Technical Memorandum

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THE DIRECT READING HEIGHT GAUGE AND ITS APPLICATIONS TO INSPECTION WORK

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MODEL 1 and MODEL 2

ABSTRACT

The direct reading height gauge is a new and fast operating instrument designed primarily for checking hole patterns, but it can also be used for a number of other purposes as well. This report gives a brief review of what the gauge is, what it will do, and how it is operated. Speed and the elimination of most of the sources of error are its chief attributes.

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INTRODUCTION

The job of checking hole patterns to drawing specifications has long been a great consumer of time, and time means money. With the advent of two models of the new Direct Reading Height Gauge, which are described herein, the checking of hole locations to three decimal places has become almost as simple as taking measurements with a yardstick. The saving in man-hours made possible by this new gauge is tremendous. In some actual cases it has been found that ten items could be checked in the same time formerly required to check one.

This report was written to acquaint the reader with the fact that this new method is here and available now, the various uses to which it can be put, and instructions on how to use the gauge. Anyone who is presently using any type of height gauge to check hole locations will definitely be interested in looking into the many advantages to be gained by using the Direct Reading Height Gauge.

THE OLD METHOD: (INDIRECT READINGS)

The required dimension is E, the vertical distance from the centerline of one hole to the basic centerline of the part (Fig. 1). To find E it is necessary to first find A, B, C, and D, and then use two equations: the basic centerline of the part is found by $\ell = A + \frac{B}{2}$ and then the required dimension $E = C + \frac{D}{2} - \ell$.

This not only consumes a great deal of time unnecessarily but allows many chances for errors to slip in during the addition, subtraction, and division, which are always necessary for each and every dimension.

THE NEW METHOD: (DIRECT READINGS)

Push the probe firmly into hole #1 (Fig. 1). Adjust the scale and the dial to read 0.000 (a simple operation which is done only once for each new set-up).

Then push the probe into hole #2 and read the scale and the dial. This gives the required dimension E directly with no addition, subtraction or division required. For each additional hole, merely push the probe in firmly and read the scale and the dial.

This results in much saving of time, wear on the surface plate by going back and forth to the Cadillac gauge, wear on the Cadillac gauge by running it up and down frequently, and eliminates several chances for making errors. If the scale and the dial are read correctly, the correct reading is obtained for the required dimension.

Simplicity in operation and confidence in the correctness of the readings obtained are the two principal advantages of this new system of direct measurement.

THE SIMPLE PRINCIPLE OF THE DIRECT READING HEIGHT GAUGE

Imagine that measurements are being made with a yardstick (Fig. 3) which has the zero mark in the center and is numbered to 18 inches in both the + direction (up) and the - direction (down). The zero mark is placed on the basic centerline of the part, and the vertical distance to the centerline of each hole is then read off directly. This same simple principle is used in the Direct Reading Height Gauge. The fixed scale is graduated accurately into one-tenth-inch increments throughout its vertical height of more than 40 inches. The numbers are on a movable flexible steel tape so that the 0 can be set at any tenth-inch line on the fixed scale without ever having to move the fixed scale. In this manner the 0 datum plane can be set at any required height and subsequent measurements made above or below that datum plane. The dial indicator is used to indicate exactly where the center of the conical probe is positioned between any two consecutive tenth-inch marks. The combined reading of the scale and the dial always reads to the center of the probe.

REQUIRED DIMENSIONS:
E AND H

FIG. 1
THE OLD METHOD (INDIRECT READINGS)

FIG. 2 Close-Up of the Model 1 Showing Conical Probe

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FIG. 3
USING THE YARDSTICK

THE MODEL ONE DIRECT READING HEIGHT GAUGE

The Model 1 gauge works on the same principles as does the Model 2 gauge. The chief difference is that the Model 1 is made as an attachment to be used with a Chesterman height gauge while the Model 2 is complete in itself, having its own stand.

Model 1 is useful only if the user has a Chesterman height gauge on hand. A Cadillac Pla-Chek gauge is not required.

Model 2 is for use by anyone not having a Chesterman height gauge or a Cadillac Pla-Chek gauge.

The photographs shown here are of the Model 1 gauge. A drawing of the Model 2 gauge is shown, but photographs of it are not presently available.

THE MODEL TWO DIRECT READING HEIGHT GAUGE

The dial indicator and the scale are mounted so as to read from the rear of the gauge. The dial is calibrated in 1/1,000-inch increments, making it easy to read to the nearest thousandth of an inch which is generally adequate. The indicator has two hands, the small hand indicates plus or minus while the large hand reads hundredths and thousandths of an inch. The small hand reads from 0 to $\pm .100$ inch and indicates at all times whether the center of the probe is above or below the tenth-inch line to which the gauge is set on the scale.

The principal improvement in Model 2 is the specially designed vertical column which supports the gauge itself and contains the adjustable flexible steel scale. This eliminates the need of the Chesterman height gauge to provide an accurate vertical scale.

The range of the Model 2 gauge is from 4.000 inches above the surface plate to 44.000 inches, an effective range of 40.000 inches or ± 20 inches from a center 0 position. Holes or surfaces at heights greater than 44.000 inches above the plate may be measured by using accurately surfaced blocks as jacks. Up to five digits or three decimal places can be read, such as 12.345 inches.

OPERATION OF THE MODEL TWO DIRECT READING HEIGHT GAUGE

A. Setting the vernier and reading the scale (Fig. 5).

Loosen both collar locking knobs so that the gauge can be freely raised or lowered on the vertical column. Adjust the height of the probe until it is slightly below the center of the hole for all holes above 0 or slightly above the center of the hole for all holes below 0. (0 is the basic centerline.) Tighten the upper collar locking knob. Use the fine adjusting knob to bring the vernier index line (long middle line on vernier) exactly in line with the first tenth-inch line below it.

FIG. 4 The Model 1 Attached to the Chesterman Height Gauge

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(TWICE ACTUAL SIZE)
SCALE READS 0.000
AFTER "ZEROING-IN"

(ACTUAL SIZE)
SCALE READS +7.400

WITH PROBE IN HOLE ON BASIC CENTERLINE:

TENTH LINE NEAREST VERNIER INDEX LINE
BECOMES THE 0.000 LINE

MOVE VERNIER PLATE DOWN
TO LINE-UP VERNIER INDEX
WITH "0" TENTH LINE

MOVE FLEXIBLE SCALE
DOWN UNTIL 0 IS IN
LINE WITH "0" TENTH LINE

BEFORE "ZEROING-IN"

FIG. 5

13

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FIG. 6 Drawing of the Model 2

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Since the dial indicator always reads the distance of the probe above (or below) the vernier index line, it is essential that the vernier index line be lined up with a scale tenth-inch mark within ± 0.0005 inch at all times. This is easy to do by observing closely the two short secondary lines on the vernier. If either of these secondary lines is lined up exactly with a tenth-inch mark, this indicates that the vernier index line is .001 inch off a tenth-inch mark on the scale. When both vernier secondary lines are equally offset from tenth-inch marks on the scale, then the vernier index line is lined up exactly with a tenth-inch mark (as illustrated in Fig. 5).

Tighten the lower collar locking knob when the vernier index line has been accurately adjusted to a scale tenth-inch mark.

Read the scale in inches and tenths of an inch (as illustrated in Fig. 5).

As the operator becomes thoroughly familiar with using the gauge, this operation of setting the vernier and reading the scale becomes very simple and fast.

B. Inserting the probe and reading the dial.

Push the probe gradually into the hole until it seats positively, then read the dial in hundredths and thousandths on the large hand (Fig. 7).

TWO SIMPLE STEPS:

1. SET THE VERNIER INDEX LINE ON THE FIRST TENTH-LINE BELOW THE CENTER OF THE HOLE. READ THE SCALE.
2. PUSH THE PROBE INTO THE HOLE UNTIL IT SEATS POSITIVELY. READ THE DIAL.

Repeat these two simple steps to get the reading for each hole.

EXAMPLE

+ 12.600	READ ON SCALE
+ .028	READ ON DIAL
+ 12.628	

C. Zeroing-in the gauge on the basic centerline of the part (when there is one).

CASE NO. 1: THE PART TO BE CHECKED HAS TWO HOLES LOCATED ON THE BASIC CENTERLINE (the centerline from which all holes are dimensioned on the drawing) (Fig. 9).

The first job is to adjust the part until the same reading is obtained when inserting the probe into each of these two holes. (The lowest

TWICE ACTUAL SIZE

DIAL READS $+0.028$

READING THE DIAL
FIG. 7

FIG. 8 Close-Up of the Model 1 Showing Dial

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CASE NO. 1
TWO HOLES ON BASIC CENTERLINE

ADJUST PART UNTIL HOLES 1 AND 5 READ THE SAME.
ADJUST SCALE AND DIAL TO READ 0.000 IN HOLES 1 & 5.
HOLES 2, 3 & 4 WILL READ + (ABOVE BASIC CENTERLINE)
HOLES 6, 7 & 8 WILL READ - (BELOW BASIC CENTERLINE)

FIG. 9

hole on the part must always be 4.000 inches or more above the surface plate when setting up the part.) This operation levels the part and assumes that these two holes are actually located on the basic centerline of the part (a necessary assumption in any case).

Then with the probe in either of the two holes on the basic centerline, the flexible scale is unlocked and moved so that the "0" is lined up with the tenth-inch line on the scale nearest to the vernier index line (middle line). Then the vernier is adjusted exactly to the 0 line by loosening the three screws which hold it and moving it up or down as may be required. Tighten the three screws which lock the vernier plate. This operation adjusts the scale to read 0.000 inch when the centerline of the probe coincides with the basic centerline of the part.

The dial is set to "0" by loosening the locknut and turning the stud until both hands of the dial are on "0". Then tighten the locknut. Use two small open-end wrenches for this adjustment. This operation adjusts the dial to read .000 inch. The total reading of the scale and the dial is now 0.000 and the gauge is "zeroed-in" on the basic centerline of the part.

CASE NO. 2: NO HOLES LOCATED ON BASIC CENTERLINE BUT ALL HOLES DIMENSIONED FROM THE BASIC CENTERLINE (Fig. 10)

Select the two holes nearest to the basic centerline and as far apart horizontally as possible. Adjust the part until the difference in readings for the two holes is the same as that shown on the drawing. This operation lines up the part so that its basic centerline is parallel to the surface plate. Then, with the probe in one of these holes, set the gauge to give the correct reading for that hole. This one adjustment should also cause the correct reading to be obtained for the other hole.

Then proceed as before, taking a reading in each hole. Each reading will give the distance from the hole to the basic centerline directly.

CASE NO. 3: NO BASIC CENTERLINE, BUT AT LEAST TWO HOLES ON A COMMON HORIZONTAL CENTERLINE (Fig. 11)

Select two holes on a common horizontal centerline and as far apart horizontally as possible. Adjust the part until the same reading is obtained in both holes. This operation will level the part assuming that these two holes are exactly on the same centerline.

It is not necessary to "zero-in" on any centerline in this case. It is advisable to lower the 0 of the flexible scale below the lowest hole to be checked. This will cause all holes to have + readings and will further simplify operation of the gauge.

CASE NO. 2
NO HOLES ON BASIC CENTERLINE

ADJUST PART UNTIL HOLE 1 READS 1.500 MORE THAN HOLE 5
ADJUST SCALE AND DIAL TO READ +.750 WITH PROBE IN HOLE 1
SCALE AND DIAL SHOULD THEN READ -.750 IN HOLE 5
BASIC CENTERLINE NOW READS 0.000
HOLES ABOVE BASIC CENTERLINE READ + ON SCALE AND DIAL
HOLES BELOW BASIC CENTERLINE READ - ON SCALE AND DIAL

FIG. 10

CASE NO. 3
RANDOM HOLES - NO BASIC CENTERLINE

ADJUST PART UNTIL "A" READS THE SAME AS "B"

TAKE READINGS OF REQUIRED HOLES AND SURFACES

$$\text{DIMENSION 1} = G - A = 12.725 - 11.125 = 1.600$$

$$\text{DIMENSION 2} = B - D = 11.125 - 8.375 = 2.750$$

$$\text{DIMENSION 3} = C - D = 9.500 - 8.375 = 1.125$$

$$\text{DIMENSION 4} = C - E = 9.500 - 7.625 = 1.875$$

$$\text{DIMENSION 5} = E - F = 7.625 - 5.125 = 2.500$$

FIG. II

Take a reading in each hole and subtract one reading from another to check the dimensions shown on the drawing.

CASE NO. 4: NO TWO HOLES ON ANY COMMON CENTERLINE (Fig. 12)

Select any two holes having a vertical dimension given on the print. It is always best to select two holes as far apart horizontally as possible in order to reduce the possible error in leveling the part. Take readings in these two holes and find the difference between them. This difference should be the required dimension shown on the print. Adjust the part with jacks until this difference between the reading of the two holes does correspond exactly with the print dimension. This operation levels the part assuming that these two holes are correctly located. Proceed by taking a reading in each hole and subtracting one reading from another to check the dimensions shown on the drawing.

D. Positive and Negative Readings.

1. Any hole or surface above the basic centerline (0.000) will read + on the scale.

Whenever reading + values on the scale, the dial should normally be read in the + direction.

A - reading on the dial and a + reading on the scale means that the correct reading is the scale reading minus the dial reading.

EXAMPLE: Suppose that a given hole reads + 7.400 on the scale and -.037 on the dial. This means that the hole center is .037 inch less than (below) the 7.400 location or + 7.363 inches.

By lowering the instrument 0.1 inch to + 7.300 on the scale, the dial will now read + .063 giving a total reading of + 7.363, the same as before.

2. All holes and surfaces located below the basic centerline (0.000) will read - on the scale.

Whenever reading - on the scale, the dial should normally be read in the - direction.

A + reading on the dial and a - reading on the scale means that the correct reading is the algebraic sum of the two readings. For example, -3.600 on the scale and + .025 on the dial would read $(-3.600) + (+.025) = -$ 3.575.

By raising the instrument 0.1 inch to - 3.500, the dial will now read - .075 giving a total reading of - 3.575, the same as before.

CASE NO. 4

NO TWO HOLES ON THE SAME CENTERLINE

ADJUST PART UNTIL "D" READS 2.250 LESS THAN "E"
 (THIS DIMENSION COMES FROM THE DRAWING)
 TAKE READINGS OF REQUIRED HOLES AND SURFACES

$$\text{DIMENSION 1} = G - A = 19.500 - 16.750 = 2.750$$

$$\text{DIMENSION 2} = A - B = 16.750 - 14.875 = 1.875$$

$$\text{DIMENSION 3} = B - C = 14.875 - 12.875 = 2.000$$

$$\text{DIMENSION 4} = C - D = 12.875 - 7.500 = 5.375$$

$$\text{DIMENSION 5} = D - F = 7.500 - 4.750 = 2.750$$

FIG. 12

REMEMBER:

ON THE SCALE:

+ MEANS ABOVE THE BASIC CENTERLINE.

- MEANS BELOW THE BASIC CENTERLINE.

ON THE DIAL INDICATOR:

+ MEANS ABOVE THE TENTH LINE TO WHICH THE VERNIER IS SET.

- MEANS BELOW THE TENTH LINE TO WHICH THE VERNIER IS SET.

VARIOUS USES OF THE DIRECT READING HEIGHT GAUGE

A. Round Holes. Finding Centers of Drilled, Reamed, Bored or Ground Holes (Fig. 13)

Insert the universal probe into the hole as far as it will go. The probe will automatically move toward the center of the hole as it is being pushed in. When approximately 360° contact is obtained, the probe will be centered in the hole. The dial indicator always reads to the center of the probe which now coincides with the center of the hole. The scale and dial, combined, read the distance from the center of the hole to any preselected centerline of the part as explained before.

B. Finding Centers of Threaded Holes (Fig. 14)

A set of conical studs is used to provide a variety of commonly used thread sizes (one stud for each thread size). The stud is screwed into the threaded hole to hand tightness. The insert is removed from the universal probe so that the probe can be slipped over the end of the conical stud until 360° contact is obtained. This point can be easily detected by the solid feel. The reading of the scale plus the dial then reads the distance from the center of the threaded hole to any preselected basic centerline of the part.

C. Slotted Holes

The probe is pushed gradually into the lower end of the slotted hole until 180° contact is obtained between the edge of the slot and the probe. This can be easily seen by looking straight toward the tip of the probe while lighting the gap with a flashlight from behind the slot. The center of the probe now coincides with the center of the slot radius. Note the reading of the scale plus the dial at this point. Then do the same with the upper end of the slot. Take the reading. Dimension A (Fig. 18) is the difference between these two readings.

D. Measuring to Horizontal Flat Surfaces (See Figs. 15, 16, and 17)

PROBE USED IN ROUND HOLES
FIG. 13

PROBE USED WITH THREADED HOLES
FIG. 14

D. MEASURING HORIZONTAL FLAT SURFACES

TO + READINGS, SUBTRACT .600

TO - READINGS, ADD .600

CASE 1A

1.200 DIA. FLAT BAND

TO + READINGS, ADD .600

TO - READINGS, SUBTRACT .600

CASE 1B

1.200 DIA. FLAT BAND

FIG. 15

TO + READINGS, SUBTRACT .300
TO - READINGS, ADD .300

CASE 2A
.600 DIA. FLAT BAND

TO + READINGS, ADD .300
TO - READINGS, SUBTRACT .300

CASE 2B
.600 DIA. FLAT BAND

FIG. 16

THIS SURFACE IS
.100" BELOW THE
CENTER OF THE PROBE

TO + READINGS, SUBTRACT .100
TO - READINGS, ADD .100

CASE 3A
.200 DIA. FLAT BAND

THIS SURFACE IS
.100" ABOVE THE
CENTER OF THE PROBE

TO + READINGS, ADD .100
TO - READINGS, SUBTRACT .100

CASE 3B
.200 DIA. FLAT BAND

FIG. 17

SLOT MUST BE IN VERTICAL POSITION:

*TAKE READING WITH PROBE
IN TOP OF SLOT*

*TAKE READING WITH PROBE
IN BOTTOM OF SLOT*

*SLOTTED HOLES
FIG. 18*

ACCURACY

The Direct Reading Height Gauge should not have a total error greater than $\pm .001$ throughout its range of 40 inches.

It is advisable to occasionally check the dial indicator when detached from the gauge by means of a Supermicrometer or similar precision measuring instrument which reads accurately in ten-thousandths of an inch. The dial indicator should not have an error throughout its range greater than $\pm .0002$ to $.0003$ (two to three ten-thousandths of an inch).

The engraved tenth-inch graduations on the scale should not have a total error greater than 3 or 4 ten-thousandths of an inch throughout the 40-inch range.

The only other possibility for errors is that the three round pins may be too loose in the V-grooved rollers which would give some play. This can be corrected and the play almost completely eliminated by proper adjustment of the eccentric studs which position the rollers against the pins. Vertical movement should be free but without noticeable play. Rotating motion of the front plate with respect to the rear plate is the only type of motion that could cause an error in the dial reading due to pin in roller fit.

CARE AND MAINTENANCE

It is necessary to occasionally remove the V-grooved rollers and carefully clean any oil or dirt which may have collected on the pins, rollers, or roller mounting studs. Disassembly is accomplished by removing the three pins with a screwdriver first. This will allow the front plate to be lifted off completely. The six roller retaining screws are removed with a large screwdriver and then the rollers can be removed. It is advisable to re-assemble the rollers on the same studs and with the same side outward as when received from the manufacturer due to minor variations in the parts which may exist. Clean all surfaces of the rollers including the inside of the center hole.

Under dusty conditions it is better to use no lubrication at all as oil tends to collect dust and dirt which would require more frequent cleaning.

Keep the gauge in its box at all times when it is not being used.

If the gauge is used a great deal, the rollers and pins may become worn and can be replaced easily. The conical end of the probe can be resurfaced if it becomes scratched due to extensive use. By accomplishing these minor repairs, the gauge would be as good as new again since these are the only parts which are subject to wear.

QUESTIONS AND PROBLEMS

It is realized that this brief report will not answer every question that may arise in the mind of the reader concerning the use and operation of the

Direct Reading Height Gauge.

This memorandum is intended only to present the basic principles in sufficient detail to acquaint the reader with some of its principal uses. Any further questions or problems concerning the Direct Reading Height Gauge should be directed to the author, Philip W. Shew, Department 1511-3, who will be glad to assist you wherever possible.

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