_1 + \sigma^2\%_2} \quad (16, \text{p.219})$$

Garrett

and the differences in percentages between the groups were determined. From these data "t" ratios $(\frac{\text{Diff}\%}{\sigma D\%})$ were determined for each item. These values are shown in Table IV for adjacent groups.

An item in order to be selected had to meet two requirements. The first of these was that a critical ratio indicating a significant difference at the one percent level of confidence or better be obtained between either the carpenters and apprentices or the apprentices and novices. The second requirement was that the percentage of novices answering the question correctly did not exceed fifty percent, and that the percentage of carpenters answering an item correctly should not be less than fifty percent.

One hundred items were then selected, this number being decided upon arbitrarily in order to facilitate computat-

Table IV

Percentage of group passing item and the "t" ratios between adjacent groups for each of 204 items.

<u>Item No.</u>	Percentage of items passed			"t" ratios $\left(\frac{\text{Diff}}{\text{SD}}\right) \%$	
	<u>Novice</u>	<u>Apprentice</u>	<u>Carpenter</u>	<u>nov.-app.</u>	<u>app.-carp.</u>
1	27	59	92	4.50	5.08
2	42	66	75	3.29	1.18
3	26	27	60	4.15	4.18
4	49	74	94	3.57	3.51
5	72	90	95	3.18	1.16
6	53	42	41	-1.20	-.12
7	36	48	86	1.62	5.38
8	48	61	86	1.76	3.59
9	22	31	66	1.35	4.43
10	28	44	64	2.26	2.44
11	12	14	30	.39	2.32
12	24	28	68	.60	7.79
13	23	23	49	.00	3.33
14	44	44	64	.00	2.44
15	35	23	29	-1.79	.81
16	5	0	2	-2.27	1.00
17	42	56	54	1.60	-.24
18	2	27	77	4.90	6.94
19	29	46	86	2.36	5.71
20	13	28	65	2.50	4.74
21	21	56	76	5.07	2.60
22	25	26	73	.15	6.35
23	18	42	70	3.58	3.50
24	44	94	90	8.77	-.87
25	24	21	19	-.47	-.40
26	33	62	95	4.03	5.50
27	76	90	97	2.55	1.79
28	16	32	73	2.50	5.39
29	16	7	24	-1.91	2.79
30	20	23	33	1.48	1.48
31	8	10	30	.46	2.98
32	69	85	98	2.58	3.02
33	31	56	83	3.33	3.60
34	35	84	90	7.78	1.09
35	21	25	22	.63	-.42
36	38	94	98	10.00	1.25
37	20	22	27	.33	.69
38	6	25	68	3.52	5.66
39	6	26	51	3.70	3.12
40	2	27	52	5.21	3.12
41	7	12	10	1.14	-.37
42	36	49	75	1.76	3.33
43	39	43	62	.54	2.43

(Table iv continued)

-53-

44	60	61	94	.13	5.41
45	76	92	92	3.02	.00
46	42	54	65	1.60	1.34
47	12	12	10	.00	-.49
48	59	79	76	4.00	.43
49	81	90	97	2.19	1.94
50	15	19	27	.70	1.13
51	40	37	22	-.41	-2.00
52	24	54	87	4.25	4.73
53	20	70	94	7.66	3.20
54	30	26	43	-.60	2.15
55	47	57	95	1.33	6.02
56	38	43	66	.67	2.83
57	55	73	95	2.54	3.90
58	63	70	97	.99	4.89
59	38	63	68	3.46	.63
60	48	87	90	6.17	..56
61	27	74	72	7.08	-.27
62	48	43	76	-.74	-4.76
63	32	46	81	1.91	4.72
64	17	30	44	2.04	1.74
65	9	22	56	2.39	4.38
66	43	54	92	1.47	5.84
67	27	49	65	3.07	1.95
68	30	32	17	.29	-2.14
69	18	51	75	4.86	3.08
70	14	41	62	4.14	2.68
71	37	54	68	2.29	1.73
72	21	91	92	13.38	.23
73	15	40	54	3.82	1.69
74	26	14	44	-2.03	4.09
75	40	87	95	7.54	1.73
76	17	27	57	1.60	3.77
77	10	14	21	.62	.93
78	4	21	36	3.43	1.98
79	24	22	41	-.31	2.46
80	27	68	57	5.96	-1.11
81	23	49	44	3.71	-.60
82	17	7	2	-2.10	-1.67
83	27	48	35	2.93	-1.59
84	15	43	54	4.24	1.32
85	31	62	90	4.32	4.25
86	41	54	56	1.72	.24
87	21	27	52	.93	3.13
88	55	74	57	2.70	-2.14
89	9	17	36	1.57	2.59
90	31	43	90	1.65	7.03
91	9	2	2	-2.12	-.18
92	51	74	75	3.26	.14
93	26	25	17	-.15	-1.19
94	36	41	65	2.68	2.95
95	32	33	19	.14	-1.95

(Table IV continued)

-54-

96	20	20	70	.00	6.87
97	58	73	75	2.02	.26
98	22	21	40	-.14	2.40
99	35	89	97	9.82	1.97
100	28	80	87	8.14	1.14
101	41	81	92	5.95	1.99
102	23	25	59	.31	4.34
103	17	23	30	.83	.94
104	36	43	83	.95	5.51
105	36	81	95	6.87	2.72
106	47	62	81	2.02	2.60
107	30	57	75	3.74	2.32
108	29	74	94	6.70	3.49
109	27	43	90	2.24	7.03
110	29	68	86	5.61	2.65
111	3	0	6	-1.73	2.00
112	38	54	54	2.15	.00
113	20	32	24	1.82	-1.07
114	33	63	95	4.17	5.31
115	15	22	70	1.19	6.50
116	45	30	30	.00	-2.09
117	30	24	36	.90	1.56
118	16	46	86	4.48	5.67
119	42	51	78	1.20	3.54
120	3	30	60	5.03	3.37
121	46	81	95	5.22	2.72
122	7	14	43	1.50	3.96
123	32	36	57	1.96	2.56
124	30	28	54	-.29	3.24
125	18	42	78	3.56	5.09
126	30	47	73	2.34	3.30
127	4	24	44	3.88	2.55
128	8	5	11	.86	1.30
129	40	66	100	3.60	6.46
130	63	90	95	4.54	1.16
131	19	57	81	5.59	3.25
132	27	47	60	2.80	1.57
133	22	42	43	2.89	.12
134	31	70	86	5.62	2.39
135	30	64	92	4.79	4.42
136	21	27	49	.93	2.75
137	40	41	62	.13	2.68
138	21	44	62	3.34	3.99
139	36	54	38	2.43	-2.03
140	24	21	25	2.48	.56
141	8	20	60	2.29	5.26
142	32	53	90	2.88	5.51
143	46	57	65	1.47	.98
144	60	68	95	1.11	4.61
145	35	75	94	5.85	3.36
146	29	43	62	1.94	2.44
147	60	56	78	-.54	2.90

148	18	38	54	3.00	1.92
149	41	44	84	.40	5.56
150	37	24	27	- 1.74	.27
151	11	58	68	7.40	1.24
152	26	16	38	-1.65	2.92
153	32	32	27	.00	- .70
154	41	33	70	-1.10	4.75
155	55	74	97	2.70	.56
156	60	72	94	1.70	3.79
157	37	51	72	1.88	2.65
158	54	77	92	3.33	2.59
159	23	15	11	-1.37	-1.07
160	29	37	32	1.12	- .63
161	37	69	65	4.49	- .51
162	35	33	56	- .28	2.82
163	57	57	78	.00	2.77
164	16	11	3	- .98	1.96
165	28	37	14	1.27	-3.32
166	28	36	54	1.14	2.19
167	15	25	10	1.64	-2.45
168	23	24	48	.16	3.05
169	28	32	27	.58	.61
170	37	40	24	.41	-2.09
171	31	31	72	.00	5.37
172	15	16	29	.14	1.85
173	26	50	60	3.37	1.21
174	34	41	25	.96	-2.08
175	14	42	44	4.29	.24
176	25	63	84	5.48	2.97
177	9	15	22	1.22	1.07
178	32	54	58	3.01	.48
179	not scored			.00	.00
180	8	18	27	1.96	1.29
181	8	5	5	- .82	.00
182	18	20	57	.34	4.84
183	48	65	54	2.31	-1.34
184	37	83	94	7.12	2.15
185	29	85	92	9.19	1.34
186	38	32	60	- .84	3.35
187	39	44	65	.67	2.58
188	42	44	62	- .31	3.00
189	32	49	49	2.33	.00
190	14	46	60	4.88	1.69
191	13	15	30	.38	2.14
192	23	36	56	1.90	2.44
193	14	41	32	4.15	1.12
194	35	58	95	3.14	6.05
195	17	11	48	-1.16	5.15
196	9	25	52	2.50	3.41
197	27	29	68	.29	3.75
198	23	25	35	.31	.63
199	10	8	16	.59	1.55

(Table 1V continued)

-56-

200	27	34	89	1.01	8.37
201	31	32	26	.14	.79
202	14	11	10	- .61	.20
203	12	31	69	3.11	4.89
204	18	34	59	2.44	3.08

ion. For clarity the percentage of each group passing the item and the critical ratios between adjacent groups are summarized in Table V.

(Table V)

Ten of the selected items did not meet the qualifications; five were not passed by the required number and five did not yield satisfactory critical ratios. Question "179" was not marked because of poor presentation due to mimeographing errors. The lowest "t" ratio used, however was 2.44 for question "194". The average "t" ratio for the items selected between carpenters and apprentices was 3.61 and between apprentices and novices it was also 3.61.

The tests were then rescored upon the basis of the one hundred selected items. The total scores were considered to be the arithmetical sum of the number of items correctly answered. Many methods exist for correcting scores to allow for chance or of weighting the individual in regard to their diagnostic value. One of the most common procedures employed to correct for chance in multiple choice items is the application of the formula

$$P_c = R - \frac{\frac{W}{n-1}}{R-W-0} \quad (41, p.234)$$

Two conditions are implied by the use of this formula. These are that (a) the subjects choice of an incorrect item is based upon an absence of information, and secondly (b), that all the choices are equally attractive and have the same "pulling Power". It seems unlikely that these conditions can be

adequately met with the present data. In many cases different weights or score values are given to items depending upon their diagnostic worth. Shouse (35), in a comparative study of different methods of scoring, concluded that counting the total number of correct items was as effective as any. Odell (27) investigating the effect of weighting items concluded that "there is so little to be gained by unequally weighting the elements that it is not worth the labour involved." Goodenough (17) in a more recent publication on testing, concurs that little is to be gained from differential weighting and that it seldom justified the labour involved. He points out, however, that subjective weighting is present in any test by the selection of the area to be tested and the importance to be attached to these areas.

For these reasons, and because of the increased complexity of marking involved, with the accompanying loss of reliability, the scoring was restricted to the total number of items correctly answered. An added consideration was the fact that, while in its present experimental form, the test scores would appear to be more meaningful in raw form.

Table V

Percentage of group passing item and "t" ratios between adjacent groups for 100 selected items.

Item Number on raw test	Percentage passing item			"t" ratios $(\frac{\text{Diff \%}}{\sigma D \%})$	
	carp.	app.	novice	app-novice	app-carpenter
1	92	59	27	4.5	5.08
2	75	66	42	3.29	1.18
3	60	27	26	.15	4.18
4	94	74	49	3.57	3.51
7	86	48	36	1.62	5.38
8	86	61	48	1.76	3.59
9	66	31	22	1.35	4.43
12	68	28	24	.60	7.79
13	49	23	23	.00	3.33
18	77	27	2	4.90	6.94
19	86	46	29	2.36	5.71
20	65	28	13	2.50	4.74
21	76	56	21	5.07	2.60
22	73	26	25	.15	6.35
23	70	42	18	3.58	3.50
24	90	94	44	8.77	.87
26	95	62	33	4.03	5.50
28	73	32	16	2.50	5.39
32	98	85	69	2.58	3.02
33	83	56	31	3.33	3.60
34	90	84	35	7.78	1.09
36	98	94	38	10.00	1.25
38	68	25	6	3.52	5.66
39	51	26	6	3.70	3.12
40	52	27	2	5.21	3.12
42	75	49	36	1.76	3.33
44	94	61	60	.13	5.41
52	87	54	24	4.25	4.73
53	94	70	20	7.66	3.20
55	95	57	47	1.33	6.02
57	95	73	55	2.54	3.90
58	97	70	63	.99	4.89
59	68	63	38	3.46	.63
60	90	87	48	6.17	.56
61	72	74	27	7.08	-.27
63	81	46	32	1.91	4.72
65	56	22	9	2.39	4.38
66	92	54	43	1.47	5.84
67	65	49	27	3.07	1.95
69	75	51	18	4.86	3.08
70	62	51	14	4.14	2.68
72	92	91	21	13.38	.23
73	54	40	15	3.82	1.69
75	95	87	40	7.54	1.73
76	57	27	17	1.60	3.77

84	54	43	15	4.24	1.32
85	90	62	31	4.32	4.25
87	52	27	21	.93	3.13
90	90	43	31	1.65	2.95
94	65	41	36	.68	2.95
96	70	20	20	.00	6.87
99	97	89	35	9.82	1.97
100	87	80	28	8.14	1.14
101	92	81	41	5.95	1.99
102	59	25	23	.31	4.34
104	83	43	36	.95	3.31
105	95	81	36	6.87	2.72
106	81	62	47	2.02	2.60
107	75	57	30	3.74	2.32
108	94	74	29	6.70	3.49
109	90	43	27	2.24	7.03
110	86	68	29	5.61	2.65
114	95	63	33	4.17	5.31
115	70	22	15	1.19	6.50
118	86	46	16	4.48	5.67
119	78	51	42	1.20	3.54
120	60	30	3	5.03	3.37
121	91	85	46	5.22	2.72
124	54	28	30	-.29	3.24
125	78	42	18	3.56	5.09
126	73	47	30	2.34	3.30
129	100	66	40	3.60	6.46
1.31	80	57	19	5.59	3.25
1.32	60	47	27	2.80	1.57
1.34	86	70	31	5.62	2.39
1.35	92	64	30	4.79	4.42
1.38	75	44	21	3.34	3.99
141	60	20	8	2.29	5.26
142	90	53	32	2.88	5.51
144	95	68	60	1.11	4.61
145	95	75	35	5.85	3.36
148	54	38	18	3.00	1.92
149	84	44	41	.40	5.56
151	68	58	11	7.40	1.24
157	72	51	37	1.88	2.65
158	92	77	54	3.33	2.59
171	72	31	31	.00	5.37
173	60	50	26	3.37	1.21
176	84	63	25	5.48	2.97
182	57	20	18	.34	4.84
184	94	83	37	7.12	2.15
185	92	85	29	9.19	1.34
190	60	46	14	4.88	1.69
192	56	36	23	1.90	2.44
194	95	58	38	3.14	6.05
196	52	25	9	2.50	3.41
197	68	29	27	.29	3.75
200	89	34	27	1.01	8.37
203	69	31	12	3.11	4.89
204	59	34	18	2.44	3.08

11. Analysis of Test Scores Based Upon 100 Selected Items.

The final distributions obtained for the three groups when the tests were marked upon the basis of the selected items were determined. These distributions along with their means or, in this case, the average percentage correct, and the standard deviations are tabulated in Table V1. A graphical distribution is given for comparison with the original distribution. (figure 11)

(Table V1)

The standard errors of the means, the standard errors of the differences between the means and the critical ratios were determined as upon the original scoring and are presented in Table V11.

(Table V11)

The "t" ratios indicated in Table V11 are well beyond that which may be accepted as indicating a difference in performance beyond that which could be attributed to chance. They would indicate pronounced differences between each of the three groups. Shortening the test by more than one half did not reduce its discriminatory value.

The standard deviations of the two forms and of the groups were compared by the means of the co-efficient of variation. This permits comparison of the standard deviations of the groups allowing for differences in central tendency. It is expressed by the formula

$$V = \frac{100 \times \sigma}{M} \quad (16 \text{ p. } 65)$$

The use of this formula implies an absolute zero point but

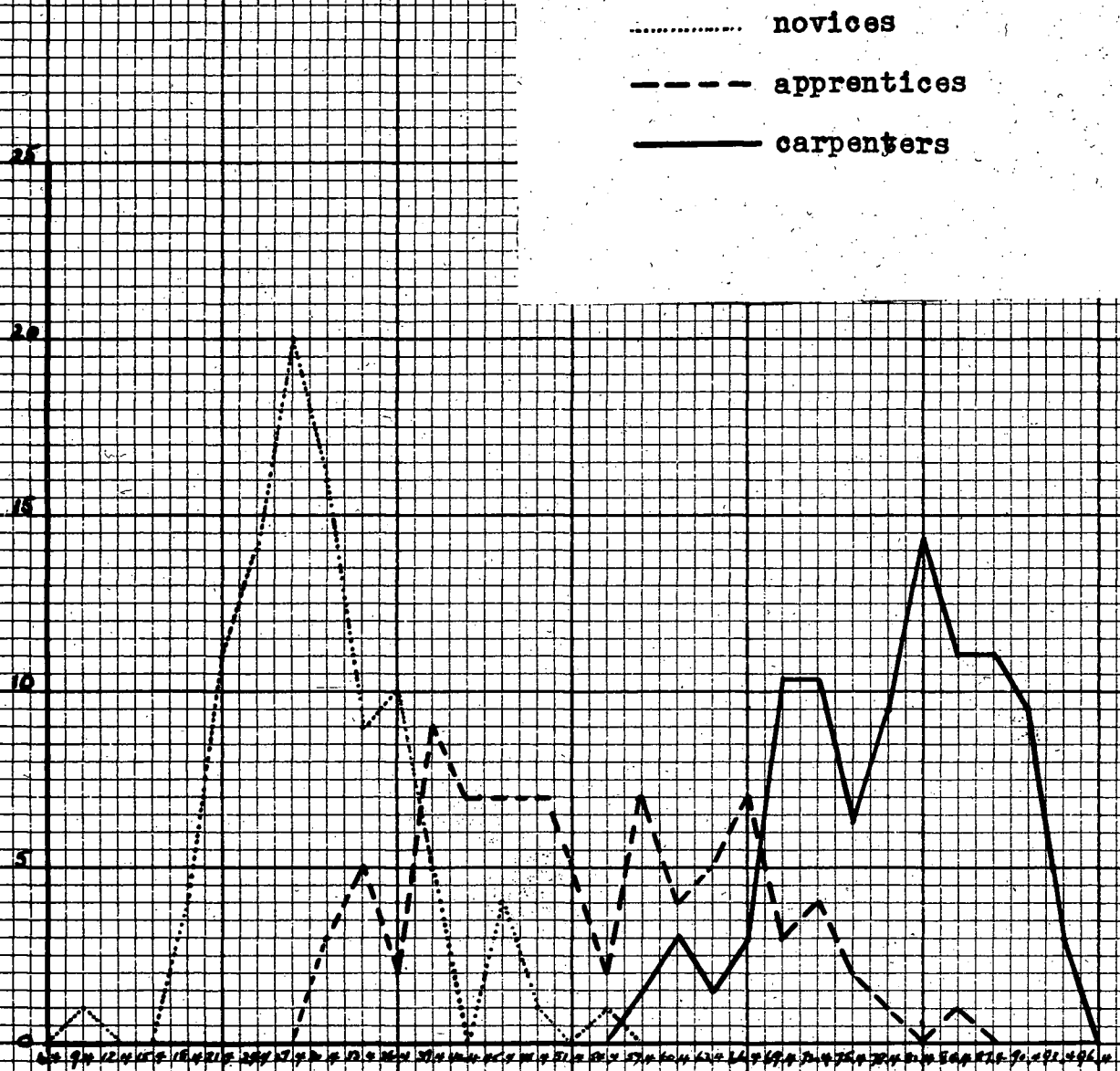


Fig. 2 Percentage distributions for carpenters, apprentices and novices for 100 item trade test

Table VI

Distributions and derived data obtained from analysis of 100 selected items.

<u>Scores</u>	<u>Carpenters</u>	<u>Apprentices</u>	<u>Novices</u>	<u>Cumulative Frequency</u>
94-92	2			2
91-89	6			6
88-86	7			7
85-83	7	1		8
82-80	9	0		9
79-77	6	1		7
76-74	4	2		6
73-71	8	4		12
70-68	8	3		11
67-65	2	7		9
64-62	1	5		6
61-59	2	4		6
58-56	1	7		8
55-53		2	1	3
52-50		5	0	5
49-47		7	1	8
46-44		7	4	11
43-41		7	0	7
40-38		9	5	14
37-35		2	10	12
34-32		5	9	12
31-29		3	16	21
28-26			20	20
25-23			14	14
22-20			11	11
19-17			4	4
16-14			0	0
13-11			0	0
10- 8	—	—	1	1
Totals	63	81	96	240
means	78.58	52.72	29.68	
standard dev	8.88	13.68	7.35	
σ M	1.13	1.53	.75	
Fiducial limits .05	76.32-80.84	49.66-55.78	28.18-31.18	
Fiducial limits .01	75.76-81.40	48.90-56.54	27.81-31.55	

Table VII

Determination of "t" ratios between adjacent groups for 100 item test.

	σ_M	σ_{Dm}	Diff	"t" ratios ($= \frac{\text{Diff}}{\sigma_D}$)
Carpenters	1.13	1.90 carp-app.	25.86	13.61
Apprentices	1.53	1.70 app.-nov.	23.04	13.55
Novices	.75	1.39 nov.-carp.	48.90	35.18

it's use here is permissible since comparisons are being made of variabilities upon the same scale. Table VIII presents the comparable variability of the groups.

(Table VIII)

From Table VIII the conclusion could be drawn that the item analysis increased the relative variability in both the apprentice and novice range, but that a slight decrease resulted in the carpenter's range. The variability was largest in the apprentice group. This could be accounted for by the wide diversity of range comprising this group and is as would be expected. The carpenter's group yielded the smallest variability and reflects the selective process which no doubt effected the sample previous to testing. The 100 item test is included in Appendix H.

Table VIII

Comparison of variability of the groups on 204 and 100 item tests.

	<u>204 item test</u>			<u>100 item test</u>		
	mean	S.D.	V.	mean	S.D.	V.
Carpenters	123.1	14.25	11.57	78.58	8.88	11.3
Apprentices	90.5	15.7	17.35	52.72	13.68	25.95
Novices	59.3	11.7	19.73	29.68	7.35	24.76

12. Reliability of Test.

Meaning of reliability.

An important attribute of any test is its reliability. Considerable confusion exists regarding the precise meaning of reliability. Otis (28) defines the reliability of a test as meaning the amount of agreement between the results secured from two or more applications of a test. Sandiford (31) expresses reliability as meaning the accuracy with which a test measures whatever it does measure. Jackson and Ferguson (20) suggest that reliability really expresses two meanings which are not adequately indicated by the blanket term of reliability. They express the opinion that two separate measures should be employed; an absolute and a relative value. In this way they suggest the use of the reliability co-efficient as a measure of the relative accuracy of measurement and the standard error of measurement as the absolute value. Both of these would seem to have value in the description of a psychological measuring instrument.

Reliability co-efficient.

The reliability co-efficient of a test is the correlation between successive scores upon the same test. The reliability co-efficients reported in this study were derived by the split-half method increased by the Spearman-Brown formula to allow for a test twice the length. The co-efficient is derived from correlating, for each subject, the total number of odd items with the total number of even items correctly

answered on a single administration of the test. This is actually splitting the test into two component parts and treating the parts as being equivalent. The correlation coefficient is then increased to allow for the result that would have been obtained if the test had been twice as long. The assumption of equivalence of parts involves the consideration that they have equality of difficulty and standard deviations. Reliability co-efficients derived by this method tend to be higher than those obtained by other methods (21) but there is the advantage of eliminating subject variability since chance factors are more likely to influence both parts equally in a single administration than they are when two separate forms are administered. The basic premise in correlating the two sections is then, that each part is equivalent. This means that they must not differ significantly in standard deviations and difficulty from that which could be expected on a chance basis (20). In order to determine this, the standard deviations and the difficulty of each section for each group and for the total group were computed. The standard error of each standard deviation were determined.

$$\sigma_s = \frac{s}{\sqrt{2(N-1)}} \quad (16, p.194)$$

and the standard error of the difference between the standard deviations obtained allowing a correction for the correlation between the two parts.

$$\sigma_{D_s} = \sqrt{\sigma_{s_1}^2 + \sigma_{s_2}^2 - 2r_{12}\sigma_{s_1}\sigma_{s_2}} \quad (16, p.215)$$

"t" ratios were then determined by the use of formula

$$\text{"t" ratio} = \frac{D}{\sqrt{D_r}} \quad \begin{array}{l} (16, p. 203) \\ \text{Garrett.} \end{array}$$

By the use of statistical tables (16, p. 190) it was then possible to determine the likelihood that the two parts were significantly different in these two respects. The same procedure was employed to determine the equivalence in terms of difficulty; a correction again being applied to take into consideration the correlation between the parts. Table IX and Table X present data regarding equivalency of difficulty and standard deviation respectively.

{Table IX}
{Table X}

This would indicate that the two sections would not differ significantly in difficulty in any of the groups. The standard deviations do differ significantly at the five percent level for the total range and at the one percent level for the novice range. Noting the distribution of the novice range, it seems quite possible that the leptokurtic distribution of scores would invalidate this procedure within this range. For both the apprentice and the carpenter ranges the test could be considered equivalent, and the use of the split-half method of determining reliability would seem justified.

Kelley (22) points out that the reliability of a test will depend upon the variability of the group. Thus the interpretation of the reliability co-efficient will depend upon the group from which it is derived.

Table IX
Comparison of Difficulty of odd vs even sections of test.

	Odd	Even	r	σP		D	σd_p	"t" ratio Diff % $\frac{\sigma D}{\sigma D}$	chances in 100
			oe	odd	even				
Carpenters	.3853	.3943	.65	.0613	.0616	.0090	.0659	.137	56
Apprentices	.2497	.2602	.79	.048	.049	.0105	.0435	.24	60
Novices	.1335	.1531	.57	.034	.037	.0196	.041	.478	68
Total group	.2390	.2518	.93	.029	.030	.0128	.0104	1.23	89

Table $\bar{X}$ Comparison of Standard deviations of odd vs even sections of test.

	Odd	Even	r_{oe}		σ_o	D	σ_d	"t" ratio ($\frac{\text{Diff}}{\sigma D} \%$)	chances in 100
			odd	even					
Carpenters	4.78	4.74	.65	.43	.42	.04	.46	.087	53
Apprentices	6.94	7.22	.79	.545	.567	.28	.48	.59	72
Novices	3.72	4.58	.57	.268	.329	.86	.35	2.4	99
Total range	11.05	11.52	.93	.505	.526	.47	.253	1.86	96

Table XI gives the correlations between the two halves of the
(Table XI)

test for each group and for the total group on both the raw test and the test composed of the selected items. These correlations have been corrected by the Spearman-Brown formula to allow for a test of twice the length.

$$r_{11} = \frac{2 \times r_{\frac{1}{2} \frac{1}{n}}}{1 \times r_{\frac{1}{2} \frac{1}{n}}} \quad (\text{16, p. 390})$$

Garrett

The apprentice group yielded the highest reliability co-efficient in the group ranges. The facts that the difficulty is most nearly at the fifty percent level in this group and that the group consists of a wider range, would be contributory factors. In both the carpenter and particularly the novice group, the peaked distributions would reduce the co-efficients. The reliability for the total range would compare favourably with other tests of this nature. This information would also prove of value were later users of the test to contemplate breaking the test into two sections.

Standard error of measurement.

In determining the reliability of the scores in absolute terms, the standard error of measurement was used. This is an estimate of the amount by which an obtained score deviates from the individual's true score. It is expressed by the formula

$$\sigma_e = \sigma \sqrt{1 - r_{11}} \quad (\text{16, p. 392})$$

As is indicated in the above formula, the standard error of

Tabel XI

Correlation between number of odd and even items correctly answered for 204 and 100 item tests.

	<u>204 item test</u>			<u>100 item test</u>		
	<u>S.E.</u>			<u>S.E.</u>		
	r_{xy}	r_{xy}	r_{11}	r_{xy}	r_{xy}	r_{11}
Carpenters	.70	$\pm .06$	.82	.65	$\pm .07$	.79
Apprentices	.82	$\pm .03$	.90	.79	$\pm .04$	.88
Novices	.40	$\pm .09$	.68	.57	$\pm .07$	.73
Total	.93	$\pm .009$	.96	.93	$\pm .009$	.96

measurement is dependent upon the standard error and the reliability of the group to which it is applied and the same caution must be exercised in its interpretation as in the reliability co-efficient. Table XII indicates the standard error of measurement within the various ranges.

(Table XII)

Table XII

Standard error of measurement for 3 groups.

	σ_e
Carpenters	4.07
Apprentices	4.73
Novices	3.81

13. Relationship Between Test Scores and Other Variables.

Intelligence.

Intelligence test scores, as measured by the Wonderlic Personnel Test, were analyzed to determine the influence of intelligence upon the trade test scores. If conditions had permitted, it would have been preferable to control the intelligence variable by equating the groups in this regard. Owing to the restricted sample available, it was necessary to use all the available subjects and later statistically estimate the influence of intelligence upon the test scores. Table XIII gives the distributions obtained for the three groups and pertinent information pertaining to them.

(Table XIII)

Product moment correlations were computed between intelligence and trade test scores on the 100 item test for each of the groups and for the total group. This information is given in Table XIV.

(Table XIV)

As would be expected, in the total range the correlation was negligible. In the individual groups where other variables would be more equivalent, larger correlations were obtained and would indicate that intelligence test scores were significantly positively correlated with trade test scores. The greater variability in the carpenter group would be instrumental in allowing higher correlations. That higher intelligence test scores would accompany higher trade test scores is shown by Table XV.

Table XIII

Distribution of scores on Wonderlic for three groups and pertinent data.

Scores	F carps.	F app.	F novices	F total
41- 40			1	1
39- 38			1	1
37- 36		1	0	1
35- 34	1	0	0	1
33- 32	2	3	1	6
31- 30	2	3	3	8
29- 28	3	4	6	13
27- 26	1	2	8	11
25- 24	6	13	12	31
23- 22	4	8	6	18
21- 20	3	13	10	26
19- 18	4	7	10	21
17- 16	7	6	9	22
15- 14	4	4	14	22
13- 12	5	3	7	15
11- 10	1	3	8	12
9- 8	3	3	0	6
7- 6	3	1	0	4
5- 4	1	1	0	2
N	50	75	96	221
Mean	19.4	20.82	24.11	20.38
S.D.	7.54	6.54	6.16	6.78
V	39.4	31.4	25.5	33.3

Table XIV

Correlations between Wonderlic and Trade Test Scores.

	r_{xy}	S.E. r_{xy}	N	t value (16, p.299)
Carpenters	.42	$\pm .12$	50	beyond 1 % level
Apprentices	.23	$\pm .05$	75	beyond 5 % level
Novices	.35	$\pm .09$	96	beyond 1 % level
Total	.07	$\pm .07$	221	not significant

Table XV

Average trade test scores obtained by various levels on Wonderlic Personnel Test.

Wonderlic Scores	Trade Test Scores	N
Less than 10	71	7
10-15	76.4	10
16-21	76	14
22-27	79.4	11
more than 27	81.5	8

in which the average trade test scores were determined for various levels of attainment on the Wonderlic Personnel Test within the carpenter group. (Table XV)

While the above table makes no allowance for the variability within the group and small numbers of subjects are represented, it would indicate suggestive differences; particularly at the two extremes. Fig. 3 indicates the distributions.

Experience.

The product moment correlation between experience and trade test scores was $r = .13$ with a standard error of $\underline{x} .13$. This would indicate a negligible relationship. Average trade test scores for various amounts of experience are given in Table XVI.

(Table XVI)

While table XVI again suffers the disadvantage of inadequate sampling and information on variability, it would suggest that a negligible relationship exists up to the last category. A product moment correlation of $r = .09$ was obtained between experience and Wonderlic scores.

In order to obtain some indication of the relationship existing between test scores and experience with the variable of intelligence held constant, a partial co-efficient was computed by the use of the formula

$$r_{12.3} = \frac{r_{12} - r_{13}r_{23}}{\sqrt{1-r_{13}^2} \sqrt{1-r_{23}^2}} \quad (16, p.416)$$

Table XVI

Average trade test scores on 100 item test for various amounts of experience.

Years of experience	Trade test average scores	N
less than 5	78	20
6-10	77.7	19
11-15	76.3	16
more than 20	84.6	5

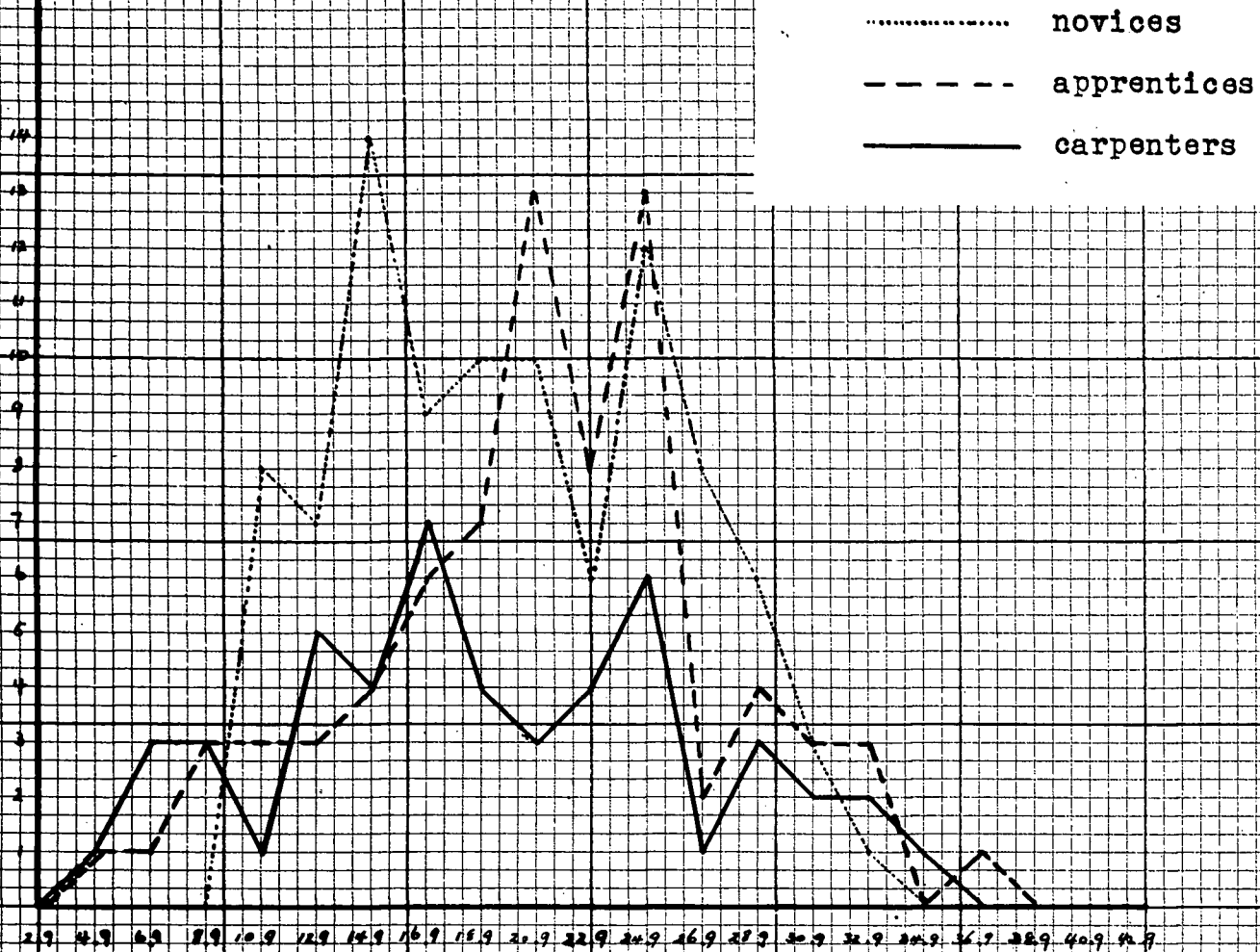


Fig. 3 Distributions of carpenters, apprentices and novices on the Wonderlic Personnel Test

The resultant co-efficient was $r = .18$ with a standard error of $\underline{x} .12$. This would suggest a negligible relationship between trade test scores and experience. The correlation technique is not entirely adequate for the data, however, owing to the fact that the majority of the carpenters fell within a range of not more than eight years experience. This resulted in an inadequate sampling of the area and a high degree of skewing in the distribution. The relationship between trade test scores and Wonderlic scores, and between age and trade test are given graphically in Figure 4. Average scores in both the trade test and Wonderlic test were computed for each age category. These were then expressed in standard deviation units. Figure 4. would suggest that the lack of relationship between increased years of experience and increased trade test scores could be accounted for by decreasing intelligence. Thus experience could act as a compensatory factor.

Age.

The groups differed widely in their ages. Modal ages for carpenters, apprentices and novices were 32, 17 and 18 respectively. A product moment correlation between age and trade test scores within the novice range was $r = .16$ $\underline{x} .10$. the age range was 17 to 28. This would not indicate a significant relationship between age and trade test scores within this range.

Education.

The influence of education upon trade test scores was investigated. Within the carpenter's range a product moment correlation of $r = .12$ with a standard error of $\underline{x} .13$ was

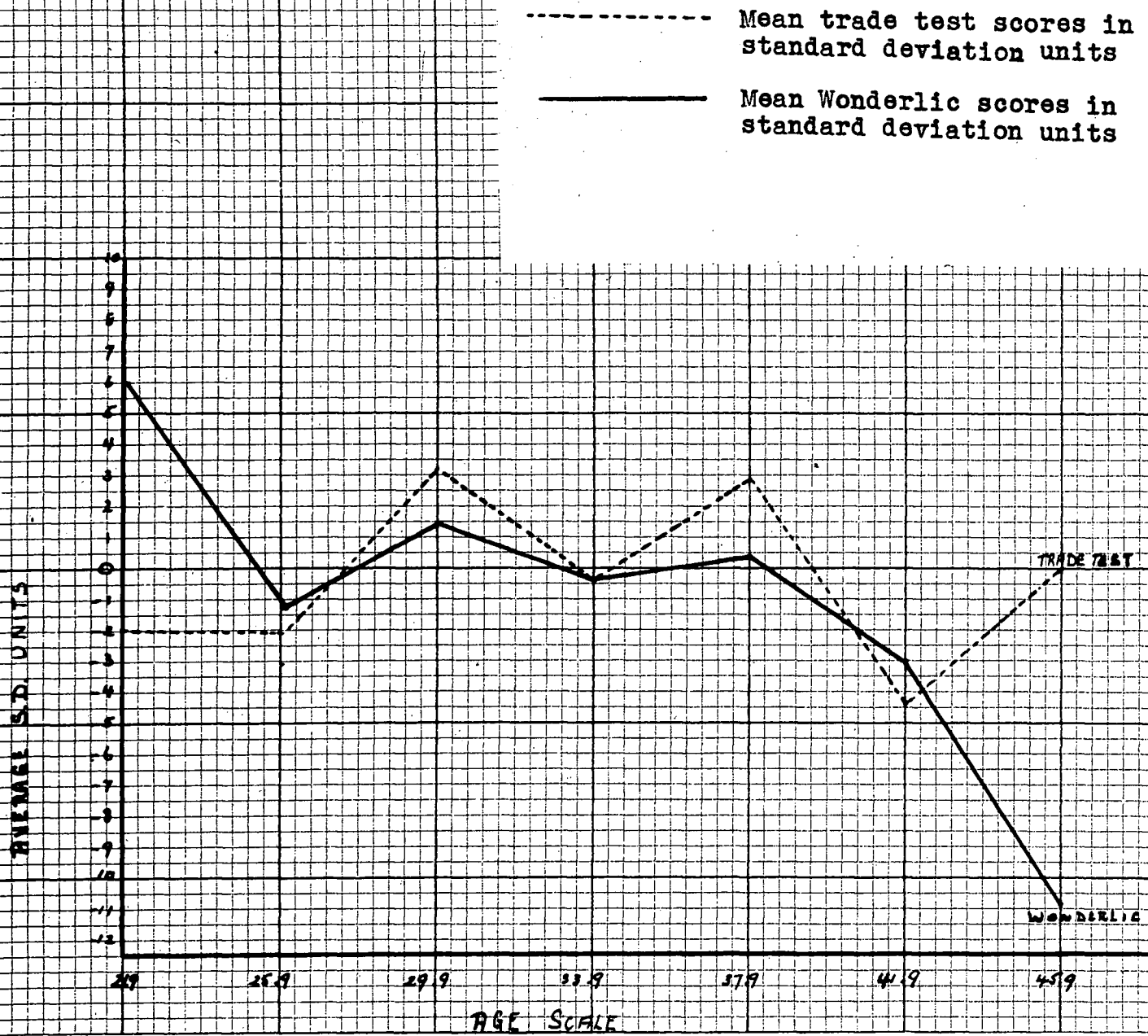


Fig. 4 Mean trade test and Wonderlic Personnel test scores in relation to age.

obtained. Table XVII presents the average trade test scores for various levels of education. This table would indicate that carpenters with more education tended to obtain higher trade test scores.

(Table XVII)

Table XVII

Average trade test scores on 100 item test for various levels of education.

Last Grade Completed	Average Trade Test Score
Less than grade 8	76.37
grade 8	76.95
Jr. High School (9-10)	79.32
Sr. High School	80.80

14. Validity

The validity of a test may be defined as the efficiency with which it measures what it attempts to measure. It is thus a relative measure. The validity of the majority of tests is reported as a correlation co-efficient between test scores and an external criterion of what the test purports to measure. The data presented in Table V1 (page 62) and Table V11 (page 63) would appear to be more meaningful in the present study than a single validity co-efficient. In Table V1 , the distributions of carpenters, apprentices and novices overlap but as indicated in Table V11 the means of the distributions, yielding "t" ratios of 13.61 between apprentices and carpenters, 13.55 between apprentices and novices and 35.18 between novices and carpenters, would indicate a very high degree of statistical probability that the obtained means are progressively significantly different. Table XX (page 89) is also presented as a measure of the tests validity for the purpose of differentiating between carpenters and apprentices. Considering the fact that the apprentice group represented a wide range of talent and many of the subjects classified in this group may well have achieved a high degree of carpentry skill it would appear that the test had a relatively high degree of validity for the purpose of differentiating subjects into carpenter, apprentice and novice groups.

15. Norms, Interpretative Data and Critical Scores.

The principal purpose for administering the test is to provide descriptive data regarding the individual. In this respect it was deemed advisable to present interpretation of test scores in terms of comparability and function. Table XVlll presents the decile norms for the three groups.

(Table XVlll)

The overlapping of the distributions present difficulties in the setting of the critical scores.

A useful method presented by Thorndike (41,p.328) which involves the concept of cost and utility. Thus the critical score for the selection of a particular group will be dependent upon the supply and demand, and can be adjusted to meet the situation. Table XIX and figure 5. demonstrate the effectiveness of various critical scores in terms of cost and utility. Thus, selecting carpenters by means of a critical score of 68 on the trade test would result in a cost or rejection of 9.5% of capable carpenters but a utility or rejection of 86.4% of semi-trained carpenters. If the demand exceeds the supply and it is necessary to reduce costs completely, a critical score of 56 would reject no carpenters but would still reject 58% of the apprentice group.

Attitude of Testees.

An important factor in a test of this nature is the attitude with which it is approached by the testee. No reliable data is available regarding the carpenter's attitude toward this test. In a few cases however, the examiner had asked

Table XVIII

Decile scores on 100 item trade test for carpenters,
apprentices and novices.

Decile	Carpenters	Apprentices	Novices	Decile
1	89	70	38	1
2	87	65	35	2
3	84	60	32	3
4	81	56	30	4
5	79	50	28	5
6	76	46	27	6
7	72	42	25	7
8	70	39	23	8
9	68	35	21	9

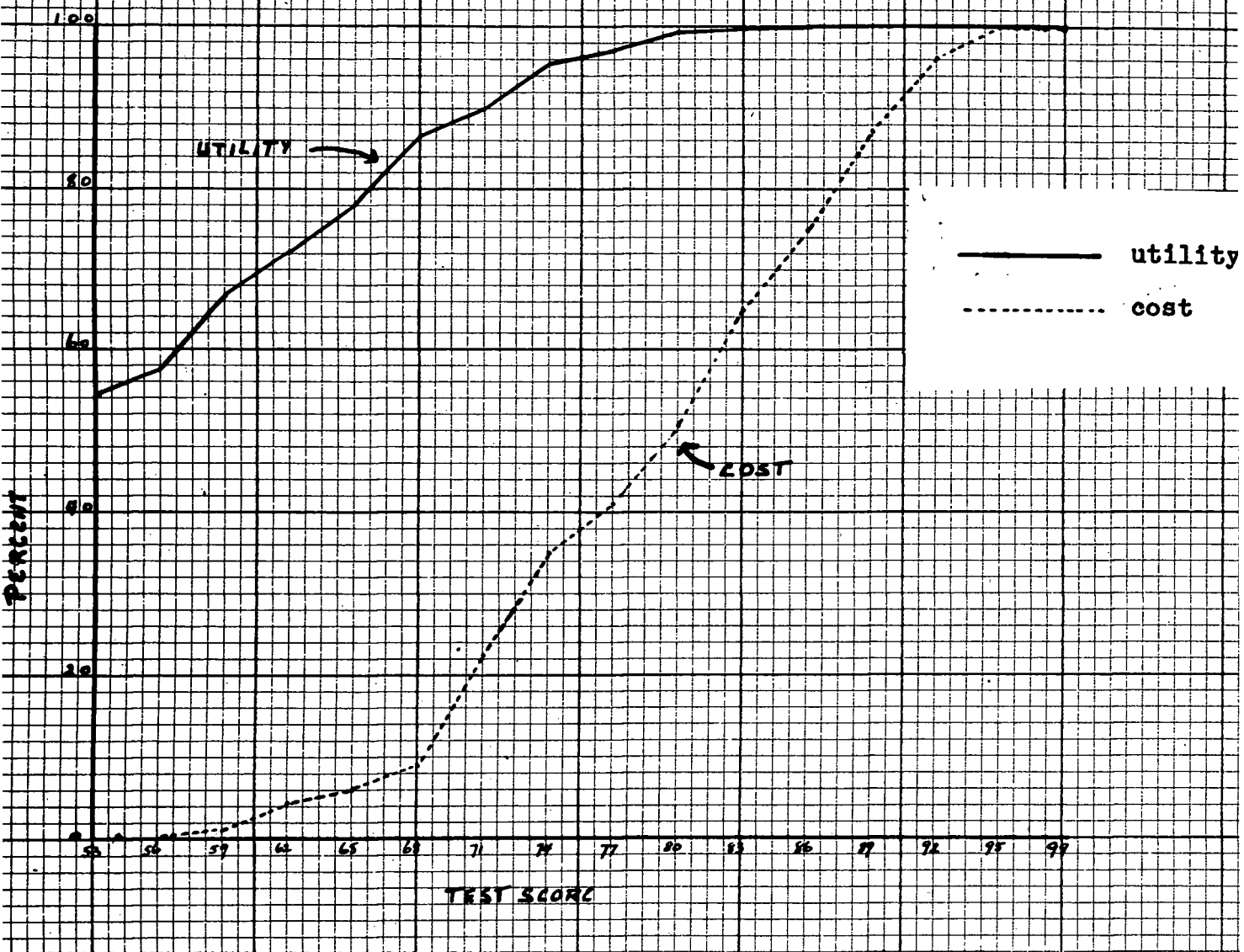


Fig. 5 Percentage cost and utility of differentiating between carpenters and apprentices by means of various trade test scores

the subjects to place comments upon the test. In all reported cases, these were positive and would indicate that the subjects felt that the test was practical. Most of the comments suggested that the subject was not acquainted with this or that particular section of the test and that they would like to have an opportunity to obtain more training. In no case was an antagonistic remark placed on the test folder and the general opinion expressed was that it represented a thorough test.

Table XIX

Effectiveness of selection by trade test.

Cost of selecting carpenters, in terms of carpenters rejected,
compared with utility, in terms of apprentices rejected.

Minimum test score to qualify	Cost Percent carpenters rejected	Utility Percentage apprentices rejected
95	100.00	100.00
92	96.8	100.00
89	87.3	100.00
86	76.2	100.00
83	65.1	98.8
80	50.8	98.8
77	41.3	97.4
74	34.9	95.1
71	22.2	90.1
68	9.5	86.4
65	6.3	77.7
62	4.8	71.6
59	1.6	66.7
56	0.0	58.0

16. Conclusions.

Many improvements could have been made to this study, but the availability of time and subjects were restrictive factors. The lack of a re-administration of the selected items and an evaluation of the validity of the presented norms in terms of their performance would represent an inadequacy that would merit correction before the test was used. The present data would seem to indicate certain conclusions, however. These are;

1. That the scores based upon selected items discriminate with reasonable validity between novices, apprentices and carpenters.
2. On the assumption that the progressive differences from novice to apprentice to carpenter represent increasing degrees of trade competence. This characteristic of the test to significantly discriminate between these groups is evidence of validity.
3. That the reliability co-efficients of the test as determined by the split half method and increased by the Spearman Brown formula are comparable to similar tests of this type.
4. That scores on the test show a statistically significant but relatively low correlation with intelligence as measured by the Wonderlic Personnel Test but that education, age and experience had

negligible relationship to test scores.

5. that the method of test construction used in this study yields satisfactory results and could be extended to the development of similar tests for other traits.

In view of these conclusions and recognizing the aforementioned considerations, the test would appear to meet the required specifications and represent a useful adjunct in the preliminary screening of trade candidates.

17. Suggestions for Further Research.

During the progress of the test development and from the resultant data further investigations were suggested.

These would include:

1. the investigation of the relationship between test scores and levels of trade proficiency within the novice, apprentice and carpenter groups.
2. Owing to the tendency for specialization within the skilled trades, it would appear that a test composed of sub-tests pertaining to the larger branches of specialization would have a diagnostic value which would be most useful in assessing individuals in relationship to a specific task.
3. if positive indications were obtained in the first suggested investigation, it would seem to increase the possibilities in an investigation of achievement tests as predictors of aptitude.
4. the determination of the influence of the time factor in the test performance

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APPENDIX A

Canadian Army trade description of required duties and expected theoretical and practical knowledge for the trade of carpenter.

Carpenter.
Trade name.

Groups 1 and 2.

Duties of the trade.

- (a) Construct, repair and alter all types of wood structures and equipment.
- (b) Install, maintain and alter the interior and exterior wood work of concrete, steel and masonry buildings.
- (c) Construct formwork for concrete.
- (d) Fit builders hardware.
- (e) Erect scaffolding and staging.
- (f) Make crates for stores and equipment.
- (g) Operate and maintain simple woodworking machinery such as small table saws, jointers, planers, hand saws, jigsaws and lathes.
- (h) Do bench work involving making and repairing boxes, shelving bins, plain furniture and other work normally done in a small woodworkingshop.
- (i) Lay out work from sketches and blueprints.
- (j) Estimate materials for carpentry work from blueprints or sketches.

Group 1.

Theoretical trade knowledge.

- (a) Be thoroughly familiar with the names of the tools in a standard carpenters' chest, and be able to describe their uses.
- (b) Have a working knowledge of the characteristics

App. A (cont'd)

and uses of commercial woods.

- (c) Have a good knowledge of the names, sizes, grades and uses of the rough and finished lumber.
- (d) Make dimensioned sketches of simple structures and equipments.

Practical trade knowledge.

- (a) Demonstrate in a workmanlike manner the use and care of the tools carried in a standard carpenter's kit.
- (b) Do simple bench work involving mortise and tenon, dovetail, plough and tongue and other simple joints and splices; gluing, bending.
- (c) Practical and correct use of hardware including nails, screws, hasps, hinges, locks, brackets, handles etc.
- (d) Make packing cases and crates.
- (e) Erect scaffolding and staging for the various building trades.
- (f) Scrape and sand wood floors.
- (g) Lay felt roofing, wooden and composition shingles.
- (h) Carry out simple frame construction, alterations and repairs from sketches and dimensions.

Group 11.

Theoretical trade knowledge.

- (a) Have a good knowledge of the principles involved in the framing of walls, rafters, stairs, partitions, doors and window openings, roof trusses and concrete formwork.
- (b) Make detailed working sketches from plans or given measurements.
- (c) Make up bills of materials for carpentry work from blueprints or measurements.

App. A (cont'd)

Practical trade knowledge.

- (a) Use and maintain with skill all carpenters' tools.
- (b) Operate and maintain simple woodworking machines, band saws, bench saws, jointers and lathes.
- (c) Lay out with a steel square the following; stair stringers, rafters of common and unpitched roofs, studs and openings.
- (d) Hang all types of sashes and doors.
- (e) Fit and place inside and outside trim in a skilled manner.
- (f) Repair wood vehicle bodies and other army equipment of wooden construction.
- (g) To be able to apply all types of wall boards, ply wood and insulation.
- (h) From blueprints and sketches lay out carpentry work for wooden buildings and concrete form work.

APPENDIX B.

Carpentry books consulted for trade test items.

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17. U.S. WAR DEPARTMENT Carpentry: Technical manual no. 5.

Wash. D.C., U.S. Govt. Printing Office, 1943.

APPENDIX C

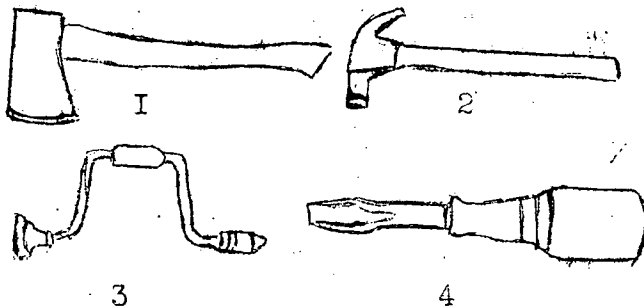
CARPENTER'S CLASSIFICATION TEST

This is a test of your knowledge of carpentry terms, tools and practices. In the following pages you will find a number of questions to be answered. After each question there are four answers. You are to select the answer that you think best answers the question asked. Put the number of your answer on the line in the right hand column. When you are not sure which answer is right make the best choice you can. Here are a few sample questions. Do them to be sure you understand what is wanted.

- S I. Nails are driven with
1. a hammer
 2. a screw driver
 3. a chisel
 4. a saw

The answer of course is number one so a 1 is placed on the line at the right. Here is another.

S 2

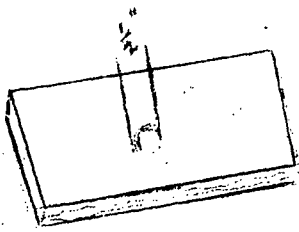


Which would you use
to chop wood

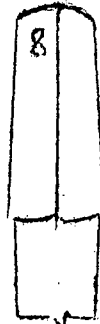
Number one is the answer so a 1 is placed on the line on the right.

Now do the rest of the questions in the booklet.

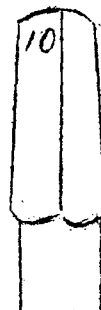
Take your time and see how many you can get right.



1.



2.



3.



4.

1. Which of the bits would be used to bore the $1/2$ " hole? _____



1



2

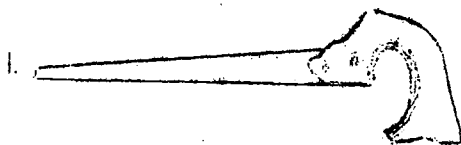


3

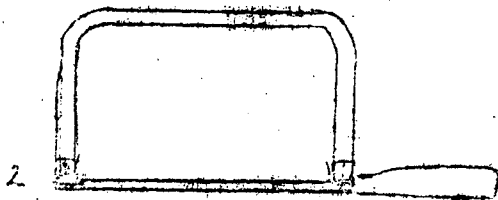


4

2. Which would be the best chisel to use in cutting out mortises? _____



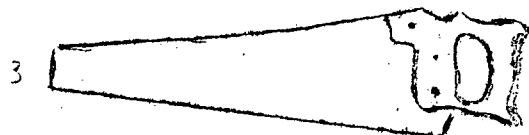
3. Which saw has the least set? _____



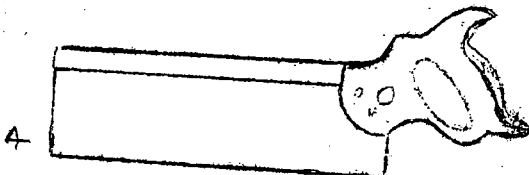
2

4. Which saw would you use for coping a moulding joint? _____

5. Which saw would you use to rough out a hole in sheathing? _____

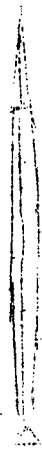


3

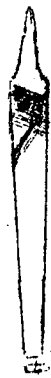


4

Turn to next page



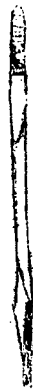
1



2



3



4

6. Which of the files on the left would be used with the tool on the right? _____

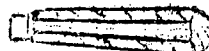




1



2



3

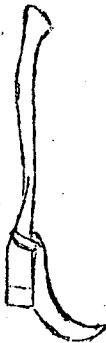


4

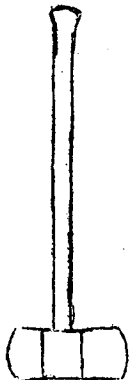
7. Which one of the above handles would be best suited for a mortise chisel? _____



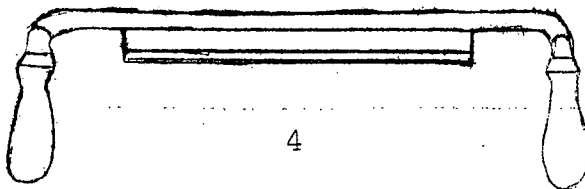
1



2



3



4

8. Which of the above tools would be used to smooth a railroad tie? _____

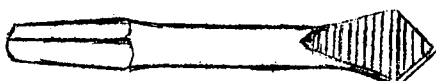
9. To turn the burr on a scraper you would use a

1. file
2. rasp
3. burnisher
4. skew chisel

The tool on the left is for

1. drilling holes
2. setting screws
3. setting nails
4. finishing wire inlets

10.

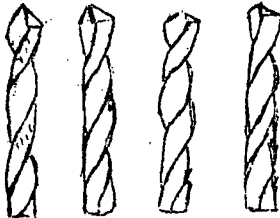


turn to next page.

- II. A Forstner bit would be used when wishing to
1. bore holes in hardwood
 2. bore to a set depth
 3. increase the size of a hole
 4. bore almost through thin stock

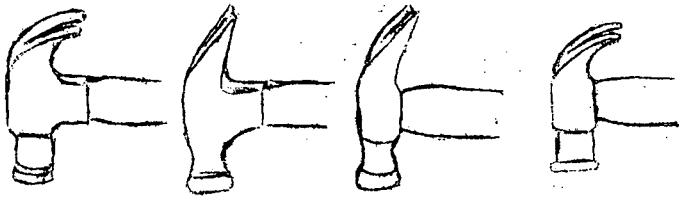
- I2. To allow screws to enter wood more easily you would use
1. soap
 2. light oil
 3. beeswax
 4. graphite

- I3. This is used for
- 
1. reaming
 2. setting heads of screws
 3. removing broken screws
 4. drilling at angles

- I4. Which bit is ground correctly for working with wood?
- 

- I5. The gimlet bit has what type of spur?
1. a fine single spur
 2. a coarse double thread
 3. a coarse single thread
 4. none of these

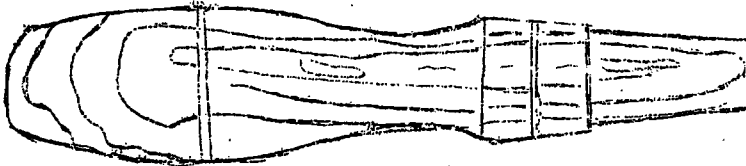
- I6. The best general purpose plane is the
1. jack plane
 2. jointer plane
 3. fore plane
 4. smoothing plane

- I7.
- 
- 1 2 3 4

Which would be the best hammer to pull firmly set nails? _____

- I8. The first step in sharpening a saw is
1. setting
 2. jointing
 3. filing
 4. shaping

19.



A chisel with this type of handle is known as

1. a stake chisel
2. a socket chisel
3. a tang chisel
4. a framing chisel

20.

Inside and outside gouges are whetted on

1. an emery board
2. a whetstone
3. a slipstone
4. a conical grindstone

21.

The tool which can be adjusted to bore various size hole is called

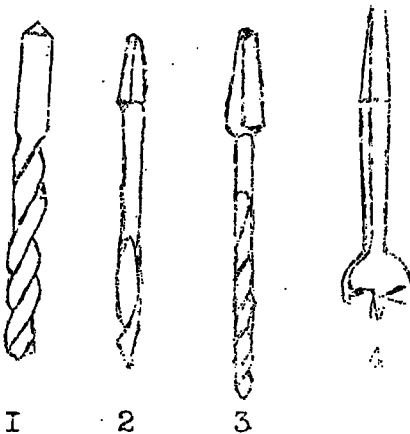
1. an extension bit
2. a twist drill
3. an expansive bit
4. an adjustable bit

22.

Twist drills are sharpened on

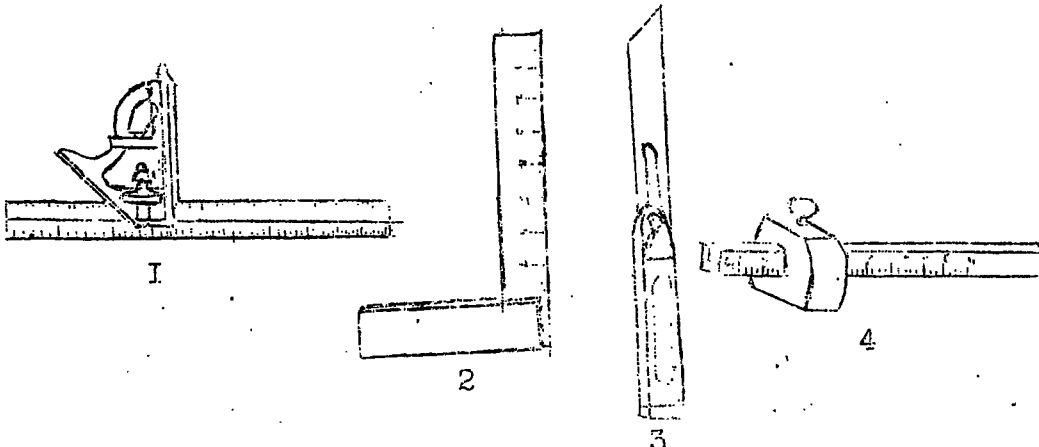
1. a grinder
2. a special file
3. a three square file
4. a rasp

23.



In drilling holes in scrap lumber where nails are likely to be met which bit would you use?

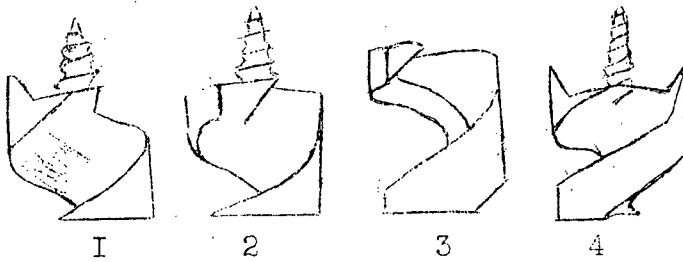
24.



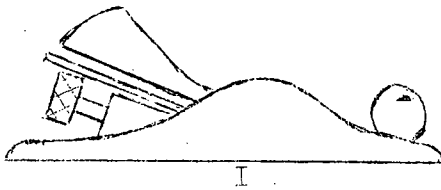
Which would you use to quickly transfer an angle?

turn to next page

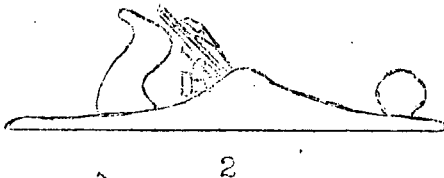
25.



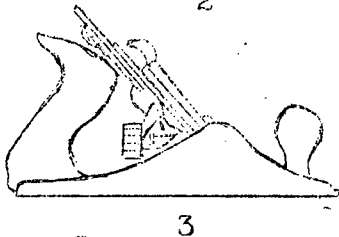
When straight boring in wet pitchy wood is necessary which bit would you use? _____



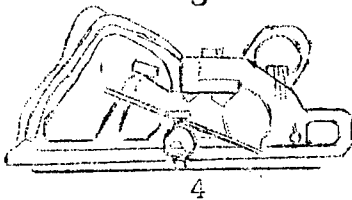
26. Which plane would you use in hanging a door? _____



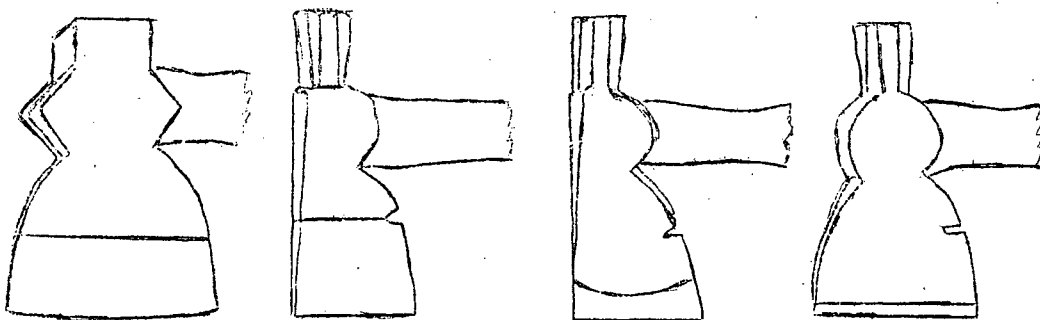
27. Which plane would you use to cut a rabbet? _____



28. Which plane would you use to smooth the end of a board? _____



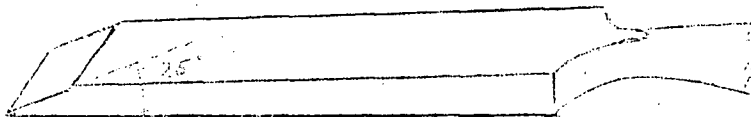
29



Which would be the best to use for shingling? _____

turn to next page

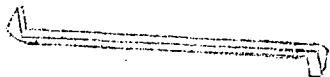
30.



This would be best used as a

1. corner chisel
2. firmer chisel
3. framing chisel
4. paring chisel

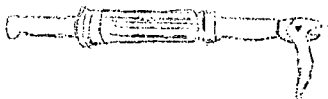
31



This is used for

1. turning screws
2. pulling spikes
3. ripping off forms
4. prying flooring

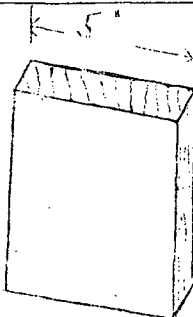
32.



This is used for

1. setting heavy screws
2. cutting wire
3. cutting sheet metal
4. none of these

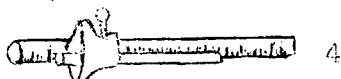
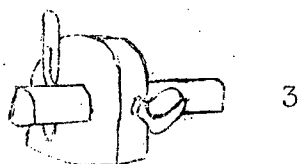
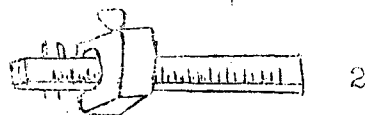
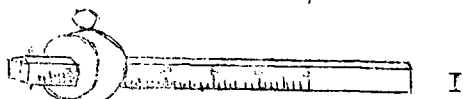
33.



To plane surface the end of this board you would use

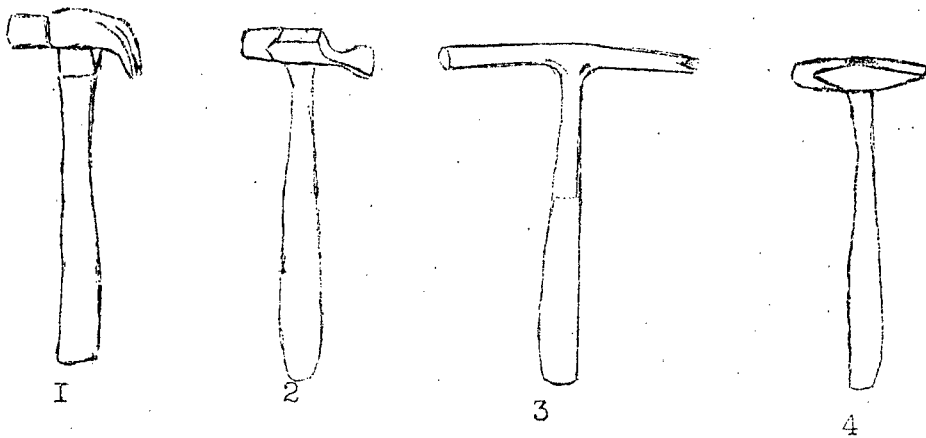
1. a jointer plane
2. a block plane
3. a smoothing plane
4. a jack plane

34.



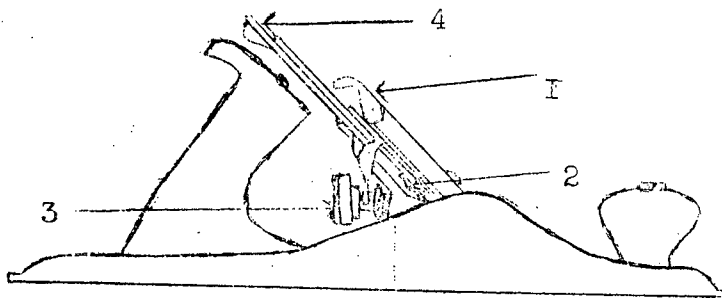
Which would you use in laying out mortises?

35.



Which of the above would be used on veneer?

36.



If the above plane is cutting too deeply on one side (unevenly) which number indicates the part to adjust?

37.

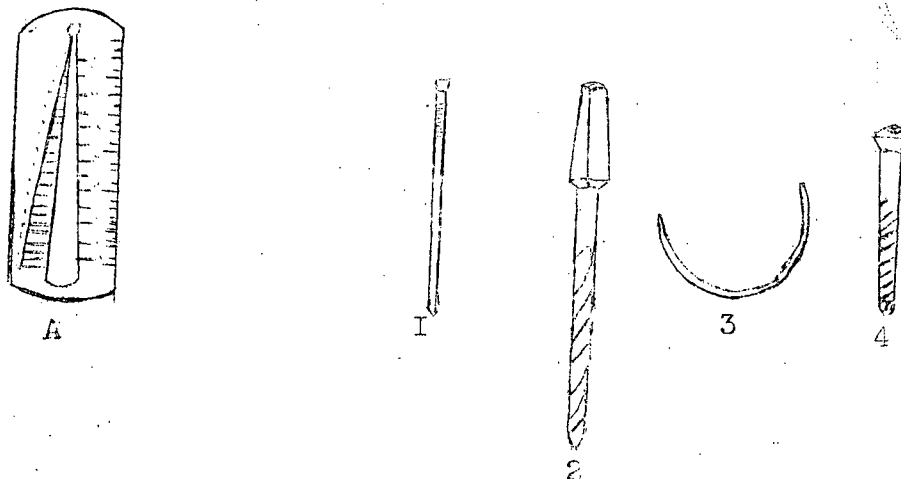


Figure A is used with which number on the right?

38. A help in driving long screws is to apply

- 1 oil
2. soap
3. beeswax
4. graphite

turn to next page

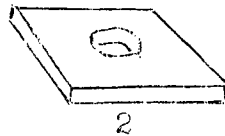
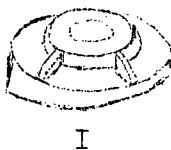
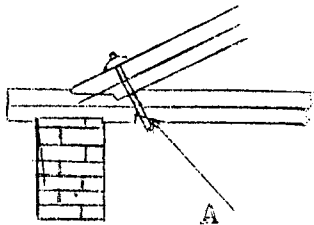
39. R H B refers to

1. screws
2. brads
3. drills
4. screws

40. When working with 5/8" ceiling material you would use

1. 2" common nails
2. 1 1/2" finishing nails
3. 2 1/2" flooring nails
4. 1 1/4" brads

41.



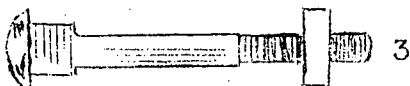
Which of the above would you use at A? _____



42. Which is a carriage bolt? _____



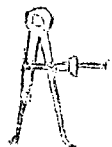
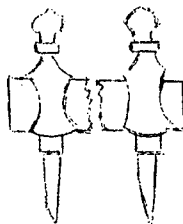
43. Which is a stove bolt? _____



44. Which one would you use to fasten framing members to a concrete post? _____



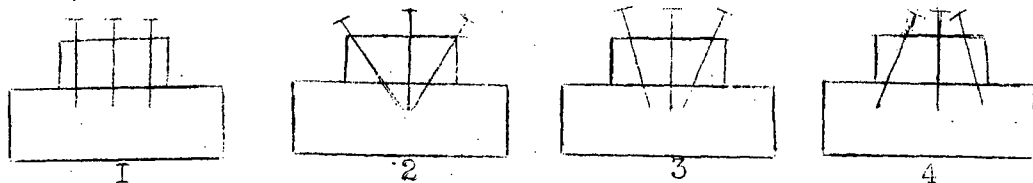
45.



To measure the overall diameter of a pipe you would use? _____

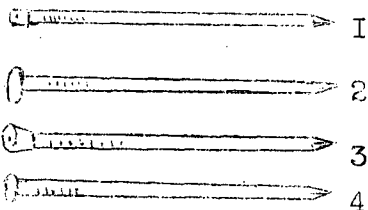
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46.



Which of the above will be the most firmly secured? _____

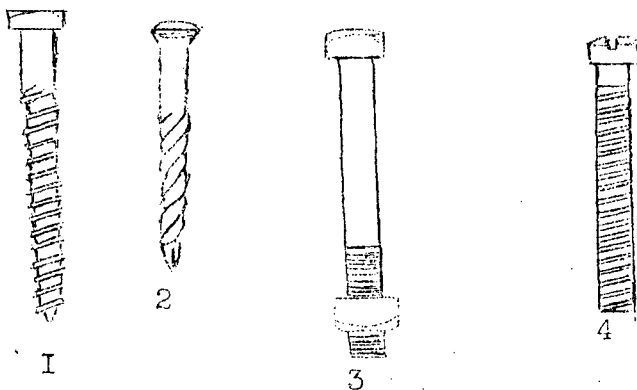
47.



47.

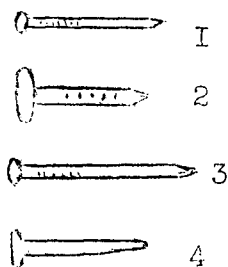
Which nail would be used when nailing cedar siding? _____

48.



Which of the fastenings would be used to fasten heavy framing members? _____

49.



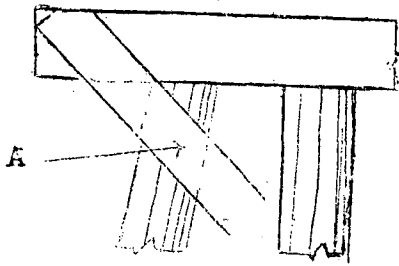
Which would be used to apply Duroid roofing? _____

50. If you needed some 2" finishing nails for a project you would ask for _____

1. 2d
2. 4d
3. 6d
4. 8d

turn to next page.

51.



1



2

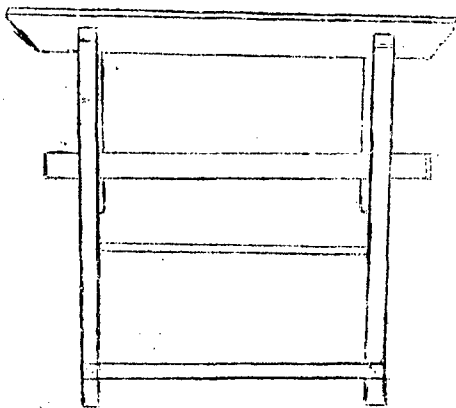


3



4

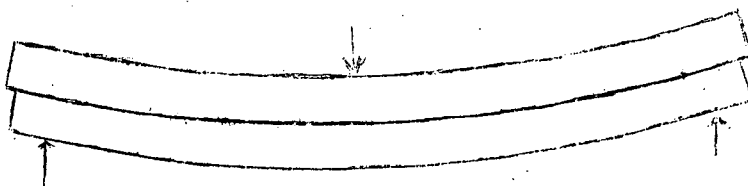
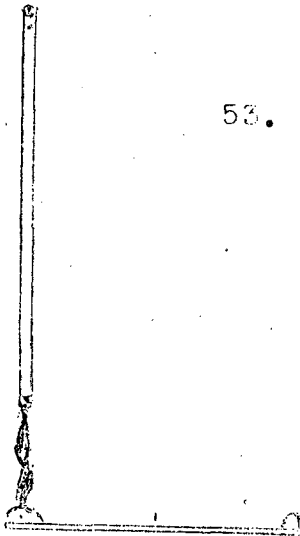
Which of the connectors would you use at A ? _____



52. This is used when
1. gluing joints
 2. applying wallboard
 3. drawing plans
 4. setting saws
- _____

53. This is a

1. sash balance
 2. measuring instrument
 3. a laying out level
 4. a crimping tool
- _____



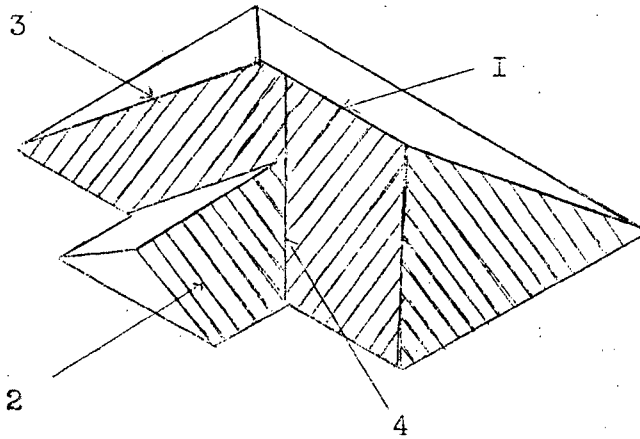
54. To overcome this sliding use
1. a machine bolt
 2. a large spike
 3. a carriage bolt
 4. a toothed ring
- _____

turn to next page

55. The best wood for making tool handles is
1. Hickory
 2. Maple
 3. Oak
 4. Walnut
-
56. If a board is milled it
1. has been sawed in a sawmill
 2. is surfaced to size on a planer
 3. contains no mill marks
 4. contains no rough places
-
57. The most widely used wood preservative is
1. petroleum
 2. creosote
 3. benzol
 4. sodium fluoride
-
58. Plywood is sold by
1. the board foot
 2. the square foot
 3. the pound
 4. the linear foot
-
59. The wood most suitable for studs is
1. Douglas Fir
 2. Red Cedar
 3. Poplar
 4. White Pine
-
60. The wood that is easiest to work is
1. Spruce
 2. Pine
 3. Fir
 4. Hemlock
-
61. The strongest general construction lumber is
1. Fir
 2. Hemlock
 3. Cedar
 4. Pine
-
62. Lumber dressed and tongued is called
1. beaded
 2. jointed
 3. patterned
 4. matched
-
63. If you wanted a floor that would be sure not to warp you would use flooring that was
1. plain sawed
 2. rotary cut
 3. bastard sawed
 4. quarter sawed
-

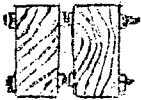
64. "right reverse bevel" indicates specifications for a
1. window
2. plane
3. chisel
4. door
65. Which one of the following tables is NOT found on the framing square?
1. brace measure
2. octagon measure
3. square measure
4. board measure
66. Lag screws are turned into wood by
1. a wrench
2. a screw driver
3. pliers
4. a hammer
67. A flight of stairs having 23 risers will have how many treads
1. 22
2. 23
3. 24
4. none of these
68. A drift bolt should be driven into a hole having a diameter
1. the same size as the bolt
2. 1/4" smaller than the bolt
3. 1/16" larger than the bolt
4. sufficient to start the bolt only
69. The template used for laying out stair carriages is called the
1. tread
2. sill
3. pitch board
4. furring
70. What device is used to fasten corrugated iron roofing to an open rafter?
1. jack rafters
2. bridging
3. cripples
4. purlins
71. In erecting a scaffold for a bricklayer you would use
1. 2" x 4" ledgers
2. 1" x 4" ledgers
3. 2"x 6" ledgers
4. 12 x 8" ledgers

72.



Which number indicates the hip rafter? _____

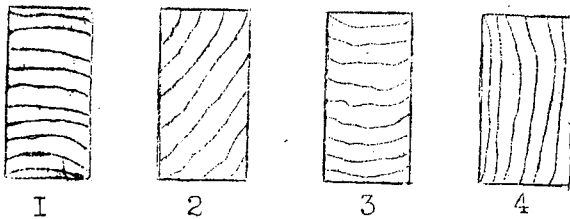
73.



The reason for using separators on the bridge beam on the left is to

1. allow for shear
 2. allow greater flexibility
 3. prevent sliding
 4. prevent decay
- _____

74.



Which of the above softwoods will have the LOWEST strength value? _____

75.

In house dwelling construction the studs are generally placed

1. 14" centres
 2. 16" centres
 3. 22" centres
 4. 36" centres
- _____

76.

What depth of joists are usually used for a floor with a 12 foot span?

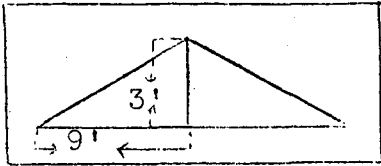
1. 6"
 2. 8"
 3. 10"
 4. 12"
- _____

77.

When trusses are secured to columns to give lateral rigidity they are called

1. transverse bents
 2. vierendeel trusses
 3. knee braces
 4. Pratt ties
- _____

turn to next page



78. In the diagram, if the rise is three feet and the run is nine feet the pitch will be

1. $1/3$
 2. 3
 3. 6
 4. $1/6$
-

79. What is the length of a common rafter having a run of 6 feet and a rise of 4 inches per foot?

1. 6'4"
 2. 6'8"
 3. 7'2"
 4. 8'0"
-

80. The end of the rafter that rests on the plate is called

1. the heel cut
 2. the sill cut
 3. the plumb cut
 4. the seat cut
-

81. The most common method of stopping air leakage through the walls is by the proper use of

1. insulation
 2. sheathing
 3. tar paper
 4. siding
-

82. The breaking load of a timber is proportional to its

1. weight
 2. length
 3. depth
 4. breadth
-

83. Which one of the following types of hardwood finished flooring is most economical?

1. matched
 2. end matched
 3. uniform width
 4. random width
-

84. The actual size of 2" x 4" S4S upon delivery is

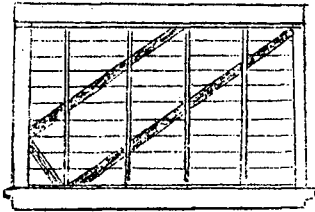
1. $1\frac{3}{4}$ " x $3\frac{3}{4}$ "
 2. $1\frac{5}{8}$ " x $3\frac{5}{8}$ "
 3. $1\frac{3}{16}$ " x $3\frac{5}{8}$ "
 4. 2" x 4"
-

85. How many board feet are there in a piece of lumber that measures 10" x 12" x 8' ?

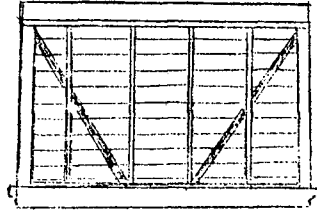
1. 120
 2. 80
 3. 72
 4. 96
-

turn to next page

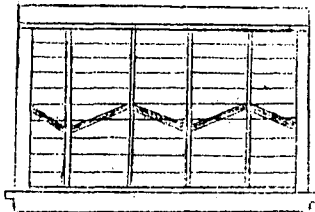
86.



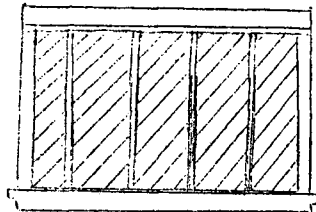
1



2



3



4

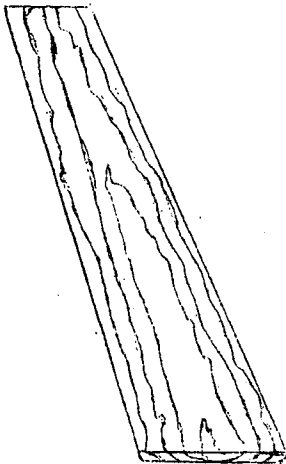
In the above diagrams, if the same materials were used in each, which would have the most stiffness and strength?

87.

The support for the second floor joists in a balloon frame is called a

1. girder
2. ribbon
3. ledger board
4. sill

88.



The piece of softwood on the left is

1. Bastard sawed
2. Plain sawed
3. Quartersawed
4. flat grained

89



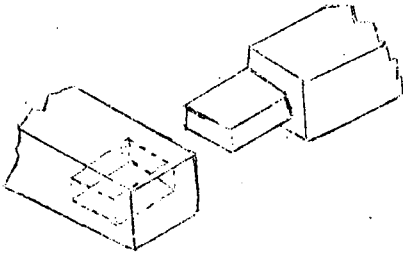
The defect in the log on the left is known as

1. Windshake
2. Wet rot
3. Starshake
4. Heartshake

turn to next page

90. The finest grade of sandpaper listed here is
1. 3/0
 2. 1/2
 3. 1
 4. 3
-
91. To get the best finish when sanding
1. sand with a circular motion
 2. sand in one direction only
 3. sand only cross grain
 4. sand in both directions
-
92. Dry shingles should be applied
1. tight jointed
 2. 1/8" open
 3. 1/2" open
 4. 3/4" open
-
93. The best shingle for withstanding weather is
1. sawn shake
 2. 4X sawn cedar
 3. sawn shake
 4. 2X sawn cedar
-
94. In laying a 16" wooden shingle the gauge should be
1. 7"
 2. 3 1/2"
 3. 5"
 4. 1 1/2"
-
95. The only difference between laying tile and laying shingles is that in laying shingles you
1. reduce the lap and increase the gauge
 2. reduce both the lap and the gauge
 3. reduce the gauge and increase the lap
 4. increase both the lap and the gauge
-
96. The principle consideration when choosing the type of r roofing to be used is
1. the rise of the roof
 2. the appearance of the structure
 3. the rafter placement in the roof
 4. the type of weather
-
97. The most desirable type of shingle nail is
1. a copper nail
 2. a wire nail
 3. a galvanized nail
 4. an iron nail
-
98. The minimum slope in which wood shingles may be used is
1. 6" rise in 24" run
 2. 6" rise in 12" run
 3. 8" rise in 24" run
 4. 4" rise in 12" run
-

99.



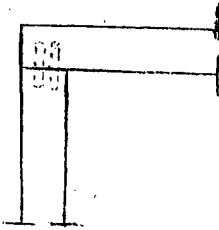
This joint is

1. a tenon joint
 2. a straddle joint
 3. a dowelled joint
 4. a miter joint
-

I00. In making a mortise and tenon joint which of the following tools would be of the least use?

1. backsaw
 2. mallet
 3. chisel
 4. jointer
-

I01.



This joint is

1. tree nailed
 2. toggled
 3. dowelled
 4. fillistered
-

I02. The best practical method of joining sills at corners is by

1. a mitre joint
 2. a lap joint
 3. an open mortise joint
 4. a butt joint
-

I03. A joint used when the material is to be curved is the

1. coopered joint
 2. dowelled joint
 3. bridle joint
 4. mitred joint
-

I04. In applying glue to members that would frequently be wet you would use

1. casein glue
 2. starch glue
 3. animal glue
 4. vegetable protein glue
-

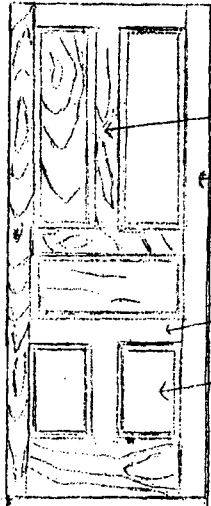
I05. The best joint to be used in the construction of a door is the

1. dovetail joint
 2. mortise and tenon joint
 3. dowel joint
 4. lap joint
-

I06. The strongest method of building shelving is to

1. screw on the shelf
 2. use a nailed butt joint
 3. nail on a cleat
 4. groove in the shelf
-

turn to next page



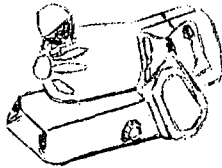
I07. Which number indicates the muntin?

I08. The joints on inside doors should be
 1. butt joints
 2. scarf joints
 3. mortise and tenon
 4. dowelled

I09. The gauge that is used for locating lines for door hinges is the

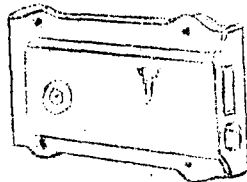
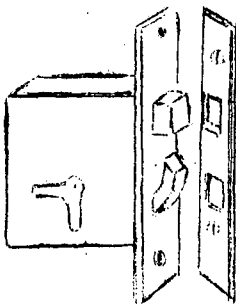
1. mortise gauge
2. marking gauge
3. pencil gauge
4. butt gauge

II0.

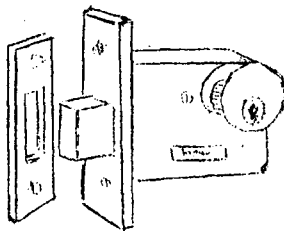
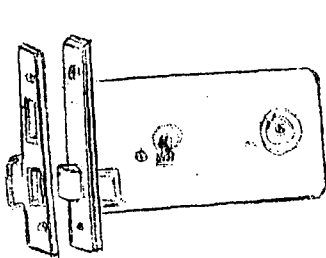


This machine is used for
 1. sawing boards
 2. sanding boards
 3. cutting grooves
 4. planing rough surfaces

III.



Which of these locks is a sliding door lock?

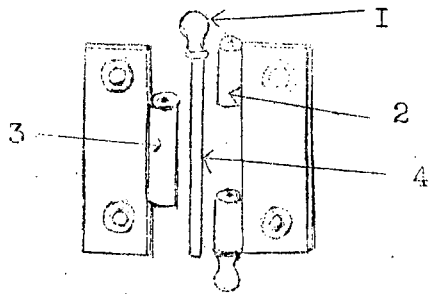


III2. When a lock is operated by a key only it is called

1. a dead lock
2. a sliding door lock
3. a rim lock
4. a latch lock

turn to next page

II3



Which number indicates the pintle?

II4. Which one of the following mouldings is NOT used in interior trim?

1. window apron
2. backband
3. dripcap
4. shoe moulding

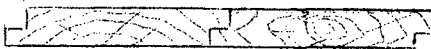
II5. To prevent the baseboard from warping you can

1. use cover moulds
2. plough out the back
3. toe-nail baseboard to floor
4. glue to floor and wall

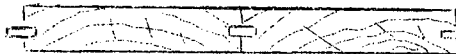
II6. In interior trim the coped joint is used for

1. picture moulding
2. window casing
3. baseboard
4. all of these

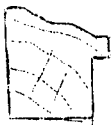
II7.



Which one of these is a rebated joint?



II8.



1



2

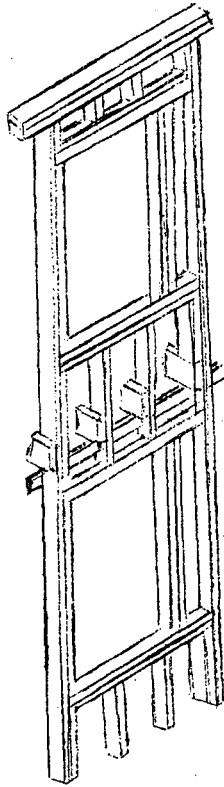


3



4

Which of the above mouldings is drip cap moulding?



- I19. The strip indicated by the letter A is used for
1. attaching window fittings
 2. a guide strip
 3. a nailing strip
 4. supporting the joists
-

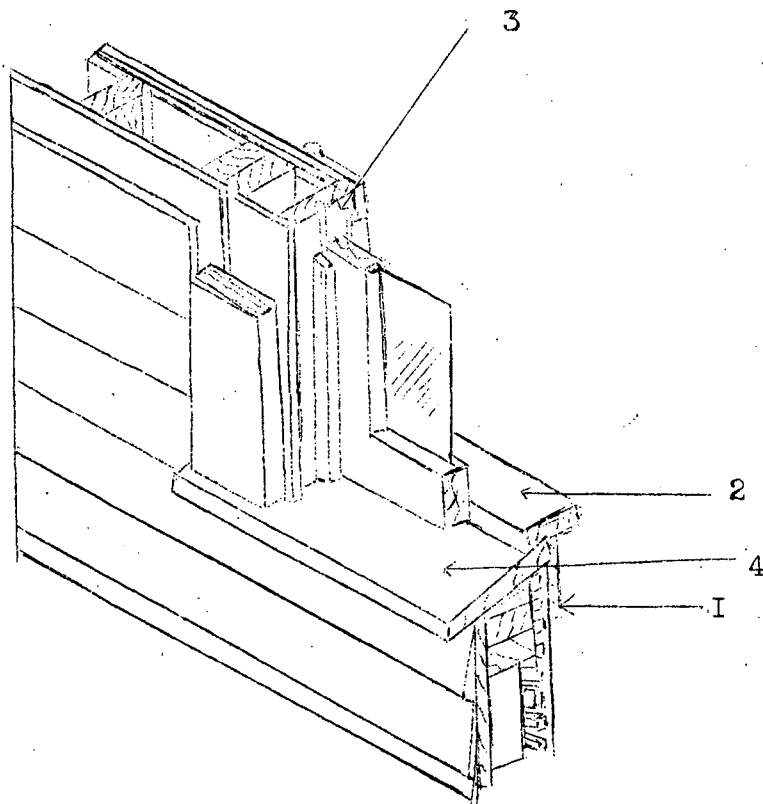
- I20. The window frame opening on the left is part of
1. a balloon frame
 2. a western frame
 3. a braced frame
 4. every frame construction
-

- I21. In double hung windows the upper sash is set outside the lower sash in order to
1. prevent leakage
 2. minimize shrinkage effect
 3. allow for extra support
 4. prevent decay
-

- I22. What do you nail to doors and windows to be used for guides in plastering?
1. furring
 2. lathes
 3. grounds
 4. battens
-

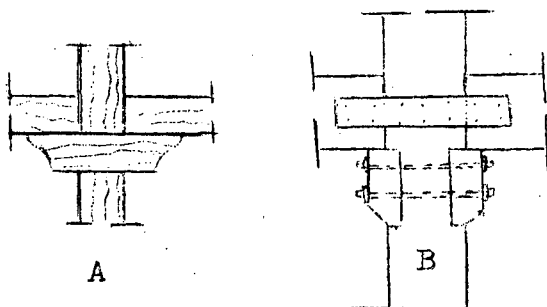
- I23. When setting glass in a new sash, the muntins and stiles should be first brushed with
1. lead paint
 2. oil
 3. glue
 4. shellac
-

- I24. In carpentry the term "shore" means a type of
1. wedge
 2. abutment
 3. brace
 4. foundation
-

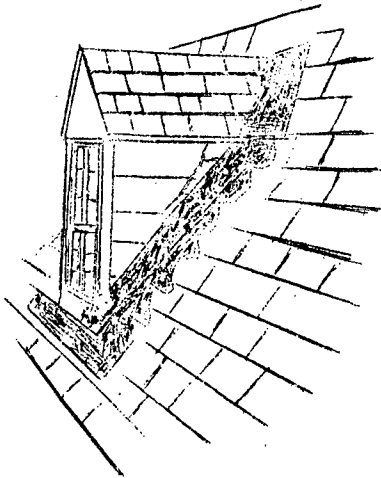


- I25. Which number indicates the stool? _____
- I26. What do you call the strips of wood that have to be taken out before the top sash can be removed?
 1. pocket cover
 2. stop sash
 3. parting strip
 4. top stile _____
- I27. If installing a 24" x 24" glass double hung with sash weight windows what is the size of the rough opening?
 1. 38" x 38"
 2. 28" x 34"
 3. 30" x 62"
 4. 34" x 58" _____

I28.



- B has the advantage over A because in B
 1. less shear will occur
 2. the effect of shrinkage is less
 3. the load is more evenly distributed
 4. it gives greater rigidity _____



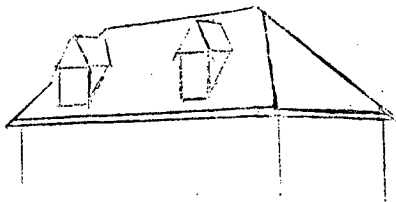
I29 The shaded portion is called

1. the tiling
2. the blocking
3. the shouldering
4. the flashing

I30 Its main purpose is

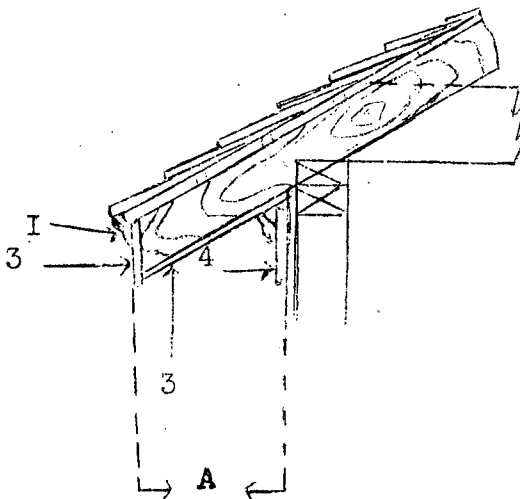
1. to stop air passage
2. to turn water
3. to stop the roof curling
4. to prevent decay

I31



This type of roof is known as

1. a mansard roof
2. a gambrel roof
3. a hip roof
4. a gable roof



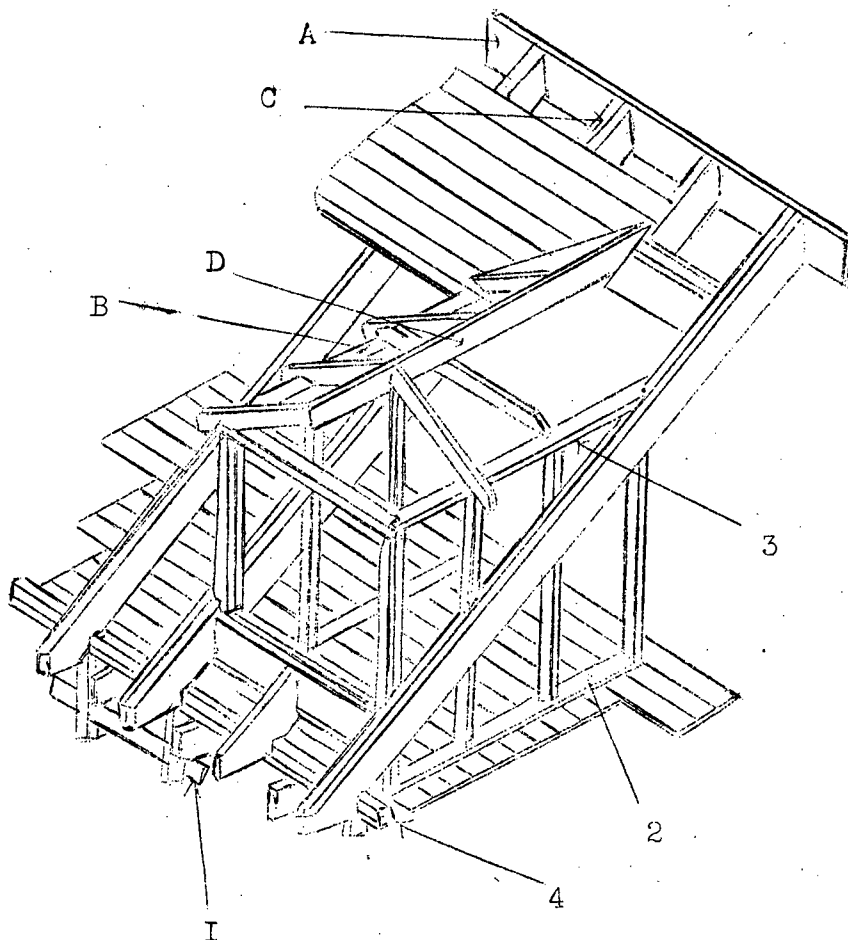
I32. Which number indicates the frieze?

I33. The distance marked "A" is

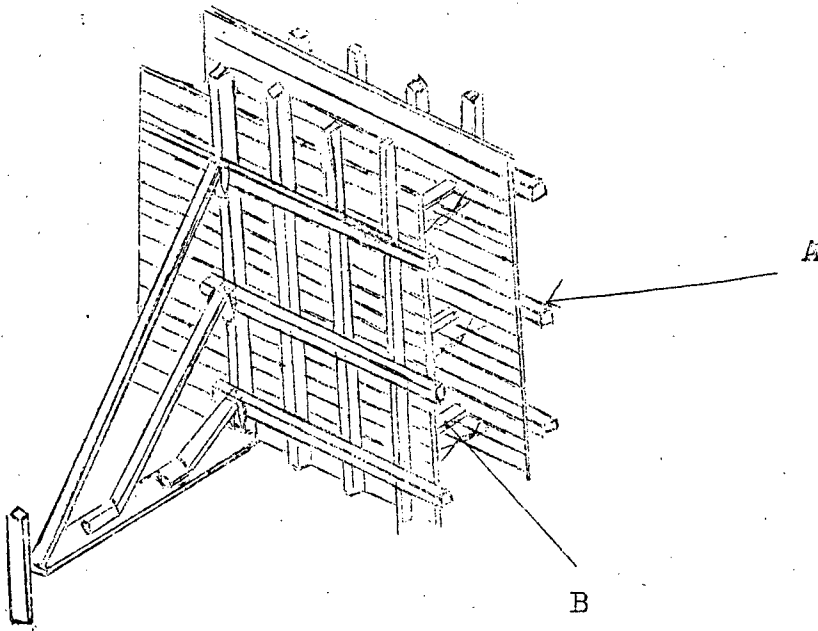
1. the water table
2. the watershed
3. the plancia
4. the lookout

I34. In laying shiplap subflooring it should be laid

1. cross grain to the final flooring
2. at right angles to the joists
3. diagonally to the joists
4. parallel to the joists



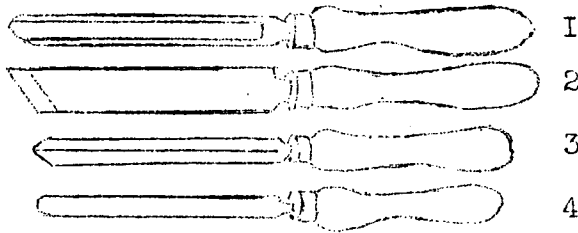
- I35. Which letter indicates the dormer ridge? _____
- I36. Which number indicates a sole? _____
- I37. The diagram is a detail of
 1. a hip roof
 2. a gable roof
 3. a gambrel roof
 4. a mansard roof _____
- I38. You would apply wallboard with
 1. 2 1/2" finishing nails
 2. 1 1/4" fine nails
 3. 1 1/2" common nails
 4. 2" flooring nails _____
- I39. Masonite for finished table tops is applied with
 1. liquid cement
 2. brads
 3. casein glue
 4. fine nails _____
- I40. 18" shingles should never be laid with a lap larger than
 1. 7 1/2"
 2. 6 1/2"
 3. 5 1/2"
 4. 4 1/2" _____



- I41. "A" indicates what is known as
1. wales
 2. battens
 3. ribbons
 4. shores
-
- I42. "B" is called
1. a spreader
 2. a form joist
 3. a cross tie
 4. a separator
-
- I43. Which one of the following would be used for extreme bending with the least amount of strength lost?
1. Ash
 2. Douglas Fir
 3. Yellow Pine
 4. Oak
-
- I44. What kind of bolts are most commonly used to attach a wooden truck body to the chassis?
1. Expansion bolts
 2. drift bolts
 3. stove bolts
 4. carriage bolts
-
- I45. Which of the following tools is used to make dowel joints?
1. brace and bit
 2. dado head
 3. panel saw
 4. mortiser
-

153. To cut cylindrical stock on a lathe you would use
1. a parting tool
 2. a spear chisel
 3. a gouge
 4. a skew chisel
-
154. Leather belting is kept soft and pliable by occasionally cleaning and treating it with
1. rosin
 2. lubricating oil
 3. neatsfoot oil
 4. graphite
-
155. The best machine for doing inside cutting and small sharp curves is a
1. jigsaw
 2. bandsaw
 3. circular saw
 4. benchsaw
-
156. Broken bandsaws are joined by a process known as
1. lacing
 2. brazing
 3. gumming
 4. jointing
-
157. The purpose of a riving knife on a circular saw is
1. to act as a guard
 2. to allow larger stock to be cut
 3. to prevent binding
 4. to remove shavings
-
158. The speed of rotation in an overhead lathe is controlled by
1. changing the diameter of the face plate
 2. changing the power inlet
 3. by moving the belt on the cone pulley
 4. varying the pressure on the spindle
-
159. The cutting speed of a bandsaw having a diameter of 3' and making 700 r.p.m. is
1. 233 $1/3$ ft. p.m.
 2. 6600 ft. p.m.
 3. 2100 ft.p.m.
 4. 703 ft. p.m.
-
160. What diameter should the pulley be if the counter-shaft runs at 800 r.p.m., the diameters of the tight and loose pulleys are 10" and the shaft makes 500 r.p.m.?
1. 28"
 2. 22"
 3. 16"
 4. 12"
-

I61.

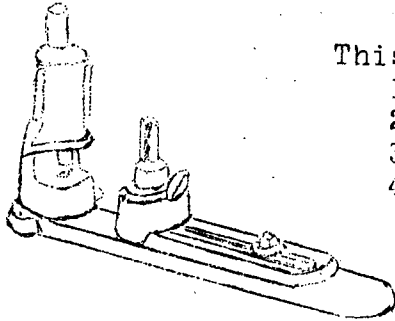


Which tool would you use to make a shearing cut when using a lathe?

I62. To use a metal working lathe for turning wood it would be necessary to

1. place a lathe chuck on the head spindle
 2. place in valve guide bushings
 3. substitute spur and cup centres
 4. use special pulleys on the shafts
-

I63.



This is used for

1. filing circular saws
 2. gumming circular saws
 3. jointing circular saws
 4. setting circular saws
-

I64. A bandsaw can be tracked on the wheel by

1. tilting the table
 2. tilting the top wheel
 3. removing the guard
 4. using the guide post
-

I65. The plane iron cap can be removed by first loosening

1. the iron cap
 2. the cam lever
 3. the lateral adjustment
 4. the adjusting nut
-

I66. Good plumb bobs are

1. solid steel
 2. filled with mercury
 3. hollow shafted
 4. weighted with sand
-

I67. How long should it take one man to lay 1000 ft B.M. flooring, yellow pine, 3 1/4" face, smoothed and sanded?

1. 45 hours
2. 34 hours
3. 20 hours
4. 10 hours

turn to next page

I68. 18" shingles should never be laid with a lap larger than

1. 4 1/2"
 2. 5 1/2"
 3. 7"
 4. 8 1/2"
-

I69. The rough opening for a door 7' x 3' finished should be

1. 7'2" X 3'6"
 2. 7'5" X 3'9"
 3. 7'10" X 4'2"
 4. 8'2" X 4'6"
-

I70. If you were required to lay 1000 shingles, using 1 1/4" nails, how many pounds of nails would you need

1. 8 lbs
 2. 5 lbs.
 3. 3 1/2 lbs
 4. 1 1/2 lbs
-

I71. How many squares of roofing material will be required to roof an area 20' X 33', allowing 5% wastage?

1. less than 2
 2. 4
 3. 7
 4. 9
-

I72. When estimating 1 x 3" flooring how much should be allowed for waste?

1. 33 1/3%
 2. 25%
 3. 20%
 4. 15%
-

I73. A formula for finding board measure is

1. $\frac{t" \times w" \times l"}{12}$
 2. $\frac{t" \times w" \times l'}{12}$
 3. $t" \times w" \times l"$
 4. $\frac{t" \times w" \times l'}{144}$
-

I74. How many pounds of 2 1/2" nails would be required to sheath a frame 40' x 40' x 15', using 10" shiplap and 3 nails to a stud?

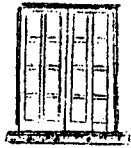
1. 48
 2. 37
 3. 25
 4. 13
-

I75. What kind of a drawing does a builder use to locate all the doors, windows, walls and fixtures?

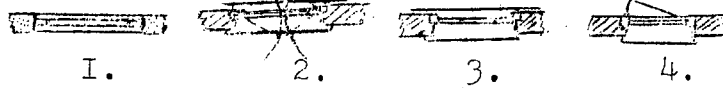
1. an elevation
 2. a sectional view
 3. a detail view
 4. a floor plan
-

turn to next page

I76



A



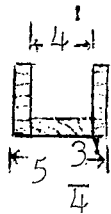
Which of the plan views is that of elevated view "A"

I77.

The window in the diagram is a

1. casement window
2. Dutch Window
3. double hung window
4. French Window

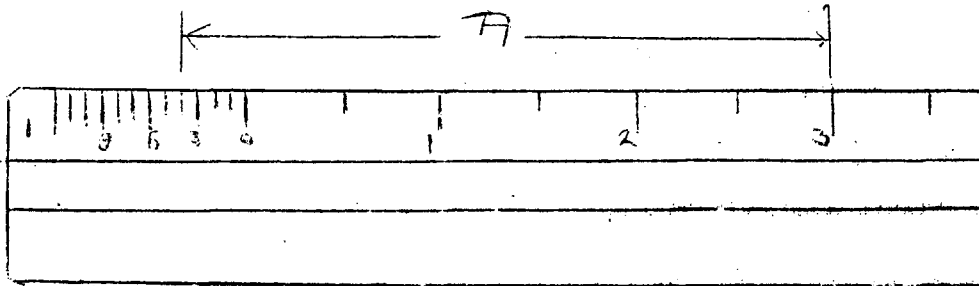
I78



The thickness of the boards used on the sides of the above miter box are

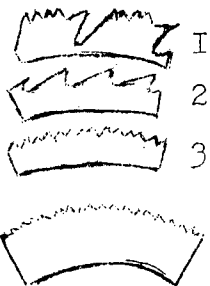
1. $7/8'$
2. $3/4'$
3. $1/4'$
4. $3/4'$

I79



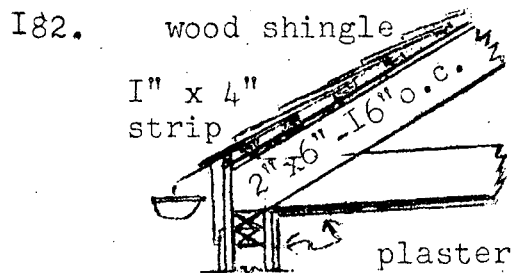
If the scale used above was $1/2"$ equals $6'$ then the length of "A" is

1. $18'$
2. $20'$
3. $21'$
4. $23'$



I80. Which of these saws has the least set?

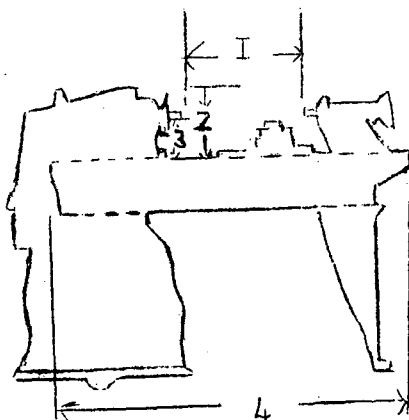
I81. Which saw would be the best for fine work?



The actual distance between rafter faces will be

1. not known
2. 16"
3. 14 $\frac{3}{8}$ "
4. 13 $\frac{5}{8}$ "

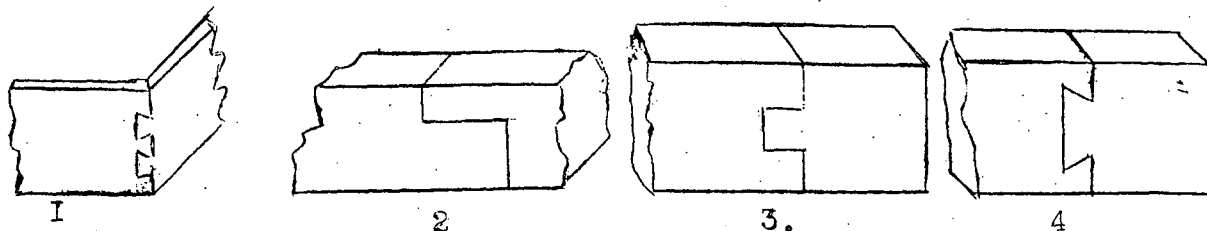
I83.



I83. Which number indicates the length of the bed? _____

I84. Which number indicates the swing of the lathe? _____

I84.

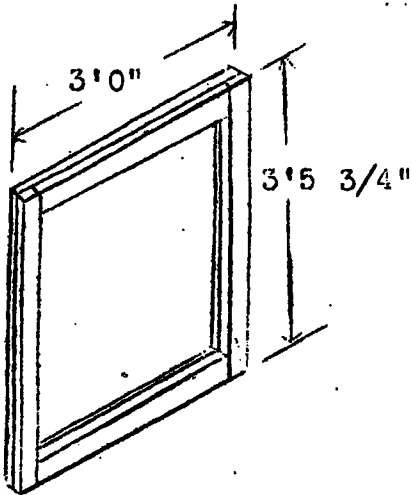
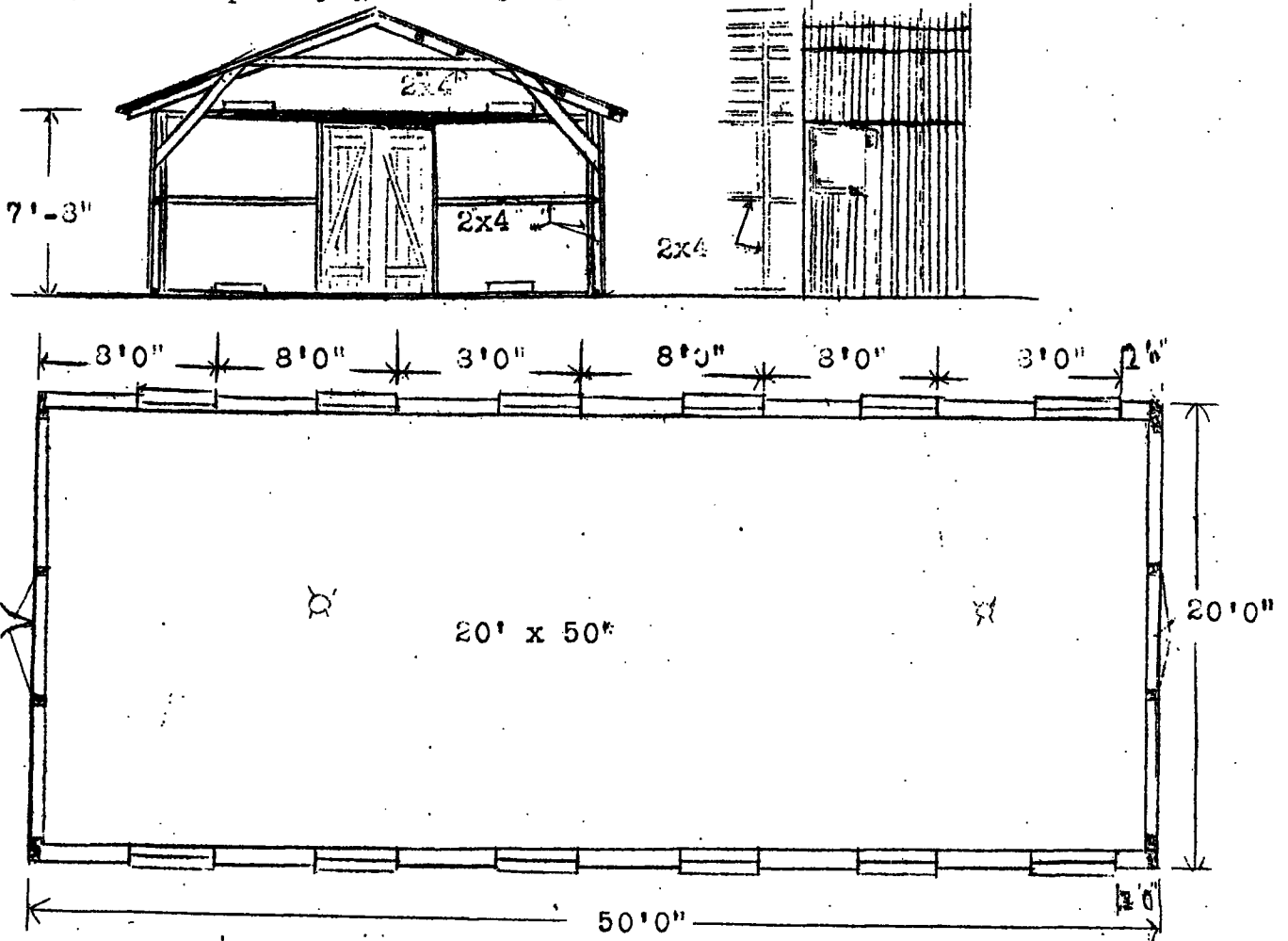


Which is a shiplap joint? _____

I85. What do you call the pieces between the joists on long spans that are used to brace the joists?

1. battens
2. bridging
3. bridle joists
4. purlins

Floor plan, two elevations, and diagram of a window sash for a temporary general purpose building.



186. What is the largest nail that will be needed?

1. 4 1/2"
2. 3"
3. 4"
4. 3 1/2"

187. What is the smallest nail that will be needed?

1. 1 1/2"
2. 2"
3. 2 1/2"
4. 3"

188. How long will it take two carpenters and four helpers to erect this building in daylight?

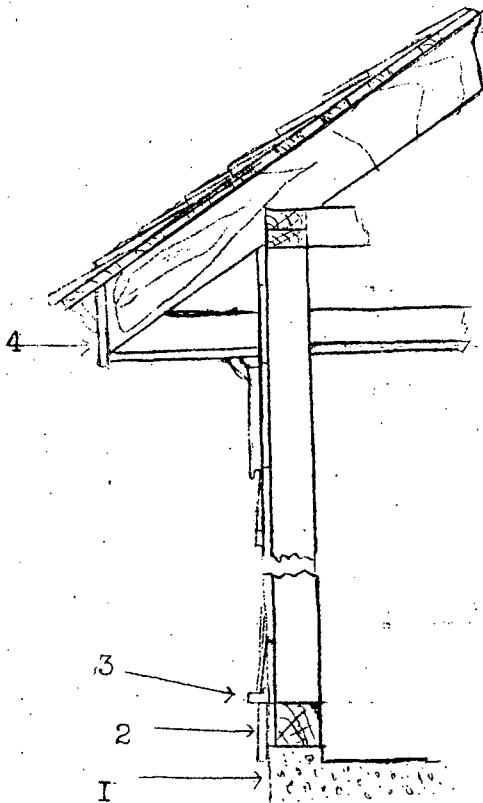
1. 16 hours
2. 8 hours
3. 48 hours
4. 24 hours

189. The size of the largest piece of lumber needed to complete this building is

1. 2" x 4" x 12'
2. 2" x 6" x 10'
3. 2" x 4" x 8'

I90. Rafters that run between the hip and valley rafters are called

- 1.hip jacks
- 2.valley jacks
- 3.ridge rafter
- 4.cripple jacks



I91. Which number indicates the water table?

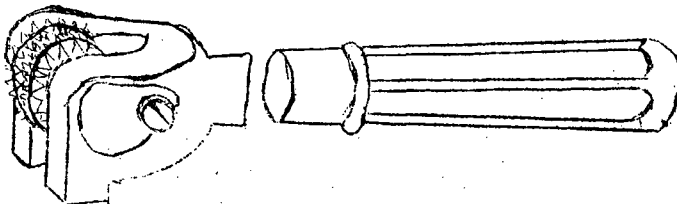
I92. If the total area to be covered by 6" siding, laid 4 1/2" to the weather, is 400 sq. ft. how much siding would you order?

1. 200 ft.B.M.
2. 500 ft.B.M.
3. 400 ft.B.M.
4. 250 ft.B.M.

I93. Which of the following planes is usually ground slightly curved?

1. smooth plane
2. trying plane
3. jack plane
4. fore plane

I94.



This is used for

- 1.patterning hardwood
- 2.dressing emery wheel discs
- 3.setting saws
- 4.threading screws

I95. To join a broken oil stone you would apply
1. heated casein glue
2. heated liquid cement
3. acetone and then heat
4. powdered shellac and then heat _____

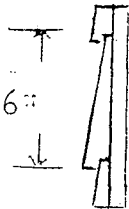
I96. Which size board would be best used as a ribbon?
1. 1" x 6"
2. 1" x 2"
3. 2" x 4"
4. 2" x 2" _____

I97. The term "ogee" applies to
1. drawings
2. joints
3. mouldings
4. a type of chisel _____

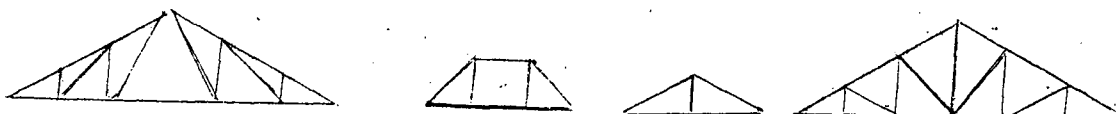
I98. To stop the concrete from sticking, the forms should be
1. sprayed with a white lead paint
2. made of kiln dried lumber
3. wetted with a mixture of linseed and kerosene
4. wetted with a mixture of fuel oil and paraffin _____

I99. The purpose of a header is to
1. support a trimmer
2. support tail joists
3. secure end joists
4. support an overhead opening _____

200. The term "T and G" refers to
1. joints
2. nails
3. screws
4. hinges _____

201.  The diagram on the left is an example of
1. shiplap siding
2. novelty siding
3. drop siding
4. bevel siding _____

202 .



Which one of the above diagrams shows a queen post truss? _____

203. Which of the following statements is generally accepted?

1. Tread plus twice the riser equals 42
 2. Tread plus twice the riser equals 68
 3. Tread multiplied by the riser equals 36
 4. Tread multiplied by the riser equals 72
-

204. What do you call the operation of chopping or planing joists so that all will have the same crown

1. cambering
 2. spreading
 3. furring
 4. chamfering
-

PERSONNEL TEST

FORM A

NAME.....Date.....
(Please Print)

READ THIS PAGE CAREFULLY. DO EXACTLY AS YOU ARE TOLD.
DO NOT TURN OVER THIS PAGE UNTIL YOU ARE
INSTRUCTED TO DO SO.

This is a test of problem solving ability. It contains various types of questions. Below is a sample question correctly filled in:

REAP is the opposite of

1 obtain, 2 cheer, 3 continue, 4 exist, 5 sow [5]

The correct answer is "sow." (It is helpful to underline the correct word.) The correct word is numbered 5. Then write the figure 5 in the brackets at the end of the line.

Answer the next sample question yourself.

Gasoline sells for 23 cents per gallon. What will 4 gallons cost? [____]

The correct answer is 92¢. There is nothing to underline so just place "92¢" in the brackets.

Here is another example:

MINER MINOR—Do these words have

1 similar meaning, 2 contradictory, 3 mean neither same nor opposite?..... [____]

The correct answer is "mean neither same nor opposite" which is number 3 so all you have to do is place a figure "3" in the brackets at the end of the line.

When the answer to a question is a letter or a number, put the letter or number in the brackets. All letters should be printed.

This test contains 50 questions. It is unlikely that you will finish all of them, but do your best. After the examiner tells you to begin, you will be given exactly 12 minutes to work as many as you can. Do not go so fast that you make mistakes since you must try to get as many right as possible. The questions become increasingly difficult, so do not skip about. Do not spend too much time on any one problem. The examiner will not answer any questions after the test begins.

Now, lay down your pencil and wait for the examiner to tell you to begin!

This page is not to be turned until you are told to do so.

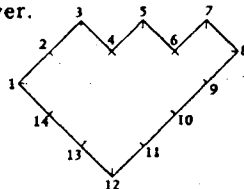
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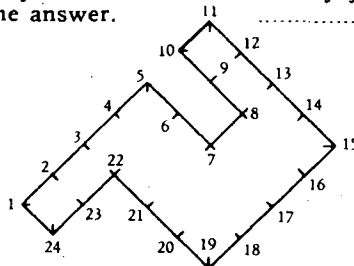
1. The last month of the year is
1 January. 2 March. 3 July. 4 December. 5 October []
 2. CAPTURE is the opposite of
1 place. 2 release. 3 risk. 4 venture. 5 degrade []
 3. Most of the items below resemble each other. Which one is least like the others?
1 January. 2 August. 3 Wednesday. 4 October. 5 December []
 4. Answer by printing YES or No—Does R.S.V.P. mean "reply not necessary"? []
 5. In the following set of words, which word is different from the others?
1 troop. 2 league. 3 participate. 4 pack. 5 gang []
 6. USUAL is the opposite of
1 rare. 2 habitual. 3 regular. 4 stanch. 5 always []
 7. Which figure can be made from these two parts? []
-
8. Look at the row of numbers below. What number should come next?
8 4 2 1 $\frac{1}{2}$ $\frac{1}{4}$? []
 9. CLIENT CUSTOMER—Do these words have
1 similar meanings. 2 contradictory. 3 mean neither same nor opposite? []
 10. Which word below is related to smell as chew is to teeth?
1 sweet. 2 stink. 3 odor. 4 nose. 5 clean []
 11. AUTUMN is the opposite of
1 vacation. 2 summer. 3 spring. 4 winter. 5 fall []
 12. A train travels 300 feet in $\frac{1}{2}$ second. At this same speed, how many feet will it travel in 10 seconds? []
 13. Assume the first 2 statements are true. Is the final one:
1 true. 2 false. 3 not certain?
These boys are normal children. All normal children are active.
These boys are active []
 14. REMOTE is the opposite of
1 secluded. 2 near. 3 far. 4 hasty. 5 exact []
 15. Lemons sell at 3 for 10 cents. How much will $1\frac{1}{2}$ dozens cost? []
 16. How many of the five items listed below are exact duplicates of each other? []
- | | |
|----------|----------|
| 84721 | 84721 |
| 9210651 | 9210561 |
| 14201201 | 14210210 |
| 96101101 | 96101161 |
| 88884444 | 88884444 |
17. Suppose you arranged the following words so that they made a true statement. Then print the last letter of the last word as the answer to this problem.
always A verb sentence a has []
 18. A boy is 5 years old and his sister is twice as old. When the boy is 8 years old, what will be the age of his sister? []
 19. IT'S ITS—Do these words have
1 similar meanings. 2 contradictory. 3 mean neither same nor opposite? []
 20. Assume that the first 2 statements are true. Is the final statement:
1 true. 2 false. 3 not certain?
John is the same age as Sally. Sally is younger than Bill. John is younger than Bill. []
 21. A dealer bought some cars for \$4000. He sold them for \$5000, making \$50 on each car. How many cars were involved? []
 22. Suppose you arrange the following words so that they make a complete sentence. If it is a true statement, put a (T) in the brackets; if false, put an (F) there.
eggs lay All chickens []
 23. Two of the following proverbs have the same meaning. Which ones are they? []
 1. Many a good cow hath a bad calf.
 2. Like father, like son.
 3. A miss is as good as a mile.
 4. A man is known by the company he keeps.
 5. They are seeds out of the same bowl.
 24. A watch lost 1 minute 18 seconds in 39 days. How many seconds did it lose per day? []
 25. CANVASS CANVAS—Do these words have
1 similar meaning. 2 contradictory. 3 mean neither same nor opposite? []
 26. Assume the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain?
All Quakers are pacifists. Some of the people in this room are Quakers. Some of the people in this room are pacifists []
 27. In 30 days a boy saved \$1.00. What was his average daily saving? []
 28. INGENIOUS INGENUOUS—Do these words have.
1 similar meanings. 2 contradictory. 3 mean neither same nor opposite? []
 29. Two men caught 36 fish; X caught 5 times as many as Y. How many fish did Y catch? []

30. A rectangular bin, completely filled, holds 800 cubic feet of grain. If the bin is 8 feet wide and 10 feet long, how deep is it? []
31. One number in the following series does not fit in with the pattern set by the others. What should that number be? $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{6}$ $\frac{1}{8}$ $\frac{1}{10}$ $\frac{1}{12}$ []
32. Answer this question by printing YES or NO. Does A.D. mean "In the year of our Lord"? []
33. CREDITABLE CREDULOUS—Do these words have
1 similar meaning, 2 contradictory, 3 mean neither same nor opposite? []
34. A skirt requires $2\frac{1}{4}$ yards of material. How many can be cut from 45 yards? []
35. A clock was exactly on time at noon on Monday. At 2 P.M. on Wednesday, it was 25 seconds slow. At that same rate, how much did it lose in $\frac{1}{2}$ hour? []
36. Our baseball team lost 9 games this season. This was $\frac{3}{8}$ of all they played. How many games did they play this season? []
37. What is the next number in this series? 1 .5 .25 .125 ? []
38. This geometric figure can be divided by a straight line into two parts which will fit together in a certain way to make a perfect square. Draw such a line by joining two of the numbers. Then write the numbers as the answer. []



39. Are the meanings of the following sentences 1 similar, 2 contradictory, 3 neither similar nor contradictory? A new broom sweeps clean. Old shoes are easiest. []
40. How many of the five items listed below are exact duplicates of each other? []
- | | |
|------------------|------------------|
| Rexford, J. D. | Rockford, J. D. |
| Singleton, M. O. | Simbleton, M. O. |
| Richards, W. E. | Richard, W. E. |
| Siegel, A. B. | Seigel, A. B. |
| Wood, A. O. | Wood, A. O. |
41. Two of the following proverbs have similar meanings. Which ones are they? []
1. You cannot make a silk purse out of a sow's ear.
 2. He that steals an egg will steal an ox.
 3. A rolling stone gathers no moss.
 4. You cannot damage a wrecked ship.
 5. It is the impossible that happens.

42. This geometric figure can be divided by a straight line into two parts which will fit together in a certain way to make a perfect square. Draw such a line by joining two of the numbers. Then write these numbers as the answer. []



43. Which number in the following group of numbers represents the smallest amount?
10 1 .999 .33 11 []
44. Are the meanings of the following sentences:
1 similar, 2 contradictory, 3 neither similar nor contradictory?
No honest man ever repented for his honesty. Honesty is praised and starves. []
45. For \$1.80 a grocer buys a case of oranges which contains 12 dozen. He knows that two dozen will spoil before he sells them. At what price per dozen must he sell the good ones to gain $\frac{1}{3}$ of the whole cost? []
46. In the following set of words, which word is different from the others?
1 colony, 2 companion, 3 covey, 4 crew, 5 constellation []
47. Assume that the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain: Great men are ridiculed. I am ridiculed. I am a great man. []
48. Three men form a partnership and agree to divide the profits equally. X invests \$4500, Y invests \$3500 and Z invests \$2000. If the profits are \$1500, how much less does X receive than if the profits were divided in proportion to the amount invested? []
49. Four of the following 5 parts can be fitted together in such a way as to make a triangle. Which 4 are they? []



50. In printing an article of 30,000 words, a printer decides to use two sizes of type. Using the larger type, a printed page contains 1200 words. Using the smaller type, a page contains 1500 words. The article is allotted 22 pages in a magazine. How many pages must be in the smaller type? []

APPENDIX E

Personal data sheet completed by novices and civilian apprentices.

NAME.....
 (Last) (Given)

AGE.....

Place of birth.....
 (Town) (Country)

Have you ever worked as a carpenter or carpenter's helper.....

If so, for how long?.....

What particular jobs did you do?.....

.....

.....

Other jobs you held before enlistment.....

.....

P.S.

APPENDIX F.

Personal data sheet completed by enlisted apprentices and
carpenters.

NAME.....
 (Last) (Given)

NUMBER.....RANK.....

PLACE OF BIRTH.....
 (Town) (Country)

AGE.....PRESENT TRADE AND GROUPING.....

LAST SCHOOL GRADE COMPLETED.....

WHAT YEAR WAS THIS?.....

HOW LONG HAVE YOU BEEN IN YOUR PESENT TRADE?.....

HOW LONG HAVE YOU BEEN IN THE FORCES AT YOUR PRESENT TRADE?...

.....

APPENDIX G .

Administration instruction sheet distributed to examiners.

Instruction for examiners.

1. You may explain the purpose of the test; to find out, by giving the test to carpenters and shipwrights in the three services, how many of the questions qualified carpenters can answer. When this is known it will be possible to use the test at a later date on men who claim to be carpenters in order to see whether, in fact, it is likely that they are carpenters. This particular stage right now is, therefore, experimental. Those who take the test now are helping us to carry out a scientific experiment; they need feel no concern about taking it because it is not they who are being tested; rather, it is the test which is being tested. It will be a fair test of the test, however, only if those taking it do their best to answer all the items.
2. The procedure will be:
 - (a) First, give the PERSONNEL TEST. The first (front) page is for practice. It should be worked through and any questions asked dealt with. After this the tradesmen will be given twelve (12) minutes (carefully timed) to answer the fifty questions.
 - (b) Then, give the CARPENTER'S CLASSIFICATION TEST. The cover page should be filled in first; then the following pages of instructions and sample questions should be followed through to be sure the man understands what is wanted. After that, the test itself is to be worked through at the man's own time.
3. It will be most useful if, for each man tested the examiner can obtain and append to his test a statement or description of his formal trade qualifications, or standing, trade test scores, levels of skill or competence, and any other facts indicative of just how good a carpenter he is. Such will provide additional criteria by which to assess the efficacy of the test itself.

CARPENTERS CLASSIFICATION TEST

This is a test of your knowledge of carpentry terms, tools and practices. In the following pages you will find a number of questions to be answered. After each question there are four alternative answers. You are to select the answer that you think best fits the question asked. Cross out the number in the box in the right hand column which indicates the answer you have selected. When you are not sure which answer is correct make the best choice you can. Here are a few sample questions. Do them to be sure you understand what is wanted.

S1 Nails are driven with 1. a hammer, 2. a screw driver, 3. a chisel, 4. a saw?.....

1	2	3	4
---	---	---	---

The answer, of course, is number one so a cross has been put in box number 1. Here is another.



S2 Which would you use to chop wood?.....

1	2	3	4
---	---	---	---

Number two is right so a cross has been put in box number 2.

Now do the rest of the questions in the booklet. Take your time and see how many you can get correct.

1.



This is used for

1. setting heavy screws
2. cutting wire
3. cutting sheet metal
4. none of these

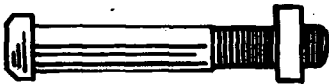
1	2	3	4
---	---	---	---

2.

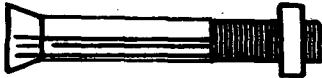
Plywood is sold by the 1.board foot 2.square foot 3.pound 4.linear foot.

1	2	3	4
---	---	---	---

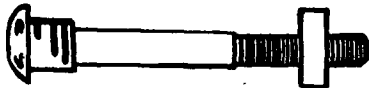
1



2



3



4



3. Which is a carriage bolt ?.....

1	2	3	4
---	---	---	---

4. Which one would you use to fasten framing members to a concrete post?.....

1	2	3	4
---	---	---	---

5.

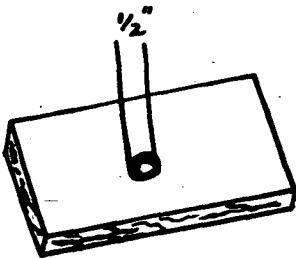
What kind of bolts are most commonly used to attach a wooden truck body to the chassis, 1.expansion bolts 2.drift bolts 3.stove bolts 4.carriage bolts

1	2	3	4
---	---	---	---

6.

The most commonly used wood preservative is 1.petroleum 2.creosote 3. benzol 4.sodium fluoride

1	2	3	4
---	---	---	---



1

2

3

4

7.

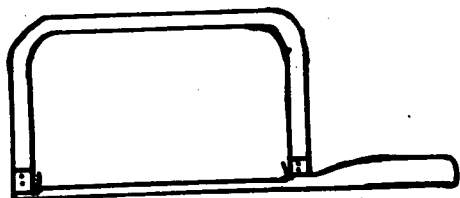
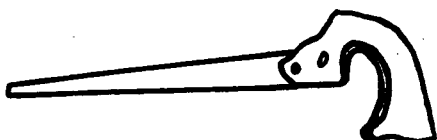
Which of the bits would be used to bore the 1/2" hole ?

1	2	3	4
---	---	---	---



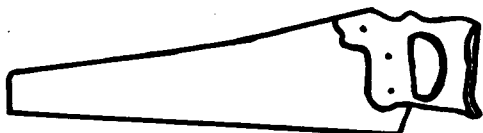
8. Which would be the best chisel to use in cutting out mortises?

1	2	3	4
---	---	---	---



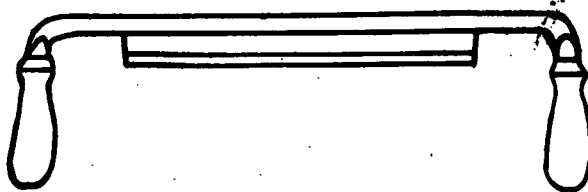
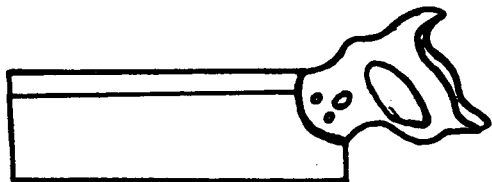
9. Which saw has the least set?.....

1	2	3	4
---	---	---	---



10. Which saw would you use for coping a moulding joint?....

1	2	3	4
---	---	---	---



11. Which of the above tools would be used to smooth a railroad tie?.....

1	2	3
---	---	---

- 12. To turn the burr on a scraper you would use a 1. file, 2. rasp, 3. burnisher, 4. skew chisel.....

1	2	3	4
---	---	---	---
- 13. To allow screws to enter wood more easily you would use 1. soap, 2. light oil, 3. beeswax, 4. graphite.....

1	2	3	4
---	---	---	---
- 14. The first step in sharpening a saw is 1. setting, 2. jointing, 3. filing, 4. shaping.....

1	2	3	4
---	---	---	---

- 15.  This is used for 1. reaming 2. setting heads of screws 3. removing broken screws 4. drilling at angles.....

1	2	3	4
---	---	---	---

- 16.  A chisel with this type of handle is known as a 1. stake chisel 2. socket chisel 3. tang chisel 4. framing chisel.....

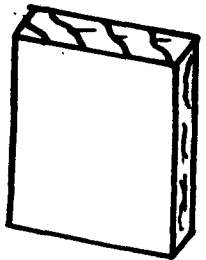
1	2	3	4
---	---	---	---

- 17. Inside and outside gouges are whetted on 1. an emery board, 2. a whetstone, 3. a slipstone, 4. a conical grindstone....

1	2	3	4
---	---	---	---
- 18. The tool which can be adjusted to bore various size holes is called 1. an extension bit, 2. a twist drill, 3. a slip stone, 4. an adjustable bit.....

1	2	3	4
---	---	---	---
- 19. Twist drills are sharpened on 1. a grinder, 2. a special file, 3. a three square file, 4. a rasp.....

1	2	3	4
---	---	---	---

- 20.  To plane surface the end of this board you would use 1. a jointer plane, 2. a block plane, 3. a smoothing plane, 4. a jack plane.....

1	2	3	4
---	---	---	---

- 21. " R H B" refers to 1. screws, 2. brads, 3. drills 4. nails.

1	2	3	4
---	---	---	---
- 22. The best wood for making tool handles is 1. Hickory, 2. Maple, 3. Oak, 4. Walnut,

1	2	3	4
---	---	---	---
- 23. Lag screws are turned into wood by 1. a wrench, 2. a screw driver, 3. pliers, 4. a hammer,.....

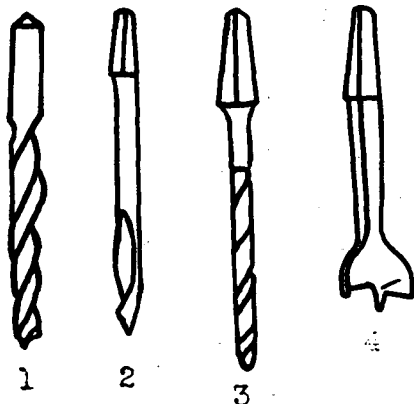
1	2	3	4
---	---	---	---



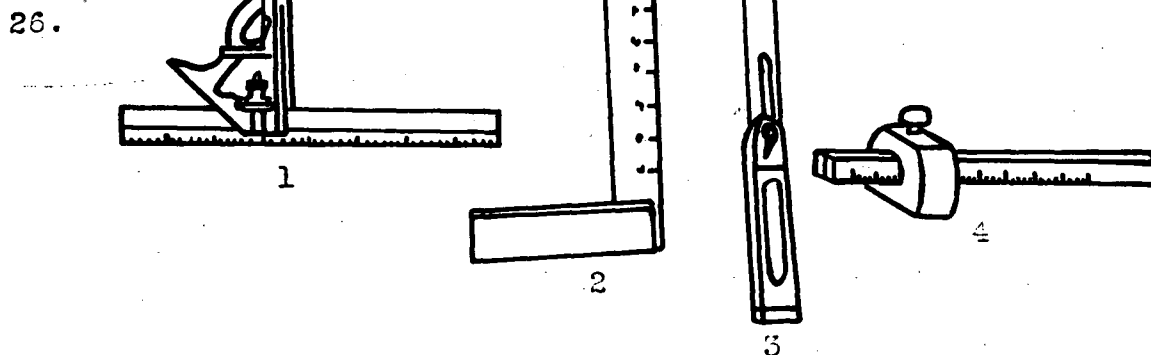
24. Which one of the above handles would be best suited for a mortise chisel?.....

1	2	3	4
---	---	---	---

25. In drilling holes in scrap lumber where nails are likely to be met which bit would you use?.....

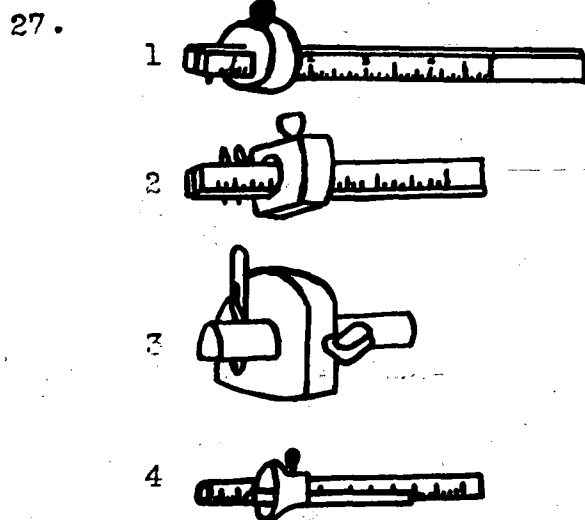


1	2	3	4
---	---	---	---



26. Which of the above would you use to quickly transfer an angle?.....

1	2	3	4
---	---	---	---



27. Which would you use in laying out mortises?.....

1	2	3	4
---	---	---	---

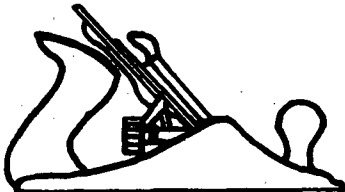
1



2



3



4

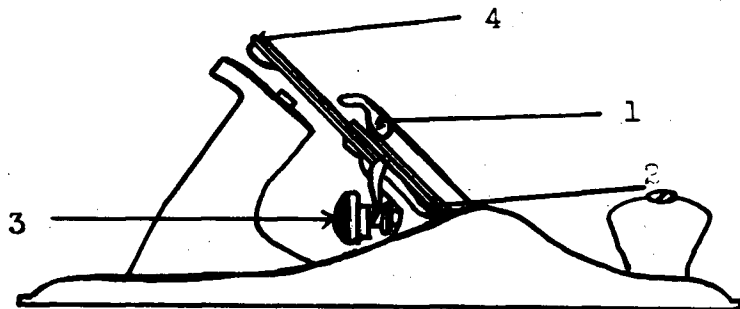


28. Which plane would you use in hanging a door?....

1	2	3	4
---	---	---	---

29. Which plane would you use to smooth the end of a board?.....

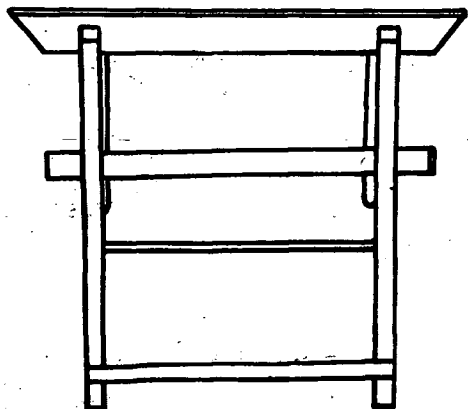
1	2	3	4
---	---	---	---



30. If the above plane is cutting too deeply on one side (unevenly) which number indicates the part to adjust?.....

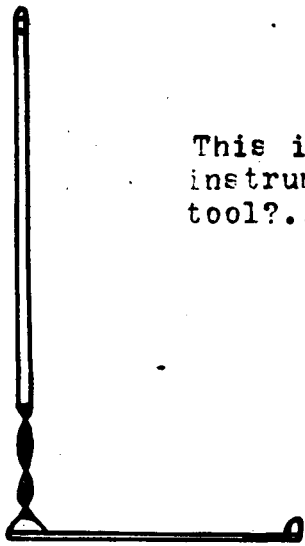
1	2	3	4
---	---	---	---

31.



This is used when 1. gluing joints, 2. applying wall-board, 3. drawing plans 4. setting saws?.....

1	2	3	4
---	---	---	---



This is a 1. sash balance 2. measuring instrument 3. laying out tool 4. crimping tool?.....

1	2	3	4
---	---	---	---

33. When working with 5/8" ceiling material you would use 1. 2" common nails, 2. 1 1/2" finishing nails, 3. 2 1/2" finishing nails, 4. 1 1/4" brads?

1	2	3	4
---	---	---	---
34. The wood most suitable for studs is 1. Douglas Fir, 2. Red Cedar, 3. Poplar, 4. White Pine.....

1	2	3	4
---	---	---	---
35. The wood that is easiest to work is 1. Spruce, 2. Pine, 3. Fir, 4. Hemlock?.....

1	2	3	4
---	---	---	---
36. The strongest general construction lumber is 1. Fir, 2. Hemlock, 3. Cedar, 4. Pine?.....

1	2	3	4
---	---	---	---
37. If you wanted a floor that would be sure not to warp you would use flooring that was 1. plain sawed, 2. rotary cut, 3. bastard sawed, 4. quarter sawed?.....

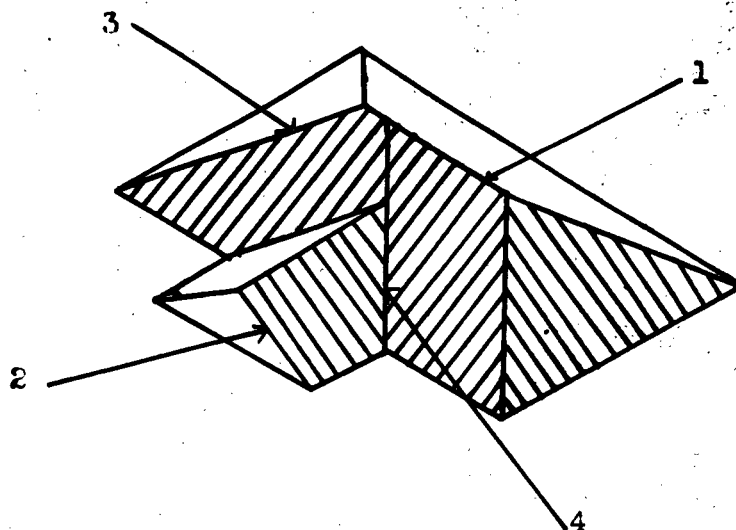
1	2	3	4
---	---	---	---
38. Which one of the following tables is NOT found on the framing square 1. brace measure, 2. octagon measure, 3. square measure, 4. board measure?.....

1	2	3	4
---	---	---	---
39. A flight of stairs having 23 risers will have how many treads 1. 22, 2. 23, 3. 24, 4. none of these?.....

1	2	3	4
---	---	---	---
40. The template used for laying out stair carriages is called the 1. tread, 2. sill, 3. pitch board, 4. furring?.....

1	2	3	4
---	---	---	---
41. What device is used to fasten corrugated iron roofing to an open rafter 1. jack rafters, 2. bridging, 3. cripples, 4. purlins?.....

1	2	3	4
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42. Which number indicates the hip rafter?.....

1	2	3	4
---	---	---	---

43.



The reason for using separators on the bridge beam on the left is to 1. allow for shear, 2. allow greater flexibility, 3. prevent sliding, 4. prevent decay?.....

1	2	3	4
---	---	---	---

44. In house dwelling construction the studs are usually placed 1. 14" centres, 2. 16" centres, 3. 22" centres 4. 36" centres?.....

1	2	3	4
---	---	---	---

45. What depth joists are usually used for a floor with a 12 foot span 1. 6", 2. 8", 3. 10", 4. 12"?.....

1	2	3	4
---	---	---	---

46. The actual size of 2" X 4" S4S upon delivery is 1. 1 3/4" X 3 3/4", 2. 1 5/8" X 3 5/8", 3. 1 3/16" X 3 5/8", 4. 2" X 4"?.....

1	2	3	4
---	---	---	---

47. How many board feet are there in a piece of lumber that measures 10" X 12" X 8' 1. 120, 2. 80, 3. 72, 4. 96?.....

1	2	3	4
---	---	---	---

48. The support for the second floor joists in a balloon frame is called a 1. girder, 2. ribbon, 3. ledger board, 4. sill?.....

1	2	3	4
---	---	---	---

49. The finest grade of sandpaper listed here is 1. 3/0, 2. 1/2, 3. 1, 4. 3 ?.....

1	2	3	4
---	---	---	---

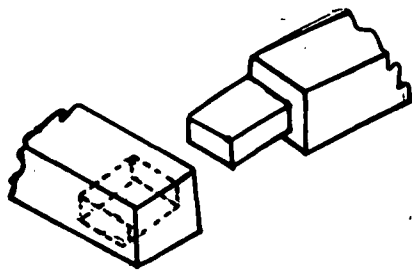
50. In laying a 16" wooden shingle the gauge should be 1. 7", 2. 3 1/2", 3. 5", 4. 1 1/2"?.....

1	2	3	4
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51. The principle consideration when choosing the type of roofing to be used is 1. the rise of the roof, 2. the appearance of the roof, 3. the rafter placement in the roof, 4. the type of weather?.....

1	2	3	4
---	---	---	---

52.



This joint is a 1. tenon joint, 2. straddle joint, 3. dowelled joint, 4. miter joint?.....

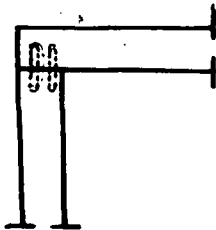
1	2	3	4
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53.

In making a mortise and tenon joint which of the following tools would be of the least use 1. backsaw, 2. mallet, 3. chisel 4. jointer?.....

1	2	3	4
---	---	---	---

54.



This joint is 1. tree nailed, 2. toggled 3. dowelled, 4. fillistered?.....

1	2	3	4
---	---	---	---

55.

The best practical method of joining sills at corners is by 1. a mitre joint, 2. a lap joint, 3. an open mortise joint, 4. a butt joint?.....

1	2	3	4
---	---	---	---

56.

In applying glue to members that frequently would be wet you would use 1. casein glue, 2. starch glue, 3. animal glue, 4. vegetable protein glue?.....

1	2	3	4
---	---	---	---

57.

The best joint to be used in the construction of a door is the 1. dovetail joint, 2. mortise and tenon joint, 3. dowel joint, 4. lap joint?.....

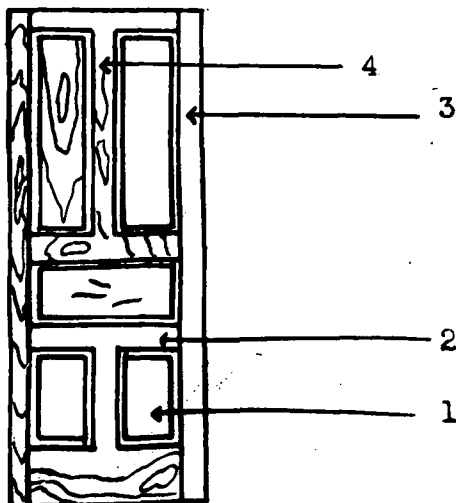
1	2	3	4
---	---	---	---

58.

The strongest method of building shelving is to 1. screw on the shelf, 2. use a nailed butt joint, 3. nail on a cleat, 4. groove in the shelf?.....

1	2	3	4
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59.



Which number on the left indicates the muntin?.....

1	2	3	4
---	---	---	---

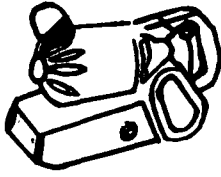
60. The joints on inside doors should be 1. butt joints, 2. scarf joints, 3. mortise and tenon, 4. dowelled?.....

1	2	3	4
---	---	---	---

61. The gauge that is used for locating lines for door hinges is called the 1. mortise gauge, 2. marking gauge, 3. pencil gauge, 4. butt gauge?.....

1	2	3	4
---	---	---	---

62.



- This machine is used for 1. sawing boards, 2. sanding boards, 3. cutting grooves, 4. planing rough surfaces?....

1	2	3	4
---	---	---	---

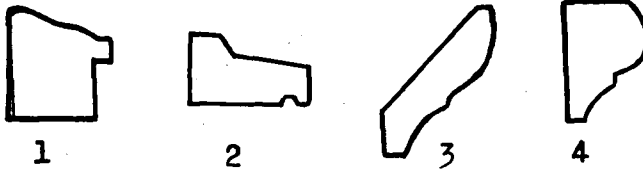
63. Which one of the following mouldings is NOT used in interior trim 1. widow apron, 2. backband, 3. drip cap, 4. shoe moulding?.....

1	2	3	4
---	---	---	---

64. To prevent the baseboard from warping you can 1. use cover moulds, 2. plough out the back, 3. toe-nail base board to floor, 4. glue to floor and wall?.....

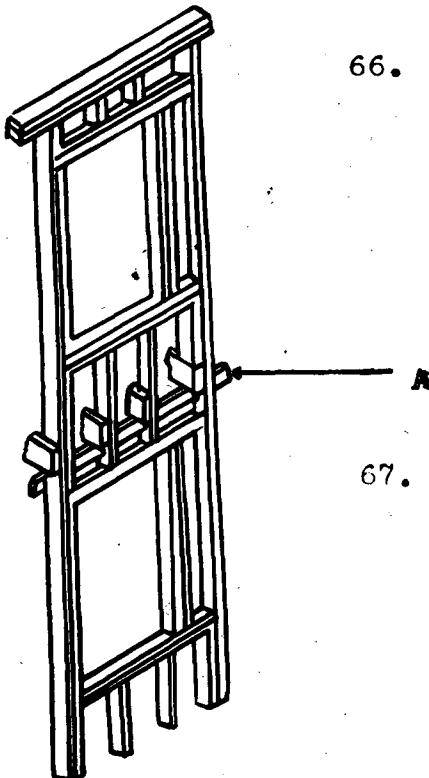
1	2	3	4
---	---	---	---

65.



- Which of the above mouldings is a drip cap moulding?.....

1	2	3	4
---	---	---	---



66. The strip indicated by the letter A is used for 1. attaching window fittings, 2. a guide strip, 3. a nailing strip, 4. supporting the joists?.....

1	2	3	4
---	---	---	---

67. The window frame opening on the left is part of 1. a balloon frame, 2. a western frame, 3. a braced frame, 4. every frame structure?.....

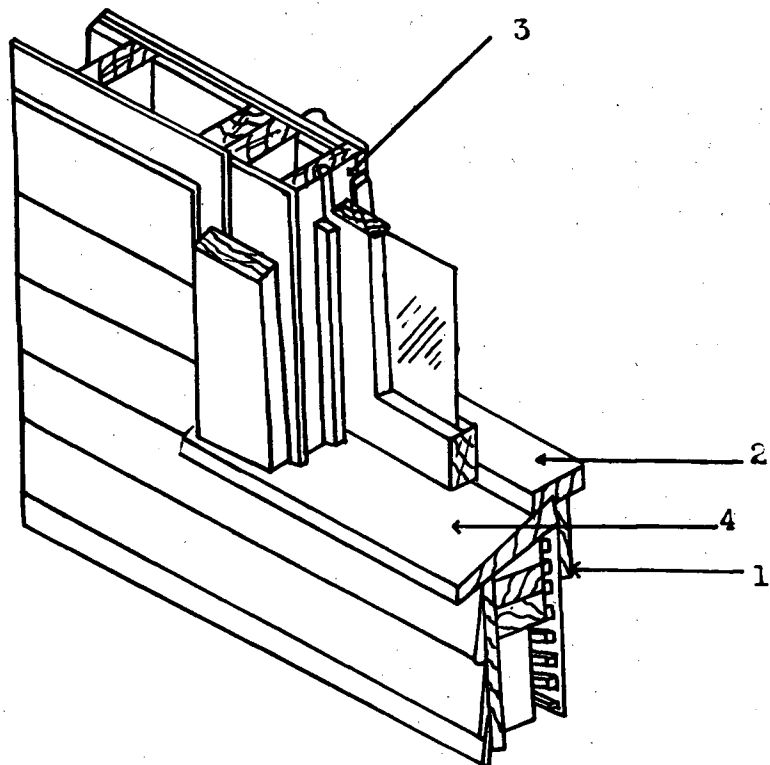
1	2	3	4
---	---	---	---

68. In double hung windows the upper sash is set outside the lower sash in order to 1. prevent leakage, 2. minimize shrinkage effect, 3. allow for extra support, 4. prevent decay?.....

1	2	3	4
---	---	---	---

69. In carpentry the term "shore" means a type of 1. wedge, 2. abutment, 3. brace, 4. foundation?.....

1	2	3	4
---	---	---	---



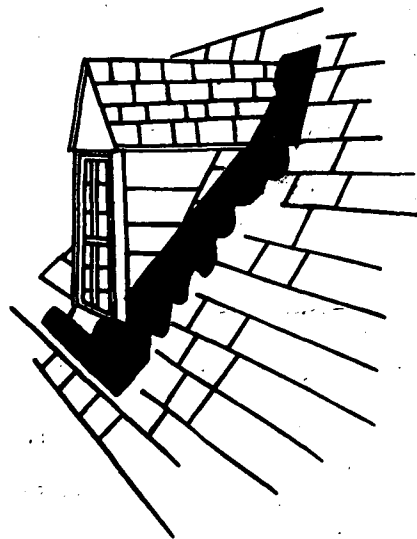
70. Which number indicates the stool?.....

1	2	3	4
---	---	---	---

71. What do you call the strips of wood that have to be removed before the top sash can be removed 1. pocket cover, 2. stop sash, 3. parting strip, 4. top stile?.....

1	2	3	4
---	---	---	---

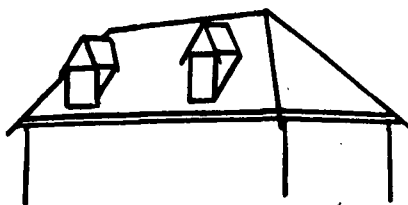
72.



The shaded portion is called the 1. tiling, 2. blocking, 3. shouldering, 4. flashing?.....

1	2	3	4
---	---	---	---

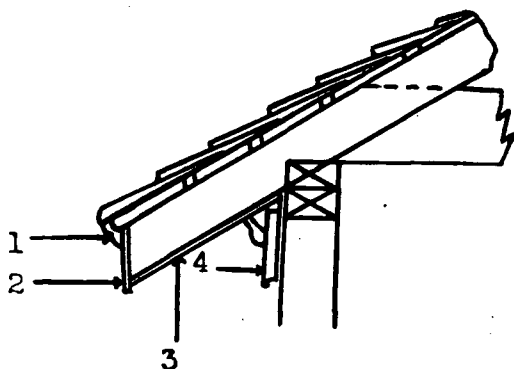
73.



This type of roof is known as a
 1. mansard roof, 2. gambrel roof,
 3. hip roof, 4. gable roof?.....

1	2	3	4
---	---	---	---

74.



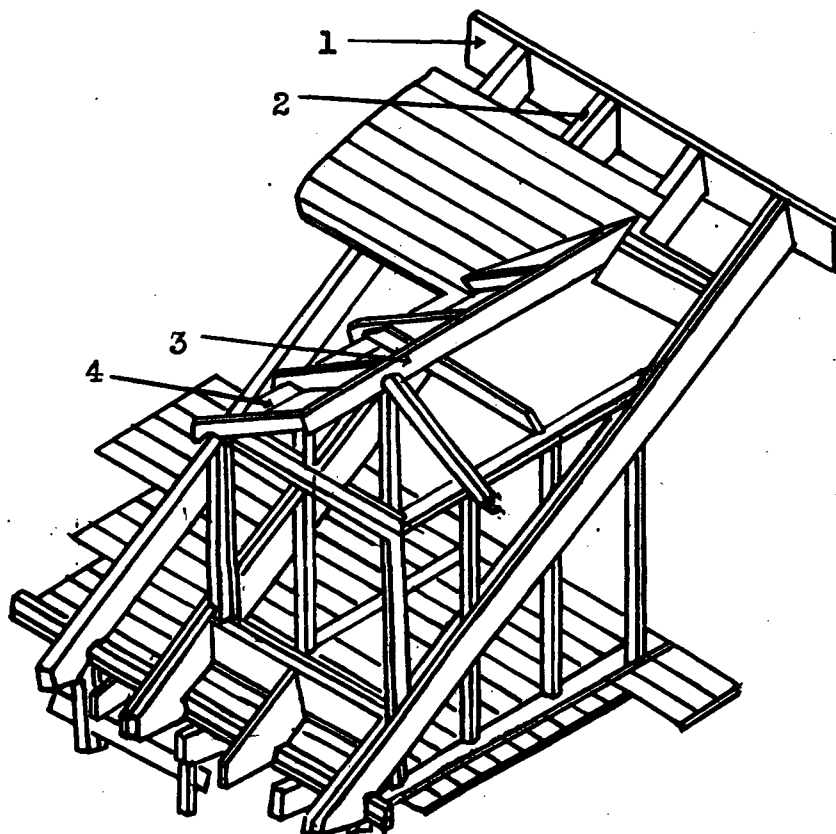
Which number indicates the
 frieze?.....

1	2	3	4
---	---	---	---

75.

In laying shiplap subflooring it should be laid 1. cross
 grain to the final flooring, 2. at right angles to the
 joists, 3. diagonally to the joists, 4. parallel to the
 joists?.....

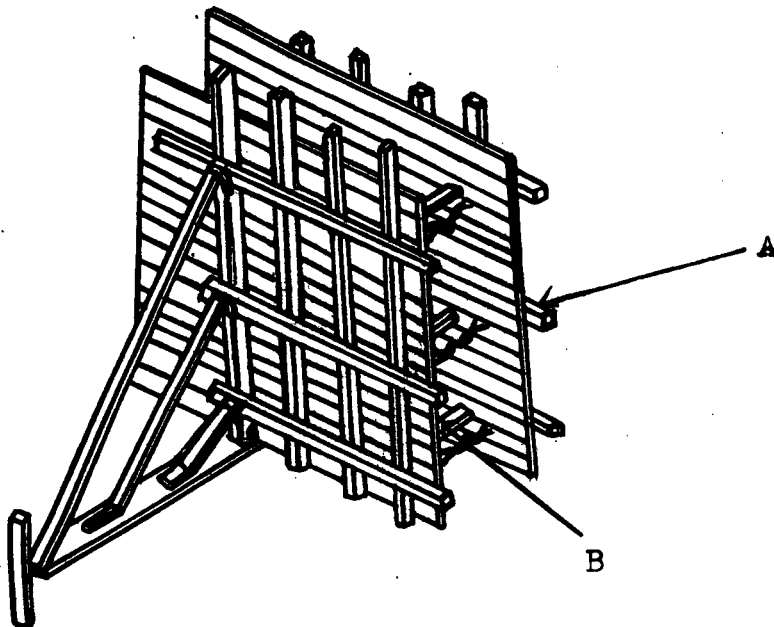
1	2	3	4
---	---	---	---



76.

Which number indicates the dormer ridge?

1	2	3	4
---	---	---	---



77. In the above diagram "A" indicates what is known as
1. wales, 2. battens, 3. ribbons, 4. shores?.....

1	2	3	4
---	---	---	---
78. In the above diagram "B" is called a 1. spreader, 2. form
joist, 3. cross tie, 4. separator?.....

1	2	3	4
---	---	---	---
79. Which of the following tools is used to make dowel joints
1. brace and bit, 2. dado head, 3. panel saw 4. mortiser?.....

1	2	3	4
---	---	---	---
80. Moisture within walls and ceilings can be prevented by
the proper use of 1. vapour barriers, 2. sheathing,
3. tar paper, 4. caulking?.....

1	2	3	4
---	---	---	---
81. The best type of insulation to place in a remodelled
house is 1. reflective insulation, 2. blanket insulation,
3. fill insulation, 4. bat insulation?.....

1	2	3	4
---	---	---	---
82. The depth of cut in a jointer is regulated by 1. adjusting
the front table, 2. adjusting the knife clamping screw,
3. vertical movement of the cutter head, 4. moving the
adjustable fence?.....

1	2	3	4
---	---	---	---
83. The purpose of a riving knife on a circular saw is 1. to
act as a guard, 2. to allow larger stock to be cut, 3. to
prevent binding, 4. to remove shavings?.....

1	2	3	4
---	---	---	---
84. The speed of rotation in an overhead lathe is controlled
by 1. changing the diameter of the face plate, 2. changing
the power inlet, 3. by moving the belt on the cone pulley,
4. varying the pressure on the spindle?..

1	2	3	4
---	---	---	---

85.

How many squares of roofing material will be required to roof an area 20' X 33' allowing 5% wastage 1. less than 2, 2. 4, 3. 7, 4. 9?.....

1	2	3	4
---	---	---	---

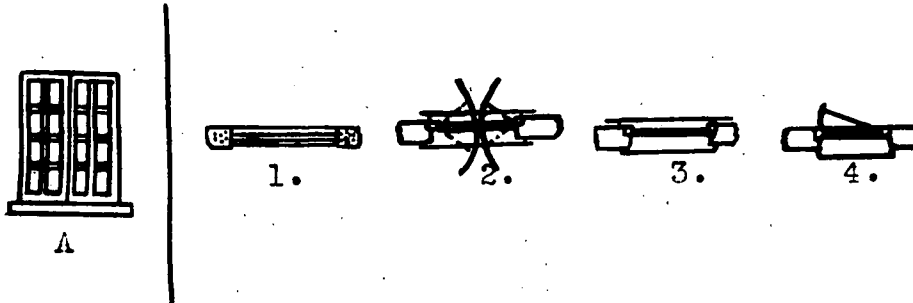
86.

A formula for finding board measure is 1. $\frac{t'' \times w'' \times l''}{12}$,

2. $\frac{t'' \times w'' \times l'}{12}$, 3. $t'' \times w'' \times l''$, 4. $\frac{t'' \times w'' \times l'}{144}$?.....

1	2	3	4
---	---	---	---

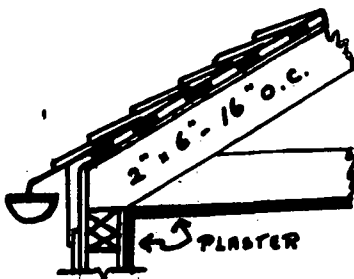
87.



Which of the plan views is that of elevated view "A" ?...

1	2	3	4
---	---	---	---

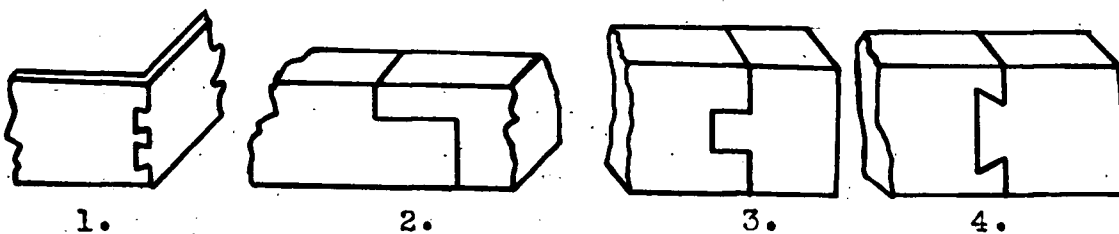
88.



The actual distance between rafter faces will be

1. not known
2. 16"
3. 14 3/8"
4. 13 5/8".....

1	2	3	4
---	---	---	---



89.

Which of the above is a shiplap joint?.....

1	2	3	4
---	---	---	---

90.

What do you call the pieces between the joists on long spans that are used to brace the joists 1, battens, 2. bridging, 3. bridle joists, 4. purlins?.....

1	2	3	4
---	---	---	---

91.

Rafters that run between the hip and valley rafters are called 1. hip jacks, 2. valley jacks, 3. ridge rafters, 4. cripple jacks?.....

1	2	3	4
---	---	---	---

92. If the total area to be covered by 6" siding, laid 4 1/2" to the weather, is 400 square feet, how much siding would you order 1. 200 ft. B.M., 2. 500 ft. B.L., 3. 400 ft. B.M., 4. 250 ft. B.M.?.....

1	2	3	4
---	---	---	---

93. Which size board would be best used as a ribbon? 1. 1" x 6", 2. 1" x 2", 3. 2" x 4", 4. 2" x 2".....

1	2	3	4
---	---	---	---

94. The term "ogee" applies to 1. drawings, 2. joints, 3. mouldings, 4. a type of chisel?.....

1	2	3	4
---	---	---	---

95. The term "T and G" refers to 1. joints, 2. nails, 3. screws, 4. hinges?.....

1	2	3	4
---	---	---	---

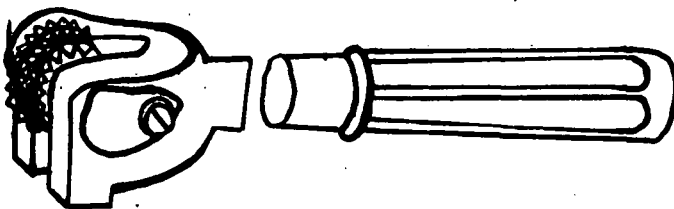
96. Which of the following statements is generally accepted
1. tread plus twice the riser equals 42
2. tread plus twice the riser equals 68
3. tread multiplied by the riser equals 36
4. tread multiplied by the riser equals 72?.....

1	2	3	4
---	---	---	---

97. What do you call the operation of chopping or planing joists so that all will have the same crown 1. cambering, 2. spreading, 3. furring, 4. chamfering?.....

1	2	3	4
---	---	---	---

98.



This is used for
1. patterning hard-wood
2. dressing emery wheel discs
3. setting saws
4. threading screws..

1	2	3	4
---	---	---	---

99. You would apply wallboard with 1. 2 1/2" finishing nails, 2. 1 1/4" fine nails, 3. 1 1/2" common nails, 4. 2" common nails?.....

1	2	3	4
---	---	---	---

100. What do you nail to the doors and windows to be used for guides in plastering 1. furring, 2. lathes, 3. grounds, 4. battens?.....

1	2	3	4
---	---	---	---