THE

GERBER VARIABLE SCALE

No. 368

AN INSTRUCTION MANUAL
FOR MODEL TP007100

INTERNATIONAL SLIDE RULE MUSEUM

Published by
THE GERBER SCIENTIFIC INSTRUMENT CO.
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TABLE OF CONTENTS

	Page
INTRODUCTION	1
CONSTRUCTION	2
CARE AND USE OF INSTRUMENT	3
ADJUSTMENT	3
PARTS LIST	4

PROBLEMS AND EXAMPLES

Spacing Rivets	5
Reading Unreadable Scales. . .	
Converting Units.	6
Odd Scales.	7
Nondimensional Curves	8
Linear Interpolation	9
Non Linear Interpolation	10
Determining Pitch of Screw Threads	11
Laying Out Airfoil Sections.	12
Construction Layouts	13
Calibrating Instruments.	14
Odd Scale Drawing Reproduction	15
Direct Measurement of Shadowgraphs	16
Reading Oscilloscope Screens	17
Reading Trigonometric Functions and Derivatives. . .	18
Stress Analysis — Vector Addition	19
Center of Gravity Location	20
Analyzing Indicator Cards.	21
Navigation	22
Interpreting Aerial Photographs.	23
Plotting Contours.	24

APPENDIX

REFERENCE TABLES (Multiplication & Division) 25, 26, 27, 28, 29

THE

GERBER VARIABLE SCALE

This booklet explains the basic uses of the GERBER VARIABLE SCALE and includes examples which illustrate its applications to the solution of specific problems.

INTRODUCTION

The Gerber Variable Scale is an instrument designed to solve graphical problems quickly and accurately.

The device is related more closely to a standard engineers' scale than to a slide-rule, although it replaces both in some operations.

Probably every engineer and architect has had occasion to wish for a "rubber ruler"; the Gerber instrument is the answer to this wish, and can be used as such at once with no reference to written instructions. There are, however, many uses for the device that are not immediately apparent, and it is the purpose of this booklet to explain some of these uses.

Users of the Gerber Variable Scale have discovered applications to their particular work, some of which are included here. Because the instrument is new to the engineering profession, such original applications will continue to be discovered. The Gerber Scientific Instrument Company will be interested to hear from users about new applications to specialized problems.

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CONSTRUCTION

The simple and precise construction of the instrument features a triangular SPRING, fixed at the left end, and attached at the right to a SLIDE, which is marked with a hairline. This hairline is used to position the spring with respect to two scales, the I SCALE (or percentage scale) and the R SCALE (or reciprocal scale).

For convenience in reading, every 10th coil of the 100-coil spring is red, and the half-way coils between red are green. The 50 coil has a yellow dot.

In any position of the spring, the number of coils per inch will equal the total number of coils divided by the length of the spring in inches. If, then, the hairline is set at 4 on the I scale, the number of coils per inch will be 100/4, or 25.

Because of practical considerations in the construction of the instrument, there are actually 101 coils in the spring instead of 100. The error due to this discrepancy has been entirely eliminated by marking the I scale in proportion. This means that the distance between say 2 and 3 on the I scale is not 1 inch, but 1.01 inches. This does not affect the operation of the instrument, and need concern the user no more than the fact that the "10-inch" slide-rule is actually 25 cm., or 9.83 inches long. If the hairline on the Gerber instrument is set to 4 on the I scale, there will be exactly 100/4, or 25 coils per inch on the spring.

The reciprocal, or R scale, has been included so that the number of coils per inch can be set directly. The numbers on this scale are analogous to those on the familiar triangular engineers' scale, and any engineer who has turned from "40" to the "50" scale and back, wishing there were one between, is one of those for whom this instrument has been designed. The Gerber Variable Scale provides not only the six standard scales, but also a "42.3" scale, a "51.6" scale, or any other scale which will fit a particular need.

CARE AND USE OF INSTRUMENT

The Gerber Variable Scale is a scientific instrument, and must be treated as such to insure continued accuracy of operation. The scale must not be dropped, or subjected to other severe mechanical shock.

To obtain the greatest accuracy possible from the scale, the user should be careful to eliminate errors due to parallax. That is, he should look at each coil with his eyes in the plane of that coil, and not from an angle to the right or left.

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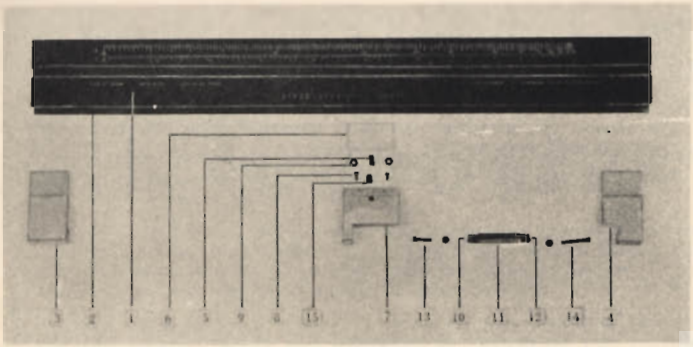
ADJUSTMENT

There may be occasions to readjust the instrument, and the following procedure is recommended. Pull out the spring until the 0 and 100 coils are exactly 5 inches apart on a standard scale. Then loosen the window screws (No. 10) and move the window so that the hairline coincides with 5 on the I scale. Finally tighten the screws and the instrument is adjusted.

Screw No. 7 is used for the friction adjustment of the slide.

PARTS LIST

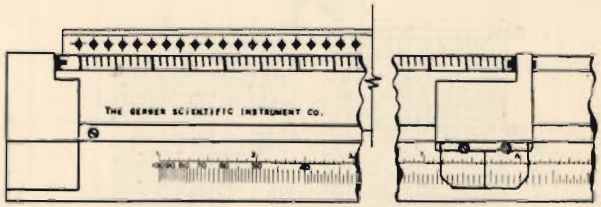


# 1	ALUMINUM BASE
# 2	ALUMINUM INLAY (Fixed to the base)
# 3	RIGHT END PIECE
# 4	LEFT END PIECE
# 5	FRICTION PLUG
# 6	PLEXIGLAS WINDOW (Adjustable)
# 7	SLIDE
# 8	SCREWS
# 9	WASHERS
#10	RIGHT SPRING CONNECTION (Fixed to the spring)
#11	SPRING
#12	LEFT SPRING CONNECTION (Fixed to the spring)
#13	SCREW AND NUT (Left)
#14	SCREW AND NUT (Right)
#15	LOCK SCREW

PROBLEMS AND EXAMPLES

SPACING RIVETS

In many instances, the plotting of equally spaced lengths entails an accumulation of error. For such problems, the Gerber Variable Scale eliminates those errors, and also allows for direct proportioning.



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PROBLEM

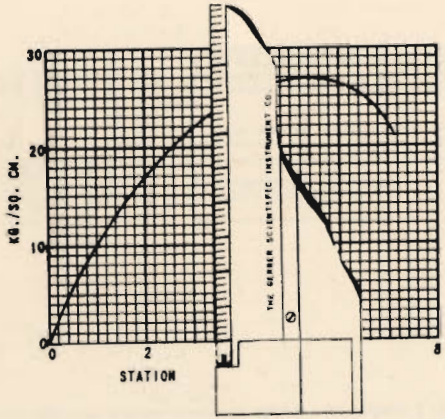
On a drawing of a bridge showing a certain built-up channel section, rivets are to be laid out with a spacing of 3.3 to the foot. The scale of the drawing is 1"= 2'.

SOLUTION

Since the drawing is 1/24 size, 6.6 rivets per inch are required. Set the hairline at 2x6.6 = 13.2 on R scale and mark off rivet centers at every other coil.

CONVERTING UNITS

In working with curve sheets from foreign publications, it is convenient to set the conversion factor (Kg.,-lb., meters,-ft., etc.) directly on the Gerber Variable Scale.



PROBLEM

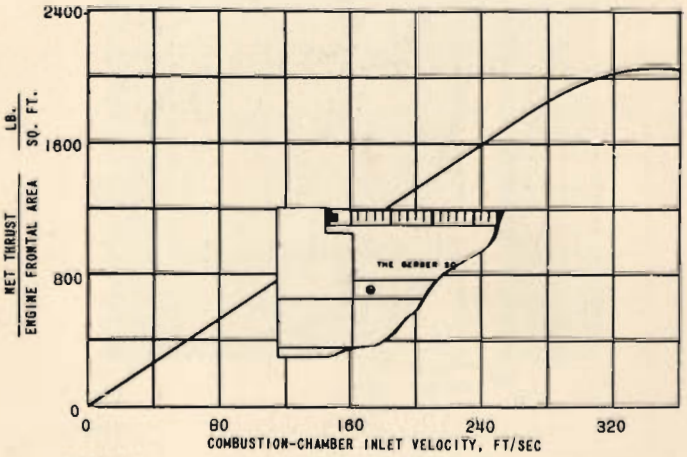
Read the pressure at each station in lbs./sq.in.

SOLUTION

Since 10 Kg./sq.cm. = 142.2 lbs./sq.in. (from conversion table), set the instrument so that 14.2 coils cover the space between 0 and 10 Kg.

ODD SCALES

Unfortunately, the use of the unit in which one is interested, say lb./sq.ft., does not always insure a readable curve. The scales on the example shown below have been taken from a publication of a large government research agency.



PROBLEM

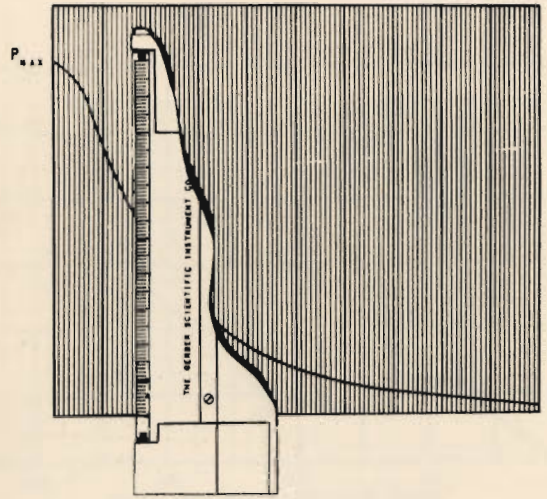
Read inlet velocity at net thrust/engine frontal area = 1200 lb./sq.ft..

SOLUTION

Set the Gerber Variable Scale as shown. At net thrust/engine frontal area = 1800 lb./sq.ft., read inlet velocity = 182 ft./sec.

NONDIMENSIONAL CURVES

It is sometimes desired to convert values to a non-dimensional form by dividing them by a reference value. With the Gerber Variable Scale, the reference value can be set at once.



PROBLEM

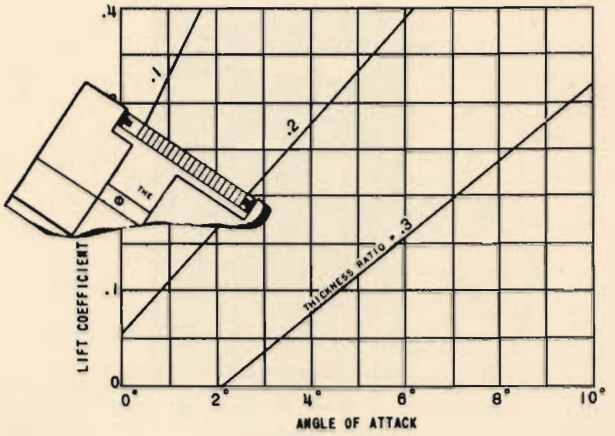
From the pressure curve in the sketch, find values of the ordinate in terms of P/P_{max}

SOLUTION

Set the 0 coil on the horizontal reference line, and the 100 coil at the maximum ordinate. Read the desired ordinates in terms of this automatically established scale. The particular pressure ratio shown in the sketch is .568.

LINEAR INTERPOLATION

Many engineering jobs involve reading from a family of curves, and often the value of the parameter at which the curves are to be read is different from the values for which the curves are drawn.



PROBLEM

To find the lift coefficient with an angle of attack of 2° and thickness ratio of .17

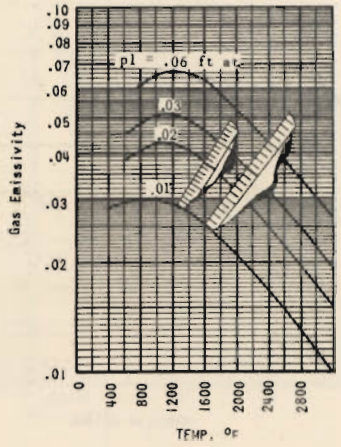
SOLUTION

Stretch the Gerber Variable Scale with the 0 and 100 coils (first and last red coils) on the lines for h/b = .1 and h/b = .2, so that the 70 coil intersects the angle of attack = 2 line.

Read lift coefficient = .225 on a horizontal line with this intersection.

NON-LINEAR INTERPOLATION

Many types of interpolation require the locating of additional curves. This is rather difficult if the curves are not spaced equally apart; however, by the use of the Gerber Variable Scale, such curves can be plotted readily and with a reasonable degree of accuracy by taking into account the ratio by which the curves diverge or converge.



PROBLEM:

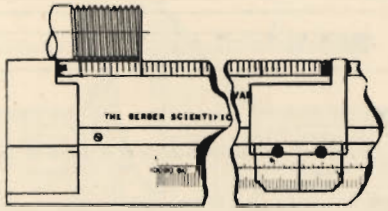
On the graph shown above locate pl = .06 ft. at

SOLUTION:

Set 0 coil at pl = .01 and 10 coil at pl = .02 and read the 15 coil at .03. Next extend spring so that 10 coil is at pl = .03 and the 15 coil will locate pl = .06.

DETERMINING PITCH OF SCREW THREADS

It is occasionally necessary to determine the number of threads per inch in threaded machine parts. The Gerber Variable Scale provides a rapid and accurate method for this determination.



PROBLEM

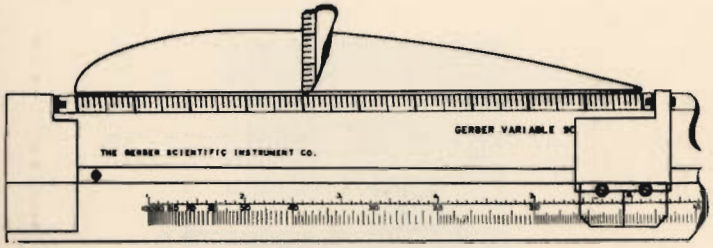
To determine the pitch of the bolt shown in order to specify a mating nut.

SOLUTION

Set the 0 coil on a convenient thread and pull out the slide until the coils correspond to the adjacent threads. Read the pitch = 16 threads/inch on the R scale at the hairline.

LAYING OUT AIRFOIL SECTION

Airfoil dimensions are usually presented in a table as functions of the per cent of chord. With the chord known and set on the I scale of the Gerber Variable Scale, the airfoil may be plotted at once.



PROBLEM

Lay out an NACA 2418 Airfoil with a 5.92 in. chord.

SOLUTION

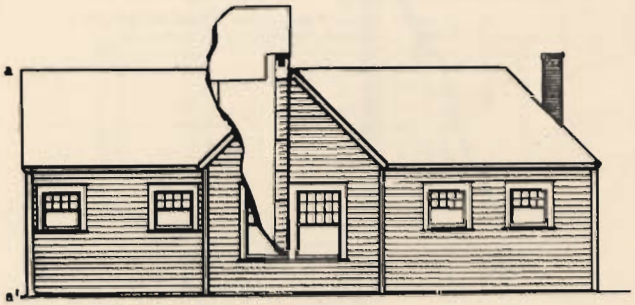
First draw a horizontal reference line and mark an arbitrary zero point. Set the hairline on the slide to 5.92 on the I scale, and mark the right end of the chord on the 100 coil. Then mark off the numbers given in the table under "Station-% chord".

At the stations so marked, and without changing the position of the slide, mark a point on the upper ordinate at each station. In the sketch, 10.7 has been laid off at the 40% station. The lower ordinate is then plotted in the same manner.

STATION % CHORD	0.00	1.25	2.50	5.00	7.50	10.00	15.00	20.00	25.00
UPPER ORD. % CHORD	0.00	3.28	4.45	6.09	7.17	8.05	9.34	10.15	10.65
STATION % CHORD	30.00	40.00	50.00	60.00	70.00	80.00	90.00	95.00	100.00
UPPER ORD. % CHORD	10.88	10.71	9.89	8.65	7.02	5.08	2.81	1.55	.19

CONSTRUCTION LAYOUTS

Architects are frequently required to lay out 8" bricks or 4½" shingles or 9" pickets on a drawing. Here the Gerber Variable Scale will obviate the cumulative error that is eliminated from work with dividers only by repeated trials.



PROBLEM

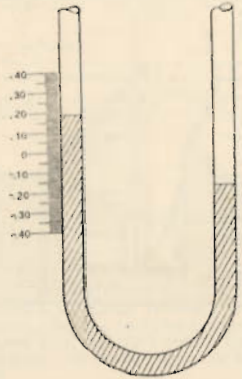
To draw 5½ in. clapboards on the house shown in the sketch.

SOLUTION

Since the distance between aa' is 16'-½", 35 clapboards are needed. Place instrument with 0 coil at a and 35 coil at a' and mark off the spacings.

CALIBRATING INSTRUMENTS

Whenever an arbitrary scale is to be made, the Gerber Variable Scale will supply the proper spacing of lines at once. The rapidity with which such calibrations can be made suggests the use of this scale to make new calibrations to correct automatically for changes in density, temperature or other variables which affect the reading linearly.



PROBLEM

Mercury is used in a pitot tube to measure pressure, and it is desired to calibrate the instrument lb./sq.in.

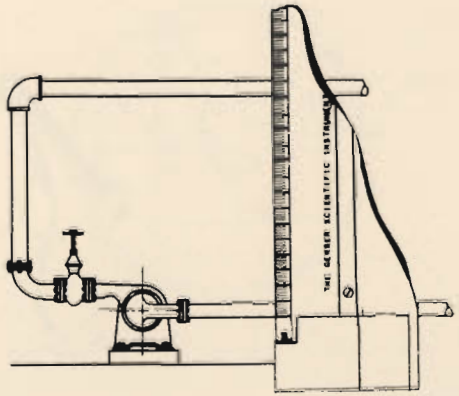
SOLUTION

Since 2.04 in. Hg = 1 lb./sq.in., set the hairline at 2.04 on the 1 scale, and mark off a graduation at each coil. Then the spacing between each coil will represent .01 lb./sq.in.

ODD SCALE DRAWING REPRODUCTION

Engineering drawings as reproduced in reports and in small photostatic copies will seldom fit exactly any of the standard engineer's scales. The Gerber Variable Scale may be used to measure dimensions directly from such drawing reproductions.

This method also permits automatic allowance for the shrinkage of blue prints.



PROBLEM

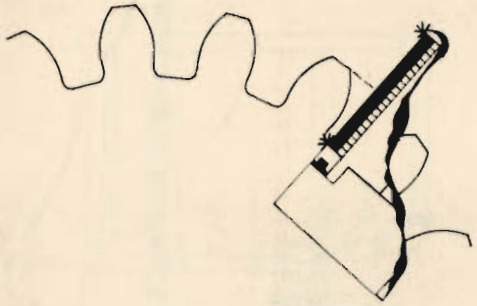
To find the distance between the bottoms of the upper and lower pipes to determine bracket spacing. The lower pipe diameter is known to be 4.2 inches.

SOLUTION

Without reference to any scale given, place scale as shown with the 0 coil at the bottom side and the 4.2 coil at the top side of the lower pipe. Then read required distance as 71.1 inches.

DIRECT MEASUREMENT OF SHADOWGRAPHS

The shadowgraph is finding increasing applications in industry, and the Gerber Variable Scale will extend the usefulness of this instrument by making possible direct readings of dimensions from the screen.



PROBLEM:

Determine depth of tooth on watch gear.

SOLUTION:

1) Mark some point of image on screen.
2) Move piece over by .100 inches with micrometer and mark new position of same point.
3) Set 100 divisions of spring between the two marks.
4) Read depth of teeth from image directly with scale in thousandths.

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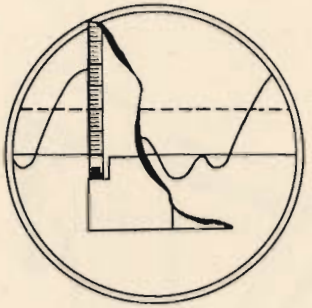
READING OSCILLOSCOPE SCREENS

The rapidity of reading made possible by the Gerber Variable Scale is is of particular value in measuring transients on an oscilloscope screen.



PROBLEM

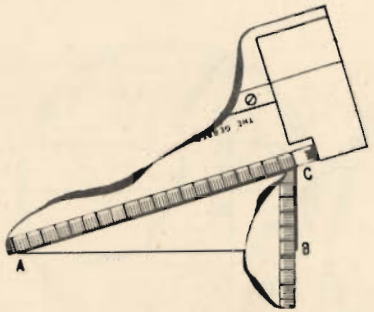
Find the maximum instantaneous voltage produced by an experimental oscillator.

SOLUTION

Apply the D.C. calibration voltage - say 100 volts-to the oscilloscope, and stretch the scale so that the 0 coil is at the neutral line and the 10 coil at this calibration voltage. Then connect in the experimental oscillator, and measure the maximum voltage produced as 18.9 coils, or 189 volts.

READING TRIGONOMETRIC FUNCTIONS AND DERIVATIVES

The application of the Gerber Variable Scale to the measurement of of trigonometric functions and derivatives is best shown by a specific example.



PROBLEM

Find the sine, coscent and tangent of the angle A.

SOLUTION

Erect a perpendicular to either side of A at any distance. Set the 0 coil at C, and with the instrument lai'd along AC, set the 100 coil at A. Now lay the instrument along CB, with the 0 coil at C, and read the scale at B. Since the 28.1 coil falls at B, the sine of angle A is 28.1/100, or .281. Now set the hairline at 2.81 on the I scale, and read the cosecant = 35.6 on the R scale. The cosecant will thus be 3.56.

To find the cotangent of angle A, set the 10 coil at B. Move the scale to lie along AB, and read 34.2 at B. The cotangent is 34.2/10 = 3.42

The derivative of a function at any point is, of course, the slope of the tangent at that point, and may be read in the same way as the tangent in this example.

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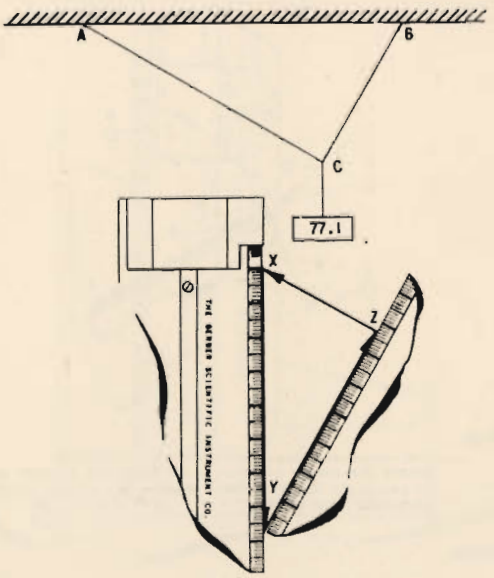
STRESS ANALYSIS — VECTOR ADDITION

The application of the Gerber Variable Scale to problems involving vectors may be illustrated by a simple example of stress analysis.



PROBLEM

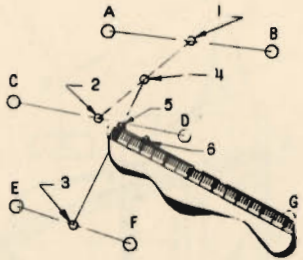
A load of 77.1 lbs. is suspended by wires as shown. Find the loads in wires AC and BC.

SOLUTION

Since the resultant force at point C must be 0, the vectors involved will form a closed triangle. Lay off any convenient vertical distance XY and draw XZ and YZ parallel to AC and BC respectively. Now set the 0 coil at X and the 77.1 coil at Y. With this setting, read XZ = load in AC = 67.3 lbs.; YZ = load in BC = 37.6 lbs.

CENTER OF GRAVITY LOCATION

In calculating stresses in rivets and bolts, it is in many cases necessary to find the center of gravity.



PROBLEM

Locate the center of gravity of the rivet pattern in order to calculate the stresses. (Assume all rivets of the same cross-sectional area).

SOLUTION

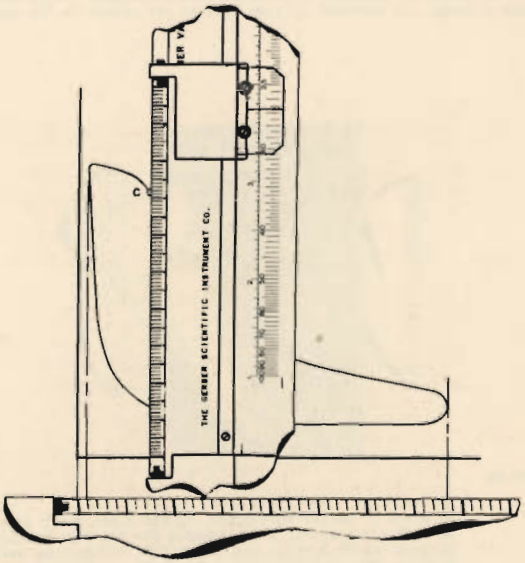
Divide distance A-B in half to get point 1. Do the same to C-D & E-F to obtain the respective points 2 & 3. Then find one half the distance between points 1 & 2 to obtain point 4. Finally, 1/3 the distance between 4 and 3 or point 5 is the answer. Of course the 1/3 is toward the point 4.

If an additional rivet, G, is added, then 1/7 the distance between points 5 and G, or point 6 is the new center of gravity.

If the rivets are of variable cross section, then areas as well as distances are to be proportioned.

ANALYZING INDICATOR CARDS

The indicator card from an engine is often used to find the pressure in various parts of the cylinder.



PROBLEM

Find the pressure at cut-off (point c) and the compression ratio from this indicator card of a non-condensing steam engine.

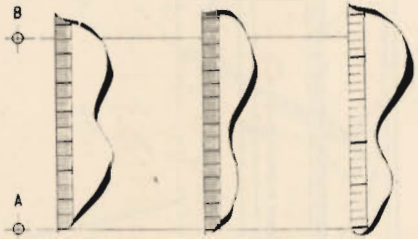
SOLUTION

Set the spring constant (we will assume 26.65 lb./in.^{2}/in) with the hairline on the R scale, and read the pressure at cut-off from point c to the atmospheric line as 71.8 lb./in.^{2}

To find the compression ratio, set the 0 coil at the line representing 0 volume, and the 1 coil at the farthest left position of the indicator diagram. Then move the instrument to the lower horizontal position shown, and read compression ratio = 38.5.

NAVIGATION

By means of the Gerber Variable Scale, solutions can readily be found for navigational problems involving distance, velocity, time, drift, etc. The instrument is invaluable in making scales reading automatically ground mileage, air mileage; or time between any points on the course.



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PROBLEM

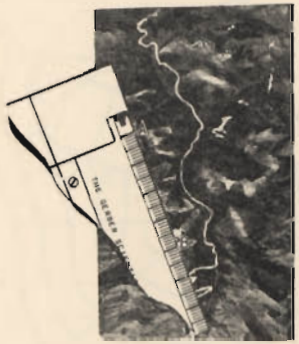
On a map or aerial photograph, points A and B are known to be 65.4 miles apart, and allowance for drift gives the air mileage as 72.3 miles and the total flying time as 22.4 minutes. Make scales reading directly:
a) ground mileage,
b) air mileage, and
c) time (minutes) between all points on the course.

SOLUTION

a) Set 0 coil at A and 65.4 coil at B
b) Set 0 coil at A and 72.5 coil at B
c) Set 0 coil at A and 22.4 coil at B

INTERPRETING AERIAL PHOTOGRAPHS

For Army intelligence work or scaling from aerial photographs, it is important to make scales that can be immediately applied to the picture.



PROBLEM

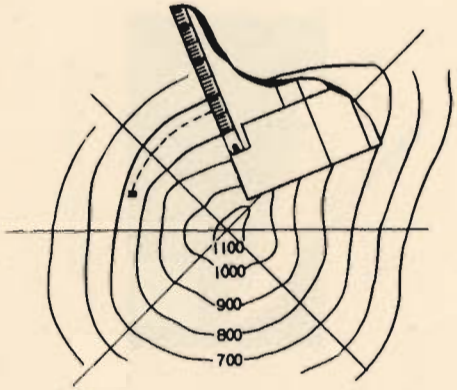
If two gun positions A and B are known to be 38.8 miles apart, make a scale reading any distance on the photograph in miles.

SOLUTION

Place instrument along AB with the 0 coil at A and the 38.8 coil at B.

PLOTTING CONTOURS

In the application shown below, the Gerber Variable Scale may be used to draw in as well as to read from curves.



PROBLEM

Given the contour map shown in the sketch, draw in a line of constant elevation at the bench mark shown.

SOLUTION

With the 0 coil at 800 and the 10 coil at 700 ft., and the scale normal to these contour lines, measure the elevation as 732 ft. With the scale kept normal to the curves, and the length between the 0 and 10 coils varied as required to keep them on the same lines, mark as many points as are needed to indicate the new contour.

APPENDIX

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REFERENCE TABLES

Tables on methods of multiplication and division are included to help the user in cases where the settings are not immediately apparent.

The steps involved in the multiplication or division of a length by a number depend on the magnitudes of the original and resulting lengths.

In the table for multiplication, in three cases, a choice of methods is given; the first is quicker, and the second more accurate.

For a length between 1 and 10 inches multiplied by a number between 1 and 10, the first method given is applicable if the resulting length is less than 10 inches. If the resulting length is more than 10 inches, the second method must be used.

In the table for division, there are alternate methods in each case. Only one method will work in a particular problem. It is suggested that the user try step 2 of the first method. If this step is impossible, use the alternate method.

In every case, for both multiplication and division, the first step is to set the 0 coil at the left of the length involved. In the table, the coils are considered to be numbered from 0 to 100, with the 10's red and the 5's green to facilitate reading. References to the "38.2" coil are not, of course, to an actual coil, but to a visual interpolation between the 38 and 39 coils.

The digits 3-8-2 have been chosen for illustration, but have no particular significance.

In the special case in which a length between .1" and 1" is to be divided by a number between .01 and .1, and the first method is impossible, steps 4 through 6 may need to be varied. If the resulting length is sufficiently short (less than 10"), the 10 coil instead of the 20 may be set in step 4, and the answer read at once on the 100 coil. In a very few instances, it will be necessary to set the 33.3 coil in step 4, and to lay off two times the 100 coil in step 6. This matter will be as obvious in using the instrument as it is obscure in reading it.

INTERNATIONAL SLIDE RULE MUSEUM

MULTIPLICATION

NOTE: IN ALL CASES STEP 1 IS: Set 0 coil at left of length

	TO MULTIPLY BY .01 to .1 Say .0382	**TO MULTIPLY BY .1 to 1** Say .382
IF LENGTH IS .01 to .1 in.		2. Set 1 coil at rt. of length 3. Mark at 38.2 coil 4. Set 100 coil at mark 5. Answer at 1 coil
IF LENGTH IS .1 to 1 in.	2. Set 10 coil at rt. of length 3. Mark at 38.2 coil 4. Set 100 coil at mark 5. Answer at 1 coil	2. Set 10 coil at rt. of length 3. Answer at 3.8 coil 2. Set 10 coil at rt. of length 3. Mark at 38.2 coil 4. Set 100 (or 10) coil at mark 5. Answer at 10 (or 1) coil
IF LENGTH IS 1 to 10 in.	2. Set 100 coil at rt. of length 3. Answer at 3.8 coil 2. Set 100 coil at rt. of length 3. Mark at 38.2 coil 4. Set 100 (or 10) coil at mark 5. Answer at 10 (or 1) coil	2. Set 100 coil at rt. of length 3. Answer at 38.2 coil

TO MULTIPLY BY 1 to 10 Say 3.82	**TO MULTIPLY BY 10 to 100** Say 38.2
2. Set 1 coil at rt. of length 3. Answer at 3.8 coil 2. Set 1 coil at rt. of length 3. Mark at 38.2 coil 4. Set 100 coil at mark 5. Answer at 10 coil	2. Set 1 coil at rt. of length 3. Answer at 38.2 coil
2. Set 10 coil at rt. of length 3. Answer at 38.2 coil	2. Set 10 coil at rt. of length 3. Mark at 38.2 coil 4. Set 10 coil at mark 5. Answer at 100 coil (For distance less than .382 inches)
2. Set 100 coil at rt. of length 3. Mark at 38.2 coil 4. Set 10 coil at mark 5. Answer at 100 coil or 2. Set 100 coil at rt. of length 3. Set 0 coil at rt. of length and lay off required No. of digits (in this case 3) 4. Set 0 coil at last mark 5. Answer at 82 coil	

DIVISION

NOTE: IN ALL CASES STEP 1 IS: Set 0 coil at left of length

	TO DIVIDE BY .01 to .1 Say .0382	**TO DIVIDE BY .1 to 1** Say .382
IF LENGTH IS .01 to .1 in.	2. Set 3.8 coil at rt. of length 3. Answer at 100 coil 2. Set 1 coil at rt. of length 3. Mark at 10 coil 4. Set 38 coil at mark 5. Answer at 10 coil	2. Set 3.8 coil at rt. of length 3. Answer at 10 coil 2. Set 1 coil at rt. of length 3. Mark at 10 coil 4. Set 38.2 coil at mark 5. Answer at 10 coil 2. Set 1 coil at rt. of length 3. Mark at 100 coil 4. Set 38.2 coil at mark 5. Answer at 1 coil
IF LENGTH IS .1 to 1 in.	2. Set 3.8 coil at rt. of length 3. Answer at 100 coil 2. Set 38.2 coil at rt. of length 3. Mark at 100 coil 4. Set 20 coil at mark 5. Mark at 100 coil 6. Slide 0 coil to 2nd mark 7. Answer at 100 coil	2. Set 38.2 coil at rt. of length 3. Answer at 100 coil 2. Set 10 coil at rt. of length 3. Mark at 100 coil 4. Set 38.2 coil at mark 5. Answer at 10 coil
IF LENGTH IS 1 to 10 in.		2. Set 38.2 coil at rt. of length 3. Answer at 100 coil 2. Set 100 coil at rt. of length 3. Mark at 10 coil 4. Set 38.2 coil at mark 5. Mark at 100 coil 6. Set 20 coil at mark 7. Mark at 100 coil 8. Slide 0 coil to 2nd mark 9. Answer at 100 coil

TO DIVIDE BY 1 to 10 Say 3.82	
2. Set 38.2 coil at rt. of length 3. Answer at 10 coil 2. Set 3.82 coil at rt. of length 3. Answer at 1 coil 2. Set 10 coil at rt. of length 3. Mark at 100 coil 4. Set 38.2 coil at mark 5. Answer at 1 coil	
2. Set 38.2 coil at rt. of length 3. Answer at 10 coil 2. Set 100 coil on rt. of length 3. Mark at 10 coil 4. Set 38.2 coil at mark 5. Answer at 100 coil	

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