A HISTORY OF LAYOUT TOOLS USED IN THE WOODWORKING SHOP

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ABSTRACT

Layout tools are instruments used by man to transfer his calculations to the material he wishes to work, in this case, wood. These tools are closely interwoven with the historical changes made in organized society, and they are used in measuring, depicting and testing operations.

For man to develop these tools effectively, it was necessary that he have a system of numbering and an organized method of measurement. These tools seem to have developed slowly, forming into a natural division within the total group.

The two most fundamental tools from the earliest dates found in making this study were the simple straightedge and the flexible cord. Most of the other tools seemed to develop from this source.

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CHAPTER I

INTRODUCTION

Introduction to the Problem

Since early in the time of man's existence on earth, he has been concerned with two great periods--the past and the present. In the present he mixes in use, not only the latest developments, but also the ancient methods of long ago, perhaps even from prehistoric times. In this passing of time he has developed a series of reference tools whose primary purpose has been to correct the error of human estimation and the inaccuracy of hit-and-miss construction. These tools have made possible a change from the time-consuming process of building by matching and fitting parts on the spot to the construction of parts in many different places and assembling them at a predetermined time and place.

To many people these reference tools are known as layout tools. A history of layout tools is a record of tool growth and development which is closely interwoven with the historical evolution of culture, commerce, warfare, religion, and the changes made in organized society. Daniel Brinton recognozes the importance of the development of accurate layout tools when he says:

> Positive progress in constructive art can be accurately estimated by the kind and perfection of the instruments of precision employed by the artists. A

> correct theory of architecture or of sculpture must have as its foundation a correct system of weights and standards of gravity and extension. Where these are not found, all is guess-work, and a more or less haphazard rule-of-thumb.[1]

The historical records of layout tools are fragmentary. Such records were not plentiful even in early eras, and many of those have been destroyed by man and by nature. Thomas Martin writes that often in times of war, sacred and public buildings were destroyed and leveled with the ground; at one stroke the works of ages were destroyed, and the labors and ideas of thousands perished.[2] The Mongols in China sometimes destroyed almost all the population of entire provinces and cities.[3] Wind, floods, and fire, as well as superstition and mistrust, have also taken their toll of records. Consequently, society has been deprived of many of the arts, crafts, tools, and processes of the destroyed areas.

Statement of the Problem

This thesis is a study of the historical development of the common layout tools used in the woodworking shop. In this development an attempt will be made to rename the

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[1]Daniel G. Brinton, Essays of an Americanist (Philadelphia: Porter and Coates, 1890), p. 433.

[2]Thomas Martin, The Circle of the Mechanical Arts (London: Gale Curtis and Fenner and Sherwood, Neely and Jones and W. Curtis, Plymouth, 1813), p. 20.

[3]Kenneth Scott Latourette, The Chinese, Their History and Their Culture (New York: MacMillan Co., 1934), p.235.

groupings of layout tools, to picture these tools by written descriptions and photography, and to show their influence on industry.

Developmental Factors Involving the Problem

When people are brought together and their ideas are integrated, it is then that the inventive process begins to bear its best fruit. Our history books have numerous references of expansion by the Egyptian, Greek, Roman, French, British, Spanish, Mongolian, Russian, American, and other peoples. Troops of force have been known to travel many miles to conquer and enslave people. Alice Zimmern states:

> All the social and economic conditions of antiquity are based on the institution of slavery, and without it would have been impossible; in fact, slavery is so closely interwoven with the whole life of antiquity that even the political development of the ancient nations and their achievements in the domain of art and industry would be inexplicable without the existence of a large slave population.[4]

William Ridgeway shows again how people are brought together when he concludes:

> From Central Asia there was unbroken communications with Northern Italy, so likewise from Northern Italy there was from remote ages a definite trade route into Gaul and Spain, and that these routes were in turn connected with the great routes which lead from the Mediterranean to the Baltic and North Sea.[5]

In less than five centuries the United States has risen from a land of nomadic Indians making the straight line, the

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[4]Hugo Blummer, Home Life of the Ancient Greeks, Translated by Allice Zimmern (London: Cassell and Company, 1895), p. 519

[5]William Ridgeway, The Origin of Metallic Currency and Weight Standards (Cambridge: University Press, 1892), p. 111.

square, and the circle without the use of a rule, square, or compass. They have advanced from the tedious work of the man with the best eye at guessing[6] to a world power made up of people of every walk of life, representing many nations. From the beginning these people brought with them intangible things, such as ideas, technical skills, and a will to work. They have mixed freely, spreading their skills and knowledge and acquiring the ideas of others. From this exchange of ideas, patents have been issued and are still being issued daily.

Henry Mercer notes, after studying collections of carpenter tools made in colonial America, that though made in this country, they were not invented here; these tools represent long-existing types of world-wide usage and were brought here by the colonists. Therefore, these tools are neither local nor national, but international, and are of general ethnological interest.[7]

Need of the Study

1. Those who understand the development of layout tools should have a deeper appreciation and interest in the tools they are using.
2. If many people understand the advancements made in woodworking tools to date, there may be new ideas brought

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[6]Joseph Moxon, Mechanik Exercises or Doctrine of Handy-Works (London: Ludgate-Hill, 1677), p. A3, (Preface).

[7]Henry C. Mercer, Ancient Carpenters' Tools (Doylestown, Pennsylvania: The Bucks County Historical Society, 1929), p. v.

forth now that would have been years off were it not for this understanding.

3. Nearly all children are attracted by the family tree, letters and papers written by some deceased ancestor, and by the simple mechanics of yesterday's tools. Because of this interest, there seems to be a need for organizing material based on studying layout tools to fit the interests and capacities of growing youth.
4. The fact that people are interested in antiques is shown by the number of homes containing antiques, the towns having museums, and the different institutions such as schools, industrial plants, and churches that have rooms or corners devoted to items of the past which contrast that past with the improved conditions of today. Few people know or understand the operations or tools man used in making these items.
5. There is a need to show layout tools in the light of their true importance; this can probably be done best with a historical study taught as related subject matter.

Purpose of the Study

1. To give teachers and prospective teachers of woodworking an authentic background of the layout tools in common use in the woodworking shop.
2. To make available to the woodworking instructor organized historical material that may be used in making better and

more reliable information sheets.

3. To group layout tools not as specifically named tools, but as to their basic functions.

4. To encourage others to make historical studies in various areas of tool development in order to make available more material for instructors of industrial education.

Sources of Data

The material for this study has been gathered whenever possible from original sources. When other material was used, every effort was made to choose from writings which are most generally recognized as being authentic. Books have been obtained through the Interlibrary Loan System. The writer made visitations to near-by museums and held conferences with residents of this area.

Limitations of the Study

This study has been limited to the development of the common layout tools. This includes the rule, square, compass, gauge, level, and awl. No effort has been made to picture the tools in this study according to scale. Source material has been limited to that which could be obtained within the United States.

CHAPTER II

LINEAR MEASURE

Definition of Layout Tools and Linear Measure

In the woodworking shop, layout tools are reference tools of established standards used by the craftsman in direct contact with the material in measuring, depicting, and testing operations. Linear measures are the backbone of layout tools. To figure surface area in square measure, two dimensions in linear measure must be used; and to figure volume in cubic measure, three dimensions in linear measure are used. Thus, linear measure is a basic measure, and linear measure, as defined by Webster, is "a measurement of length; also, a system for such measurement."[1]

Origin of Numbers

> The ability to create symbols and respond to symbols is an essential difference between the world of brutes and the world of man. Without symbols, man's life would be one of immediate appetites, immediate sensations; limited to a past shorter than his own lifetime, at the mercy of a future he could never anticipate, never prepare for. In such a world out of hearing would be out of reach, and out of sight would be out of mind. By means of symbols man builds a coherent world out of patches of sense--

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[1] *Webster's Collegiate Dictionary*, 5 Edition (Springfield, Mass.: G. & C. Merriam Co., 1947), p. 582.

data and gleams of individual experience.[2]

After man has conceived an idea of more than one, has gained a concept of length and depth, and has reached a point where he wishes to describe and to duplicate the things he sees, it becomes necessary to have symbols sufficient to express his ideas. Numbers are probably the most common symbols used by man. Conant explains this when he states that number sense is never completely lacking no matter how limited may be the mental development of a tribe. Even the higher orders of brute creation seem able to distinguish between one and two. A study of the origin of numbers must, therefore, begin with modes of expression of number rather than with numbers themselves. Counting with the assistance of the fingers is a universal starting point for number systems; it is the method of childhood. The decimal is a natural scale because of the ten fingers, and seems destined to supplant all other systems as it already has done in many cases.[3]

Mason gives a clear description of some counting methods used by various groups of people. He explains that among the North American Indians the common method of keeping account was by means of shells, stones, or notches cut in a stick, one for each unit being laid away or kept after some manner. In the United States National Museum there is a

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[2]Lewis Mumford, <u>The Condition of Man</u> (New York: Harcourt, Brace and Co., 1944), p. 8.

[3]Levi L. Conant, "Primitive Number Systems," <u>Proceeding of the American Association for the Advancement of Science</u>, XLI (December, 1892), pp. 270-71.

census of a tribe of Comanche Indians. It is nothing but a collection of bundles of straws--one for women, one for men, and one for children. Many groups of people use memory-helping devices for numbers, such as notched sticks or knotted strings. The Maoris used notched pieces of wood, especially for recording genealogies. In China, the invention of recording by the use of knotted cords is attributed to the Emperor Luy-jin. In Hawaii, although some tax-gatherers can neither read nor write, they keep a very exact account of all the articles collected from inhabitants throughout the island. This is done by one man whose register is a line of cord. Distinct portions of this cord are allotted to various districts, which are distinguished from one another by knots, loops, and tufts of various sizes, shapes, and colors. Each taxpayer has his part in this string, and the number of dogs, hogs, pieces of sandalwood, etc., for which he has to pay are recorded.[4]

Lucien Biart, in his account of some measuring systems of the Aztec Indians, says:

> For figures, one of the numerical signs was the dot (.) which marked the units and which was repeated either up to 20 or up to the figure 10, represented by a lozenge. The number 20 was represented by a flag, which repeated five times gave the number 100, which was marked by drawing quarters of the barbs of a feather. Half of the barbs was equivalent to 200, three-fourths to 300, the entire feather to 400. Four hundred multiplied by the figure 20 gave 8,000, which had a purse for its symbol. From sign to sign,

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[4]Otis T. Mason, <u>Origins of Invention</u> (New York: Charles Scribner's Sons, 1901), pp. 66-67.

always multiplied, one by another, hundreds of millions were reached.[5]

Brose, in his translator's preface, tells us that recent advances in physics seem to be bringing us back to a form of the ancient theory, due chiefly to Pythagoras, that number is the essence of reality. The German physicist, Planck, defines real quantities as only those which are measurable and this same definition is at the basis of Einstein's theory of relativity. The most recent theory of the atom (founded on Schrodinger's wave-mechanics) seems to add even more proof to this theory.[6]

Use of Body Measures

Body measures were among the first methods man used in expressing length. The importance of the use of these body measures is shown by the fact that in all the references used in this study, no record was found or suggested of any group of people whose first system of measuring was not based upon parts of the human body.

Quennell states that in the time of Augustus the Roman measures used in building were derived from the members of the human body, as the digit, the palm, the foot, and the cubit. There were sixteen digits, and four palms in the

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[5] Lucien Biart, The Aztecs, Their History, Manners and Customs, translated by J. L. Garner (Chicago: A. C. McClurg and Co., 1887), p. 319.

[6] Albert Neuburger, The Technical Arts and Sciences of the Ancients, translated by Henry L. Brose (London: Methuen and Co., 1930), p. vii.

Roman foot, and the cubit was equal to six palms.[7]

The Greeks used the finger-breadth, the knuckle, and the palm in their early system of measuring.[8]

The Biblical Hebrew measures of length were subdivisions and multiples of the cubit. At the bottom of the scale was the digit or fingerbreadth. Four digits went together to make the palm or handbreadth and three palms were equal to one span. Two spans equaled the cubit or the length of the forearm from the elbow to the tip of the middle finger.[9]

Brinton makes many references to the use of body measures among Indian tribes. In the Maya system of lineal measure the foot, the hand, and other body measures were of nearly equal prominence, but the foot unit was the customary standard. The Aztec terms for lineal standards are apparently of Maya origin and this suggests that their standard was derived from that nation. In the Aztec System, hand and arm measures were of secondary importance, while the foot measure was adopted as the official and required standard, both in architecture and commerce. Their lineal standard was widely recognized and very exact. Government officials regularly examined the measures used by the merchants and compared them with the correct standard. If they

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[7]Marjorie and C.H.B. Quennell, Everyday Life in Roman Britain (New York: G. P. Putnam's Sons, 1927), p. 43.

[8]Charles Burton Gulick, The Life of the Ancient Greeks, (New York: Appleton-Century Co., 1902), p. 243.

[9]James Hastings and John A. Selbie, A Dictionary of the Bible, Vol. IV. (New York: Charles Scribner's Sons, 1902), pp. 906-09.

fell short, the measures were broken and the merchant severely punished. In the Cakchiquel system, hand and body measures were used almost exclusively, and hand measurements prevailed.[10]

When J. Owen Dorsey was at the Siletz Agency, Oregon, in 1884, he obtained the following units of measurements from Alex Ross, the chief of the Naltunne tunne, an Athabascan people. Some of the measurements listed were:

1. The double arm's length, from the meeting of the tips of the thumb and forefinger of one hand to the meeting of the tips of the thumb and forefinger of the other hand.
2. Single arm's length, extending from the tip of the middle finger along the extended arm to the shoulder joint.
3. From the middle of the sternum along the extended arm to the meeting of the tips of the thumb and index finger.
4. From the inner angle of the elbow to the meeting of the tips of the thumb and index finger.
5. From the first wrinkle of the wrist to the meeting of the tips of the thumb and index finger.
6. From the middle of the fore-arm to the meeting of the tips of the thumb and index finger.
7. The width of the hand (when grasping a stick), one grasp being equal to the width of four fingers (No. 11).
8. One finger width.
9. Two finger widths.
10. Three finger widths.
11. Four finger widths (the hand being open), equal to number 7.

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[10] Daniel G. Brinton, Essays of an Americanist (Philadelphia: Porter and Coates, 1890), p. 433.

12. Five finger widths (including the thumb.)

13. From the point of the right shoulder horizontally across the body to the meeting of the tips of the thumb and forefinger of the extended left arm.

14. From the tip of the right elbow (the right arm being bent and held horizontally, the hand touching the shoulder) horizontally across the body to the tip of the middle finger of the left hand, the left arm also being extended horizontally.[11]

Use of Simple Aids in Measuring

As man progressed in his world, his needs became more than survival, and his wants turned to production and the things made by others. To avoid confusion and inaccuracy, it became necessary to transfer his body measurements to the materials at hand. This transfer was an important step in the establishment of standards in linear measure.

Biblical quotations show this transfer to materials such as flax and reeds. Ezekiel 40:3 records, "And he brought me thither, and, behold, there was a man, whose appearance was like the appearance of brass, with a line of flax in his hand, and a measuring reed: and he stood in the gate." Ezekiel 40:5 relates, "And behold a wall on the outside of the house round about, and in the man's hand a measuring reed of six cubits long by the cubit and a hand breadth: so he measured the breadth of the building, one reed, and the height, one reed."[12]

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[11] J. Owen Dorsey, "Naltunne Tunne Measures," <u>Science</u>, XX (September 30, 1892), p. 194.

[12] <u>Holy Bible</u>, King James Version (Philadelphia: John C. Winston Company, n.d.), p. 760.

This transfer is again suggested by Quennell in the establishment of Anglo-Saxon sixteenth century measures. There is an explanation of the determination of the length of a rod.

> Stand at the door of a church on a Sunday and bid sixteen men to stop, tall ones and small ones, as they happen to pass out when the service is finished; then make them put their left feet one behind the other, and the length thus obtained shall be a right and lawful rod to measure and survey the land with, and the sixteenth part of it shall be a right and lawful foot.[13]

From this reference it is shown that an average of body measurement was being brought into use.

The writer in discussing mid-nineteenth century cabin construction with his grandfather, W. M. Sooter, born 1859, found that his great-grandfather, M. C. Sooter, measured with one and two foot marks on an axe handle. The foot marks were found by transferring a hand measure. This measure's accuracy was within one-eighth inch. It was made with hands flat and extended thumbs placed end to end.

Development of Standards of Linear Measure

Before standards of measurement can be properly discussed, there must be a definite understanding of some of the basic terms, such as units and standards. According to the National Bureau of Standards of the United States Department of Commerce, a unit is a value, quantity, or magnitude

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[13]Marjorie and C.H.B. Quennell, Everyday Life in Anglo-Saxon, Viking, and Norman Times (New York: G. P. Putnam's Sons, 1927), p. 54.

in terms of which other values, quantities, or magnitudes are expressed. In general, it is fixed by precise definition, and it is independent of such physical conditions as temperature and position. Examples are the yard and the meter. A standard is not independent of physical conditions, and is a true example of the unit only under specified conditions. For example, a meter standard would have a length of one meter when at a specified temperature and supported in a certain manner. If supportedin a different manner, it would be necessary to have it at a different temperature in order to have a length of one meter.[14]

The early standards of linear measure were undoubtedly not very exact because they were often based on parts of the human body or some other object which varied in size. The Biblical dictionary explains that it is often through studies of these early measures that we find a clue to the forces at work in shaping the social and economic development of a nation. Through these metrological studies information is frequently found that isolder than any such information found in literature. For example, as early as 3,000 B.C., during the era of Gudea, the Babylonians had discarded the more primitive or natural system of lineal measures and had established a rigidly scientific system constructed on a sexagesimal basis.[15]

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[14] U.S. National Bureau of Standards, "Units and Systems of Weights and Measures, Letter Circular LC681, (Washington: Government Printing Office, 1942), p. 1.

[15] Hastings and Selbie, op. cit., p. 907.

The inch was originally a thumb's breadth. It was defined as one-twelfth of a foot in the Roman duodecimal system, and it was introduced into England during Roman occupation. It later became a part of the English system of weights and measures.[16]

Wyatt states that in 1324, Edward II of England decreed that three barley corns, round and dry, should be equal to one inch, and that twelve inches should equal one foot.[17]

The yard appears to have had a double origin. One of threse is the length of an Anglo-Saxon gird or girdle, and the other is the length of a double cubit. There is an old tradition, often stated as a fact, that Henry I decreed that the yard should thereafter be the distance from the point of his nose to the end of his thumb.[18]

Gulich explains that the principle linear measures used by the Greeks were the foot, the cubit, and the fathom. The foot was not exactly the same length in all parts of Greece; consequently, there were three standards: the Aeginetan, the Olympic, and the Attic. By the last quarter of the fifth century, Attic commerce was predominant in all parts of Greece. Therefore, the Athenian standard for

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[16]U.S. National Bureau of Standards, op. cit., p. 3.

[17]Edwin M. Wyatt, Common Woodworking Tools, Their History (Milwaukee, Wisconsin: The Bruce Publishing Co., 1936), p. 49.

[18]U.S. National Bureau of Standards, loc. cit.

measure was familiar to all Greeks. The Attic foot, as determined by measurements of the cella of the Parthenon, was 295.7 millimeters or about 11.65 inches; a cubit measured one and one-half feet; four cubits made a fathom; and one hundred fathoms, or six hundred feet, was equal to a stadion. The stadion was the length of one side of a race-course, and at Athens measured 582½ feet. A more complete table of these measurements is shown in Figure 1.[19]

2 δάκτυλοι (finger-breadths)			= 1 κόνδυλος (knuckle).
2 κόνδυλοι			= 1 παλαστή (palm).
4 παλασταί	=	16 δάκτυλοι	= 1 πούς (foot).
1½ πόδες			= 1 πῆχυς (cubit).
4 πήχεις	=	6 πόδες	= 1 ὀργυιά (fathom).
16⅔ ὀργυιαί	=	100 πόδες	= 1 πλέθρον (plethrum).
6 πλέθρα	=	600 πόδες	= 1 στάδιον.
30 στάδια			= 1 παρασάγγης (parasang).

Figure 1

Greek Measurements

It is found that the subdivision of units of measurements is closely associated with arithmetical systems of numbers. The systems of measures, used in this country for commercial and scientific work, show traces of the various

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[19]Charles Burton Gulick, <u>The Life of the Ancient Greeks</u>, (New York: Appleton-Century Co., 1902), p. 243.

number systems associated with their origins and developments. According to the National Bureau of Standards, the binary subdivision has come to us from the Hindus; the duodecimal system of fractions descended from the Romans; the decimal system was taken from the Chinese and Egyptians; and the sexagesimal system was derived from the ancient Babylonians.[20]

L. A. Fischer states that the linear measures in common use in this country at the time of the Revolutionary War were all of English origin, and that they were in use in England at that period. Variations in these measures were quite common because the system of measures in England was not itself well established. The importance of exact measures was recognized by the American people in the Articles of Confederation; and again in Article One, Section Eight, of the United States Constitution, in which Congress was given the power to establish standards of measurement throughout the United States. The first action taken by Congress was in 1799, when an act was passed which provided for inspection of the instruments used in ascertaining the duties on imports, with standards to be provided by each collector at public expense. However, since no standards had been adopted, this legislation was not put into operation until nearly thirty-five years after its passage.

In 1830, Congress asked the Secretary of the Treasury

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[20] U.S. National Bureau of Standards, op. cit., p. 9.

to make a comparison of weights and measures being used at the principle custom houses. As was expected, many variations were found, and the Treasury Department took immediate steps to establish uniformity. A thirty-six inch yard was adopted, this being the space between the twenty-seventh and the sixty-third inches of a certain eighty-two inch bar. This bar was supposed to be identical with the English standard at $62^{o}F$; however, it had never been directly compared with it.[21]

In 1836, Congress passed the following resolution:

> Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, that the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all the weights and measured adopted as standards, and now either made or in progress of manufacture, for the use of the several custom houses, and for other purposes, to be delivered to the Governor of each State in the Union, or such person as he may appoint, for the use of the States respectively, to the end that an uniform standard of weights and measures may be established throughout the United States.[22]

The use of the metric system in the United States was legalized by a law passed in 1866, which established:[23]

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[21]U.S. Department of Commerce and Labor, Address by S.W. Stratton, (_First Conference on Weights and Measures in the United States, 1905_. Washington: Government Printing Office, 1907), pp. 6-12.

[22]_U.S. Laws of the United States of America from the 4th of March, 1833, to the 3rd of March, 1839_. (Washington: Bioren and Co., 1839), pp. 571-72.

[23]U.S. Department of Commerce, National Bureau of Standards. _Units of Weight and Measure, Definitions and Tables of Equivalents, Miscellaneous Publication_, M121., 1936. (Washington: Government Printing Office, 1946), p. 1.

$$\frac{\text{1 U.S. Yard}}{\text{1 Meter}} = \frac{3600}{3937}$$

This action did not in any way alter the values of the customary weights and measures. It simply fixed them in terms of standards that represented the highest development of metrology.[24]

Recent laws showing how the bureau was established with the Department of Commerce are listed in the following statements:

In 1901, an act of Congress designated that the Office of Standard Weights and Measures should thereafter be known as the National Bureau of Standards, and that it should remain under the supervision of the Treasury Department.[25] In 1903, the National Bureau of Standards was transferred from the Treasury Department to the Department of Commerce and Labor.[26] In 1913, the Department of Commerce and Labor was divided into two departments, and the National Bureau of

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[24]U.S. Department of Commerce and Labor, Bureau of Standards. State and National Laws Concerning the Weights and Measures of the United States. (Washington: Government Printing Office, 1912), p. IX.

[25]U.S. Statutes At Large of the United States of America, from December, 1899, to March, 1901, and Recent Treaties, Conventions, Executive Proclamations, and the Concurrent Resolutions of the Two Houses of Congress. Volume XXXI. (Washington: Government Printing Office, 1901), p. 1449.

[26]U.S. Statutes At Large of the United States of America, from December, 1901, to March, 1903, Concurrent Resolutions of the Two Houses of Congress, and Recent Treaties, Conventions, and Executive Proclamations. Volume XXXII. (Washington: Government Printing Office, 1903), p. 826.

Standards remained under the auspices of the Department of Commerce.[27]

Existing Standards of Linear Measure in the United States

The basic linear measures used by the United States today are the same as those used by several other nations.

The National Bureau of Standards furnished the writer with the following data:

> The primary standard of length in the United States is the United States Prototype Meter 27, a platinum-iridium line standard having an X-shaped cross section. The length of this bar, which is deposited at the National Bureau of Standards in Washington, is known in terms of the International Prototype meter which is deposited at the International Bureau of Weights and Measures at Sevres, near Paris, France.
>
> A supplementary definition of the meter in terms of the wave length of light was adopted provisionally by the Seventh General (International) Conference on Weights and Measures in 1927. According to this definition the relation for red cadmium light-waves under specified conditions of temperature, pressure, and humidity, is
>
> 1 meter = 1 553 164.13 wave lengths.
>
> From this relation the wave length of the red radiation from cadmium, under standard conditions of temperature, pressure, and humidity, is found to be 6438.4696×10^{-7} millimeters.
>
> The United States yard is defined by the relation
>
> 1 yard $= \frac{3600}{3937}$ meter (exactly)

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[27] U.S. Statutes At Large of the United States of America, from March, 1911, to March, 1913, Concurrent Resolutions of the Two Houses of Congress and Recent Treaties, Conventions, and Executive Proclamations. Volume XXXVII. (Washington: Government Printing Office, 1913), p. 736.

From this relation it follows that

1 yard = 0.9144018 meter (approx.)

and 1 inch = 25.4000508 millimeter "

For industrial purposes a relation between the yard and the meter has been adopted by the American Standards Association (A.S.A. B48.1-1933), and by similar organizations in 15 other countries. This relation is

1 inch = 25.4 millimeters (exactly)

from which 1 yard = 0.9144 meter "

The adoption of this relation by industry, for use in making conversions between inches and millimeters, did not change the official definition of the yard or of the meter. Its legal adoption in the United States and in Great Britain would be a desirable step in the direction of international uniformity in precision length measurements.

The National Bureau of Standards tests standards of length including yard, bars, meter bars, miscellaneous precision line standards, steel tapes, invar geodetic tapes, precision gage blocks, micrometers, and limit gages. It also measures the linear dimensions of miscellaneous apparatus such as penetration needles, cement sieves, and haemacytometer chambers. Tests are made in accordance with test-fee schedules, copies of which may be obtained by application to the Bureau.

The Bureau does not test carpenter's rules, machinist's scales, draftsman's scales, and the like. Such apparatus, if test is required, should be submitted to State or local weights and measures officials.[28]

The writer, in a conference with John W. Ellis of the Missouri State Department of Agriculture, found that the division of weights and measures is a part of the Department

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[28] U.S. National Bureau of Standards, "Standards of Length, Mass, and Time," Letter Circular LC930 (Washington: Government Printing Office, 1949), pp. 1-2.

of Agriculture in Missouri. There are a few checks made on the weights in various business places, but no provisions are made for checking on linear measures as dealt with in woodwork.

As listed by the National Bureau of Standards in Washington, D.C., the table of metric linear measure is as follows:

10 millimeters (mm)	= 1 centimeter (cm)
10 centimeters	= 1 decimeter (dm) = 100 millimeters
10 decimeters	= 1 meter (m) = 1 000 millimeters
10 meters	= 1 dekameter (dkm)
10 dekameters	= 1 hectometer (hm) = 100 meters
10 hectometers	= 1 kilometer (km) = 1 000 meters[29]

The table of customary linear measure used in the United States is as follows:

12 inches (in.)	= 1 foot (ft)
3 feet	= 1 yard (yd)
5½ yards	= 1 rod (rd), pole, or perch = 16½ ft.
40 rods	= 1 furlong (fur.) = 220 yds. = 660 ft.
8 furlongs	= 1 statute mile (mi) = 1 760 yds. = 5 280 ft.
3 miles	= 1 league = 5 280 yds = 15 840 ft.[30]

<u>Tools Used in Linear Measure</u>

In a study of Howard Carter's, <u>The Tomb of Tut-Ankh-Amen</u>, the writer found that the Etyptians made extremely fine furniture. In one example, over 45,000 pieces of inlay were used in the decoration of a single piece of furniture.[31]

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[29] U.S. National Bureau of Standards, "General Table of Weights and Measures," Letter Circular LC682 (Washington: Government Printing Office, March 25, 1942), p. 5.

[30] <u>Ibid</u>., p. 2.

[31] Howard Carter, <u>The Tomb of Tut-Ankh-Amen</u>, Vol. III, (London: Cassell and Company, Ltd., 1933), p. 66.

Wilkinson explains that the early Egyptian cabinet makers constructed chairs, ottomans, boxes, tables, sofas, and other pieces of furniture which were near perfection. They had developed the art of applying two planks together in the same plane, by means of broad pins, or tongues, or hard wood; and they also made dovetails.[32]

Many of the occupations of the Egyptians are portrayed on the walls of the tombs at Thebes. Carpenters and cabinet makers comprised a large class of workmen, and their works form one of the most important subjects in the paintings, which represent the trades of the Egyptians.[33]

Along with the carpenters were mentioned the makers of coffins, the coopers, and the wheelwrights. This subdivision of one class of artisians shows that they had systematically adopted the specialization of trade.[34]

The usual tools of the carpenter were the adze, axe, handsaw, chisels, drill, and two sorts of planes. One plane resembled a chisel and the other was apparently of stone acting as a rasp on the surface of the wood, which was afterwards polished by a smooth instrument, probably also of stone. These, with the ruler, plummet, and right angle, a leather bag containing nails, the hone and the horn of oil, were the principle, and perhaps the only tools he used.[35]

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[32]J. Gardner Wilkinson, A Popular Account of the Ancient Egyptians, Vol. II (New York: Harper and Brothers, n.d.) p. 111.

[33]Ibid., p. 109.

[34]Ibid., p. 117.

[35]Ibid., p. 111.

Figure 2 shows some of these tools in actual use.[36]

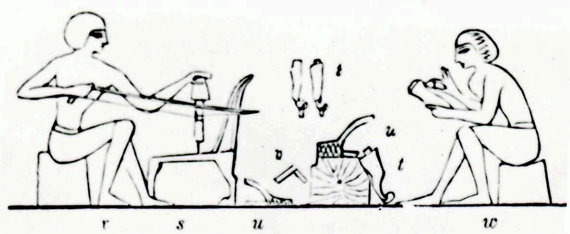

Figure 2

Egyptian Woodworkers

Thus, it is shown that early man had tools which served his purpose. As Thomas Carlyle says, "Nowhere do we find man without Tools; without Tools he is nothing, with Tools he is all."[37]

John Beaton states that the measuring tools make up a group of the fundamental hand tools for constructive woodwork, and that there are no more than six groups of the really fundamental hand tools. The simpler and more elementary a tool is, the wider is its area of usefulness; and the easier it is to use, the more manual skill it requires to get the best results with it.[38]

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[36] Ibid., p. 94.

[37] Thomas Carlyle, Sartor Resartus, (New York: MacMillan Company, 1927), p. 32.

[38] John Beaton, "Wood Working Tools", Hand and Eye, I (December 15, 1892), pp. 4-5.

The rule, as an instrument for measuring, was mentioned as far back as the book of Isaiah in the Bible. Isaiah 44:13 states, "The carpenter stretcheth out his rule--he marketh it out with a line...."[39]

According to the measure mentioned in Ezekiel 40:5, which was quoted earlier in the study, the reed would be approximately nine and one-half feet in length.

Wilkinson has made a study of the Egyptian wooden cubit measure and states that although there were variations in the lengths of some of them, he is sure they were all intended to represent the same measure, which he calculates to be one and one-half feet.[40]

Three groups of masons' insignia from Roman tombstones and doorplates are pictured by Neuburger in his book.[41] Each group contained a rule as part of the insignia. One of these rules is illustrated as having no unit divisions, while the other two do have some form of unit division. These three rules are shown in Plate I, Figures A, B, and C, of the Appendix.

Moxon states that the use of the early rule was to measure feet, inches, and parts of inches. Therefore, these divisions were marked upon the flat and smooth sides of the rule. Each inch was divided into eighths, and the inches

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[39]<u>Holy Bible</u>, <u>op</u>. <u>cit</u>.

[40]Wilkinson, <u>op</u>. <u>cit</u>., p. 259.

[41]Neuburger, <u>op</u>. <u>cit</u>., p. 394.

were numbered from one end of the rule to the other. There were usually 24 inches and the rule was called a Two Foot Rule. The rules usually had both board and timber measures marked on them, to be used in finding both the superficial and solid content of board or timber. However, the three principle uses of the rule were to measure length, to draw a straight line by the side of it, or to test the straightness or flatness of their work.[42] He also describes the ten foot carpenter's rule. It was ten feet long and one inch square and was divided into ten equal parts. If inches were desired, this rule could not be used.[43]

Quennell believes that during the sixteenth century the rod was a common English measure used in building. He explains the situation which arises when a carpenter arrived to build a certain building:

> He meets the man who wants to build and with his rod, which he is shown holding upright, proceeds to peg out on the ground the plan of the Hall. When the carpenter said, 'Your Hall will be two rods wide, with aisles at the side, which will be half a rod in width, and you can have it two, or three bays, each of a rod in length,' he was talking in terms which the owner understood.[44]

This example is illustrated in Figure 3.[45]

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[42]Joseph Moxon, <u>Mechanik Exercises or Doctrine of Handy-Works</u>. (London: Ludgate-Hill, 1677), p. A3, (Preface).

[43]<u>Ibid</u>., p. 129.

[44]Quennell, <u>Everyday Life in Anglo-Saxon, Viking, and Norman Times</u>, <u>op</u>. <u>cit</u>., p. 57.

[45]<u>Ibid</u>., p. 50.

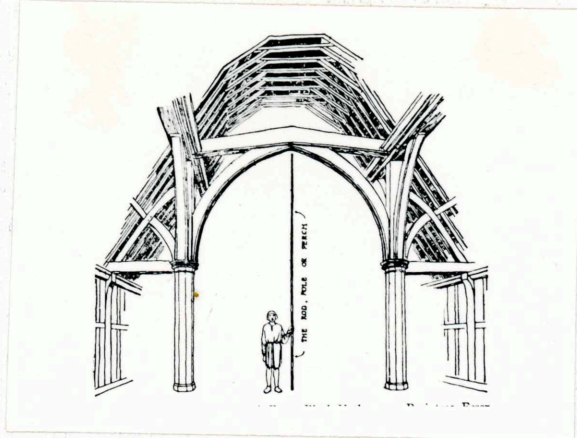

Figure 3
Sixteenth Century English Building Measure

Martin states in his book written in 1813 that the rod used by most bricklayers for measuring was either five or ten feet long, and was divided by notches on the edge into as many feet. The last foot was then divided into inches.[46]

Today, mechanical clamps are made to be used with two wooden bars of any desired length. The clamps and bars together are very convenient for carpenters to use as adjustable measuring rods, as well as for extension beams.[47] With these clamps, it is in many instances unnecessary to use both the rod and the two-foot rule as was described by Joseph Moxon earlier in the study. An example of these clamps is shown in Figure 4.[48]

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[46] Martin, op. cit., p. 90.

[47] L. S. Starrett Company, Fine Mechanical Tools, Catalog No. 26, (Athol, Mass.: L. S. Starrett Co., 1938), p. 217.

[48] Ibid., p. 217.

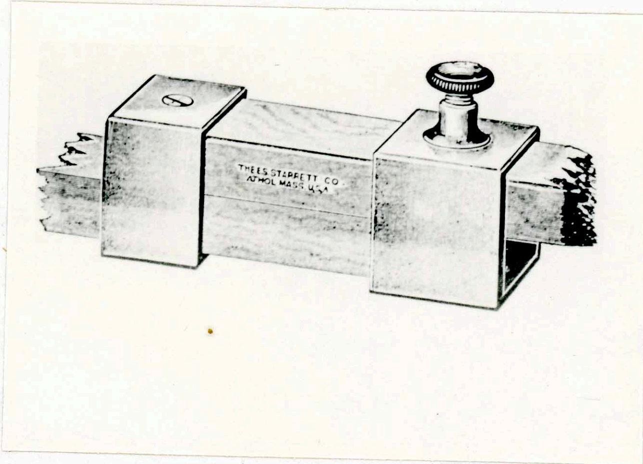

Figure 4
Modern Mechanical Bar Clamps

Mercer states that in the seventeenth century a straight edge, a flat, home-made, wooden strip, was used as a rule. It was either one or two feet long, scaled to inches, halves, quarters, and eighths. By the nineteenth century, this rule was being made in factories and had become hinged, first in two, and later into four tipped boxwood sections.[49]

One early example found in this study was a two foot, two fold rule having a metal hinge and metal tipped ends. There was a metal pin near one end to keep the hinge from being twisted while the rule was closed. This rule is pictured on Plate I, Figure D,[50] of the Appendix.

Another example can be found in the Kansas Historical Museum in Topeka, Kansas. This tool is a wooden foot rule, ten inches to the foot, and was made in Switzerland. It

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[49]Mercer, op. cit., p. v.

[50]Martin, op. cit., Plate I, Figure 38.

was brought from that country by the donor, John Fry, who had used it since 1848. This rule is shown on Plate I, Figure E, of the Appendix. The writer was permitted to photograph this rule through the courtesy of those in charge of the Kansas Historical Museum in Topeka.

In more recent times, there has been manufactured a series of rules known as the boxwood rules. These rules have been highly advertised by the Stanley Tool Company in New Britain, Connecticut. This company has been making boxwood rules since 1850 and states that occasionally a Stanley boxwood rule nearly three generations old is returned to the factory for repair at any cost. Boxwood has these qualities which make it suitable for such use: light and uniform color; workability and ability to hold shape; strength; fine and uniform texture that takes a high, smooth natural finish; hard and straight grained, yet flexible.[51]

Examples of various types of boxwood rules are listed in catalogs of major tool companies and are illustrated in many school test books. Park shows an example of the latter in his book, Educational Woodworking for School and Home. He states that the most common size is the two-foot, four-fold length as is shown in Plate I, Figure F,[52] of the Appendix.

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[51] Stanley Tool Company, I Supervise the Making of Boxwood Rules, "Tool Talks," No. 11 of a Series, We Make Them--You Sell Them (New Britain, Conn.: Stanley Tools, 1938).

[52] Joseph C. Park, Educational Woodworking for Home and School (New York: MacMillan Co., 1912), p. 26.

Knight explains that a caliper rule is a rule having two cross-heads, one of which is adjusted slightly by a nut, the other being movable along the rule. The cross-heads on one side are adapted to the measurement of interior diameters or sizes, and on the other side to the measurement of external sizes.[53] An early example of the caliper rule in America is the sliding scale from Pennsylvania used for finding the diameter of trees or logs. This tool is shown on Plate I, Figure G,[54] of the Appendix. Today's caliper rule is much more exact than this early rule just described. An example of a modern caliper rule is shown in Plate I, Figure H, of the Appendix.[55]

Another type of folding rule would be the zig-zag rule, so called because its joints can turn either to the right or to the left. An early example of such a rule made in this country is a part of the Hasner Collection of the Missouri Historical Society, located in St. Louis, Missouri. This rule was made by hand about 1840. The first twelve inches of the rule are divided into eighths; the next twelve twelve into fourths; and the next twelve into halves; and the last twelve are divided only into inches. This follows the pattern of the early Romans as shown in Plate I, Figure B, of the Appendix. This early zig-zag rule is shown in Figure 5.

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[53]Edward Knight, American Mechanical Dictionary, Volume I, (Cambridge, Massachusetts: University Press, 1877), p. 473.

[54]Mercer, op. cit., p. 49.

[55]"Tool Talks", op. cit., p. 20.

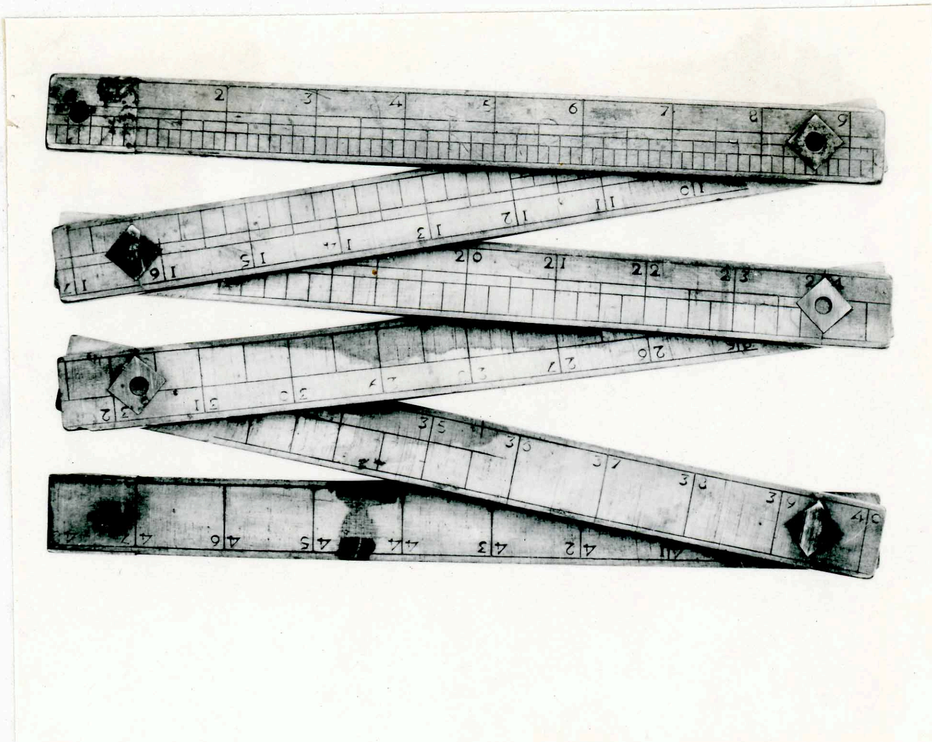

Figure 5
1840 Hand-Made Zig-Zag Rule

Rules are sometimes divided into units of meter measure and these are especially good for measuring off and subdividing measurements. Saloman, in a book written in 1900, explains that a rule of hard wood, one meter or one-half meter long, divided into centimetres and millemeters, is the best for that purpose. A thin folding rule of strong wood or ebonite may be used for less exact measurements and is more convenient to carry about; however, it is not altogether trustworthy because of the looseness of its construction and the gaps at the joints. Such a rule is shown on

Plate I, Figure I,[56] of the Appendix.

Today zig-zag rules are finished in various colors and are usually graduated in sixteenths of inches. Today's price of a six foot rule of this type, as listed by the Stanley Tool Company, is ninety cents. This rule is pictured on Plate I, Figure J,[57] of the Appendix.

Mercer states that the lumber merchants' log measure, a polygonal, scaled staff of wood, used to measure the diameter and length, and hence to calculate from its scale the cubic content of logs, was used in parts of the United States until about 1840.

Another example of the lumberman's rule can be found in the Kansas Historical Museum in Topeka, Kansas. It is a log rule which was used at the first sawmill in Kansas, which was at Lawrence. E. D. Smith of Meade, Kansas, gave this rule to the museum. The writer was permitted to photograph this rule through the courtesy of those in charge of the museum. This photograph is shown on Plate I, Figure K, of the Appendix.

The first examples in this study leading up to the push-pull rule are found in the Bible. Zechariah 2:1, 2 states, "I lifted up mine eyes again, and looked, and behold

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[56]Otto Salomon, <u>Handbook of Sloid</u>, translated by Mary Walker and William Nelson (Chicago: Silver, Burdett, And Co., 1900), p. 70.

[57]Stanley Tool Company, <u>Stanley Tools</u>, Catalog No. 34, (New Britain, Connecticut: Stanley Tools, 1948), p. 16.

a man with a measuring line in his hand."[58]

Knight defines a tape measure as a "ribbon of tape or other material winding upon an axis inside a case."[59] They are made of linen or steel, from ten to one hundred feet in length, and are divided into feet, inches, and subdivisions of an inch. Knight explains that the best quality tapes are interwoven with fine brass wire to prevent stretching.[60]

In another book Knight states that the metallic tape has many advantages over that made of linen because it will not be affected by moisture or liable to extension of length by tension. Measuring tapes are frequently accompanied by registering devices, the axis of the tape being connected to a set of gearing and pointers.[61]

In 1926, Hiram A. Farrand of Berlin, New Hampshire, produced the first concavo-convex rule ever made. This rule has the remarkable characteristic of being both rigid and flexible, and yet can be coiled into a watch size case.[62] Two examples of these metal rules[63] are shown in Plate I, Figures L and M, of the Appendix.

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[58] Holy Bible, op. cit., p. 817.

[59] Knight, Vol. III, op. cit., p. 2495.

[60] Ibid.

[61] Knight, Vol. I, op. cit., p. 1414.

[62] Stanley Tool Company, "Pull-Push" Rules, "Tool Talks," No. 10 of a Series, We Make Them--You Sell Them (New Britain: Stanley Tools, 1938).

[63] Stanley Tool Company, Stanley Tools, Catalog No. 34, op. cit., p. 11.

CHAPTER III

ANGULAR MEASURE

Definition of Angular Measure

According to Webster, angular measure is "a measure of the amount of turning necessary to bring one line or plane into coincidence with or parallel to another."[1]

Development of the Carpenter's Square

A square is like making a first joint when laid out and marked off, in that it is the first comparison made and the rest are brought to conform to it.

Although many people have laid claim to the invention of the square, Radford states that the square is older than those people believe it to be. He feels sure that the square must of necessity have had a place among the tools of the earliest builders. Evidence of its presence is abundant in the remains of ancient Petra, Ninevah, Babylon, Brazil, Peru, and other places. Egypt, however, gives us the most numerous, and perhaps the oldest evidence of the use of the square. An entire kit of tools was found in a tomb at Thebes, and two of the tools have the name of Thothmes III of the eighteenth dynasty stamped on them. That fact showed that they

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[1] Webster's Collegiate Dictionary, op. cit., p. 41.

had been made nearly 3,500 years earlier when constructive and decorative arts were in their zenith in Egypt. Since it must have taken at least 1,000 years to reach that stage, the square must have been long in use by the workmen of that country.[2]

Petrie says that the first actual example of the square in Egypt was found during the 19th dynasty in the tomb of Sen-nehen.[3] This square is now in the Cairo Museum and is the large square shown in Plate II, Figure A, of the Appendix.

A plain square of wood was found in the destroyers' rubbish at the pyramid of Lahun. This square was put together with glue and wooden nails. One arm was slightly longer than the other, but the square was preserved by the dry climate of Egypt.[4] This square is shown on Plate II, Figure B, of the Appendix.

The first reference to a metal square found in this study was that of a plain bronze square from Pompeii. The small square in Plate II, Figure A, of the Appendix, pictures this square.[5]

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[2]William Radford, The Steel Square and Its Uses, Vol. I (Chicago: The Radford Architectural Co., 1915), pp. 19-20.

[3]W. M. Flinders Petrie, Tools and Weapons (Leicester Square, W. C.: Constable and Co., 1917), p. 43.

[4]Ibid.

[5]Ibid.

Neuburger pictures a crude square having a foot.[6] This square was found in a Roman tomb and is illustrated on Plate II, Figure C, of the Appendix.

Mercer describes a sixteenth century woodcut, possibly by Hans Schauffein of Nuremburg. This picture shows saws, axes, the line and reel with ink or chalk pot. The workman to the right of the picture carried his square stuck in his belt. A photograph of this woodcut is shown in Figure 6.[7]

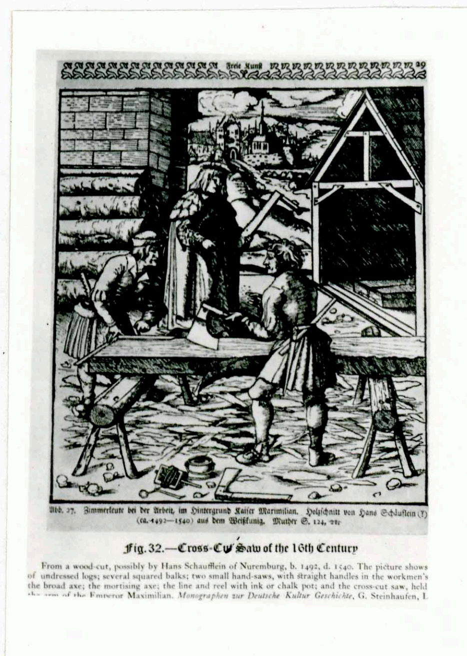

Figure 6
Sixteenth Century Woodworkers

Moxon describes in detail the square and its use. For joiners use, it is made of two pieces of wood, one about an

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[6]Neuburger, op. cit., p. 319.

[7]Mercer, op. cit., p. 32.

inch thick and the other about a quarter of an inch thick. These two pieces are exactly straight and have each of their sides parallel to each of their own sides. The piece which is one inch thick is called the handle and has a mortise in it a quarter of an inch shorter than the thin piece, called the tongue, and it is broad, and wide enough to contain the thickness of the tongue. Glue and wooden pins fasten the handle and tongue firmly in the mortise. The two pieces are so aligned that they are at right angles to each other. The handle is made thicker than the tongue so that the handle on either side becomes a fence to the tongue. The tongue is left about a half inch out of the end of the handle to prevent the point of a pricker (awl) from being thrown farther out when drawing past the bulky handle. If the pricker often strikes against the tongue, the tongue becomes ragged or uneven; however, it can be planed even again with little trouble if the "stuff" is of equal strength all the way, and the workman does not have to plane the cross-grained shoulders of the handle. Moxon's square is illustrated on Plate II, Figure D, of the Appendix.

The use of the square, according to Moxon, is for the striking of lines square to other lines or to straight sides, or to check the squareness of the material.[8]

Following Moxon's report of 1677, Martin in 1813 pictures an L-shaped square having graduations of one-quarter

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[8]Moxon, <u>op</u>. <u>cit</u>., p. A3.

inch and a mitered corner in the joint of the two pieces.[9] This square is pictured on Plate II, Figure E, of the Appendix.

A wooden square with wooden pegs, which was made by hand about 1840, by Henry Gates, is on display in the Hasner Collection at the Missouri Historical Society in St. Louis, Missouri. This square is shown in Figure 7.

Figure 7
1840 Wooden Square

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[9]Martin, op. cit., Plate I, Carpentry.

In the Missouri Resources Museum in Jefferson City, Missouri, is an old German iron or steel square, a gift of Mrs. Frank H. Rephlo of Jefferson City, Missouri. This square was made about 1837. The large blade was estimated to be about 28½ inches by 1½ inches, and the smaller blade was about 12 inches by one-half inch. A third piece on this square was an overlay of metal welded to reinforce the corner. It was noticed that a crude grindstone had been used to straighten the edges and corner of the square.

Today the square is more than just a right angle as in the days of the Egyptians. Its blades are now covered with figures and calculations, some of which are made up of the following scales: octagonal, brace rule, board, plank, and scantling measure, the diagonal scale, the essex table, the rafter or framing table, and the hundredth table. Such a square is pictured in use in the Stanley Tool Catalog and is shown in this study in Figure 8.[10]

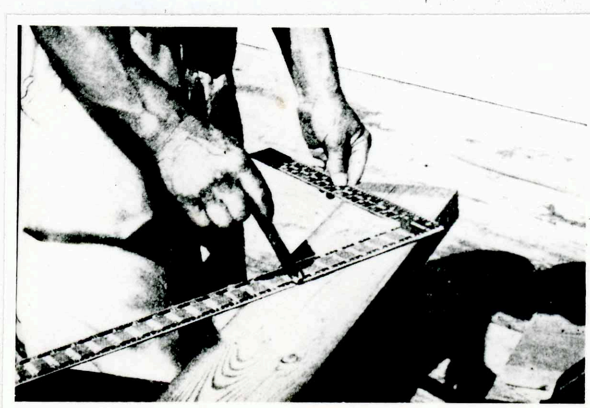

Figure 8
Modern Steel Square

[10] Stanley Tool Company, Stanley Tools, Catalog No. 34, op. cit., p. 107.

Development of the Try Square

The try square is a contracted form of the square and is used extensively for testing and layout work. Rusch and Conway give a simple method of using the try square for testing. The butt of the try square is held against a surfaced side and the inside edge of the blade is rested on the edge of the piece. If the blade touches all the way across the block of wood, the piece is square.[11]

The try square seemingly has its origin, as does the carpenter's square, with the Egyptians. Such a small square is shown in Figure 2, used earlier in this study. Wilkinson refers to this instrument as a right angle.[12]

The next example of the try square found in this study is shown by Martin. This square has a blade of approximately eighteen inches, and the handle is slightly shorter. The handle and the blade are held together by three rivets with triangular metal backings.[13] This square is pictured on Plate II, Figure F, of the Appendix.

Near the beginning of the twentieth century metal became more prominent in the construction of try squares. First came the use of ametal blade with a wooden handle. Then came the application of a metal protective edge for the

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[11] Herman F. Rusch and Claud Carlton Conway, _Shop Work_ (Indianapolis: Industrial Book and Equipment Company, 1918), p. 11.

[12] Wilkinson, _op. cit._, p. 94.

[13] Martin, _op. cit._

handle. Finally came a cast iron handle on a steel blade, and today an all steel try square is coming into use. An example of a try square with a steel blade and a wooden handle faced with brass on the inner side[14] is pictured in Plate II, Figure G, of the Appendix.

Larsson pictures an all metal try square which is used for testing surfaces which should be at right angles to each other, and for squaring lines across the wood. The handle is of cast iron, with insertion made in the iron for lightening the weight of the handle.[15] This tool is illustrated on Plate II, Figure H, of the Appendix.

Hooper and Shirley believe that every shop should be equipped with a large wooden square, varying in size from ten to twenty-four inches in length.[16] An example of such a square is pictured on Plate II, Figure I, of the Appendix.

Squaring Processes

Man in his age of construction has worked with many materials in different ways. It is felt by some that from time to time industries provide tools and methods of work that support action in areas other than their own. Also, some methods which played a very effective role in the

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[14]Salomon, *op. cit.*, p. 75.

[15]Gustaf Larsson, *Elementary Sloyd and Whittling* (New York: Silver, Burdett and Co., 1906), p. 97.

[16]John Hooper and Alfred Shirley, *Handcraft in Wood and Metal* (London: B. T. Batsford, Limited, 1913), p. 202.

industrial processes of the day have been surpassed and are now out of common use.

One method in a field outside woodworking which deals with a layout tool used in the early days is that of squaring stone with the help of a piece of string. Petrie effectively describes this Egyptian process in the following way:

> For dressing down large blocks to a true face, the system was to run saw cuts about half an inch in on all sides; the surface was then hammer dressed, nearly down to the plane of the cuts. The fine dressing--as shown in the tomb of Rekhmara.... was done by holding two rods of wood square to the face, upon the saw cut on the opposite sides. A string was stretched between the tops of the rods. Then a mason held a rod of equal length on any point of the stone, and the amount which that stood above the string showed how much had to be chiselled away. Many of these rods have been found. B49,xLix, is a set of round rods, 3·00 inches long; B50 is a set of square rods from Beni Hasan 3·40 long; other odd rods are B44 (2·64 inches), 45 (3·12), 46 (2·93), 47 (3·51), 48 (3·11 inches). The two end rods always have a hole from the side coming out on the top, for the string; the third rod is plain.[17]

The rods listed above are pictured in Plate II, Figure B, of the Appendix.

Wilkinson also notes this art of leveling and squaring of stone at Thebes. His illustration is shown in Figure 9.[18]

Another method using cuts along the edges is that of using "winders", "winding strips," winding laths, or straight edges. Described by Saloman, by Hooper and Shirley, and in the book, <u>Woodworking Tools and How to Use Them</u>, this method

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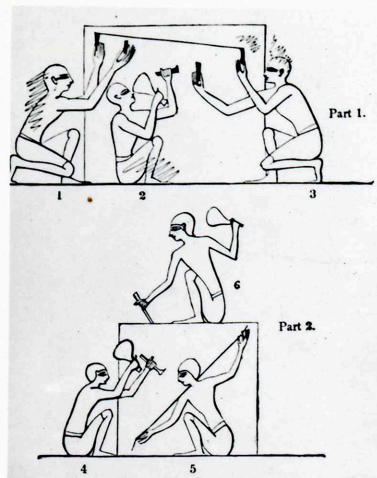
[17]Petrie, <u>op</u>. <u>cit</u>., p. 42.

[18]Wilkinson, <u>op</u>. <u>cit</u>., p. 313.



Part 1, levelling, and Part 2, squaring a stone.
Figs. 2, 4, 6, are using the chisel and mallet

Figure 9
Use of String in Squaring Stone

must have been in common use before and around the change of the century. Used to test the accuracy of plane surfaces,[19] the following description tells of the use of "winders" in producing a plane from a warped surface.

> To produce a plane from a warped surface, using saw, chisel, block-plane, and jack-plane. Lay a warped board, of even thickness, on the bench, with the hollow side up, and observe that it will rock on the bench. Put wedges underneath to prevent it from rocking. So adjust the wedges, that the high corner of the board will be equally distant from the bench. Draw a line, on each end of the board, parallel to the top of the bench, and touching the lowest part of the upper edge. About three-fourths of an inch from each end, make a cut with a cross-cut saw, from the top of the board downward. Let it end in a line, parallel

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[19] Saloman, op. cit., pp. 76-7.

with the surface of the bench, but not quite so near to that surface as the line drawn across the end. Remove, with a chisel and block-plane, all of the wood lying between each saw-cut and the nearest end, thus producing a surface nearly or quite parallel to the bench, and containing the line drawn upon the end. Take two straight-edged sticks of equal width, about twenty or thirty inches long, having one thin or feather edge. These sticks are called "winders." Place one of them in each notch, with the thin edge uppermost. Sight across them, as in Figure X, C. If the thin edges are found to be in line, the surfaces upon which the winders rest are in the same plane; if the thin edges are not in line, one or both of those surfaces must be cut away, until they do come into the same plane. Join the edges of the surfaces then formed, by straight lines drawn on each of the long sides of the board. Remove all of the wood that lies above the plane surface containing the lines. The result is the desired plane surface. The saw, the chisel, and the plane, may all be used in removing the superfluous wood. Test the surface, occasionally, with a straightedge, placed crosswise of the board.[20]

See Figure 10.

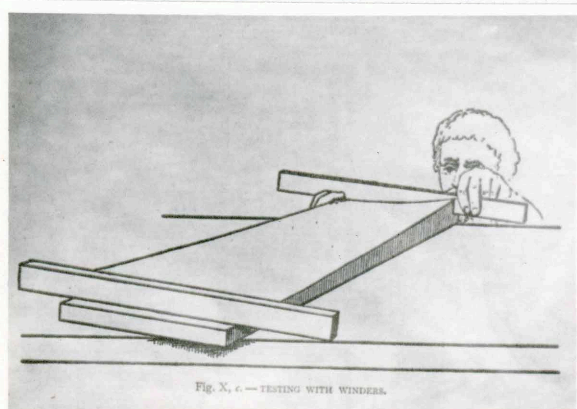

Figure 10
Testing With Winders

Hooper and Shirley note that their winding strips were made of mahogany with ivory sights. Short dowels were used

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[20] Wood-Working Tools and How to Use Them, Edited by the Industrial School Association. (Boston: D.C. Heath and Co., 1896), pp. 69-71.

to hold them together when they were not in use.[21] Plate II, Figure J, of the Appendix, from the Handbook of Sloid, illustrates a pair without sights.[22]

In use from an early date and very closely related to the "winders," the straightedge probably precedes the former in use. It may be made from mahogany, rosewood, satinwood, ebony, walnut, iron, or steel; and it may vary in length. The first example found in this study of the tool's use was in the day of the ancient Egyptian. Wilkinson and Neuburger both picture a person of Thebes working with wood. Wilkinson believes that he is applying a piece of veneer,[23] (see Figure 11) and Neuburger thinks he is using a metal straightedge to square up wood.[24]

Figure 11
Egyptian Working with Wood

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[21]Hooper and Shirley, op. cit., p. 202.

[22]Saloman, op. cit., p. 77.

[23]Wilkinson, op. cit., p. 114.

[24]Neuburger, op. cit., p. 394.

In testing the flatness of newly planed surfaces, a plane was used as a straightedge. The book, Wood-Working Tools and How to Use Them, gives the following explanation: To test the flatness of a newly-planed surface, plase either edge of the sole upon the surface and look toward the light between the edge and the surface. Repeat the test at different places along the board. Sight lengthwise of the board; then sight diagonally across the board.[25] (See Figure 12.)

Figure 12
Use of Plane as a Straightedge

A wooden straightedge having parallel sides, curved ends, and holes by which it can be hung is described by Hooper and Shirley.[26] This can be seen on Plate II, Figure J,

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[25] Wood-Working Tools and How to Use Them, op. cit., p. 31.

[26] Hooper and Shirley, loc. cit., p. 202.

of the Appendix. Today straightedges are made of wood and metal.

The late Charles Wasser, woodworking instructor at Kansas State Teachers College, Pittsburg, Kansas, kept a long straightedge (about ten feet) in his shop. The steel square and the rule have been, and are still being, used as straightedges. Different manufacturers of tools over the country turn out this instrument every day. The Starrett Company of Athol, Massachusetts, manufacturers of precision tools, lists several in its catalog. These instruments vary in shape, being in length from 3-3/4 inches to 72 inches, in width from 7/8 inch to 3-1/16 inches, and in thickness from 1/16 inch to ½ inch. In design they are rectangular; some have beveled edges, some are plain, and others are graduated. They may also be used as rules or "winders."[27]

The Mitre Square

The mitre, like the right angle, is the established angle of a first joint, and tools used to lay out this joint are like some other tools described in this study. Their origin seems to go back to the ancient Greeks.

The need of a mitre square was felt in Egypt; a carpenter of the eighteenth dynasty had a form with a foot to slide along the edge.[28] An example of this mitre square can

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[27] L. S. Starrett Company. Catalog No. 26, op. cit., pp. 28-30.

[28] Petrie, op. cit., p. 43 and Plate XLVII.

be seen on Plate II, Figure L, of the Appendix.

The Romans, too, made use of the mitre. A bronze square with a foot and mitre slope was found in Pompeii, and a bronze mitre square without a foot is represented on a stele which can be seen on Plate II, Figure M,[29] of the Appendix.

Moxon says, "By miters are meant the Joyning of two pieces of wood, so as the Joyn makes half a square, and does comply with the Mitre Square, marked E."[30] (See Figure 13.)

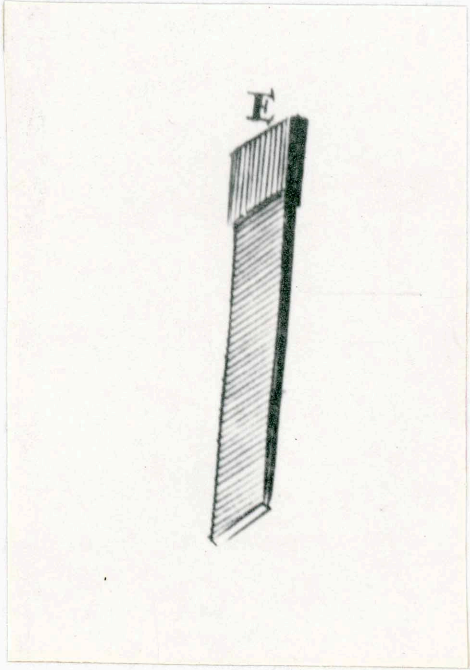

Figure 13
1677 Mitre Square

[29] *Ibid.*

[30] Moxon, *op. cit.*, p. 60.

In Moxon's own language, the following is a description of the making, and some of the uses, of an English mitre square in 1677.

> The Miter square marked E hath (as the Square) an Handle marked a one Inch thick, and three Inches broad, and a Tongue marked b of about the same bredth: the Handle and the Tongue (as the Square) have both their sides parallel to their own sides. The Handle (as the square) hath in the middle of its narrowest side a Mortess in it, of an equal depth the whole length of the Handle: Into this Mortess is fitted one end of the Tongue, but the end of the Handle is first Bereld off to make an Angle of 45 Degrees with its inside. This Tongue is (as the square) Pind and Glewed into the Mortess of the Handle.
>
> It is used for striking a Miter line, as the Square is to strike a square line, By applying the Inside of the Handle to the outside of the Quarter or Batten, you are to work upon: and then by striking a line by the side of the Tongue: For that line shall be a Miter line. And if upon two Battens you strike two such lines, and Saw and Pare them just off in the lines, when the flatts of those two sawn ends are applyed to one another, the out and inside of the Battens will form themselves into the Figure of a Square.
>
> Thus Picture Frames and looking Glass-frames are commonly made, as by a more full Example you may see the next Section.[31]

Saloman refers to the mitre square as a set bevel. He explains that it consists of a stock and a blade, but the blade, which generally extends beyond the end of the stock, is fastened in such a way as to form on one side an angle of 45 degrees, and on the other side an angle of 135 degrees, or the complementary angle of a straight angle. It is used when a rectangular corner is made by joining together pieces cut at an angle of 45 degrees. Such pieces are said to be

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[31] Ibid., pp. 84-5.

mitred.[32] An illustration of this is shown on Plate II, Figure N, of the Appendix.

Today the set bevel is still used. It may be found on the handle of a combination square, and on modified forms of the try-square.

The Bevel

Moxon says that as the square is made to strike an angle of 90 degrees, and the miter an angle of 45 degrees, so the bevel has its tongue movable upon a center and may be set to strike angles of any greater or smaller sizes, depending upon the way the tongue is set. It is used as the square and the mitre and will perform the duties of both of them, although it is not purposely made for either.[33] This tool is illustrated on Plate II, Figure O, of the Appendix.

Mercer explains that although he made use of repeated correspondence, searches of shop rubbish, and questionings of old carpenters, he failed to find a true model of the bevel as described by Moxon.[34] This might indicate that this type of bevel may have originated in the period just preceding Moxon's writing.

A century later Martin describes the bevel as an instrument used to take any angle with or to mark a line which is not square. For this purpose the blade is made to move in

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[32] Saloman, op. cit., p. 76.

[33] Moxon, op. cit., p. 85.

[34] Mercer, op. cit., p. 57.

a long groove inserted in the handle and fixed to it by a nut and screw. It may then be altered to suit any degree required.[35] This is illustrated on Plate II, Figure P, of the Appendix.

Saloman describes a wooden bevel in which the blade rotates on a screw in the stock. To fasten the blade in any given position, the screw is furnished with a nut by means of which it may be screwed fast.[36] This bevel is shown on Plate II, Figure Q, of the Appendix.

Up to this point it has been shown that the tongue of the bevel was held in place by a hole in the tongue and by pins or screws. By the latter part of the nineteenth century, Knight pictures a bevel with brass fittings on the handle, tongue of steel, and a slot in the place of the hole. He describes a bevel square as one whose blade is adjustable to any angle in the stock and retained at any set by a clamping screw.[37] The cut on Plate II, Figure R, of the Appendix, shows several forms and positions.

Stanley shows an all metal bevel with the same type blade as described by Knight.[38] Instead of having a set screw at the side, an arrangement with a thumb screw and a patented connection for loosening and tightening the blade

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[35]Martin, op. cit., p. 116.

[36]Saloman, op. cit., p. 76.

[37]Knight, Vol. I, op. cit., p. 279.

[38]Stanley Tool Company, Stanley Tools, Catalog No. 34, op. cit., p. 16.

is found in the handle. This bevel is pictured on Plate II, Figure S, of the Appendix.

CHAPTER IV

CIRCULAR MEASURE

Definition of Circular Measure

Circular measure concerns two points used in such a way that while one point is kept stationary, the other can pivot at a constant distance around it. In some cases, points are maneuvered in such a way that when set and then measured, the distance between these two points would represent the shortest line between the materials limiting the points.

Characteristics of Tools of Circular Measure

With the above description, a number of tools used in describing arcs and circles, for measuring distance, or for measuring the diameter of convex or concave bodies, seem to find a common action. Some of these are the beam compass or trammel points, compass or divider, calipers--inside and outside, and pencil compass.

Some of these tools are described in the following manner:

A beam compass is an instrument for depicting large circles. It has a rod or beam and has two sliding sockets which carry the steel point and the pencil. There are set-screws on the sockets to hold them in place on the beam.[1]

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[1]Knight, Vol. I, *op. cit.*, p. 257.

The divider is a form of compass usually with an adjusting and retaining arrangement. Its name is derived from its specific use in dividing lines into any given number of equal parts. The legs are driven apart by a spring as the nut is retracted on the screw, and they are closed by the opposite motion of the nut. The screw has a fine thread which makes possible a very delicate adjustment.[2]

A caliper is an instrument, jointed like a pair of dividers, but with arched legs, and are especially adapted for taking the diameter of convex or concave bodies. Inside calipers are used for measuring boxes and inside diameters of tubes, while outside calipers are used for outside measuring.[3]

Pencil compasses are much the same as dividers except that on one leg of the pencil compass is inserted a device for holding the pencil. The primary use of the pencil compass is for describing arcs and circles.

History of Tools of Circular Measure

In history these tools have been known since early times. The compass was mentioned in I Kings 7:35, "And in the top of the base was there a round compass of half a cubit high."[4] Jeremiah 31:39 seems to suggest the use of a

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[2] *Ibid.*, p. 712.

[3] *Ibid.*, p. 429.

[4] *Holy Bible*, *op. cit.*, p. 334.

measuring line to serve the purpose of the compass. "And the measuring line shall yet go forth over against it upon the hill, Gareb, and shall compass about to Goath."[5]

Petrie notes:

> There is no sign of compasses being used in Egypt before Graelo-Roman influence. No compasses have been found, nor any traces of struck circles, or of intersecting circular patterns. Nor did such patterns take root in Egypt even in later times. The case was quite different in Asia, where the device of intersecting circles was used in Assyria, and in Palestine became a favorite decoration.[6]

However, it is noticed that the Egyptians used the wheel and made round pottery, which indicates they had a knowledge of the circle.

In this study, the next evidence of the compass is from the days of the Roman. There the compass was made from different materials and in various sizes and shapes. Most of them had two legs with a joint at the top, and the position being secured with the use of a wedge through the joint pin. Figure 14 shows a Roman wedge pin compass.[7]

Three other wedge pin compasses were shown by Petrie; two were from Rome and the third was found at Pompeii. The one from Pompeii[8] is shown on Plate III, Figure A, of the Appendix.

Another type compass is the Roman right angle compass,

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[5]*Ibid*., p. 690.

[6]Petrie, *op. cit*., p. 60.

[7]*Ibid*., p. 60, Plate LXXII, Figure 217.

[8]*Ibid*., p. 60, Plate LXXII, Figure 215.

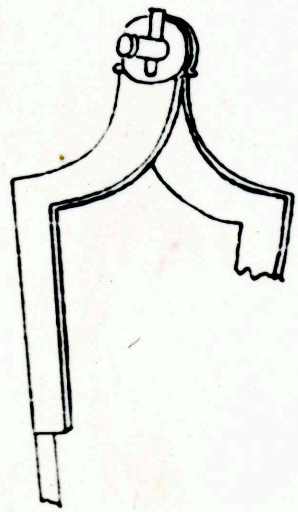

Figure 14
Roman Wedge Pin Compass

so called because the points were turned out at a right angle. Petrie gave no indication that any method other than friction was used to secure the position of the legs. He indicates, though, that this type of compass is only good for measuring distances and could not be used for drawing circles efficiently. Plate III, Figure B, of the Appendix, shows one of the examples listed by Petrie.[9]

An unusual example of an early Roman compass is one made of iron.[10] The long top handle has been revived in

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[9] *Ibid.*, p. 60, Plate LXXII, Figure 218.

[10] *Ibid.*, p. 60, Plate LXXII, Figure 212.

modern use in order to turn the compass more readily. This iron compass is shown on Plate III, Figure C, of the Appendix.

The crossing leg compasses were also used by the Romans. These were made so they could be easily opened and closed with one hand by pressing above or below the crossing. Two illustrations of these are shown on Plate III, Figures D[11] and E,[12] of the Appendix.

Calipers were well known among the Romans. Petrie shows a pair of "egg calipers" made of bronze, inlaid with silver, and having a vine pattern along the leg. This is pictured on Plate III, Figure F,[13] of the Appendix.

In the famous painting "Melancholia" by Albert Durer, painted in 1514, the seated figure holds a metal compass in her right hand. Other layout tools shown in this picture are the rule and the mitre square. This painting is shown in Figure 15.[14]

A wood cut by the German engraver, Jost Amman, shows an old German cooper of the sixteenth century using his long jointer plane. The lower end of the plane rests on a block, thus extending its range. Below it lies a handmade wooden compass with a stop arm. This wood cut is shown in Figure 16.[15]

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[11]*Ibid*., p. 60, Plate LXXII, Figure 221.

[12]*Ibid*., p. 60, Plate LXXII, Figure 220.

[13]*Ibid*., p. 60, Plate LXXII, Figure 223.

[14]Mercer, *op. cit*., p. 111, Figure 107.

[15]*Ibid*., p. 109, Figure 104.

Figure 15
1514 Painting "Melancholia"

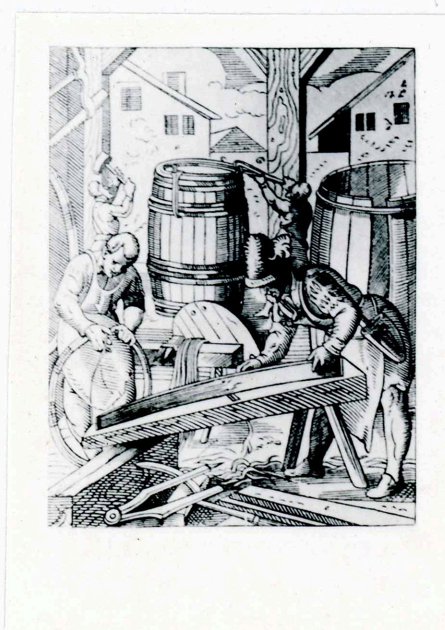

Figure 16
Sixteenth Century German Cooper

Three metal specimens of sixteenth century compasses were found in 1885 on Nova Zembla where they had been stored by a Dutch expedition in 1596.[16] These compasses are pictured on Plate III, Figure G, of the Appendix.

Mercer describes an illustration of a pole lathe of the seventeenth century and calls attention to a compass on the tool rack in the background.

> The picture, one of a series of eighteen small copper engravings, illustrating workmen employed at their various trades, by the Dutch painter-engraver, Jan Joris Van Vliet, born at Delft, Holland, in 1610, shows a man turning the "stuff", i.e., the leg of a chair or spinning wheel, as seen in the engraving, with a back and forth action pole-lathe. The two puppet posts, one of which slides in the "bed", the "rest", or crosspiece on which he holds his chisel, the foot treadle working the thong twisted on the "stuff", and with it the spring pole, in the ceiling, are clearly shown. A compass and several chisel-shaped turning tools, are racked against the wall or laid across the lathe bed.[17]

See Figure 17.

The following is a description by Moxon of compasses shown in his book. "aa The Joynt, bb the cheeks of the Joynt, cc the shanks, dd the Points. Their office is to describe circles, and set off Distances from their Rule, or any other measure, to their Work."[18] This picture is shown in Figure 18.

During the eighteenth century the French had applied

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[16]Mercer, _Ibid_., p. 61.

[17]_Ibid_., p. 218, Figure 189.

[18]Moxon, _op_. _cit_., p. 101, E in Plate 5.

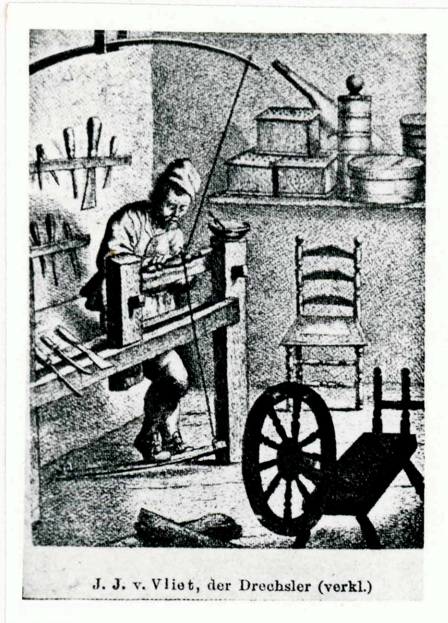

Figure 17
Seventeenth Century Pole Lathe

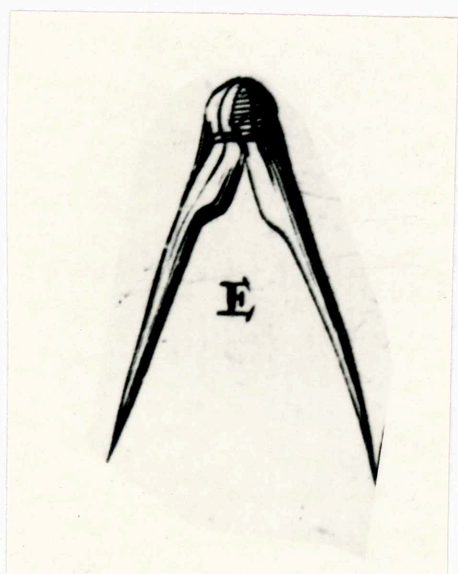

Figure 18
Moxon's Compass

the use of screw threads to military calipers.[19] This is interesting because this is the first indication of screws being used on tools of circular measure found in this study. Such use of screws is shown on Plate III, Figure H, of the Appendix.

Martin, in 1813, shows instruments of circular measure used in wood turning.[20] There are a few similarities between those tools and the Roman tools described previously in this study. The calipers shown seemed to indicate the use of screw threads at the joint. The legs are heavy and taper to a point at the bottom. The form is somewhat in the shape of a C.[21] These calipers are shown on Plate III, Figure I, of the Appendix.

The outside calipers presented by Martin have a solid bow attached to one arm. A set screw in the other arm allows the instrument to be adjusted and set.[22] These calipers are pictured on Plate III, Figure J, of the Appendix.

The next instrument shown by Martin is a combination inside-outside caliper. It has a steel bow and set screw similar to the one just described in the study. The legs for the inside caliper in this instrument are straight, with

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[19] Bron, le S'N., Traite de la Construction et des Principaux Usages des Instrumens de Mathematique, Troisieme Edition (Paris: Michel Brunet, 1725), p. 182.

[20] Martin, op. cit., Plate I, Turning.

[21] Ibid., Figure 22.

[22] Ibid., Figure 23.

the points turned out. The outside caliper is C-shaped.[23] This instrument is shown on Plate III, Figure K, of the Appendix.

The next caliper shown by Martin has one leg straight, and about three-fourths of the lower portion of the other leg is semi-circular. Using a stiff joint, the instrument holds its set by friction.[24] This picture is shown on Plate III, Figure L, of the Appendix.

The compass pictured by Martin has two straight, pointed legs and probably has a friction joint at the top to hold the set.[25] Plate III, Figure M, of the Appendix, pictures this compass.

In the following quotation, Mercer gives the name of the early Roman compass, explains a particular use of the compass, and tells of specimens found in Bucks County in eastern Pennsylvania:

> <u>The 'Circinus' of the Romans</u>
>
> Besides its chief purposes in scratching circles and spacing geometrical patterns, etc., the compass is used to close-fit irregular board margins by 'scribing' them. In the latter case, one point of the partially opened tool, held close to and pulled along the rough or waved margin, follows its irregularities, while the other point scratches (scribes) a duplicate, waved line on the close-pushed board. When worked down to this line the board must fit the crooked margin.
>
> The wooden compasses (Fig. 59B), adjustable on sliding arms, are old Bucks County and eastern

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[23] <u>Ibid</u>., Figure 24.

[24] <u>Ibid</u>., Figure 26.

[25] <u>Ibid</u>., Plate I, "Carpentry", Figure 36.

> Pennsylvania specimens. They are often found on farms as heirlooms of farmer-carpenters, and are sometimes still used by the latter, if Pennsylvania Germans, to outline the decorative painted circles, stars, swastikas, etc., conspicuous since the mid-nineteenth century on their wooden barn fronts.
>
> Among these, No. 16565 (lower left) is presented by Dr. B. F. Fackenthal, Jr., was bought at the sale of George W. Laubach, 88 years old, in 1919, at Riegelsville, Pa.[26]

Saloman explains that the compass generally used in slojd is a simple one made of steel with a hinge. As it is often necessary to maintain the distance between the arms unchanged, this compass is provided with a bow, which is attached to one arm, and which can be secured to the other by a screw. Such a compass is called a bow-compass, and an illustration of one is shown on Plate III, Figure O, of the Appendix.[27]

The caliper compass is used to measure the thickness of round or oval objects. This compass has very strong curved arms with points which taper obliquely. An ordinary caliper compass may be used to measure the diameter of a hole by turning the arms around the hinge until the points are turned away from one another.[28] This is shown on Plate III, Figure P, of the Appendix.

When segments of large circles have to be described, beam compasses are used. Instead of the arms of the ordinary

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[26] Mercer, *op. cit.*, p. 62.

[27] Saloman, *op. cit.*, p. 73, Figure 24.

[28] *Ibid.*, p. 74, Figure 26.

compass, these are furnished with trammels, (a) united by a cross-piece, (b) and pointed at one end, where there is a steel pin. One trammel is fastened to the cross-piece; the other is movable, and is adjusted by means of a pin.[29] This beam compass is shown on Plate III, Figure Q, of the Appendix.

In this country Parks notes that calipers are indispensable in wood turning, but have little use in bench work. In his description of calipers he tells that the legs are of steel, and clearly shows the screw forming the joint. Figures R and S on Plate III, of the Appendix, clearly illustrate these calipers.[30] Dividers illustrated by Parks have a removable leg and a spring and thumbscrew attachment for making fine adjustments, in addition to the coarse adjustments made by the wing and side screw.[31] This can be seen on Plate III, Figure T, of the Appendix.

Larsson recommended the new pencil compasses for woodwork use in 1906. To adjust and use this compass, he says:

> Keep point of pencil about one inch long. In sharpening, remove wood with knife and point the lead on No. 1 sandpaper.
>
> In using compasses adjust point to equal length with pencil point and hold at top between thumb and forefinger.[32]

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[29] Ibid., p. 73-74, Figure 25.

[30] Parks, op. cit., pp. 37-38.

[31] Ibid., p. 38.

[32] Larsson, op. cit., p. 17. See Plate III, Figure V, in the Appendix.

The modern tools of circular measure have various improvements for making fine adjustments and ease of use. Some of those shown by Brown and Sharp are inside and outside calipers with the spring top and fine threaded spring nut, which adjusts the legs. Figure V on Plate II of the Appendix shows a set of inside calipers of this design.[33]

This company also makes a screw adjusting, firm-joint, outside and inside calipers. The shape is still a curve; the joint has a patented attachment for speedy rough settings, and a screw for fine adjustments. Figure W on Plate III of the Appendix shows an outside caliper of this type.[34]

The combination firm-joint caliper does the work of two larger tools. The legs and connecting member are each eight inches long. It will take outside diameters to eleven inches, and over greater lengths where tools do not have to span a periphery. It takes inside measurements up to twenty inches.[35] This is illustrated on Plate III, Figure X, of the Appendix.

The firm-joint, hermaphrodite calipers have one of the straight leg with an adjustable point set by a thumb screw, and the other leg is straight until a short distance from the tip, which is turned inside. The joint is fastened by a bolt and nut.[36] These calipers are shown on Plate III, Figure Y, of the Appendix.

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[33]Brown and Sharp Mfg. Co., Small Tools, Catalog No. 34, (Providence, R.I.: Brown and Sharp Mfg. Co., 1941), p. 249.

[34]*Ibid.*, p. 252.

[35]*Ibid.*, p. 253.

[36]*Ibid.*, p. 234.

CHAPTER V

GRAVITORIAL MEASURE

Definition of Gravitorial Measure

Gravitorial measures are so called due to a reference line formed by gravitorial activity, through which the differences in surface alignment of one surface with another may be measured, with reference to a point tangent to the earth's surface.

The function of this series of tools is to establish a definite line -- horizontal, vertical, or otherwise -- in relation to an imaginary vertical line extending from the earth's center indefinitely above and below the earth's surface. This is determined by the gravitorial pull of the plummet or by the rising of a bubble to the surface of some liquids.

Development of Tools of Gravitorial Measure

References to gravitorial measures are found in the Bible. Amos 7:7,8 relates:

> Thus he shewed me: and, behold the Lord stood upon a wall made by a plumbline in his hand. And the Lord said unto me, Amos, what seest thou? And I said, a plumbline. Then said the Lord, Behold, I will set a plumbline in the midst of my people Isreel; I will not again pass by them anymore.[1]

From Isaiah 28:17 comes: "Judgment also will I lay to

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[1]Holy Bible, op. cit., p. 800.

the line and the righteousness to the plummet: and the hail shall sweep away the refuge of lies and the waters shall overflow the hiding place."[2] In II King 21:13 the plummet is again mentioned: "And I will stretch over Jerusalem the line of Samaria, and the plummet of the house of Ahab: And I will wipe Jerusalem as a man wipeth a dish, wiping it, and turning it upside down."[3]

The following are definitions for some of the tools used in gravitorial measure:

A plumb is a line with a suspended plummet to prove the perpendicularity of work.

A plum-bob is a conoidally shaped piece of metal suspended by a cord attached to its upper end, and used for determining verticals, or in connection with a level or straight edge, horizontal lines. It is indispensable in building operations, and is also employed by surveyors and astronomers for placing an instrument centrally over a station point of departure.

A plumb-level is a level in which the horizontality of the base is determined by a suspended line with a plumb-bob.

A plummet level is a form of a level having a suspended plummet in a standard at right angles to the base-piece.

A plumb line is the cord by which a plumb-bob is suspended.[4]

The first actual example of these tools was found with

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[2]*Ibid*., p. 628.

[3]*Ibid*., p. 382

[4]Knight, Vol. II, *op. cit*.,

the Egyptians. After the plumbline had been in use for some time, it reached a new application when tied to a wooden frame or block. In Petrie's book an example is shown of a wooden square with legs of equal length, and a cross-member, having in its center a vertical mark. A plumbline tied to the apex falls vertically past the cross member, indicating a level surface when the plumbline and vertical mark exactly correspond. These were used during the nineteenth dynasty of Egypt.[5] Plate IV, Figure A, of the Appendix, pictures this ancient level.

An instrument for testing the vertical surface is also shown by Petrie.[6] This tool consists of three blocks of wood, a plumbline, and a plumb-bob. In construction, the form is pictured having a long vertical member approximately twice as wide as it is thick. The length was about fifteen times the width. The base of this member is rounded under from the face to the back edge. Two equal blocks fastened at right angles to the face of the long member, and the length is one and one-half times the width. These equal blocks divide the long member into three spaces of unequal lengths. From the top down, these spaces have a ratio of about three, five, and seven. The tool functions by having a vertical line in the center of the bottom block and a plumbline tied to the upper block. When the instrument stands true, the plumbline and the vertical line exactly

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[5]Petrie, _op. cit._, p. 60 and Plate XLVII, Figures 58-59.

[6]_Ibid._, Figure 57.

correspond without the plumbline hanging too far away or being bent. See Plate IV, A picture of this instrument can be seen on Figure C, of the Appendix.

The plumb-bobs of the Egyptians were made of stone and metal.

Petrie estimates that the use of the plumbline must have started with Egyptian building. A stone plumb-bob with a groove around it, in which to tie the line, was found at the end of the third dynasty of Egypt. Others of later dates were made of limestone, alabaster, marble, and steatite. Their sizes varied. Some were pear-shaped and others cubic, with the hole being common in those of later dates. Lead came into use probably during the Greek age. The Roman bobs were made also of stone and metal. Examples of marble with a bronze loop, and again of just bronze, were cited by Petrie[7]

Seemingly, the plumb level had very little change for the builder until very recent times. Neuburger shows the "A" type level used by the bricklayer. This is very similar to the one used by the Egyptians. The plumb-bob, too, is very similar[8] See Plate IV, Figures D and E, of the Appendix.

Moxon also gives a description of a plumb level which was from two to ten feet long, and in action like the one described by Petrie. See Plate IV, Figure F. Appendix.[9]

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[7]Petrie, op. cit., pp. 42-3

[8]Neuburger, op.cit., 394, Fig. 536.

A plumb level is shown also by Martin, but this level has a heavy horizontal base and a vertical member supported by diagonals on either side. The action of the plumb line is the same as that of the others described. For example, see Plate IV, Figure G, of the Appendix. A simpler form for testing vertical lines is also shown on Plate IV, Figure H, of the Appendix.[10]

About the same time in Colonial America, Mercer describes two plumb levels having different shapes, but operating under the same principle as those already described. One level is in the form of a wooden "T".[11] For example, see Plate IV, Figure I, of the Appendix. The second had a wooden semi-circle set upright on a piece of carpenter's work, and a suspended string with a leaden plummet hanging from the semi-circle. When the suspended string coincides with a vertical line or crack marked on its cross-piece, above the swing-hole, the work is level.[12] For example, see Plate IV, Figure J, of the Appendix. From the beginning these plumb levels, made by hand, were hampered by nature in that when the wind blew, the lines would not hang still. No doubt, wind breaks and other such devices must have been used to gain more accuracy. These windbreaks must have been costly, time consuming, and bulky. This led to experimentation, and

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[10]Martin, op. cit., Plate I, Carpentry, Fig. 19.

[11]Mercer, op. cit., p. 67.

[12]Ibid., p. 66.

an attempt to produce a more efficient level. One of these attempts is described by Marcus Vitruvius, a civil and military architect of the time of Augustus and Julius Caesar:

> The chorobates is a rod about twenty feet in length, having two legs at its extremities of equal length and dimensions, and fastened to the ends of the rod at right angles with it; between the rod and the legs are cross-pieces fastened with tenons, whereon vertical lines are correctly marked, through which corresponding plumb lines hang down from the rod. When the rod is set, these will coincide with the lines marked, and show that the instrument stands level. But if the wind obstructs the operation, and the lines are put in motion, so that one can not judge by them, let a channel be cut on the top of the rod five feet long, one inch wide, and half an inch high, and let water be poured into it; if the water touch each extremity of the channel equally, it is known to be level. When the chorobates is thus adjusted level, the declivity may be ascertained. Perhaps some one who may have read the works of Archimedes will say that a true level cannot be obtained by means of water, because that author says that water is not level, but takes the form of a spheroid, whose centre is the same as that of the earth. Whether the water have a plane or spheroidal surface, the two ends of the channel on the rod right and left, when the rod is level, will nevertheless sustain an equal height of water. If it be inclined towards one side, that end which is highest will not suffer the water to reach to the edge of the channel on the rule. Hence it follows that though water poured in many have a swelling and curve in the middle, yet its extremities to the right and left will be level.[13]

The writer checked the accuracy of this translation from an original German translation[14] through the assistance of Dr. Samuel J. Pease of Kansas State Teachers College at Pittsburg, Kansas. It was found that the wording was very nearly the same.

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[13] The Architecture of Marcus Vitruvius Pollio, Translated by Joseph Gwilt from the Latin (Boston: Lockwood and Co., 1874), pp. 195-96.

[14] Dr. Frang Reber, Des Vitruvius Behn Bucker uber Architektur (Stuttgart, Krais and Hoffman, 1865), Book viii, Part 5.

The next great improvement in the process of leveling, and like the chorobates not classed as a carpenter's tool, was the spirit level. This was invented by Thevenot in 1666 or by Dr. Hooke in 1680.[15]

Knight tells of the spirit level in the following lines:

> A description of this instrument, accompanied with figures, was first published in the 'Journal des Savants,' Paris, November 15, 1666, under this title: 'Machine nouvelle pour la conduite des eaux, pour les la plupart des autres arts.' The instrument is there called an air-level; and is described as a glass tube, hermetically sealed at both ends, containing spirits of wine, which do not freeze, and a small quantity of air forming a bubble. It is stated that the instrument is capable of giving, with much exactness, the direction of the horizon, the perpendicular to the horizon, and vertical angles; and that it is easier to make, more convenience to use, and indicates a level line more readily and accurately than any other instrument.[16]

As the exactness required in making, filling, sealing, and setting of the level's glass tube was beyond the home craft of the carpenter, it became a factory product from the start. It was not adopted by the builders until its reliability was established, and it was simplified and made less expensive towards the middle of the nineteenth century.[17]

In 1912, Park illustrated a level having glass for both the horizontal and vertical settings.[18] A vertical setting is shown in Figure 19 and a horizontal setting is shown in

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[15]Mercer, op. cit., p. 66.

[16]Knight, op. cit., Vol. II, p. 1294.

[17]Mercer, op. cit., p. 66.

[18]Park, op. cit., p. 35, Fig. 12, 13, and 14.

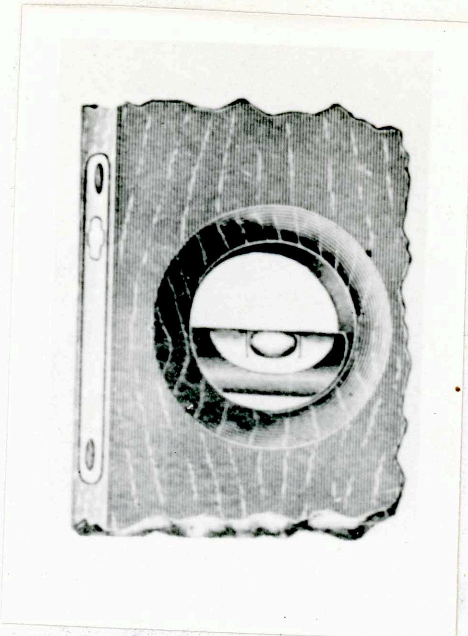

Figure 19
Level--Vertical Setting

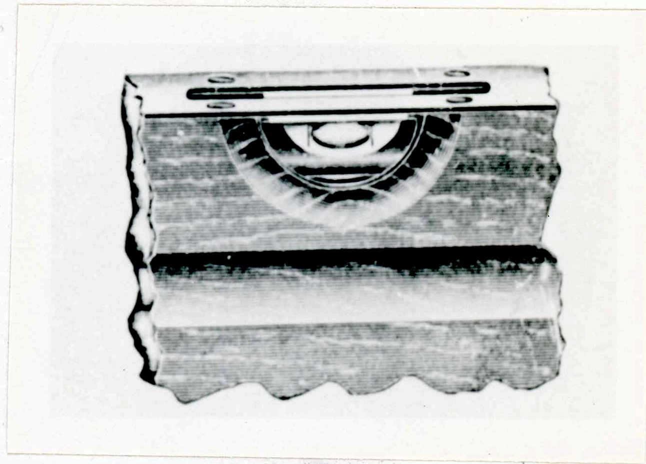

Figure 20
Level--Horizontal Setting

Figure 20. When only one level glass is used, it is called a spirit level. See Plate IV, Figure K, of the Appendix, for example.

Levels used today are made of both metal and wood of light weight construction, and designed to be used at any angle. They may be found on a variety of tools, such as a combination square and other instruments of precision. An all metal level to test the horizontal, vertical, and forty-five degree slope is produced by the Disston Tool Company.[19] This level is pictured on Plate IV, Figure L, of the Appendix.

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[19]Disston Tool Co., Disston Saw, Tool and File Manual, Philadelphia, Pa.: Henry Disston & Sons, Inc.,), P. 50.

CHAPTER VI

PARALLEL MEASURE

Definition of Parallel Measure

Parallel measure is the accurate depicting of a line equal distance to another line or reference surface. Man, early in history, undoubtedly used parallel measures to mark timbers or boards for parallel cutting.

Development of Tools of Parallel Measure

An early example of parallel measure is shown in a picture representing Noah building the ark. This picture is from a fresco by Christofano Buffalmacco in the Campor Santo at Pisa, and was painted about 1350. The squared log on which the "topman" stands is shown as set, not horizontally over a pit or on a scaffold, but on a trestle with one end on the ground. The saw teeth are raked to cut downward, and the "pitman" on the ground does all the cutting. The other two men in the picture are chalk-lining the next balk. (See Figure 21).[1]

The first marking gauge found in this study is that illustrated by Moxon. It is possible that the French, in building their fine furniture, may have had an earlier gauge, but no examples were found in this study. Moxon's gauge of 1677 is described as follows:

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[1] Mercer, op. cit., p. 24.

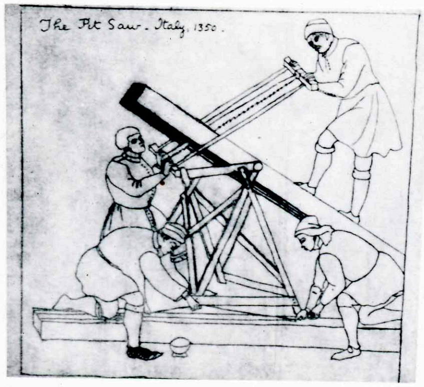

Figure 21
Use of Chalk-Line, About 1350

The Gage mark'd G (in Plate 4.) The Oval b is fitted stiff upon the Staff c, that it may be set nearer or farther from the Tooth a. Its Office is to Gage a line parallel to any straight side. It is used for Gaging Tennants, and for Gaging to an equal thickness.

When you use it, you must set the Oval to the intended Distance from the Tooth: If the Oval stand too near the Tooth, Hold the Oval in your right hand, and knock the hinder end of the Staff upon the work bench, till it remove to its just distance from the Tooth: If it stand too far off the Tooth, knock the fore end of the Staff (viz. the Tooth end) till it remove to its just distance from the Tooth: If the Oval slide not stiff enough upon the Staff, you may stiffen it by striking a wooden wedge between the Mortess and the Staff: So may you apply the side of the Oval next the Tooth, to the side of any Table or any other straight side, with the Tooth Gage a line parallel (or of equal distance) all the way from that side.[2]

(See Figure 22).

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[2]Moxon, op. cit., p. 90.

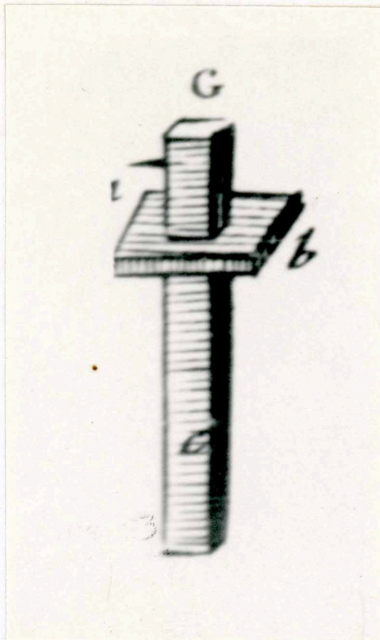

Figure 22
1677 Marking Gauge

Martin, in 1813, illustrated a marking and a mortice gauge. It is interesting to note the mortice gauge was made of a rectangular block of wood with a piece cut out, leaving a shoulder to hook over the edge of the material to be marked. The markers appear to be sharpened spikes driven through the arm part of the mortice gauge. (See Figure 23.)

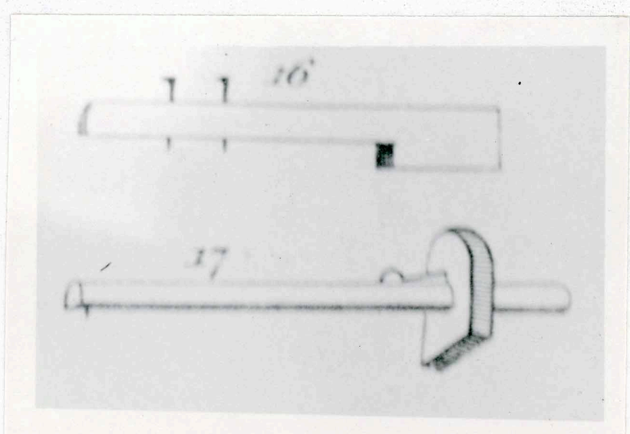

Figure 23
1813 Marking and Mortice Gauges

The marking gauge described by Martin is similar to the one described by Moxon, with the exception that the top of the head is round and a wedge is used to secure the head to the arm. (See Figure 22.)[3]

The chalk line, at this date, had not been entirely replaced by the marking gauge. Mercer described a variety of Colonial American forms of chalk lines and reels. The string is sometimes wound on a home-made rectangular frame-spool turning on a pivot. The line is whitened by pulling it against a lump of chalk, and when snapped, it makes a white line which is used as a guide line for cutting. Black ink was evidently used instead of dry chalk during the sixteenth century in Germany.[4] Examples of reels and chalk lines can be seen on Plate V, Figure A, of the Appendix.

In this country ink was made from berry juice during the middle part of the nineteenth century. The writer obtained this information from his grandfather, W. M. Sooter.

Three hand-made gauges, made by Henry Gates about 1840, are shown in Figures 24, 25, and 26. These tools are from the Hasner Collection located in the Jefferson Memorial in St. Louis, Missouri.

Anothermarking gauge was made and used by R. H. McBride of Jewell County, Kansas, in 1872, and it is now at the

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[3]Martin, *op. cit.*, Plate I, Carpentry, Figs. 16 and 17.

[4]Mercer, *op. cit.*, p. 53.

Figure 24
1840 Marking and Mortice Gauge

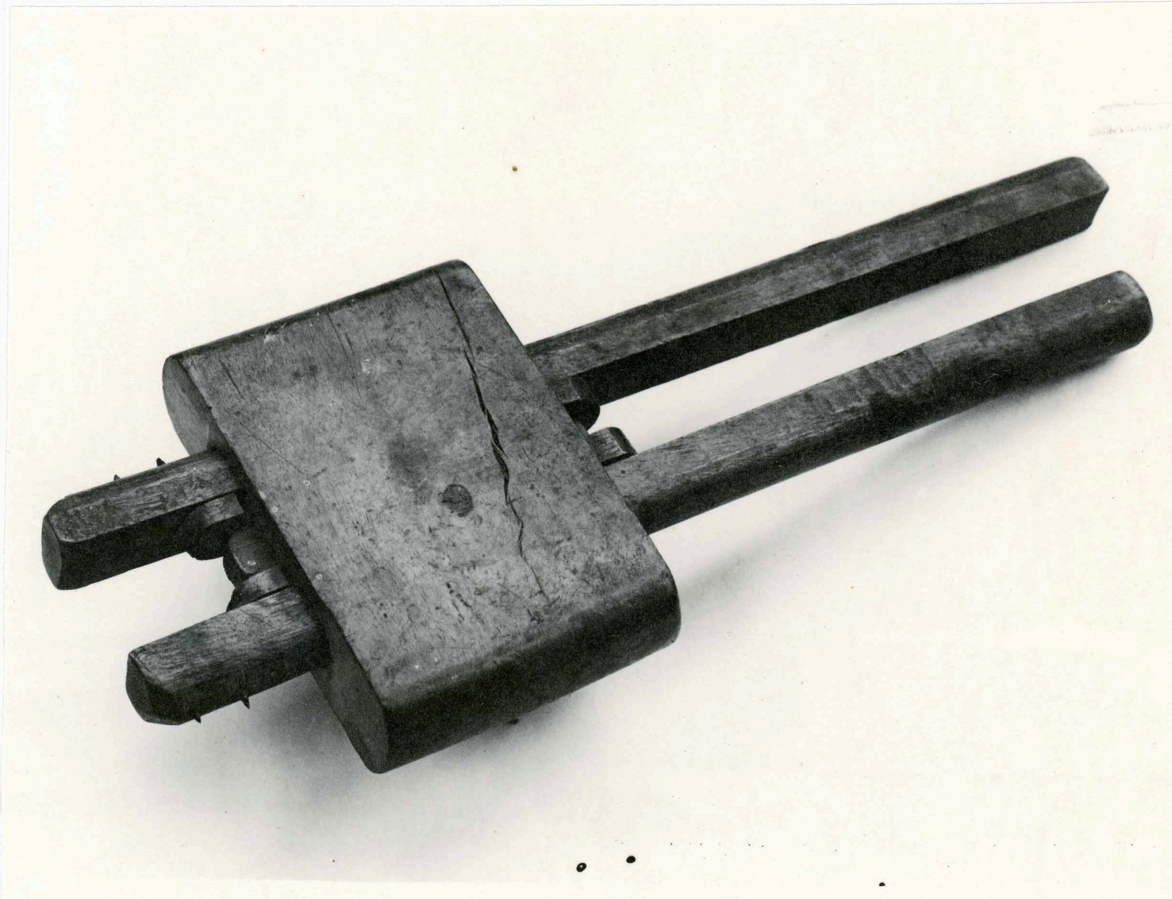

Figure 25
1840 Mortice Gauge

Figure 26
1840 Gauge

Another marking gauge was made and used by R. H. McBride of Jewell County, Kansas, in 1872, and it is now at the Kansas Historical Museum in Topeka, Kansas. The wedge in this tool is different from the ones in St. Louis, in that the wedge is on the side rather than on top. (See Figure 27.)

The book Woodworking Tools and How to Use Them, published in 1881, describes in detail the use of a chalk line:

> To join two given points of a horizontal board by a straight chalk mark. Pass the awl through the loop

Figure 27
1872 Marking Gauge

in the line, and press it into the wood at one of the given points. Chalk the line. Then stretch it tightly, covering the other given point with it. If convenient to do so, stand at the end of the board, with the right foot advanced toward it. With the left thumb press the line against the board near its end, and with the fingers of the left hand draw the line tight. Shut one eye and place the other directly over the line. Grasp the line, at a point which is about a foot distant from the left thumb, between the tips of the forefinger and thumb of the right hand. Rest the little finger of the right hand upon the board to steady the hand. Keep the surface of contact of the thumb and forefinger vertical and also parallel to the line. Raise the cord vertically with the right hand. Sight lengthwise of the line. If it appears straight when

> seen from a point directly over it, it will have been raised vertically. Let go the line on removing it, a straight chalk-mark will be found on the board joining the given points.[5]

See Figures 28 and 29.

Figure 28
Body Position in Snapping
Chalk Line

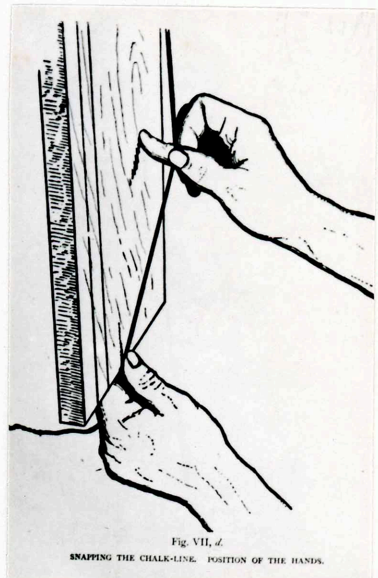

Fig. VII, d.
SNAPPING THE CHALK-LINE. POSITION OF THE HANDS.

Figure 29
Snapping Chalk Line
Position of Hands

Another method of gauging lines is shown, using the graduated rule and pencil:

> To mark, roughly, a line upon a board, parallel to an edge and at a given distance from it. Clasp the graduated rule firmly with the left hand. Rest the rule upon the board, with its length square with the edge, and with its end at the given distance from it. With the left thumb, press the rule upon the surface of the board; rest the left forefinger against the edge of the board. Place the second finger of the right

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[5] Woodworking Tools and How to Use Them, <u>op</u>. <u>cit</u>., p. 44.

> hand upon the board, and against the end of the rule. Let the marking-tool touch the end of the rule, the second finger, and the surface of the board. Slide the marking-tool and rule along the surface. The line thus drawn will be nearly parallel to the edge, and nearly at the given distance from it.[6]

(See Figure 30.)

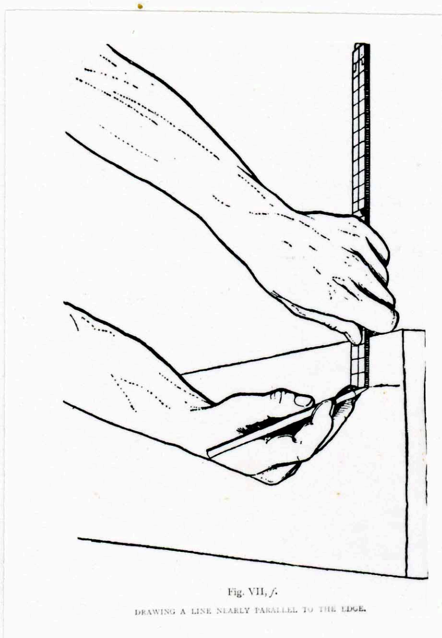

Figure 30
Gauging Lines with Rule

Saloman explains that while many different kinds of marking gauges are made, those generally used agree in main details. They usually consist of a piece of wood, called the stock, which has at least two parallel plane surfaces. There is a spindle, either circular or square, which passes through a mortice in the stock. At one end of the spindle is a sharp lancet-shaped steel marker. That side of the stock which is

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[6] *Ibid.*, p. 51.

placed against the edge to which the lines drawn are to be parallel may vary in length; but when lines are to be drawn parallel to a straight edge, the longer the stock is, the better. This makes possible more accurate management of the tool, and enables even an inexperienced person to gauge.[7]

One marking gauge described by Saloman has a rectangular long stock and a cylindrical spindle.[8] The stock is sawn into at one end as far as the mortice, and a screw put in this end holds the spindle in place. If a thumbscrew and nut are substituted for this screw, the necessary pressure can be more easily obtained. This gauge is pictured on Plate V, Figure B, of the Appendix.

Saloman also illustrates a marking gauge with a rectangular long stock and a rectangular spindle. Wedges are used to hold the spindle in place. This is an inexpensive and simple marking gauge invented by Herr Alfred Johansson, head-teacher at Nääs. It is especially practical for school use, because the stock helps inexperienced workers to gauge without difficulty.

A third marking gauge described by Saloman is an English gauge having a thumbscrew on one side of the stock, which works against the spindle and holds it in place.[9]

A cutting gauge described by Saloman has a parallelopiped shaped spindle secured by a wedge. Instead of a pin-shaped

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[7]Saloman, op. cit., p. 71.

[8]Ibid.

[9]Ibid., p. 72.

marker, it has a thin steel cutter which is adjusted by means of a pin. Cuttings may in this way be made on the surface of the work. This gauge is used primarily for gauging across the grain and in setting out for grooving and dovetailing.[10]

A panel gauge is described by Wells and Hooper. This gauge has a long stem and a wide fence, which has a rebate on the inside under edge. This gauge could be bought, but was usually made of hardwood by the workman.[11] For example, see Plate V, Figure C, of the Appendix.

Another gauge shown by Wells and Hooper is a tee gauge which has a lengthened fence to clear any projections. It can be fitted with a long point or pencil for gauging in grooves or panels below the working surface. This gauge, too, was usually made by the workman and was best made of hardwood.[12] For example, see Plate V, Figure D, of the Appendix.

Wells and Hooper describe two more gauges, each made of beech wood in approximately the same shape. However, the first gauge has a wooden wedge and a steel pin for the marker. The second has a brass wedge and a steel blade for the cutter. The cutter is bevelled with a slightly rounded face,

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[10] Ibid., p. 73.

[11] Percy A. Wells and John Hooper, Modern Cabinet Work Furniture and Fitments (New York: John Lane Company, 1910), pp. 11-13.

[12] Ibid.

which is always placed inside, near the stock, to insure a clear cut. Since the pressure on the gauge is in a forward direction, there would be a tendency for the cutter to run inwards if the bevel were on the outside.[13] Both of these gauges are shown on Plate V, Figure E, of the Appendix.

In 1912, Park gave a description of a marking gauge in common use at that time. There were four parts to his gauge: the bar, head, thumbscrew, and point. The bar had graduations in inches. The head and bar were made of apple wood, mahogany, boxwood, or rosewood, while the point was made of steel.[14] See Plate V, Figure F, of the Appendix for picture of this gauge.

Park also illustrates a mortise gauge. It is constructed like a marking gauge, except that it has two points, one of which is fixed and one which is movable. Its principle use is in the making of mortise and tenon joints.[15] For example, see Plate V, Figure G, of the Appendix.

Another description Park gives is that of a Stanley improved gauge with patent attachment. This attachment enables one to run a gauge line with perfect steadiness and accuracy around curves of any degree, and either concave or convex. The gauge head is reversible, and the flat side can

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[13] Ibid.

[14] Park, op. cit., p. 35.

[15] Ibid., p. 36.

be used for ordinary work. This patent attachment can be used on nearly every make of gauge.[16] See Plate V, Figure H, of the Appendix for example. Some know this type of gauge as the roller mortise.

Barter gives the following very clear description of a mortice gauge and its uses:

> This tool is for marking two cut lines parallel to the edge of a piece of wood, usually to indicate the limits of a mortice or slot which is to be cut in the wood. It is similar in principle to the marking gauge, but two spurs or teeth are provided, and in order to obtain the power of regulating the distance of the two cut lines from each other, one tooth is fixed into the stem, while the other is bedded in a strip of brass which slides up and down the stem, obedient to the governing screw in the end. The points of the teeth are made to cut on both edges, and are rounded somewhat on both sides. There being two teeth, the liability to run out of the straight line is not very great.[17]

Even though there are, and have been for some years, several types of marking gauges, there are still people who do not use them consistently. William Labs, while an American soldier in France in 1917-1918, saw, in a forest a few miles southeast of Montmorillor, peasants sawing rough boards and using only their eyes to judge the straightness of their sawing.[18]

Even today in some of the woodworking shops, students are taught to "gauge with a pencil." Other gauging methods

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[16] Ibid.

[17] S. Barter, Manual Instruction Woodwork (The English Sloyd), Fourth Edition (London: Sir Issac Pittman and Sons, Ltd., 1905), pp. 89-90.

[18] Mercer, op. cit., p. 23.

include using a stick or rule. Then by holding the point of the thumbnail at the proper length, and a pencil or awl at the point where the marking takes place, the workman can, by letting the back of his thumbnail ride along the edge, and by keeping the stick at the same angle, depict a line by gauging with the parallel measure. These methods just described probably go back centuries. Because of their simplicity they remain unpublished.

The tools of parallel measure of today are still very similar to those made by the workman a century ago. The difference is that today tool companies are producing less expensive instruments by mass production methods than most workmen can afford to produce them by hand in their own shops. Today the wedge is almost in total discard, being replaced by the thumb-screw.

Today tool companies make gauges of both wood and metal. Basically, they have a head and stem, as does the gauge described by Moxon, but have been improved by the addition of brass plates to prevent wear on the face of the head block, the thumb-screw, and graduations on the stem.

The Disston Marking Gauge No. 77 is made of hardwood. Two straight brass plates on the head prevent wear on the face, and the adjusting screw bears against a brass plate to prevent wear on the stem. The stem is graduated by sixteenths. Plate V, Figure I, of the Appendix pictures this gauge.[19]

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[19]Disston Tool Company, _Disston Saw, Tool and File Manual_, _op. cit._, p. 50.

The Stanley Tool Company lists several gauges in its catalog which more or less indicates the variety of gauges being sold today.

Gauge No. 61 has a square head, and stem graduated in sixteenths. The stem and head are made of beechwood. The thumb-screw is made of boxwood and the point is tempered and fixed in the stem.[20] For example, see Plate V, Figure J, of the Appendix.

Gauge No. 65 is similar to Gauge No. 61, the difference being an adjustable point, brass thumb-screw, with a brass shoe to prevent wear on the stem. This gauge has a face plate to prevent wear on the wooden head, and is primarily different in shape from that made by Disston.[21] This gauge is pictured on Plate V, Figure J, of the Appendix.

Gauge No. 64½ differs from Gauge No. 65 in that it has an oval head, while the latter has more of a square head.[22] This gauge is pictured on Plate V, Figure K, of the Appendix.

A double bar mortise Gauge No. 72 is listed by Stanley. This gauge has two independent bars with a pin fastened in each. It is graduated in sixteenths, with brass shoes and thumb-screw at the side of the head. It is noted, "After one side of a mortise is marked, the gauge can be turned to mark the other side."[23] The gauge is shown in Plate V, Figure L, of the Appendix.

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[20]Stanley Tool Co., Stanley Tools, Catalog No. 34, _op. cit._, p. 111.

[21]_Ibid._

[22]_Ibid._

[23]_Ibid._

A Slide Gauge No. 77, made of rosewood, has a brass slide in the bar. One pin is fastened to the bar and another to the slide. With this arrangement, both sides of a mortise can be marked at once. A pocket in the head permits marking to within 1/16" of the stationary pin.[24] For example, see Plate V, Figure L, of the Appendix.

Metal gauges are also made by Stanley. These gauges are nickel plated and graduated by sixteenths for five inches.

Gauge No. 90 is made with a single head and bar of metal. A single screw on the upper side of the head allows for easy adjustment of the gauge.[25] This gauge is shown on Plate V, Figure M, of the Appendix.

A roller cutter and double faced head, with side adjustment screw, seem to be the primary differences between marking Gauge No. 97 and Gauge No. 90. Gauges equipped with roller cutters are especially adapted for marking over knots and across the grain of wood.[26] See Plate V, Figure N, of the Appendix for example.

Gauge No. 91 is made with a double bar and a single head. The bars set one above the other. Screws are on the top and bottom of the head and allow for easy adjustment of the bars.[27] This gauge is shown on Plate V, Figure O, of the Appendix.

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[24] *Ibid.*

[25] *Ibid.*, p. 112.

[26] *Ibid.*

[27] *Ibid.*

Another gauge used for marking and mortise work is Gauge No. 98. This gauge has a double faced head, double bars that set side by side, and has adjustable roller cutters on one end.[28] For example, see Plate V, Figure P, of the Appendix.

The most recent change in the marking gauge is that made by the Stanley Tool Company. This change did not involve any fundamental changes in the action of the gauge, but was one of shape. This latest of gauges is triangular in the shape of the head and stem. The thumb-screw is on the top side of the head. This arrangement might give more stability to setting the head; however, as with all tools, it will have to be time tested by common use to prove its worth. This instrument was photographed by the author before itscommon publication and may be seen in Plate V, Figure Q, of the Appendix.

The Awl

Down from the earliest times man has made marks with an instrument made of the material at hand. Our museums are well supplied with examples of stone, bone, shark teeth and other items classified as awls. Metal came into use and passed from crude ice-pick-looking instruments to a polished tool. Today, however, the use of the awl is almost nil, having been replaced by the pencil.

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[28] *Ibid.*

Summary

In the early history of constructive processes, man found it was necessary to develop a series of tools, the primary function of which was to standardize the work, making it possible for many men to work together on the same job.

These tools, throughout the ages, have been made by the workmen themselves to fit the job on which they were working. They have taken a variety of sizes and shapes, their classification depending upon the task which they were to perform or a particular characteristic of the tool itself.

The total results of the study indicate that the tools have advanced from the rough, simple devices made by the workmen to the more precise instruments being manufactured by tool companies today. The tools in use at the present time were not developed by a single individual, community, or nation, but represent human effort over the entire world from the beginning of organized society.

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APPENDIX

PLATE I -- LINEAR MEASURE

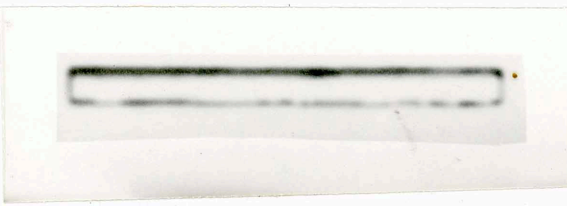

Figure A

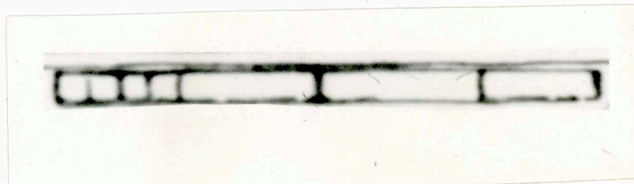

Figure B

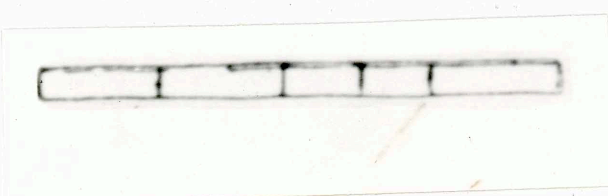

Figure C

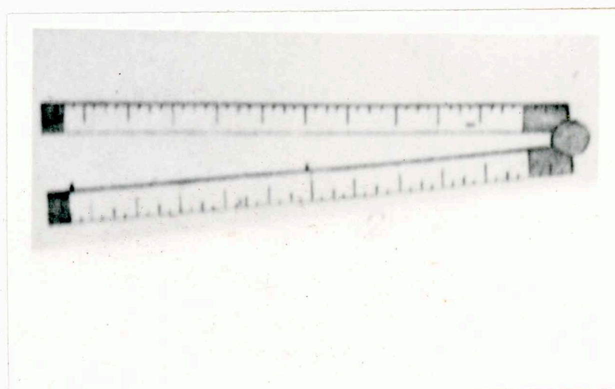

Figure D

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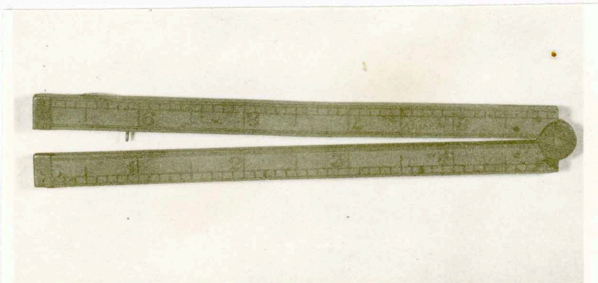

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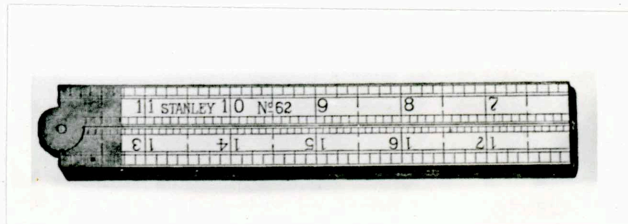

Figure F

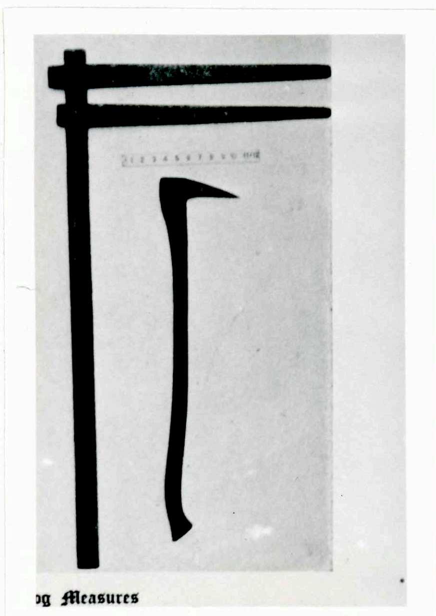

Figure G

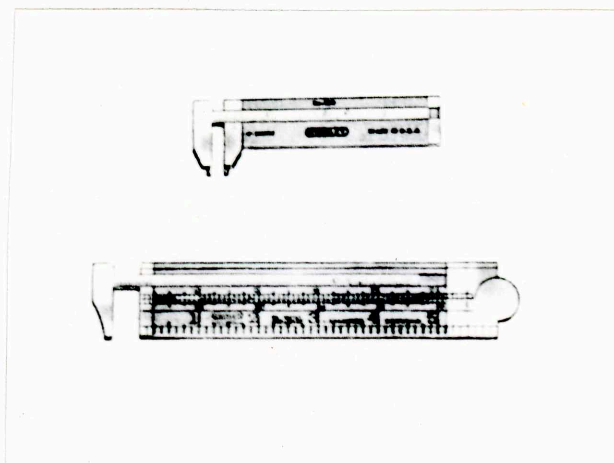

Figure H

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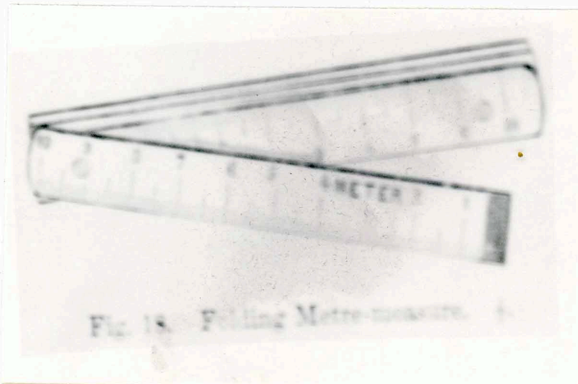


Figure I

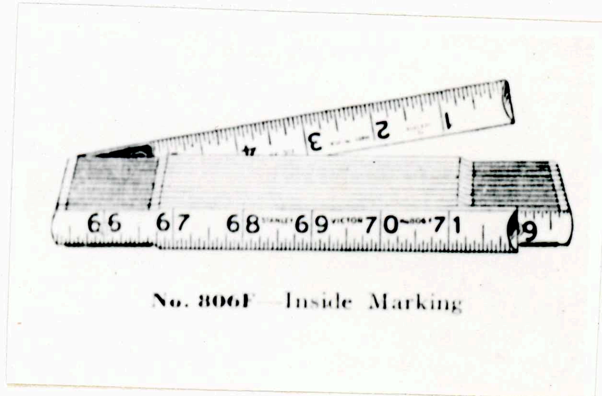


Figure J

Figure K

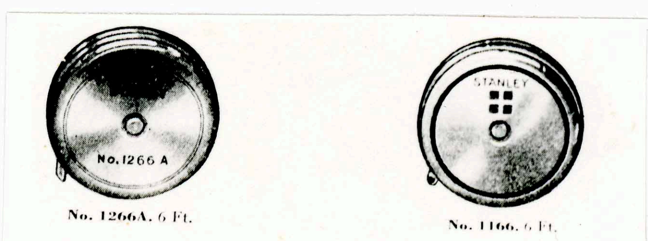


Figure L

Plate I (Continued)

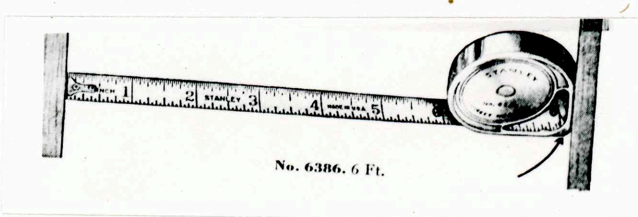


Figure H

PLATE II -- ANGULAR MEASURE

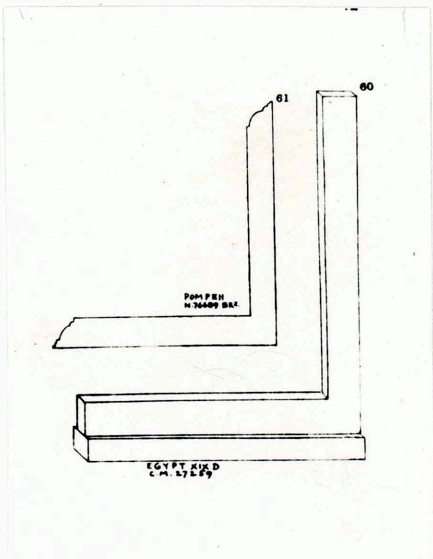


Figure A

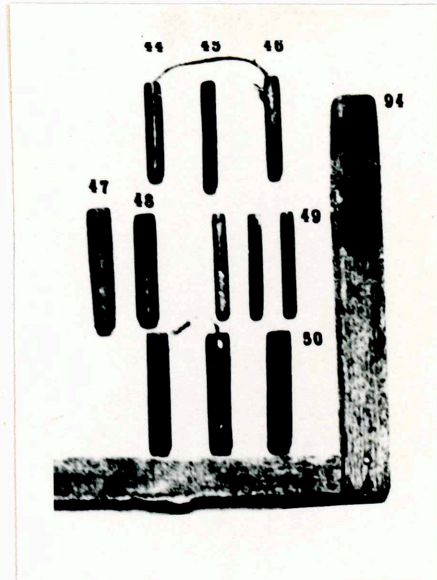


Figure B

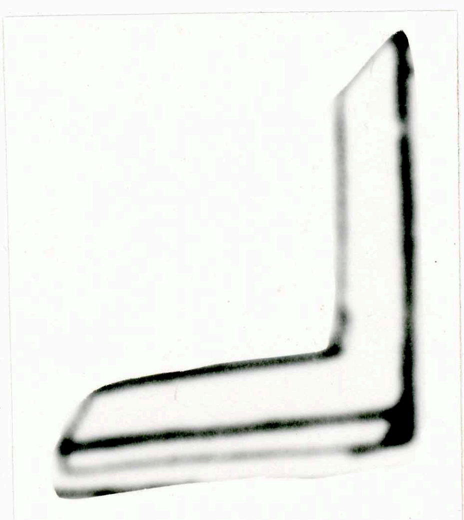


Figure C

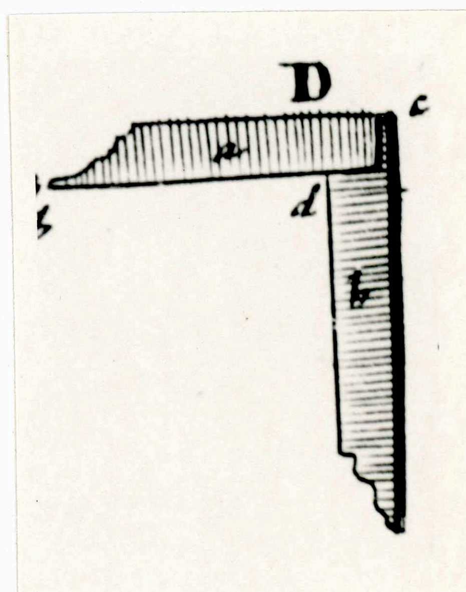


Figure D

Plate II (Continued)

Figure E

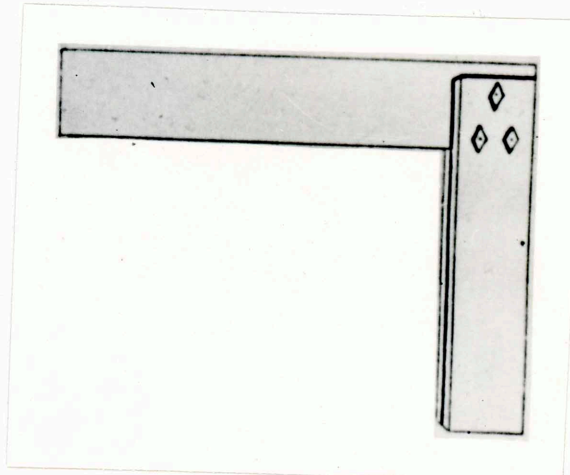
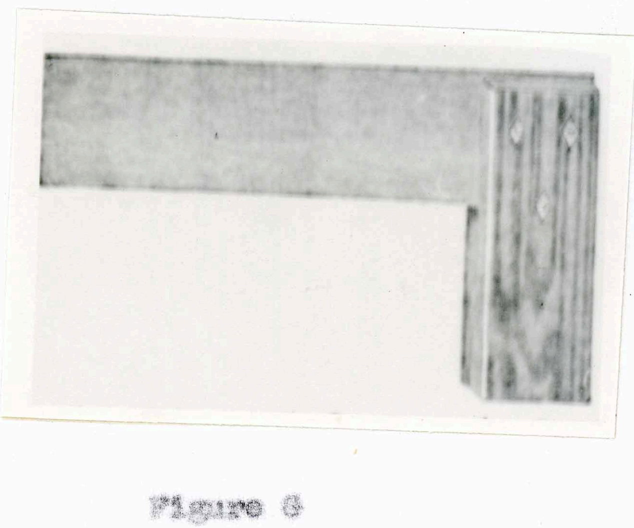


Figure F



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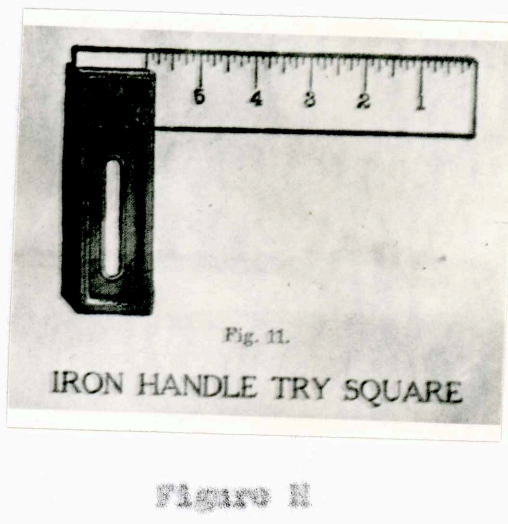

Figure H

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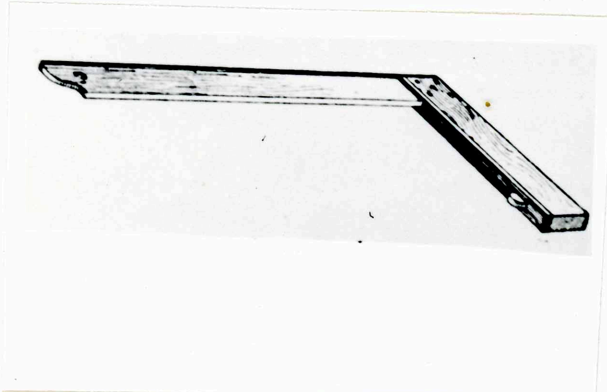

Figure I

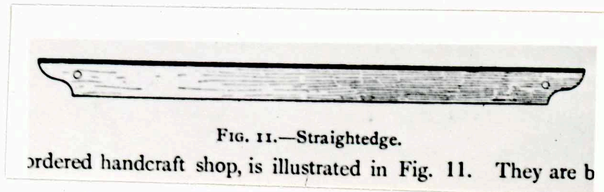

Fig. 11.—Straightedge.

ordered handcraft shop, is illustrated in Fig. 11. They are b

Figure J

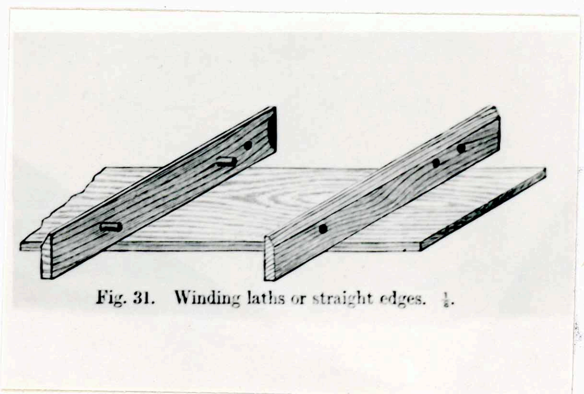

Fig. 31. Winding laths or straight edges. ¼.

Figure K

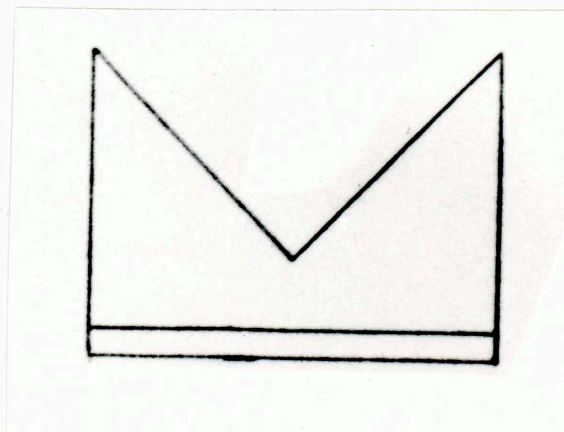

Figure L

Plate II (Continued)

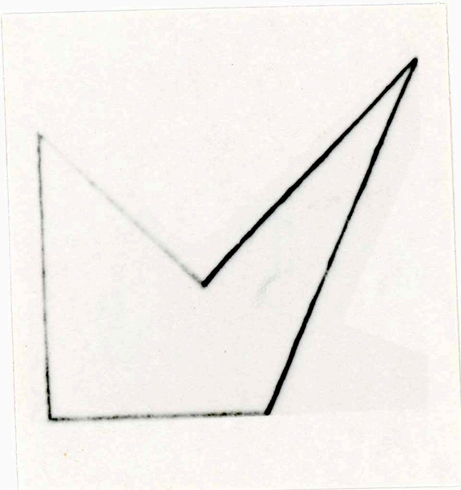

Figure M

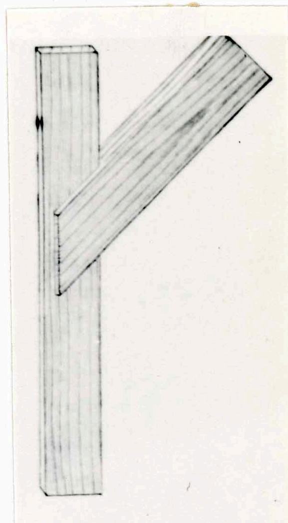

Fig. 29. Set-bevel or mitre-bevel. ⅛.

Figure N

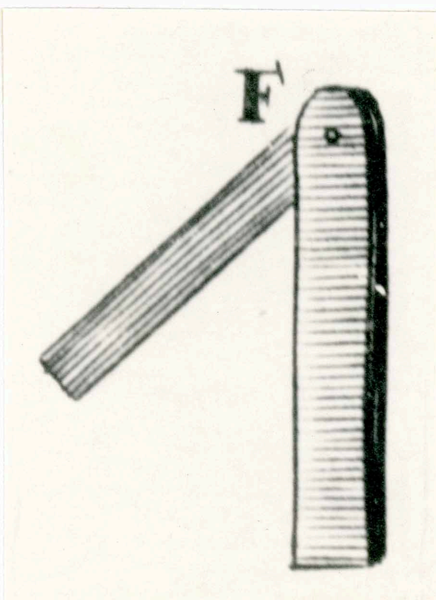

Figure O

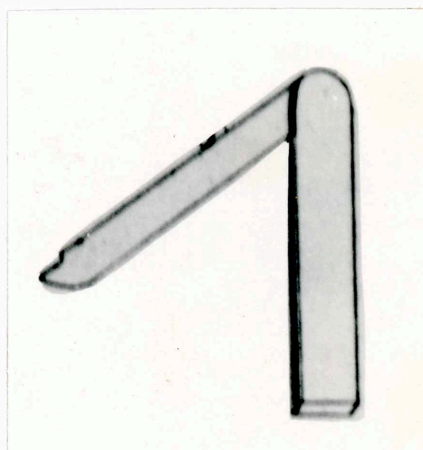

Figure P

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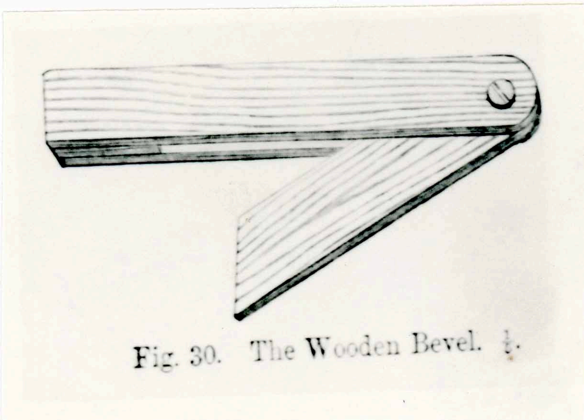


Fig. 30. The Wooden Bevel. $\frac{1}{5}$.

Figure Q

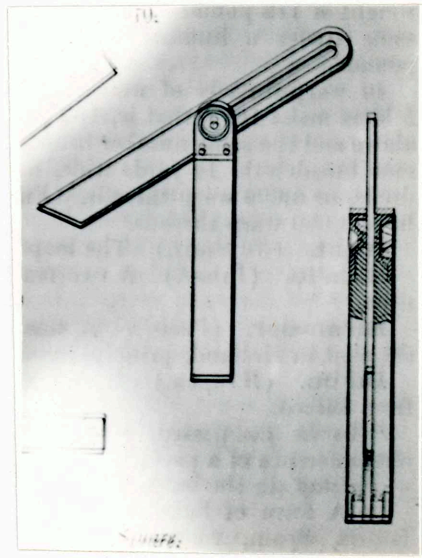


Figure R

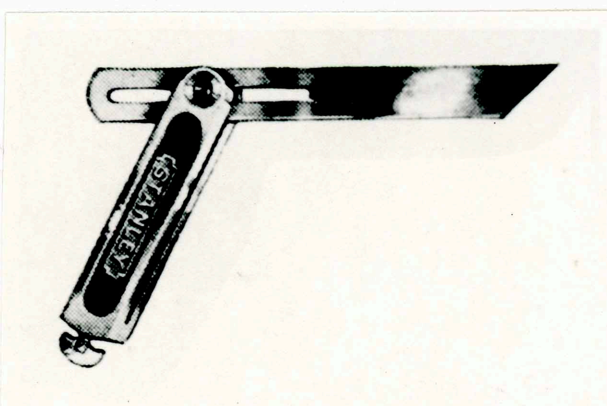


Figure S

PLATE III -- CIRCULAR MEASURE

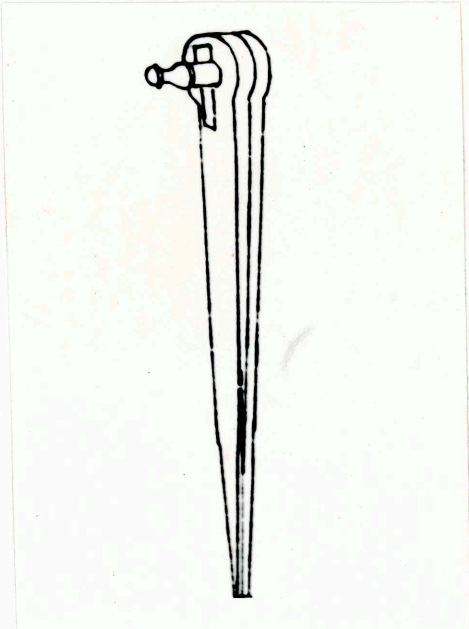
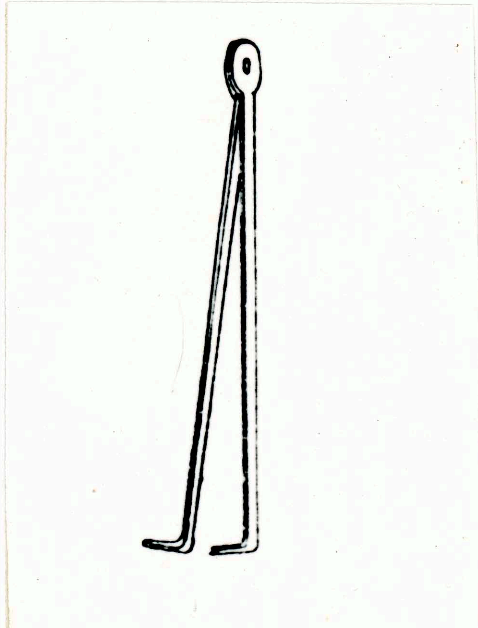


Figure A



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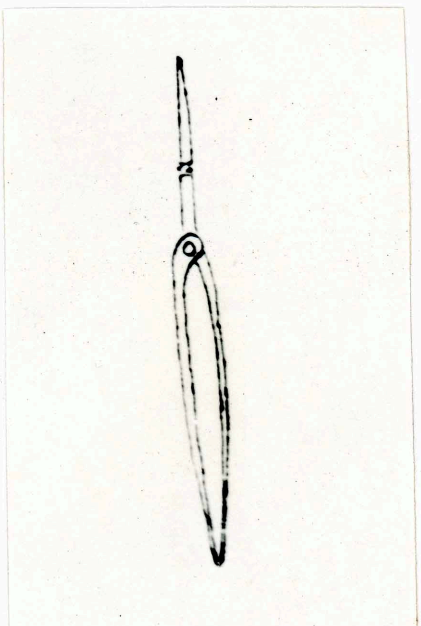

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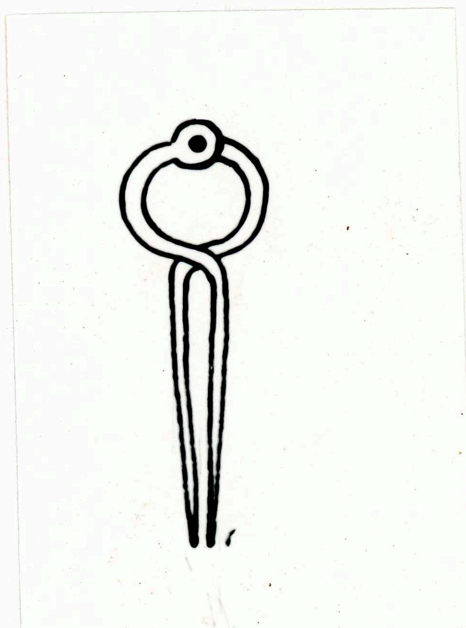

Figure D

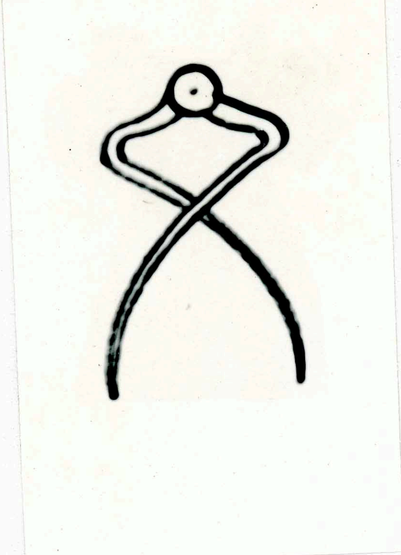

Figure E

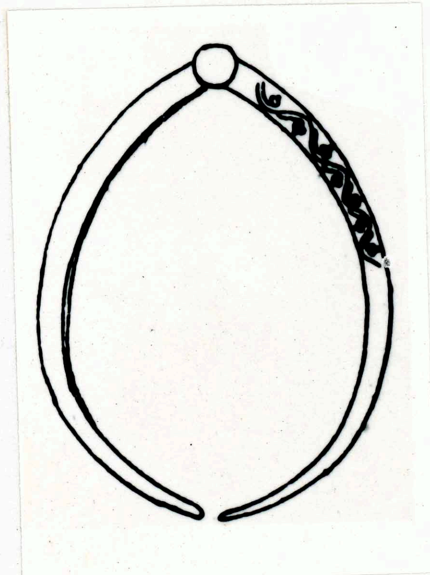

Figure F

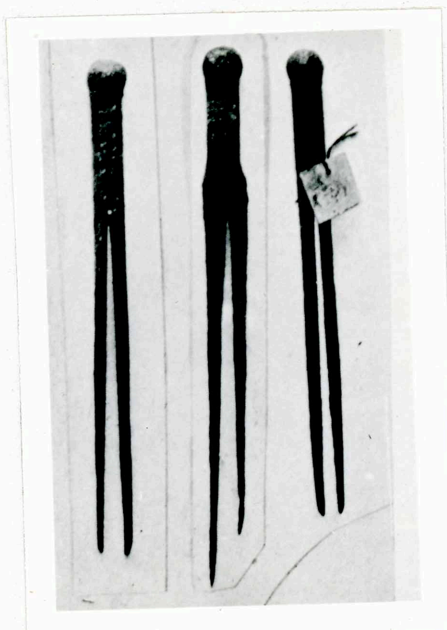

Figure G

Plate III (Continued)

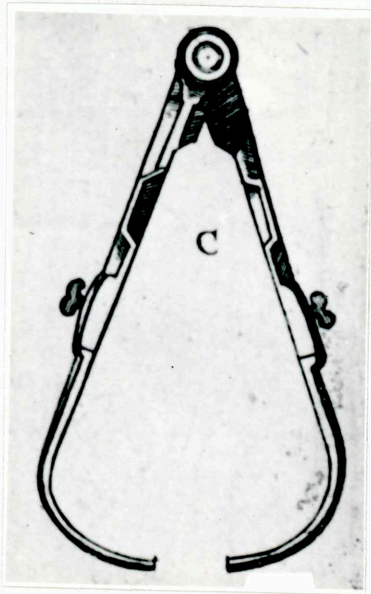

Figure H

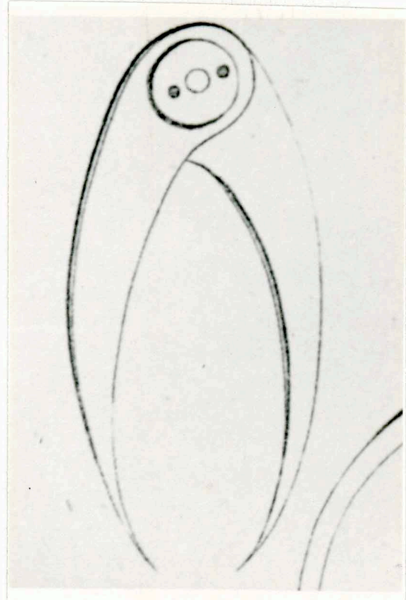

Figure I

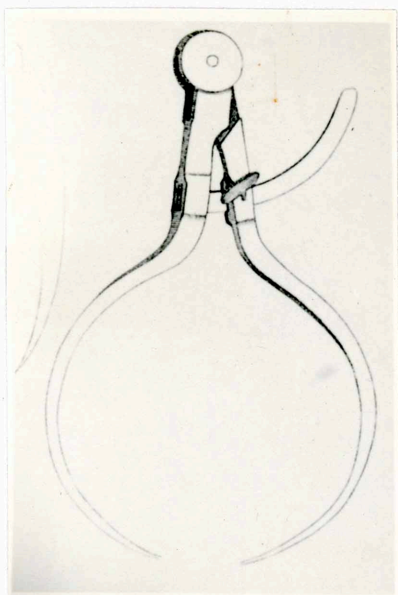

Figure J

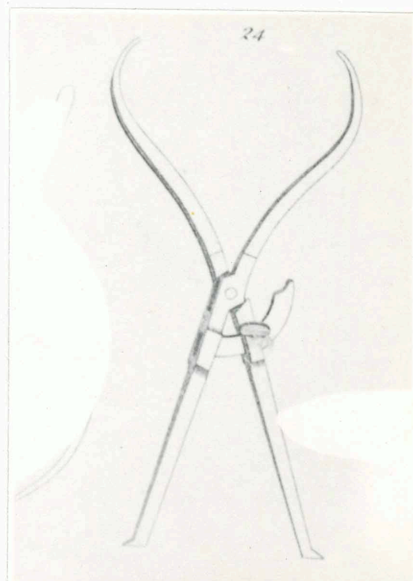

Figure K

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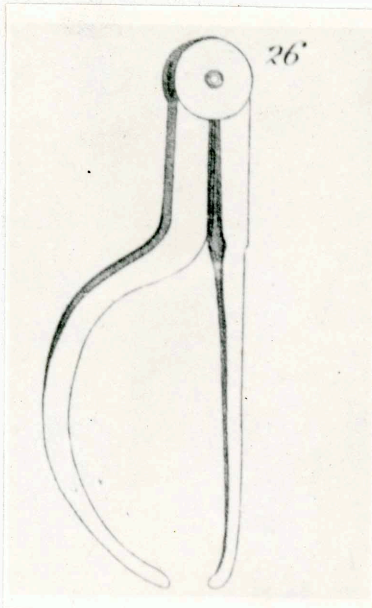
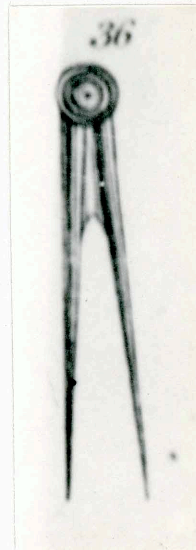


Figure L



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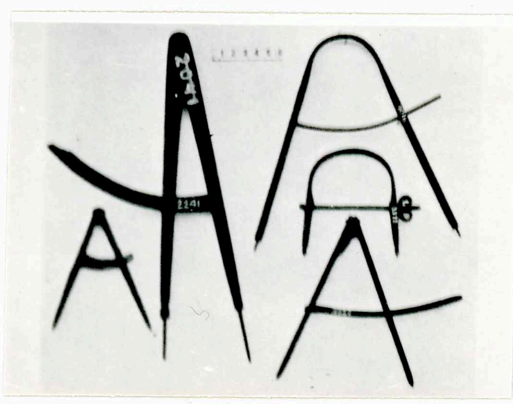

Figure N

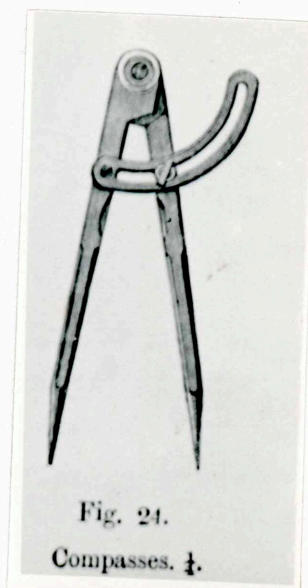

Figure O

Plate III (Continued)

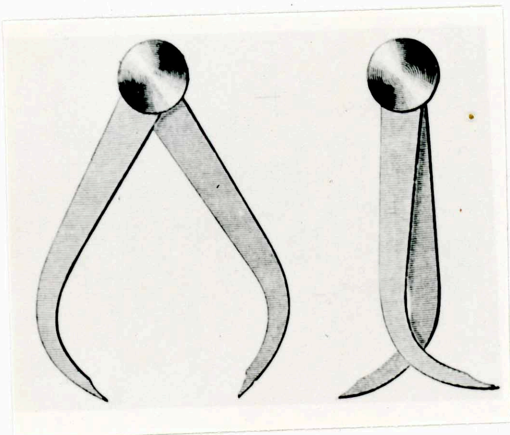

Figure P

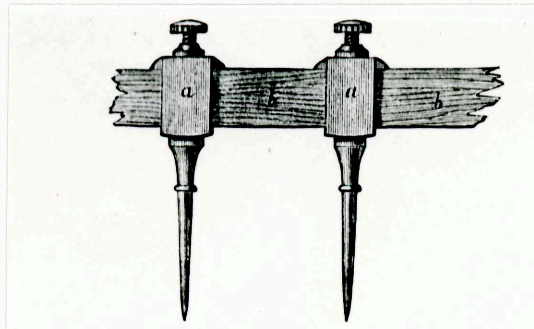

Fig. 25. Trammel Heads, or Beam Compasses.
aa. Trammels, *bb*, Beam.

Figure Q

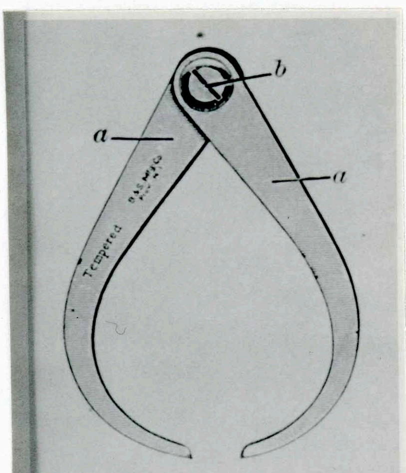

FIG. 19. — Outside calipers.
a, legs; *b*, joint.

Figure R

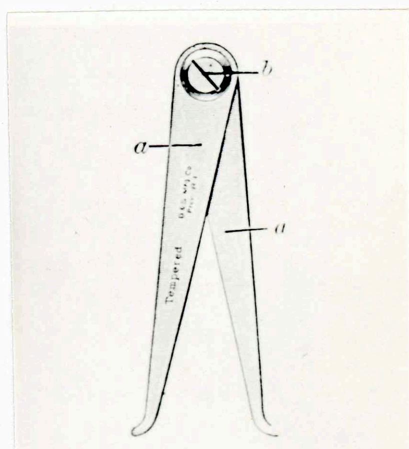

FIG. 20. — Inside calipers.
a, legs; *b*, joint.

Figure S

Plate III (Continued)

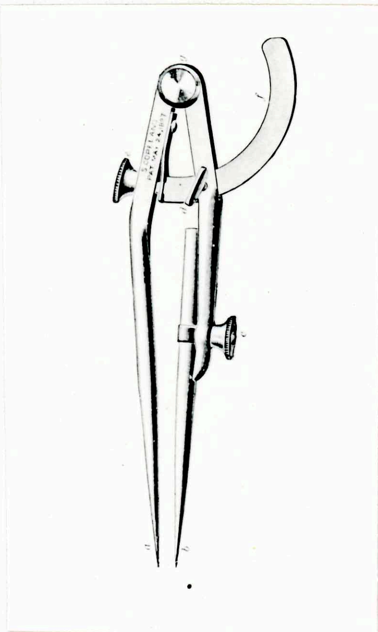

Figure T

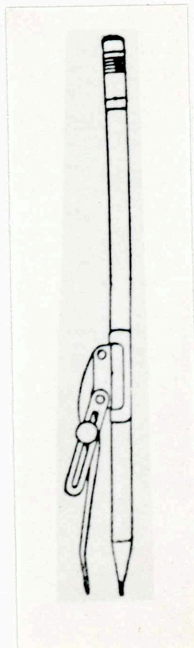

Figure U

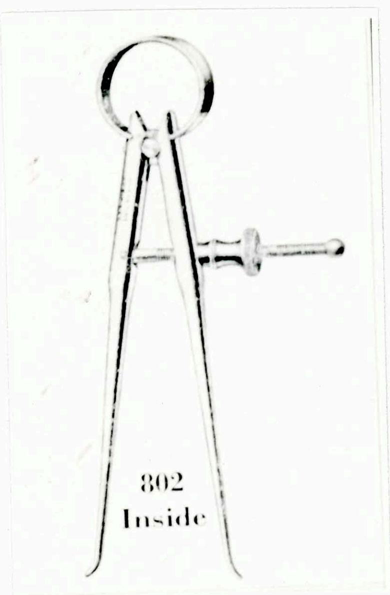

Figure V

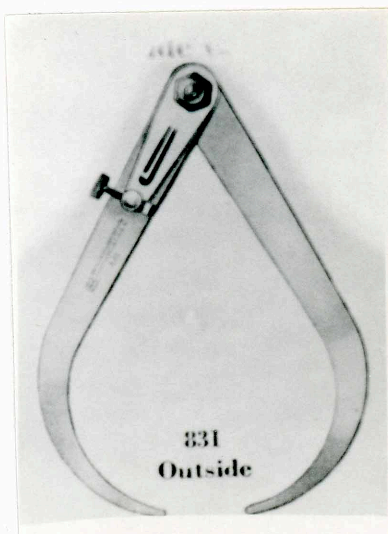

Figure W

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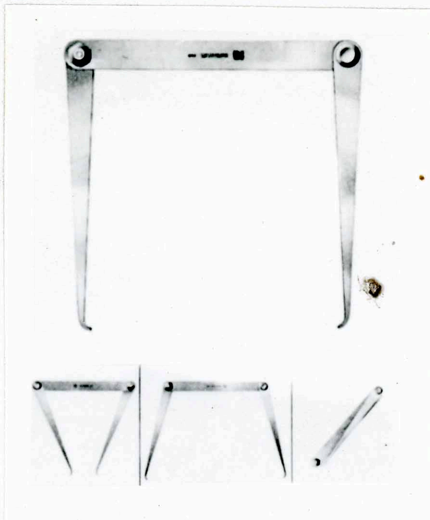


Figure X

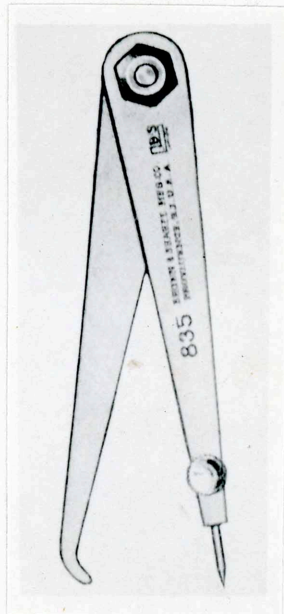


Figure Y

PLATE IV -- GRAVITORIAL MEASURE

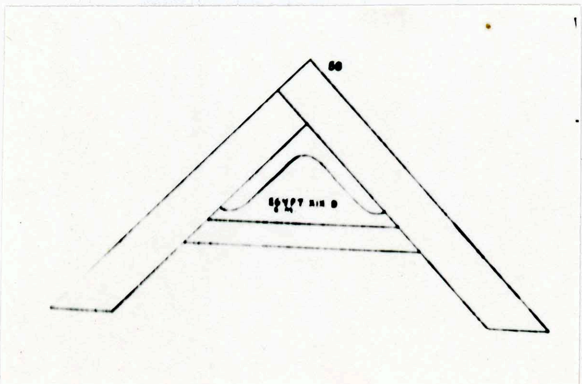


Figure A

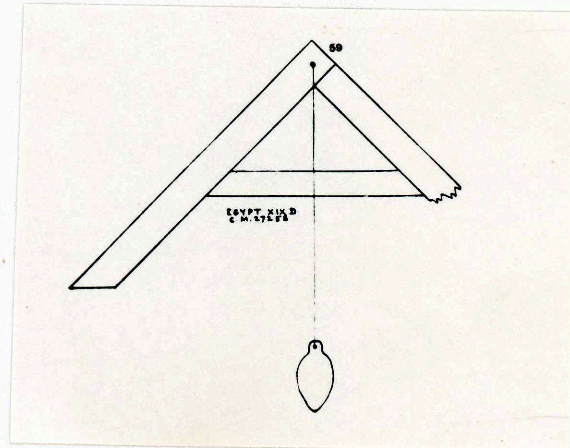


Figure B

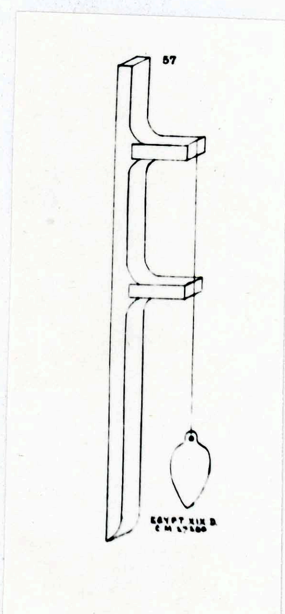


Figure C

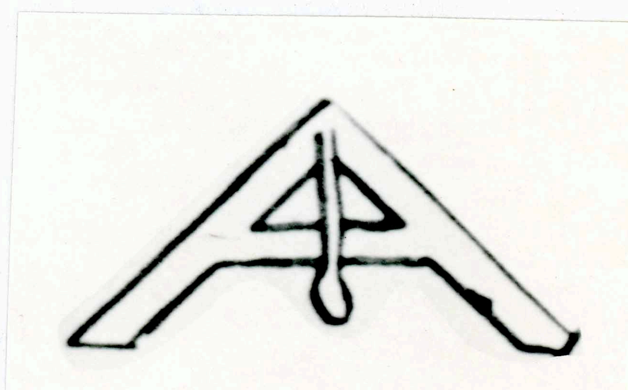


Figure D

Plate IV (Continued)

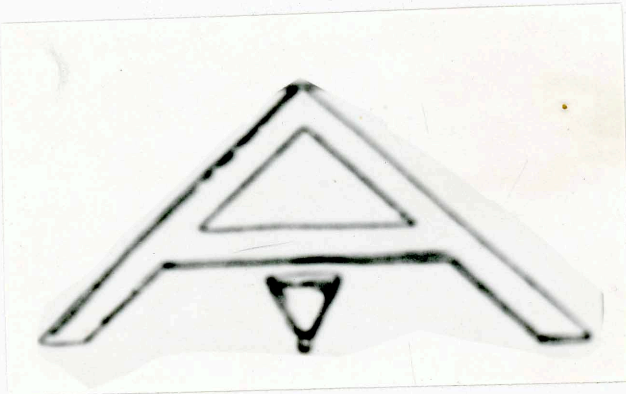


Figure E

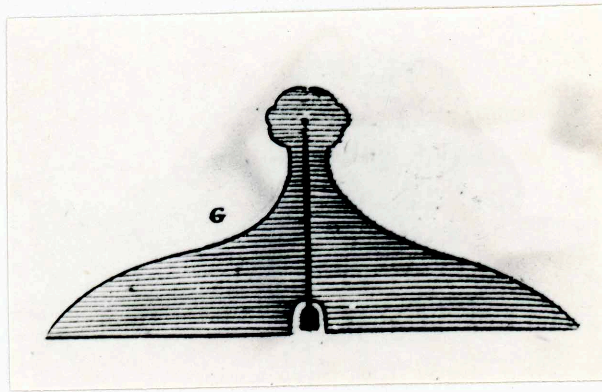


Figure F

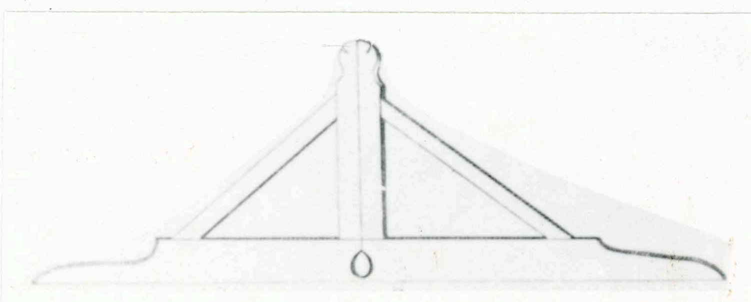


Figure G

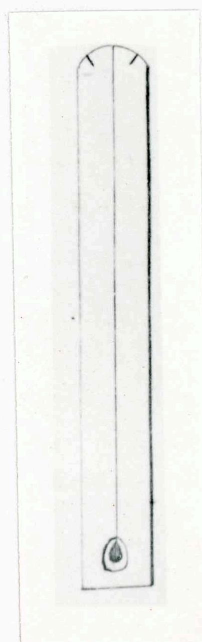


Figure H

Plate IV (Continued)

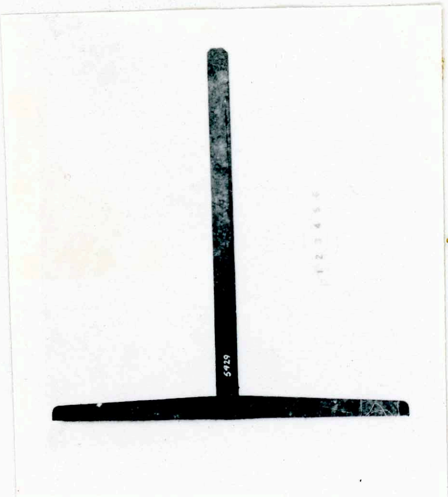


Figure I

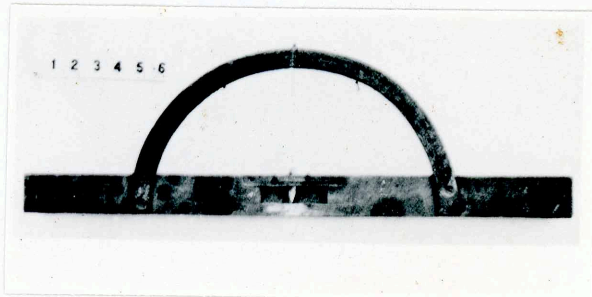


Figure J

Figure K

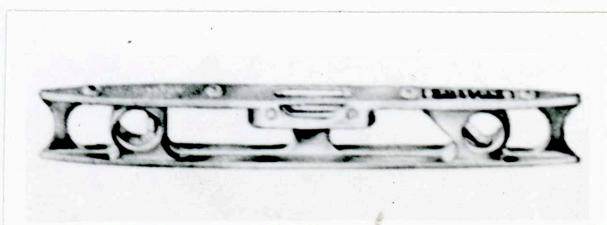


Figure L

PLATE V -- PARALLEL MEASURE

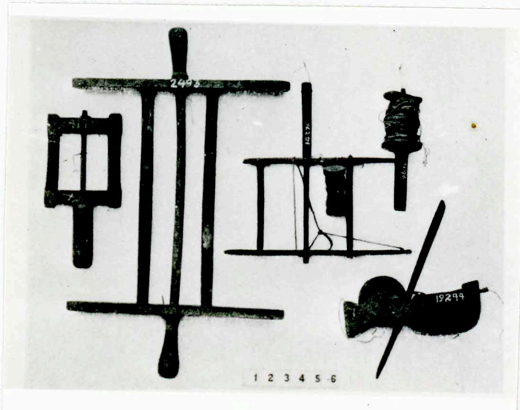


Figure A

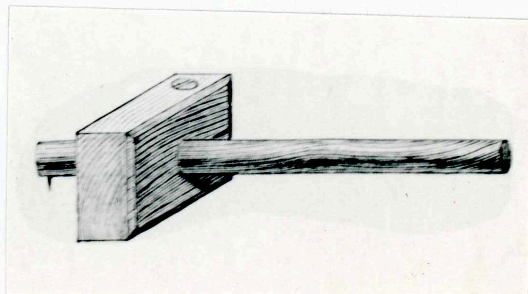
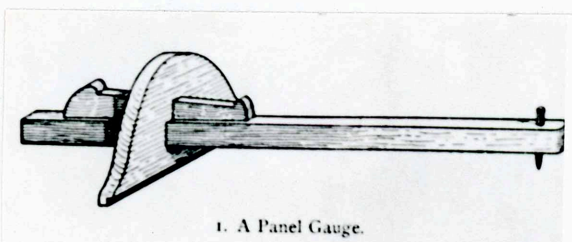
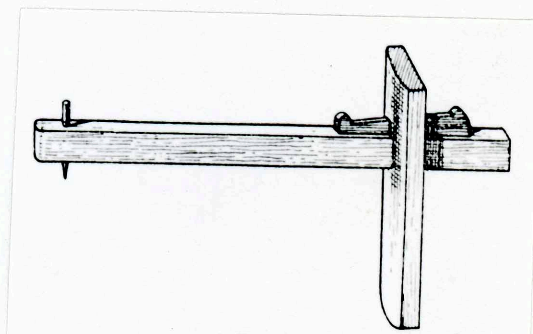


Figure B



1. A Panel Gauge.

Figure C



2. A Tee Gauge.

Figure D

Plate V (Continued)

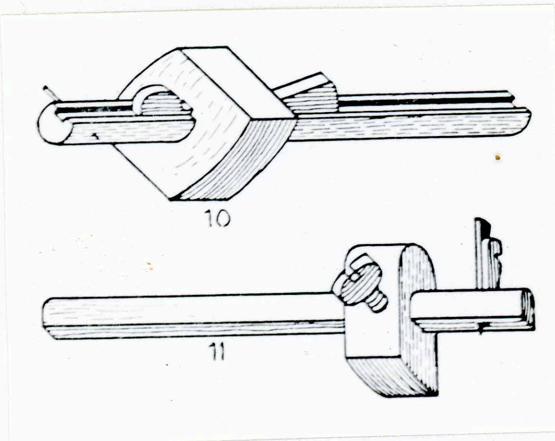


Figure E

Fig. 15. — Marking gauge. *a*, bar; *b*, head; *c*, thumbscrew; *d*, point.

Figure F

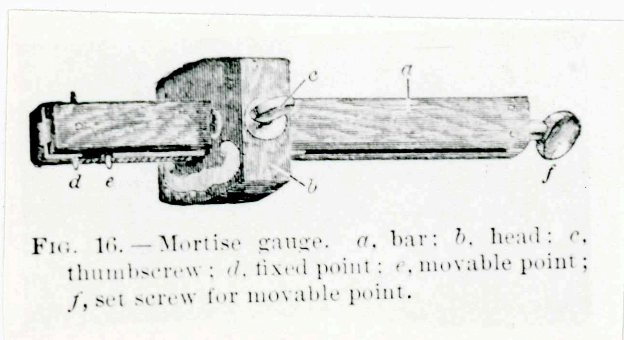


Fig. 16. — Mortise gauge. *a*, bar; *b*, head; *c*, thumbscrew; *d*, fixed point; *e*, movable point; *f*, set screw for movable point.

Figure G

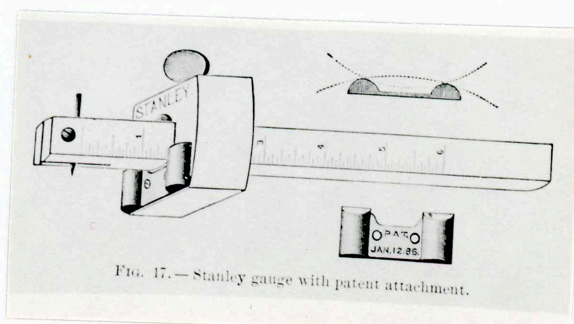


Fig. 17. — Stanley gauge with patent attachment.

Figure H

Plate V (Continued)

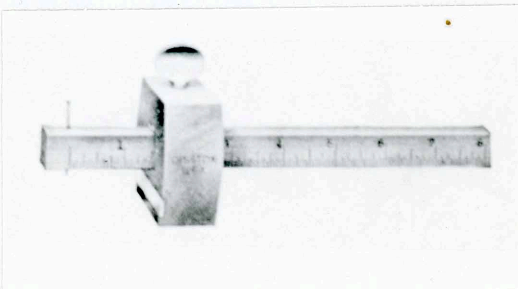


Figure I

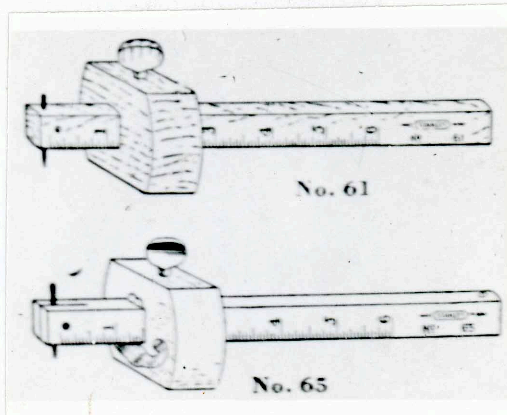


Figure J

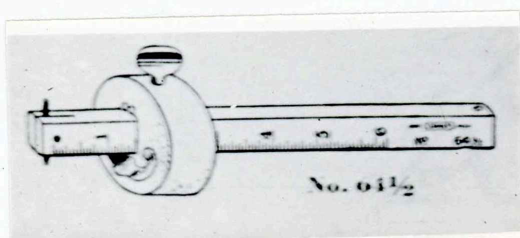


Figure K

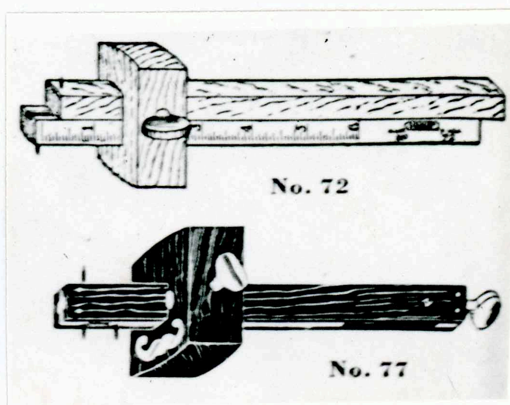


Figure L

Plate V (Continued)

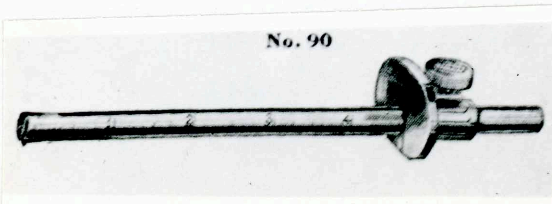


Figure M

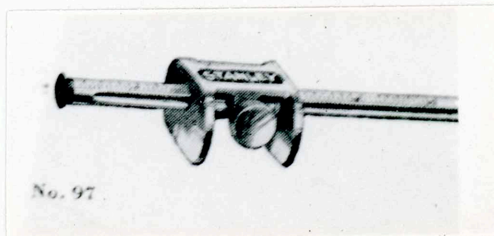


Figure N

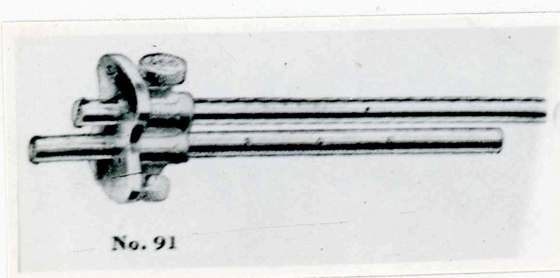


Figure O

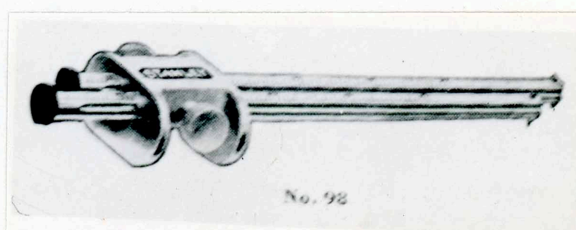


Figure P

Plate V (Continued)

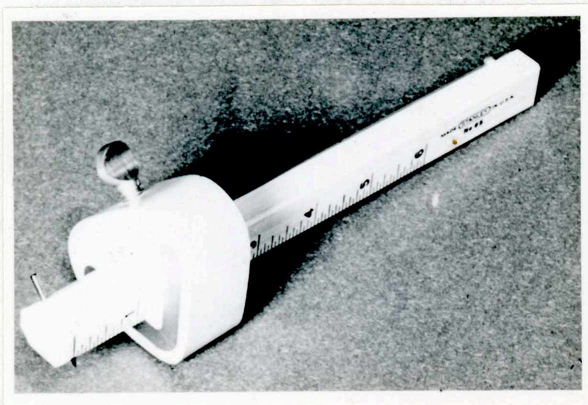


Figure 6