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A testing program of machine shop practices for a cooperative industrial school

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A TESTING PROGRAM OF MACHINE SHOP PRACTICES
FOR A COOPERATIVE INDUSTRIAL SCHOOL

Submitted by

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CHAPTER I
INTRODUCTION

The purpose of this paper is to create for industrial education a series of testing instruments, which when administered will objectively measure student progress in machine shop practices. The author has based his study on the hypothesis that within the structure of any vocational training program, a record of progressive achievement must be recognized and evaluated. It is believed that these testing instruments will not only measure manipulative progressions, but will also evaluate task-associated knowledges. It should be understood that these tests are devised primarily for testing purposes in a cooperative industrial school, and should not be considered as a course outline of study procedures; neither are they to be construed as being a series of mechanical comprehension or aptitude tests.

Within such limits of use they are intended to be of immediate value:-

1- To the teaching staff, in that they will
   a- offer measures for objective evaluation of task abilities, and
   b- provide analytical measures for diagnostic purposes.
2- To the administrative staff, in that they will
   a- assist in student selection for industrial placement and
   b- offer a means of checking on follow-up of industrial training progress.

One of the recurrent questions dogging mankind from the time when society first began to organize itself, down to our own troubled days has been this, "Is the workman worth his hire?" Answering it has posed many other questions including, "What specifically did the workman hire out to do?" "Just what is his potential ability?"

It is significant, perhaps, that the earliest written documents still extant, are not the great dramas, epic poems or historical chronicles, but "a very great abundance of the day to day memoranda of the people of Babylonia and Assyria, business accounts and ledgers of private firms, contracts drawn up in cuneiform". In other words, these ancient clay tablets measure the commercial worth of workmen who died several millennia ago.

Through the ages it has not been expected, in general, that the craftsman should govern nations:- yet as a

writer of Ecclesiasticus said of them, "All these put their trust in their hands and each becometh wise in his own work. Without these shall not a city be inhabited. They will maintain the fabric of the world, and in the handiwork of their craft is their prayer".¹/

During the Middle Ages a great forward step was taken when workingmen established their own trade guilds, the regulations governing employment conditions, and most of all elaborate systems of apprenticeships and training, to insure a steady supply of experienced laborers skilled in the techniques of the trades. In Italy, under the great Countess Matilda (1052-1115), the guild system emerged so strongly as to "form the basis of the city government of Florence".²/

Variations of these trade guilds persisted into modern times and crossed the Atlantic to the New World. Much interesting reading can still be found in the apprentice documents of Colonial America.³/ The nineteenth century, with its scientific advances and industrial revolution produced conditions which made it increasingly necessary to maintain an effective system of supervised apprenticeships.

¹/ Ecclesiasticus XXXVIII, 31-34


³/ Esther Forbes, Paul Revere And The World He Lived In, Boston, Houghton Mifflin Co., 1942, Chap. 2
Today's enormous factories, assembly-line methods, and productions demand new approaches to technical training and raise more sharply than ever the age old question, "Is the workman worth his hire?" Modern employers, pressed by business competition on the one hand and by mounting demands of labor unions on the other, must know the answer before hiring a prospective employee. There is little room for costly errors in judgment, particularly in the highly organized field of machine shop practices.

As a direct result of these historical developments, the public school system has been increasingly called upon to become the training center for the factories of the nation. Thus the educational trends within the public schools have expanded from the purely academic instruction to include education for industrial needs. The instructors in the school shop have taken over the educational work of the master craftsman. It is they who must now certify just what the school can do to make the workman worth his hire.

An effective testing program is one means of revealing the relation between student qualification and industrial need. It is hoped that through the use of the machine shop activity testing program here to be presented, a long-range closer correlation between student training and industrial demands will result.
CHAPTER II

HISTORY AND AIMS OF VOCATIONAL EDUCATION IN MASSACHUSETTS

A full and fair appreciation of the need for and purposes of an objective system of testing instruments can be arrived at more readily by reviewing the history, aims, and regulations governing vocational education in Massachusetts.

The establishment of vocational education as a part of the formal educational system of Massachusetts dates back to 1906, and is based upon the report submitted by the so called Douglas Commission:

"The report, in 1906, of the Commission on Industrial and Technical Education, appointed by Governor Douglas in the preceding year, by authorization of the General Court (Chapter 4, Acts of 1905).... The Commission found.... that the haphazard and uneven preparation of employees in skill and in industrial intelligence was already a serious problem".1/

The far reaching recommendations of the report are based upon the concept that vocational education is "education of which the primary purpose is to fit pupils for profitable employment".2/

1/ The Commonwealth of Massachusetts, Bulletin of the Department of Education, Number 5, Whole Number 326., p.6
2/ Ibid., p.6
Pupil Admission

The basic qualifications for governing the admission of students to the vocational education program, established by statutory requirements are:

"Pupils must be at least fourteen years of age:- must have made a deliberate choice of the occupation in which they are respectively enrolled:- must show presumptive ability to profit by the instruction and to succeed in the chosen occupation". 1/

From these two facts it will be noted that vocational education was organized to meet the needs of adolescent students whose interests and aptitudes were vocational.

Physical Organization

To implement the law, the Department of Education of the State of Massachusetts was faced with planning and creating suitable facilities for carrying out an effective policy of vocational education.

Over a period of time it divided the field of vocational education into the following four units:-

1- Trade and Industry
2- Household Arts and Adult Homemaking
3- Agriculture
4- Distributive Occupations 2/

1/ Ibid., p.34
2/ Ibid., p.7
In all of these areas instruction is now offered to either males or females in

1- day schools and general vocational departments in day schools
2- part-time schools
3- part-time cooperative schools and industrial departments in part-time cooperative schools
4- evening schools.

This paper, however, is concerned with only the first of these four units: viz., "trade and industry, part-time cooperative schools".

Cooperative Industrial Schools
for Machine Shop Practices

Massachusetts has four cooperative industrial schools for training machine shop practices:-

East Boston High School
Hyde Park High School
Beverly Trade School
Cole Trade School¹/

The supervision of these schools depends on the joint administration of the local school systems and the Commonwealth of Massachusetts, Division of Vocational Education, A Guide to Vocational Education in the Commonwealth

¹/ Commonwealth of Massachusetts, Division of Vocational Education, A Guide to Vocational Education in the Commonwealth
The funds for maintaining these schools are obtained from the local school budgets, plus subsidized state and federal funds allocated by the Smith Hughes Act of 1917, later supplemented by the George Dean Act.

The schools follow a balanced schedule which allows one half of the time for shop training and one half for related subjects and physical training. Through the curriculum every effort is made to develop the students attending these schools in a fashion that will enable them to go out into the community and into their respective industrial establishments equipped for living and working with others.

The purposes and aims of cooperative education are based on the following concepts:-

1- That the cooperative industrial school recognizes the possibilities inherent in vocational education.

2- That it must advance a type of education which recognizes interests and aptitudes, and prepare the individual to do the important tasks involved in bringing them to fruition.

3- That vocational education will offer a
direct contribution to those seeking immediate preparation for life's work.

4- That the study will terminate in graduation and with the award of a certificate and diploma.

The author expresses his belief that a sound strengthening agent of a testing program for shop activities, to measure objectively the student's educational status, will add materially in enhancing the purposes and aims of the expressed Act and its subsequent regulations. It is his intent to advance a plan of educational testing which, when administered and recorded, will measure the degree of adherence to which these expressed concepts are and can be fulfilled.
CHAPTER III

PURPOSE AND NEED OF TESTING INSTRUMENTS IN THE
SHOP ACTIVITIES OF AN EDUCATIONAL PROGRAM

At the very outset, it must be recognized that the educational procedures in cooperative industrial schools differ. No two schools follow the same plan: in fact, it is rare for two shops within the same school to follow an identical training pattern.

The reasons for this lack of uniformity are primarily caused by differences in 1,- the layout and equipment of the respective shops and 2,- the qualifications, interests, strengths and emphases, and background of the teaching staff. Obvious secondary differences arise from the individual problems of the student and from the varying demands of industry.

Since state and federal administrative regulations for cooperative industrial education specifically require that a 50-50 schedule be followed, i.e. one half of the curricula hours be allocated to shop training and one half to related subjects and physical education, a certain amount of coordination, of course, does exist. This coordination involves classroom instruction and training either in the school, shop, or within industry.
Two broad educational plans are substantially followed:

1- One week of class room study alternating with one week in the school shops or
2- One week of class room study alternating with one week out in industry.

In both approaches the class room instruction remains constant. That portion which concerns the shop and the student, however, is variable. Herein the student is subject to change of educational environment: - for example, readjustment to new personalities, changing industrial tempo, new working conditions with increased manual and emotional responsibilities.

Furthermore, local situations often give rise to a third plan, wherein the student has not only been subject to a change from plan 1 to plan 2 in his earlier experiences, but after a period of training in industry, is returned to the school shop for additional training. This third plan requires both re-evaluation of task abilities and student re-adjustment to the class.

These intermittent shop changes create a continuing condition of flux within the training program which result in disjointed educational progress. This in turn invites subjective evaluations of student achievements.
A still further complication stems from the fact that neither shop study plan provides for simultaneous advancement of the group as a whole. Cooperative industrial education, as it relates to its shop activities, is, by its very nature, based on the individual's ability to achieve.

Appended to the needs already pointed out are the following factors, some of which are unusually significant in industrial education:

1- shop classes are heterogeneous in student composition in that they are composed of
   a- an amalgam of sophomores, juniors and seniors, which make for age and size differences
   b- a diversity of mechanical aptitudes
   c- a variation of intelligence quotients
   d- a variance in the degree of student application.

2- shop facilities for instruction are not uniform:
   a- equipment is not laid out with reference to a common unit of instruction:
      for example, lathe work is not laid out for the exclusive use of sophomores.
b- the aggregate equipment varies in amount and content: i.e., the type and number of training stations are not consistent.

3- the teaching of related information, from school to school, is not necessarily integrated with respective shop activities. More obviously, it will vary with school shops and industrial shops.

4- under present conditions, shop teachers, industrial foremen and administrative personnel lack uniform methods for evaluating student progressions, and so present opinions which are largely subjective.

Thus, by way of recapitulation, it is clear that the program of cooperative industrial education is based upon so many diffusing factors that by its very nature it provokes some system of testing which will produce demonstrably objective evaluations. This was recognized as early as 1911 when included in the administrative regulations we find

"Some definite method of checking, inspecting and routing the pupil through a series of projects, calculated to give the desired instruction is necessary. This can be accomplished.... carefully planning the
specific requirements which the pupil is to meet and deal with... 1/

The purpose and need of testing instruments in the shop activities of an educational program extend, however, beyond the immediate needs of co-ordinating the evaluation of student progress. The acceptance of cooperative industrial education into the field of industry is dependent upon the ability of the school to produce a student whose value will be of measurable worth to its purchaser. In other words, the school must certify that the "workman is worth his hire". This necessity demands a school of increasing tempo, closely corresponding to contemporary industrial demands. The individual must be adapted, by his training, to the exacting needs of the modern work shop.

The tradition of American education has always tended to mould individuals adjusted to the world in which they are to take their place. More specifically, it has equipped its industrial workers for their particular responsibilities. When one considers that a century ago it took a capital of only $557 to provide tools, machines, and plant facilities for the American factory worker, and that today it takes eleven times as much capital, or a total of over $6,000 for the corresponding worker, the obligation upon

1/ Commonwealth of Massachusetts, Information Relating to the Establishment and Administration of State-Aided Schools Bulletin 1940, Number 5, Whole number 326, p.33
the vocational schools of the country to develop effective teaching programs is truly compelling. Only if vocational education keeps pace with the mounting demands for effectively trained youth will it fulfill its intended purpose.

More effective control of student progress through more exact testing instruments is perhaps the most direct means of increasing efficiency of school shop techniques, thus paralleling the industrial development of industry.

Summary

As has been stated, the complexities of a cooperative industrial training program, its administrative regulations, student differences, and teacher subjective tendencies, combine to present a pressing need for a progress testing program, to bind its intricacies together. Secondary needs stem from the increased costs of vocational education and the multiplying efficiencies of industry with its concomitant demand for highly trained workmen. In light of these pressing factors, vocational education is constantly being called upon to re-evaluate its own training program. The need for strengthening educational procedure is in evidence. The author feels that a well planned unit of shop practice tests is in order.

\[1/\] Trends, Vol. 5, No. 8, New York, National Association of Manufacturers.
CHAPTER IV

RESEARCH

Many studies, including those of testing instruments, are now available which purport to predetermine mechanical interests, comprehensions and aptitude factors. Systematic investigation can produce a number of industrial tests and technical information tests for machinists, for post educational analysis.\(^1\) Between the pre and post educational lies the area of supervised vocational training and its demonstrable need for a testing structure. Unfortunately, even a careful search for progress record tests covering this period reveals little material of an objective nature which can be accepted for use in the vocational schools.

The author, in his research, was limited to material which would correlate with a typical part-time industrial school. This type of program calls for three years of training, or sixty shop weeks, with units of approximately twenty-seven training hours. In total hours this means, 1620 hours of training, reinforced by such additional hours as the student has worked in industrial plants outside of the regular school program.

\(^1\) For selected list of such tests see bibliography p. 30
Study of progress records for schools show that in Massachusetts at least, the dominant practice has been to determine progression either in terms of hours of application at each fundamental practice: i.e. rough turning x hours, or in terms of progressive accomplishment in the job task, for example:- evaluated as: $\frac{1}{4}$ done, $\frac{3}{4}$ done... or completed.

It is the opinion of the author that progress determined under either of these plans cannot be objectively substantiated. Hours of application in themselves, unless tied up with a defined task, do not necessarily determine the nature and degree of progression, and therefore cannot be considered as an objective means of measurement. The same may be said of a job task evaluated when it is only partially completed. Mechanical tasks carry with them predetermined and definite associations, which include limitation in size and quality of workmanship, together with a working duration norm. Thus, it would seem, objective appraisal placed on a task which is only partially completed cannot be merited.

In his research, the author was able to find many teaching programs designed for all inclusive and progressive presentation of machine shop practices. In no instance, however, was he able to find an established testing program
to parallel these presentations. It would seem that herein lies the opportunity for a constructive study in testing for progress record purposes. These testing factors should so be devised as to eliminate subjective impressionistic ratings of the student, and in so doing also determine a quantitative and qualitative analysis. It is hoped that the author's work with this problem will promote further discussion by others in the field and thereby justify it as history in the making.

Because of the writer's hypothesis that all job tasks carry a need for associated information, the correlative purpose of his research was to ascertain if testing material was available which would measure the student's ability to carry with the job, the related knowledge of the job itself. If that hypothesis is granted, it would clearly be advisable that the coordination of task and technical related factors be included in one test, since that type of testing would result in a more thorough and understanding evaluation of the student abilities.

One outstanding psychologist has defined linkages of knowledge and responsibility as part of the "linkage theory of maturity". This theory sees man as one who learns to

live by, and through, relationships of thought and action. It is hoped that the writer's combined manipulative and mental faculties tests will, in part, contribute to life's educational process of developing this theory of maturation, that from isolated particulars grow an appreciation of the world of wholes:— a fuller realization of the "wholes of meanings".  

Appended to this paper, included in the bibliography, reference is made to a compilation of tasks issued in book form, which represents a collection of studies in machine shop practices. It also includes a quiz of information relating to the respective job. This, in part, substantiates an hypothesis that in vocational work, job tasks and associated knowledges should be closely correlated and can be included in one test appliance.

It is believed that the inclusion of questions of a factional nature relating to respective job tasks, within the structure of testing instruments will result in:

1. ascertaining a fuller comprehension of the student understanding

1/ Ibid., p.69

2- providing an analytical survey which will prove of value for diagnostic purpose
3- assisting the administration in the preparation of more effective coordination of shop activity, and class-room teaching of associated informations, and finally
4- stimulating the student for further need of insight into work relationships.
CHAPTER V

THE METHODS OF PROCEDURE FOLLOWED IN CONSTRUCTING THE TESTING INSTRUMENTS

In order to establish a valid foundation on which to base a series of objective testing instruments, the author studied the literature of machine shop practices, sent a questionnaire, and finally conducted a meticulous study of one school to obtain a working practicability of the tests.

As a result of this three-fold study it appeared that a working order could be established and a constructive plan of testing could be formulated. The following procedures were pursued in the development of the tests:

1- For that portion of test relating to the manipulative task
   a- research data of available test material was weighed,
   b- an analysis of existing training programs was made,
   c- an operation sheet of common practices was established, as a basis for the outline of the tests.

The results of the analysis disclosed certain common dexterity practices. A composite of these general practices
was then tabulated. Practices of an isolated nature peculiar to one particular school's needs, however, were not included.

**Machine Shop Practices Established**

**as an Outline for Tests.**

1- Lathe  
   a- rough turning  
   b- finish turning  
   c- angular turning  
   d- thread cutting  
   e- drilling and reaming  
   f- boring  
   g- chucking  

2- Drill  
   a- centering  
   b- plain drilling  
   c- layout for drilling  

3- Milling Machine  
   a- plain milling  
   b- end milling  
   c- angular milling  
   d- indexing  

4- Shaper and Planer  
   a- rough  
   b- finish  
   c- angular  

5- Grinding  
   a- straight  
   b- taper  

6- Miscellaneous  
   a- use of scale  
   b- micrometer  

It will be noted that certain seemingly important task tests have been eliminated from the category: the grinding of tools, for example. These have been omitted be-
cause, in the opinion of the test maker, they involve cer­
tain complexities that prove too advanced for the student
to understand against the background of its parallel relat­
ed information, and because it is felt that untested items
will be indirectly tested through the manipulative tasks in­
corporated in the tests which are advanced.

Written Responses Portion of Tests

The portions of the tests which require written re-
sponses were inserted with seven specific purposes in mind:-

1- to test for the immediate knowledge nec­
essary to carry the job task to completion
2- to test for related knowledge closely al­
lled with the job, but not vital for job
completion
3- to determine the student's ability to
carry over academic information into the
field of industrial work,
4- to provide the class room teacher of tech­
iques with a skeleton outline of coordi­
nate job task values, for teaching purposes,
5- to test for class and shop correlation ef­
ficiency
6- to test for student graded interests be­
yond the scope of dexterity,
7- to provide a summation of certain associated test questions, whose written response will provide a basis for remedial teaching.
CHAPTER VI

SUMMARY AND CONCLUSIONS

The field of machine shop practices, in its entirety, is so broad and varied that breaking it down into its component parts for an educational training program is no simple undertaking. The inherent difficulties do not mean, however, that no effort should be made. It is understood that the scope of vocational school testing implements should only be consistent with its training program, or the student's opportunity and ability to absorb its parts. Beyond this, educational testing of tasks and associated informations have no value in a vocational school.

One of our modern historians has said that a good guess is often the foundation of good history.... good guessing is not a haphazard process.¹ It may be said that in the construction of tests one must of necessity also employ reasonable deductions, as well as the testimony of other instructors in the field. In the compilation of each test advanced, the work order and its accompanying quiz had to be carefully weighed. The test program is based upon the author's formed opinion of good, but not decisive, reasoning. Decisive reasoning cannot be strictly adhered to

¹ Isabel Warrington Heaps, Five Marys, New York, Abingdon Cokesbury Press, p.7
when tasks and information factors are so multifarious.

By reason of administrative regulations, the author was cognizant in the construction of the tests, that each test job be of productive value when completed. He was also conscious of the fact that the program should not be time consuming to the extent that it interferes materially with the established training program. In reference to this, it is felt that the time consumed, in part at least, can be credited as both educational and productive in nature.

Twenty-four manipulative tests have been established, with approximately one hundred and fifty associated questions. These tests coordinate with the fundamental practices outlined in Chapter V. This overview test program result should constitute a somewhat inclusive picture of the student acquisition.

The program is now being processed, through student participation, in one cooperative industrial school. It has already been established in the author's opinion, that the test experiences are providing a well needed medium for the orientation of combined theory and task values. This new experience in testing has brought about a realization on the part of the student, that related theories and shop techniques must be retained as an integral part of his machine shop practices. The tests have also provided a motivation
for keeping note books, consulting handbooks of technical information. It is also evident that testing, with a potential school grade evaluation, has induced student reflection: that a closer check on his application, for both time and quality of workmanship, is being observed. He has become aware that the results of these tests will determine, in a measure, his progress and opportunity to enter the part-time industrial phases of work.

It was early recognized that this new structure of comprehensive testing was in need of a supporting program of preparatory instruction. Measures for more effective teaching were in order. The author enlisted the cooperation of one instructor of related shop techniques, who has appraised the testing program and is now developing and presenting a teaching program of associated science which closely parallels the purposes and needs of the test objectives. This added correlation should stimulate the necessary collective rationalization. A record of the associated teaching covering each test, and also the time of its presentation are being forwarded to the shop instructor. The shop teacher, as a result of this cooperation, is in a position to present the tests with reasonable assurance that all related content has been previously covered.

1/ Thomas O'Laughlin, Hyde Park High School, Boston, Mass.
At present, the testing program is being processed with approximately forty pupils, proportioned amongst sophomores, juniors, and seniors, which is yet too small in number to warrant conclusive decisions. It may be said, however, that the formal use of the task portion of the test has proved to be of definite value as an objective agent for evaluating qualitative shop practices. Quantitative appraisement of work must be left until such time as additional test results are available in sufficiently large quantity to establish reliable time norms.

The administrative recording of information and results has been considered. The author has prepared a summary record index plan to accompany the program. This record contains first, the date when the related task information was presented by the instructor of associated knowledges, and secondly, the quantitative and qualitative results of the individual's response to each test. It is planned that this record of cumulative results be advanced with the class to subsequent teachers, or to the administrative staff for such appraisal as it may wish to make.

1/ Copy included with tests in Part II
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PART II

THE TESTING PROGRAM

WITH DETAILED INTERPRETATION

OF ITS OBJECTIVES.
PART II

THE TESTING PROGRAM

Wherein Part I is devoted to outlining the purpose, need and procedure for the construction of testing instruments of machine shop practices, the author in Part II, presents the program with explanations and clarifications of its adherent objectives.

The program consists of twenty-two manipulative appraisals covering the major fundamental machine processes, coupled with approximately one hundred and fifty associated shop science questions. It should be emphasized that the author has stated in Part I that in the compilation of the material for such tests, the work order and the accompanying quiz had to be carefully weighed. The author's formed opinion is not to be construed as decisive. Machine shop practices provide task and related science information factors of such preponderance that conclusive reasoning for each test and its accompanying examination, is always held in abeyance. It is to be understood that these specimen tests should not be substituted for other tests, however, unless the substitutions are accompanied by objective measures.

In the presentation of the tests the author has had
in mind the student reactions. He has so arranged the pro-
gram that, among other things, the results will create an
awareness on the part of the student, that there is need
for retaining relationship of knowledges.

It will be noted that the tests contain question
matter which is taught foreign to his immediate shop expe-
riences. These pertain to mathematics, drawing, shop sci-
ence, and certain techniques:- all of which are educational
integrals taught outside of his school shop class. These
tests will solicit responses designed to encourage the
"value of wholes".

### Tests and their Objectives

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<th>Use of scale</th>
<th>Use of the micrometer</th>
<th>Centering round stock</th>
<th>Lathe - rough turning</th>
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<tbody>
<tr>
<td>Test 1</td>
<td>a- knowledge of fractions</td>
<td>a- nomenclature</td>
<td>a- working knowledge of hermaphrodite calipers, center head and scale, bell center, scriber, center punch combination drill and countersink and hammer.</td>
<td>a- material</td>
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<td></td>
<td>b- working concept of units</td>
<td>b- conversion values: fractions to decimal equivalents</td>
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<td>b- appreciation of size and use of outside calipers</td>
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<td></td>
<td>c- spatial relations</td>
<td>c- reading comprehension</td>
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c- tolerance  
d- names of cutting tools  
e- operation of machine  

Test 5 Lathe- finish turning  
a- addition and subtraction of fractions  
b- working use of the micrometer  
c- appreciation of limited sizes  
d- close machine manipulation  

Test 6 Lathe- rough taper turning  
a- machine nomenclature and purposes  
b- mathematical interpretation of a formula  

c- appreciation of limited sizes  
d- close machine manipulation  

Test 7 Lathe- finish taper turning  
a- further understanding of practical needs of a formula  
b- additional understanding of machine manipulation (taper attachment)  
c- use of handbook and names of common standard tapers  
d- differentiating of materials  

Test 8 Lathe- angular turning  
a- additional machine manipulative comprehension:- compound  
b- degree measurement  
c- understanding the purposes of "hard and soft" materials  

Test 9 Lathe- chucking  
a- purpose of universal and independent operated chucks  
b- task of "trueing up" a piece of material  

Test 10 Lathe- drilling and machine reaming  
a- sequence value of operations  
b- allowances for reaming:- use of the machine reamer  

Test 11 Lathe- boring  
a- boring to exacting size:- use of inside calipers and transfer to the micrometer  
b- inside boring and counterboring  
c- evaluation of sequence of operations
Test 12 Lathe- threading
a- threads: National coarse and fine
b- grinding tools to thread form
c- threading procedures: use of machine dials, etc.

Test 13 Drills
a- names of specific parts and their purposes
b- task of properly grinding drills

c- test

d- The author suggests that this same test and test piece be expanded to include spot facing, counterboring and countersinking

c- Test 14 Drilling
a- use of dividers for accurate layout
b- mathematics: chord, circumference, interpretation and use of formula results
c- measurement "over plugs"
d- operation of drill press
e- The author suggests that this same test and test piece be expanded to include spot facing, counterboring and countersinking

Test 15 Drilling and tapping
a- tap differentiation
b- national coarse and fine
c- selection of tap drills

c- Test 16 Shaper and shaping
This test sample piece is designed with various intents
a- for use as a specimen for simple machine manipulation: learning to "square up", which in turn requires the understanding and use of the square
b- for angular machining, degree measurement, knowledge of clapper box features
c- for knowledge and ability to measure over rods
d- for evaluating student ability to solve the related problems in trigonometry

Note
It is to be understood that the time involved in doing this test is to be based on such part or parts as the tester wishes to incorporate
Test 17 Shaper- cutting a keyway
  a- knowledge of keyways and keyway dimensions
  b- grinding the tool for accuracy
  c- determining central tool setting

Test 18 Planer- plain and angular machining
  a- mathematics: geometry (parallel lines cut by a transversal)
  b- experience of working without a vise

Test 19 Planer- advanced work
  a- parallel adjustment of the rail
  b- knowledge of down feed adjustment
  c- perception for the need for "square"

Note
The author presents this test with reservations. He is aware that the test is time consuming, and also embodies preliminary training that may not be justified in all cooperative industrial training programs. The test will justify itself only as its respective training program calls for it.

Test 20 Milling Machine- Plain and form cutting
  a- elevation and cross feed values
  b- radius cutters
  c- cutter rotation

Test 21 Milling Machine- End milling
  a- vertical milling
  b- sequence of operations
  c- law of leverage

Test 22 Milling Machine- Indexing
  a- gear tooth values
  b- selection of gear tooth cutters
  c- indexing

Test 23 Grinding- straight and taper
  a- machine manipulation for straight and taper work
  b- lapping
  c- trueing the wheel
Test 24  Forging
   a- hand and eye coordination
   b- appreciation of heat and color values
THE CUSTOMARY LENGTH OF A MACHINIST RULE IS {3", 4", 6"}

THE UNIT "1" INCH IS DIVIDED INTO 5-1/2" SCALES. TRUE - FALSE

HOW MANY 1/8" UNITS IN "1" INCH ________________

HOW MANY 1/8" THS IN THREE QUARTERS OF AN INCH ________________

THE SMALLEST UNIT ON THE RULE IS 1/1000, 1/100, 1/64 ________________

1/8" OF AN INCH HAS HOW MANY 1/32" NAS. ________________

1/32" ND OF AN INCH IS DIVIDED INTO ________________

HOW MANY OF THE SMALLEST UNITS ARE IN "1" INCH ________________

3/8" CONTAINS HOW MANY 1/16" THS. ________________

5/16" CONTAINS HOW MANY 1/32" NAS. ________________

HOW MANY 1/64" THS IN 9/16 ________________

17/32" IS WHAT RELATION TO 1/2 ________________

17/32" IS WHAT RELATION TO 9/16 ________________

THREE QUARTERS OF AN INCH CONTAINS 48" TRUE - FALSE ________________

WHAT IS THE LENGTH OF BLOCK "A" ________________

INCREASE BLOCK "A" LENGTH 1/64 ________________

INCREASE IT'S LENGTH 1/32 ________________

DECREASE BLOCK "A" LENGTH 1/64 ________________

TIME STARTED ________________ TIME COMPLETED ________________ TOTAL TIME ________________

NAME ________________ CLASS ________________ DATE ________________ TEACHER'S REMARKS GRADE ________________
NAME PARTS

"A" "T" "S" "R"

THE MICROMETER READS WHAT PART OF AN INCH
THE NUMERICAL VALUE "1" ON THE BARREL MEANS WHAT
THE LINES BETWEEN "0" AND "1" REFER TO
THE BARREL VALUES REGISTER WHAT VALUES.
READ THE VALUE REGISTERED ON "M"
READ THE VALUE REGISTERED ON "N"

CONVERT THE FOLLOWING VALUES IN MICROMETER READINGS

\[
\begin{align*}
\frac{1}{4} & \quad \frac{3}{8} & \quad \frac{9}{16} & \quad \frac{17}{32} & \quad \frac{15}{64}
\end{align*}
\]

CONVERT THE FOLLOWING MICROMETER READING INTO FRACTIONS

\[
\begin{align*}
0.025 & \quad 0.3125 & \quad 0.9375 & \quad 0.390625
\end{align*}
\]

TIME STARTED | TIME COMPLETED | TOTAL TIME

NAME CLASS DATE TEACHER'S REMARKS GRADE
CENTERING ROUND STOCK FOR MACHINE TURNING

1. MACHINE OPERATION "A" IS CALLED ________________________

2. THE TOOL COMMONLY USED FOR OPERATION "A" IS CALLED ________________________

3. INSTRUMENTS SOMETIMES USED FOR LOCATING THE CENTER OF ROUND STOCK ARE "B", "C", AND "D"—NAME THEM:
   "B" ________________________
   "C" ________________________
   "D" ________________________

4. WHEN THE WORK IS CENTERED IN A TRUE RUNNING LATHE CHUCK THE PIECE BECOMES SELF-CENTERED AND NEEDS NO LAYOUT—NOTE-CIRCLE ANSWER TRUE FALSE

5. WHICH TOOL IS MISPLACED IN THE FOLLOWING GROUPING
   1. CENTER PUNCH  2. CENTER GAGE
   3. CENTER SQUARE  4. CENTER DRILL

6. COUNTERSINKING BEYOND THE DEPTH OF THE ANGLE OF THE COUNTERSINK "B" WILL GIVE THE LATHE CENTER ________________________
   1. MORE SURFACE BEARING
   2. LESS SURFACE BEARING

TIME STARTED TIME COMPLETED TOTAL TIME ________________________

NAME CLASS DATE TEACHER'S REMARKS GRADE ________________________
**LATHE ROUGH TURNING**

![Diagram](Image)

**MATERIAL:**
COLD DRAWN STEEL

**MACHINING TOLERANCE:**
PLUS OR MINUS \( \frac{1}{64} \)

1. KIND OF MATERIAL TO BE USED IS:

2. ALL SIZES MUST BE KEPT WITHIN A PLUS OR MINUS OF:

3. THE OVERALL LENGTH OF MATERIAL WHEN FINISHED IS:

4. THE LARGEST DRAWING DIAMETER IS:

5. THE LARGEST POSSIBLE DIAMETER IS:

6. THE SMALLEST POSSIBLE DIAMETER IS:

7. WHAT ARE THE LONGEST AND SHORTEST POSSIBLE LENGTHS OF "A"?

8. CAN ALL LENGTHS BE INCREASED SIMULTANEOUSLY - YES OR NO

9. WHAT IS THE NAME OR TYPE TOOL USED FOR, MACHINING "B"?

10. WHAT IS THE NAME OR TYPE TOOL USED FOR, MACHINING "C"?

11. WHAT IS THE NAME OR TYPE TOOL USED FOR, MACHINING "D"?

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1. Material to be used is (1) Low Carbon Steel (2) High Carbon Steel (3) Neither

2. Overall length is

3. Largest diameter of 1/4 is which .1250 or .1255

4. Smallest diameter of 1/2 is which .495 or .505

5. "A" length is

6. What part of 1/1000 of an inch is .006

7. Give the largest "B" diameter

8. Give the smallest "C" diameter in thousands

9. The difference between the largest and smallest "C" diameter is

10. The difference between the largest and smallest "E" diameter is

11. Machine piece according to specifications

Time Started | Time Completed | Total Time

Name | Class | Date | Teacher's Remarks
TAPER TURNING - ROUGH

1. MATERIAL TO BE USED IS

2. OVERALL LENGTH IS _______ LARGEST FINISHED DIAMETER IS _______

3. EXPRESS THE NAME FOR THIS TYPE OF TURNING

4. THE BEST RESULT FOR TURNING THIS SHAPE IS TO
   1) TURN THE COMPOUND
   2) OFFSET THE TAILSTOCK

5. THE FORMULA FOR OFFSETTING A TAILSTOCK WHEN TURNING A TAPER IS

\[
\text{TOTAL LENGTH OF STOCK} \times \text{TAPER PER INCH} \div 2
\]

A) DETERMINE THE OFFSET IN TERMS OF THOUSANDS
B) CONVERT THIS ANSWER INTO THE NEAREST FRACTION THAT CAN BE READ ON THE RULE

6. JOB TASK:
   OFFSET TAILSTOCK AND TURN PIECE TO DRAWING SIZES

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FINISH TAPER TURNING

MORSE TAPER .608 PER FOOT

1. THE ABOVE PIECE IS TO BE USED FOR LATHE CENTERS
WHAT KIND OF STEEL SHOULD BE USED?

2. DETERMINE THE OFFSET OF THE TAILSTOCK FOR
TURNING TAPER BY RULE.

OFFSET = \frac{\text{TOTAL LENGTH OF STOCK} \times \text{TAPER PER FOOT}}{2 \times 12}

3. WITH USE OF HANDBOOK DETERMINE NUMBER OF TAPER.

4. IN WHAT OTHER MACHINE BESIDES A LATHE IS A
MORSE TAPER USED?

5. NAME ONE OTHER COMMONLY USED TAPER.

6. WHERE IS THIS OTHER TAPER USED?

7. COULD THE TAPER BE CUT OTHER THAN BY
OFFSETTING THE TAILSTOCK?

8. JOB TASK:
TURN AND FILE FINISH TO FIT TAPER GAGE

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"TRUEING UP" CENTERS

1. The operation of turning up a center is done by
   1. Taper turning
   2. Angular turning

2. The included angle of a center "A" is
   1. 30°  2. 45°  3. 60°  4. 90°

3. The lathe center is made from
   1. Machine steel  2. Cold drawn steel
   3. Tool steel

4. The angle for machining a center is obtained by offsetting
   1. The carriage  2. The tailstock
   3. The compound

5. The compound rest is graduated to read in

6. What should the compound read when ready to "true up" the center?

7. Is it the general policy to harden the headstock center after machining?  1. Yes  2. No

8. Is the same policy applied to the tailstock center

9. Explain your deduction to answers 7 and 8

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NAME          CLASS          DATE          TEACHER'S REMARKS         GRADE
LATHE - CHUCKING

COMPLETE THE FOLLOWING SENTENCES:

A UNIVERSAL CHUCK IS ONE WHOSE JAWS

AN INDEPENDENT CHUCK IS ONE WHOSE JAWS

THE ADVANTAGE OF A UNIVERSAL CHUCK IS THAT

THE DISADVANTAGE OF A UNIVERSAL CHUCK IS THAT

WHAT TYPE OF CHUCK WOULD YOU CONSIDER "A" AND "B"?

A.

B.

JOB TASK:

TRUE UP THE FOLLOWING SHAPES OF MATERIAL WITHIN 1/64 OF AN INCH USING WHICHEVER CHUCK YOU THINK BEST

1. ROUND  2. SQUARE  3. HEXAGONAL  4. OCTAGONAL

NOTE: CHECK WITH INSTRUCTOR AFTER EACH TASK MEETS THE REQUIREMENTS

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1. The first operation when machining a blank as shown is,
   A. drill hole
   B. machine face "A"
   C. center with center drill

2. The second operation is A, B or C

3. How much undersize should the hole be drilled to allow for machine reaming?

4. Give two causes for a reamer cutting a hole oversize
   A
   B

5. After machining "A," and finish reaming the hole, the next operation is:
   A. turn piece around in chuck and face "D"
   B. put work on an arbor
   C. neither

6. If answer is "C" explain answer

7. Job task: To machine ream for the hole size and finish machine all over

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Name  Class  Date  Teacher's Remarks  Grade
1. Note "A" and "B" sizes: Are they termed as standard sizes?

2. By which method would you machine finish "A" and "B" diameters?
   A. Drilling
   B. Drilling and boring
   C. Drilling, boring and reaming

3. Which internal size would be most difficult to complete and why?

4. The 2 1/2" diameter must run exactly concentric with the hole. How is it to be machined?

5. The back face must also run true with the front face. How is this to be accomplished?

6. Job task
   Machine thrust collar according to drawing specifications

   TIME STARTED  | TIME COMPLETED  | TOTAL TIME
   __________    | __________      | ________

   NAME  | CLASS  | DATE  | TEACHER'S REMARKS | GRADE
   __________ | __________ | __________ | __________ | __________
1. THE THREAD ABBREVIATION TERM N.C. MEANS

2. THE THREAD ABBREVIATION TERM N.F. MEANS

3. THE \( \frac{3}{4} \)-10 AS SHOWN IN THE SKETCH IS BROKEN DOWN TO MEAN: \( \frac{3}{4} \) FOR \(-10\) TO MEAN

4. THE INCLUDED ANGLE "A" IS 30°: TRUE OR FALSE

5. GIVE THE CORRESPONDING N.C. FOR \( \frac{1}{2} \)-20 N.F.

6. THE U.S.S. FORM OF THREAD HAS A FLAT AT THE TOP AND BOTTOM WHEN CORRECT: TRUE OR FALSE

7. THE APPROVED METHOD OF CUTTING A THREAD IN A LATHE IS BY FEEDING THE COMPOUND IN AT AN ANGLE: TRUE OR FALSE

8. THE TOOL FOR CUTTING A THREAD IS GROUND TO AN ACCURATE ANGLE BY USING WHAT GAGE

9. SET UP IN THE LATHE AND CUT BOTH THREADS AS SHOWN IN THE DRAWING

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NAME CLASS DATE TEACHER'S REMARKS GRADE
DRILL GRINDING

A" is known as:
1. Center
2. Cutting Edge
3. Cone

Angle of "B" is:
1. 56°
2. 59°
3. 60°

The heel of a drill is the portion back of lips or cutting edge — — — — — — — — — — — — — — TRUE OR FALSE

The lip clearance is the surface of point that is ground away just back of the lips — TRUE OR FALSE

The shank is another word for:—
1. Tang 2. Web 3. Portion that fits into the spindle or chuck

The commonly used taper shank is:—

The clearance surface back of the cutting edge should be:—
1) 8° to 12° 2) 12° to 15° 3) 15° to 20° 4) 25° to 30°

What will happen if the speed of drill is too great?

Job task:— To properly grind a drill to cut within 1/64 of an inch

TIME STARTED  TIME COMPLETED  TOTAL TIME

STUDENT  CLASS  DATE  TEACHER'S REMARKS  GRADE
LAYOUT, DRILL, AND MACHINE REAM

ALL HOLES $\frac{5}{16}$ REAM

A. 
B. 
C.

JOB TASK

LAYOUT, DRILL, AND MACHINE ACCORDING TO "A" "B" "C"

1 WHICH OF THE FOLLOWING TOOLS ARE NOT NECESSARY?
A PROTRACTOR
B COMBINATION DRILL AND COUNTERSINK
C CENTERPUNCH
D HAMMER
E DIVIDERS

2 IS THIS TRUE OR FALSE?
The distance from center to center is found by dividing the circumference by the number of holes

3 THE FOLLOWING CONSTANTS ARE SUPPLIED FOR YOUR CONVENIENCE
LET 
D = DIAMETER
C = DISTANCE FROM CORNER TO CORNER

4 WHAT IS THE BEST REAMER SIZE DRILL FOR $\frac{5}{16}$ REAM

5 NOTE: CHECK OVERALL DIMENSIONS OF HOLES. THE DIMENSIONS MUST COME WITHIN A TOLERANCE OF .015
DRILLING AND TAPPING

1. TAPS ARE KNOWN BY THEIR DIAMETER AND

2. THERE ARE 3 DIFFERENT KINDS OF TAPS

3. WHAT IS MEANT BY THE N.C. STAMPED ON A TAP

4. WHAT IS MEANT BY THE LETTERS M.F.

5. WHAT IS MEANT BY THE TERM "TAP SIZE DRILL"?

6. WHAT IS MEANT BY "BODY SIZE TAP"

7. HOW WOULD YOU DETERMINE THE TAP SIZE DRILL FOR A
   $\frac{1}{2} - 13$ TAP

---

**JOB TASK:** DRILL AND TAP FOR $\frac{1}{2}$ N.C. THREAD
DRILL AND TAP FOR $\frac{3}{4}$ N.C. THREAD

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Boston University
School of Education
Library
MATERIAL TO BE USED IS
ALLOWED AMOUNT OF SIZE VARIATION IS
DIMENSION "A" IS
DIMENSION "C" IS
ANGLE "B" IS
THE ANGLE ROTATION FOR SHAPER HEAD IS
1. 50° 2. 30° 3. 60°
THE SHAPER LENGTH OF STROKE IS SET FOR
2". 3". 4"
AFTER ONE ANGLE IS FINISH MACHINED, THE PIECE SHOULD BE REVERSED IN THE VISE BEFORE MACHINING OPPOSITE SIDE: TRUE OR FALSE

TIME STARTED  |  TIME COMPLETED |  TOTAL TIME

STUDENT | CLASS | DATE | TEACHER'S REMARKS | GRADE
SHAPER TO CUT KEYWAY

THE CUTTING TOOL USED FOR MACHINING A KEYWAY IS GROUND SIMILAR TO A ____ OFF TOOL.

THE PURPOSE OF THE DRILLED HOLE IS TO PROVIDE CLEARANCE FOR THE CUTTING TOOL AT THE END OF THE STROKE ———— YES □ NO □

HOW MUST THE TOOL BE LOCATED WITH REFERENCE TO THE CENTER LINE OF THE SHAFT ————_

THE DEPTH OF THE KEYWAY IS USUALLY THE SAME AS THE WIDTH ———— TRUE OR FALSE □

WHAT WOULD YOU USE AS A GAGE FOR DETERMINING THE LIMIT SIZE OF THE WIDTH OF THE KEYWAY?

ANS. ————

IS THIS TYPE OF KEY AND KEYWAY SOMETIMES REFERRED TO AS A WOODRUFF KEY? YES OR NO □

IF NOT, DRAW A SKETCH OF A WOODRUFF KEY

JOB TASK: ——
MACHINE KEYWAY TO DRAWING SPECIFICATIONS.

TIME STARTED TIME COMPLETED TOTAL TIME

NAME CLASS DATE TEACHER'S REMARKS GRADE
PLANE AND ANGULAR MACHINING

NOTE: THIS JOB IS TO BE DONE WITHOUT THE USE OF A VISE. THE MATERIAL TO BE USED IS 3"x7/8"x30".

IF SURFACE "C" IS MACHINED FIRST, WHICH OF THE FOLLOWING ARE NOT NECESSARY?

BEDRAILS, JACKS, STRAPS, BOLTS OR PINCHDOWNS

WHEN MACHINING THE 25° ANGLE THE PIECE IS SUPPORTED BY A CORRESPONDING ANGLE (SEE SKETCH)

WHAT PROBLEM IN GEOMETRY DOES THIS SUGGEST?

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THE PLANER

MACHINING AN ANGLE IRON

AN ANGLE IRON IS MADE FROM WHICH?
A FORGING
A CASTING

COMPLETE THIS SENTENCE. ALL WORKING FACES OF AN
ANGLE IRON MUST BE SQUARE

WHICH OF THE FOLLOWING TOOLS ARE NOT REQUIRED
IN THE SETUP FOR THIS JOB

STOPS
CLAMPS
JACKS

SQUARE
SHIMS
CENTER HEAD

MARK WITH A CROSS (X) THAT PORTION OF THE ANGLE
IRON CALLED THE RIB

JOB TASK: MACHINE & FINISHED WORKING SURFACES
OF AN ANGLE IRON.

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MILLING MACHINE-PLAIN AND FORM CUTTING

MATERIAL TO BE USED IS ______________________________
THE PURPOSE OF USING TOOL STEEL IS SO THAT THE PIECE CAN BE _______ AND ________
DIMENSION "A" IS ________________
EACH COMPLETE TURN OF THE ELEVATION SCREW ON THE MILLING MACHINE IS ________________
THE CUSTOMARY CUTTER ROTATION AND WORK FEED IS AS SHOWN BELOW
CUTTER ROTATION ________ IS THIS TRUE OR FALSE

JOB TASK- TO MACHINE PIECE AS SHOWN IN SKETCH
TIME STARTED ________________ TIME COMPLETED ________________ TOTAL TIME ________________

NAME ________________ CLASS ________________ DATE ________________ TEACHER'S REMARK'S GRADE ________________
1. The 1/8" slot is machined with which: broach, end mill, drill, shell reamer.

2. Slot milling of this type is most conveniently done in a _________ milling machine.

3. What is the length of distance "A" ________

4. What would you consider the first operation when machining this slot ________

5. For what size of bolt is this intended to be? ________

6. Hold down strap machinery steel ________

7. Job task: machine the slot as per drawing ________

Time Started    Time Completed    Total Time

Name          Class Date Teacher's Remarks Grade
MILLING, MACHINE INDEXING

1. THE TERM "PITCH" AS APPLIED TO A GEAR REFERS TO
   A. OUTSIDE DIAMETER
   B. ROOT DIAMETER
   C. NUMBER OF TEETH TO INCH OF PITCH DIAMETER ___

2. ADDENDUM + DECREMENT + CLEARANCE DETERMINE ___

3. STATE HOW YOU WOULD DETERMINE THE DEPTH OF A TOOTH TO BE CUT ___

4. HOW MANY GEAR TOOTH CUTTERS TO A "SET" 8-10-12 ___

5. IN INDEXING WITH A DIVIDING HEAD; HOW MANY TURNS WOULD YOU TURN FOR MACHINEING
   1. A SQUARE
   2. AN OCTAGON
   3. A HEXAGON
   4. AN 18 TOOTH GEAR ___

6. JOB TASK:
   A. SET QUADRANT FOR \( \frac{2}{9} \) OF A TURN
   B. CUT GEAR BLANK FOR NECESSARY TEETH ___

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NAME          CLASS DATE   TEACHER'S REMARKS   GRADE
THE WORD MANDREL REFERS TO DRAWING SKETCHED TRUE OR FALSE

IF STATED INCORRECTLY, INSERT YOUR ANSWER

OF WHAT MATERIAL IS THIS TOOL MADE?

SHOULD IT BE HARDENED?

EXPLAIN THE REASON FOR THE TAPERED DIAMETER
1. REASON FOR .749

2. REASON FOR .753

THE FRACTION SIZE IS ALWAYS STAMPED AT WHICH END:
"A" OR "B"

WHAT IS MEANT BY "LAPPING" THE CENTER HOLES

WHAT IS THE NAME OF THE TOOL USED TO "TRUE" THE WHEEL

JOB TASK:
1. TRUE THE WHEEL
2. GRIND MICROMETER SIZE OF DIAMETER WITHIN .005 OF SPECIFICATIONS

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COMPLETE THIS SENTENCE.
THE ARRANGEMENT OF THE BLADES OF AN OFFSET SCREWDRIVER MAKES IT POSSIBLE TO ____________
THE HARDENING TEMPERATURE OFTEN REFERRED TO AS "CHEERY RED" IS APPROXIMATELY HOW MANY DEGREES?
900° FAH. 1100° FAH. 1300° FAH. 1500° FAH. ____________
"TEMPERING" IS THE PROCESS OF ADJUSTING ____________ TO SUIT THE SPECIFIC WORK OF THE TOOLS.
WITH THE ASSISTANCE OF THE HANDBOOK FIND THE HEAT NECESSARY TO MAKE "LIGHT STRAW" ____________ "DARK STRAW" ____________ "BLUE STRAW" ____________
WHAT IS MEANT BY "ANNEALING" ____________
JOB TASK: ____________
FORGE-HARDEN AND TEMPER AN OFFSET SCREWDRIVER.

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