SERVICE DEPARTMENT

Electro-Motive Division
Of General Motors
La Grange, Illinois 60525

Maintenance Instruction

CRANKCASE MAIN BEARING STEEL BORE ALIGNMENT QUALIFICATION

INTRODUCTION

The purpose of this maintenance instruction is to define the dimensions and limits which control the size, shape, and alignment of the 567 and 645 crankcase main bearing bores. The text of the instruction is divided into four main sections as follows:

I. Determining If Line Bore Is Necessary.

II. Preparation For Line Bore.

III. Qualification Of Line Bore.

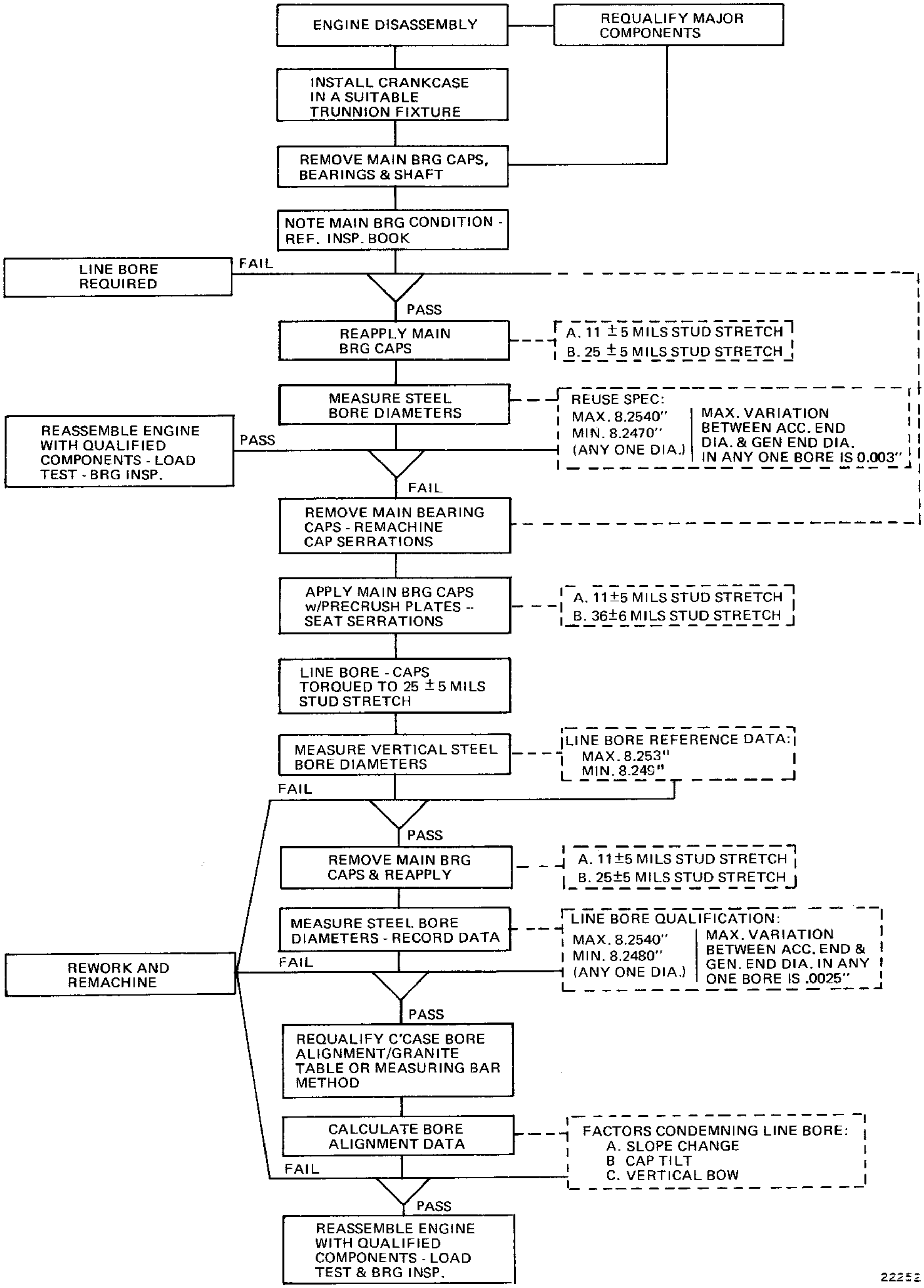
A. Granite Table Method.

B. Measuring Bar Method.

IV. Engine Rebuild And Load Testing

A flow chart is provided to show the recommended basic sequence to be followed so that this qualification process can be performed efficiently.

*This bulletin is revised and supersedes previous issues of this number.


ENGINE DISASSEMBLY
REQUALIFY MAJOR COMPONENTS
INSTALL CRANKCASE IN A SUITABLE TRUNNION FIXTURE
REMOVE MAIN BRG CAPS, BEARINGS & SHAFT
NOTE MAIN BRG CONDITION - REF. INSP. BOOK
LINE BORE REQUIRED
FAIL
PASS
REAPPLY MAIN BRG CAPS
A. 11 ±5 MILS STUD STRETCH
B. 25 ±5 MILS STUD STRETCH
MEASURE STEEL BORE DIAMETERS
REUSE SPEC:
MAX. 8.2540"
MIN. 8.2470"
(ANY ONE DIA.)
MAX. VARIATION BETWEEN ACC. END DIA. & GEN END DIA. IN ANY ONE BORE IS 0.003"
REASSEMBLE ENGINE WITH QUALIFIED COMPONENTS - LOAD TEST - BRG INSP.
PASS
FAIL
REMOVE MAIN BEARING CAPS - REMACHINE CAP SERRATIONS
APPLY MAIN BRG CAPS w/PRECRUSH PLATES -- SEAT SERRATIONS
A. 11±5 MILS STUD STRETCH
B. 36±6 MILS STUD STRETCH
LINE BORE - CAPS TORQUED TO 25 ±5 MILS STUD STRETCH
MEASURE VERTICAL STEEL BORE DIAMETERS
LINE BORE REFERENCE DATA:
MAX. 8.253"
MIN. 8.249"
FAIL
PASS
REMOVE MAIN BRG CAPS & REAPPLY
A. 11±5 MILS STUD STRETCH
B. 25±5 MILS STUD STRETCH
MEASURE STEEL BORE DIAMETERS - RECORD DATA
LINE BORE QUALIFICATION:
MAX. 8.2540"
MIN. 8.2480"
(ANY ONE DIA.)
MAX. VARIATION BETWEEN ACC. END & GEN. END DIA. IN ANY ONE BORE IS .0025"
REWORK AND REMACHINE
FAIL
PASS
REQUALIFY C'CASE BORE ALIGNMENT/GRANITE TABLE OR MEASURING BAR METHOD
CALCULATE BORE ALIGNMENT DATA
FACTORS CONDEMNING LINE BORE:
A. SLOPE CHANGE
B CAP TILT
C. VERTICAL BOW
FAIL
PASS
REASSEMBLE ENGINE WITH QUALIFIED COMPONENTS - LOAD TEST & BRG INSP.
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PROCEDURE

SECTION I

DETERMINING IF LINE BORE IS REQUIRED

Obvious failures involving the main bearing/crankshaft system will require complete disassembly of the engine and in almost all cases will also require line bore. However, those engines which have been taken out of service for reasons other than an obvious failure of this system can have the main bearing steel bore alignment requalified with a minimal amount of work.

The condition of lower main bearings removed from a "running" engine will provide the information necessary to determine whether or not steel bore alignment requires qualification. Bearings that exhibit wear-exposed bronze in excess of 1/8" wide running along either edge of any one main bearing will require complete engine disassembly to facilitate crankshaft removal.

Bearings found in good condition should be replaced with new and will thus allow the engine to be placed back into active service.

NOTE: For further information on evaluating main bearings, refer to "Inspection and Qualification of Engine Main Bearings" guide book published by the Service Department of the Electro-Motive Division of General Motors.

As noted above, an engine which has experienced an obvious failure of the main bearing/crankshaft system, or has bearings which exhibit exposed bronze in excess of the amount indicated above, should be disassembled to facilitate crankshaft removal and the following performed.

PRELIMINARY INSPECTION -- STEEL BORE DIAMETER MEASUREMENTS

With the engine disassembled and the crankshaft and main bearings removed, reapply the main bearing caps as indicated in Section II, Item C-4. Measure the steel bore diameters as shown in Fig. 1, using bore gauge 8275258 with master 9321276. Two sets of readings are required per each main frame member (MFM) taken 1/2" in from each side (accessory and generator ends of each MFM). The crankcase may be reused without bore remachining if all of the diameter readings are within the limits provided in the appendix, Table 1. If the crankcase does not meet the limits provided, proceed to Section II.

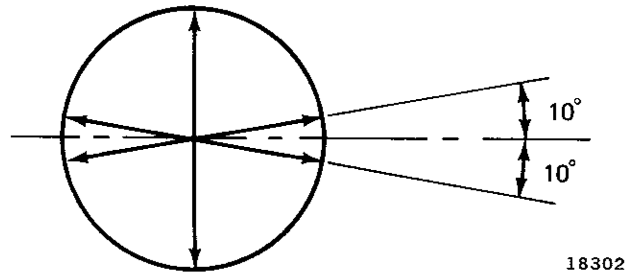


Fig. 1 – Main Bearing Bore Measurement

SECTION II

PREPARATION FOR LINE BORE

A. QUALIFICATION OF MAIN BEARING NUT TORQUE APPLICATION

Stud stretch measurements should be used as the criteria for monitoring torques. The objective of measuring stud stretch is to determine the actual clamp load of the stud/nut system and thus ensure that the torquing method is effective. Stud stretch is defined as *the overall length change of the stud evaluated as the length when torqued minus the length after the applied torque is removed.* Measurement should be as follows:

Using a 16-inch micrometer or Vernier caliper, measure the length of the stud, being careful not to locate on the small projections found on the ends of each stud. The preferred method is to hold the measuring instrument against the back end of the stud with one hand in such a manner that one finger touches the stud end and locates the point of measurement at approximately 3/8" radially from the side of the stud. The outboard end measurement point can be visually located in line with the inboard end point. Operator ability to use this method, or any other selected method, should be checked by taking repetitive readings. Note, that in order for these readings to agree, they must be taken in the same location on the stud ends to minimize errors due to tapered ends.

The method of torque application substantially affects stud stretch. A qualified air or hydraulically operated wrench is recommended for main bearing nut application. Hand torque application of main bearing nuts may not be reliable and can be expected to give a stud stretch range as high as .016".

To qualify any main bearing nut torque application system, perform the following:

1. Select twelve studs which have been prepared normally for main cap application. (See Section II, Item C.)

2. Torque nuts to 750 ft-lbs.

3. Check and record stud length while torqued.

4. Loosen nuts.

5. Record stud length after removal of torque and determine "stud stretch" by subtracting from the length recorded in Step A 3 above.

6. Reset wrench or system if necessary and repeat test until the average stud stretch is .025" ± .001".

7. Determine the "stud stretch range" by subtracting the lowest of the 12 values of stud stretch from the highest of the 12. The stud stretch range must not exceed .012".

B. MAIN BEARING CAP AND CRANKCASE SERRATION INSPECTION

Crankcases which require line bore must have the main bearing caps reworked to obtain machining stock and to upgrade the serration quality. Rework is to be as follows:

1. A minimum of .040" must be cut off the crest of the serrations during remachining to ensure adequate cleanup.

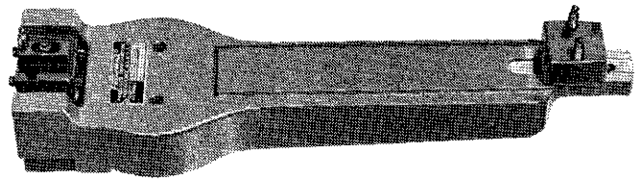
2. Cut the nut seat surface to remove any superficial discontinuities. The nut seat surface should be parallel to the serration pitch line to within .010".

SERRATION SPECIFICATIONS

NOTE: Serrations should be machined on equipment that has been checked to the specifications listed below. Checking should be done by cutting serrations on a sample piece of metal (coupon) and placing it on a shadow graph (comparator) or similar machine.

1. Serration Spacing.

Measurement from the centerline of No. 2 serration on one bank to the centerline of the No. 2 serration on the opposite bank must be 9.500" ± .010". Use gauge 9081052, Fig. 2, to determine this dimension.



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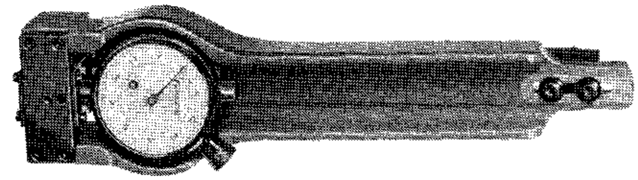

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Fig. 2 - Serration Gauge 9081052

2. Flank Angle.

Flank angle is to be measured by locating horizontal gauge lines at .020" and .120" below the top of the tooth. Draw a line (flank line) through the two points where the gauge lines intersect the tooth profile. This flank line must form a 30° ± 45' angle to the vertical. See (A), Fig. 3.

3. Deviation from nominal serration flank.

.0017" – measured perpendicular to nominal flank surface.

The projected outline of the tooth serration must fall entirely between two 30° lines which are .0034" apart. See (B), Fig. 3.

C. APPLICATION OF MAIN BEARING CAP AT LINE BORE

NOTE: Stud stretch measurements cannot be made on type "567B" or earlier crankcases. Equivalent hand torques must be used.

1. Apply main bearing cap for pre-crush and line bore using flat plate 8488128 against cap (do not use flat plates on "567B" and earlier crankcases), followed by hardened washer 8412532 and nut 8408684. Apply Texaco Threadtex Lubricant 8307731 liberally to stud threads, nut face, and both sides of the washer.

2. Tighten all nuts for pre-crush as follows:

   a. Tighten all nuts to produce 11 ± 5 mils stud stretch (350 ft-lbs Ref.).

   b. Tighten all nuts to produce 35 ± 6 mils stud stretch (1100 ft-lbs Ref. [850 ft-lbs for "567B" and earlier crankcases]).

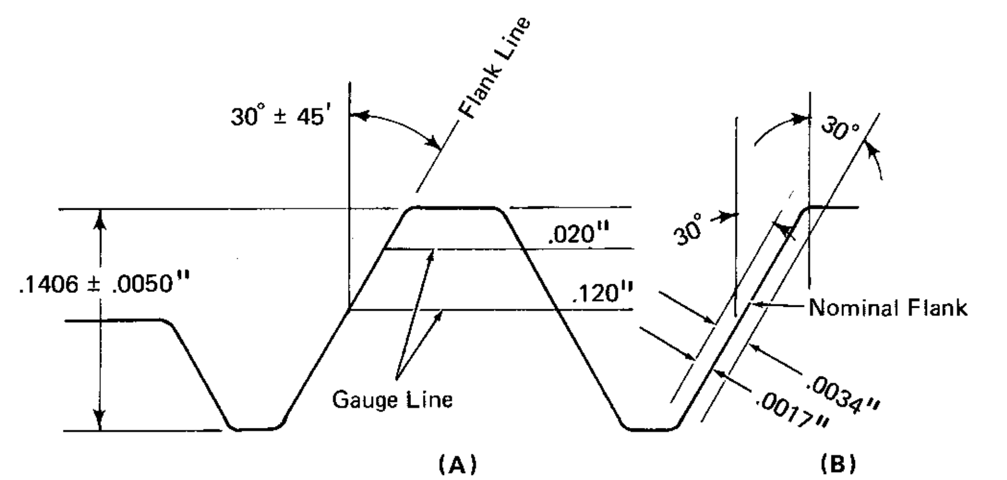

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Fig. 3 - Determination Of Serration Quality

c. Select four studs at one intermediate cap and measure stud stretch as defined in Section II, Items A2 through A6.

3. Loosen all nuts; measure and record free length on the four studs selected in Step 2c above.

4. Tighten all nuts for line bore as follows:

   a. Tighten all nuts to produce 11 ± 5 mils stud stretch (350 ft-lbs Ref.).

   b. Tighten all nuts to produce 25 ± 5 mils stud stretch (750 ft-lbs Ref. [750 ft-lbs for "567B" and earlier crankcases]).

   c. Measure and record length of the above four selected studs.

5. Ready for line bore.

D. LINE BORE

The line bore equipment used should be able to produce a bore surface finish of no greater than 200 micro inches average.

Following line bore, measure the vertical steel bore diameters. All bore measurements are to be taken 1/2" in from the generator side and 1/2" in from the accessory side of each MFM. Vertical diameters should be within the 8.253" to 8.249" limits shown in Table 1, Appendix or reworked and requalified.

Remove flat plate 8488128. Remove all caps.

E. RECAP APPLICATION FOR MEASUREMENT OF VERTICAL BORE

The purpose of this recap operation is to ensure that proper seating of the MFM and cap serrations was attained prior to line bore.

1. Assemble main bearing caps with standard washers and nuts. Apply Texaco Threadtex Lubricant 8307731 liberally to both sides of washer, stud threads, and nut face.

2. Record free length on the four studs selected in crankcase machining.

3. Tighten all nuts in two steps as follows:

   a. Apply torque to produce 11 ± 5 mils stud stretch (350 ft-lbs Ref.).

   b. Apply torque to produce 25 ± 5 mils stud stretch (750 ft-lbs Ref.).

4. Measure and record length of the four selected studs.

5. Remeasure steel bore diameters. The readings obtained must fall within the cap reapplication limits shown in Table 1, Appendix. Record the vertical diameters in the appropriate columns on the Computation Worksheet.

SECTION III

QUALIFICATION OF LINE BORE

Two procedures are offered to determine steel bore alignment. The preferred method requires the use of a precision granite table of sufficient size to support a bare crankcase. Upon request, the Electro-Motive Division Service Department will provide information concerning suppliers of precision granite tables.

A. GRANITE TABLE METHOD

The crankcase should be placed right side up on the precision granite table as shown in Fig. 4. It must be supported on its base rails as follows:

20 cylinder –	Supports centered 28" from ends of crankcase
16, 12, 8 and 6 cylinder –	Supports centered 12" from ends of crankcase

The crankcase should be leveled so that dial indicator readings at the top of the two end MFM's agree within .010". Set dial indicator to zero for reading at accessory end of No. 1 main bearing bore.

The granite table's sole purpose it to provide the source of reference for determining vertical bore alignment (case line data). This data, along with the recap steel bore diameter readings (Section II, E 5) is used to mathematically compute several alignment functions.

The case line readings, Fig. 5, are obtained using a dial indicator mounted on a surface gauge, 1/2" in from each main frame accessory and generator end face and must be made with all caps applied and torqued per Section II, E above. Take two

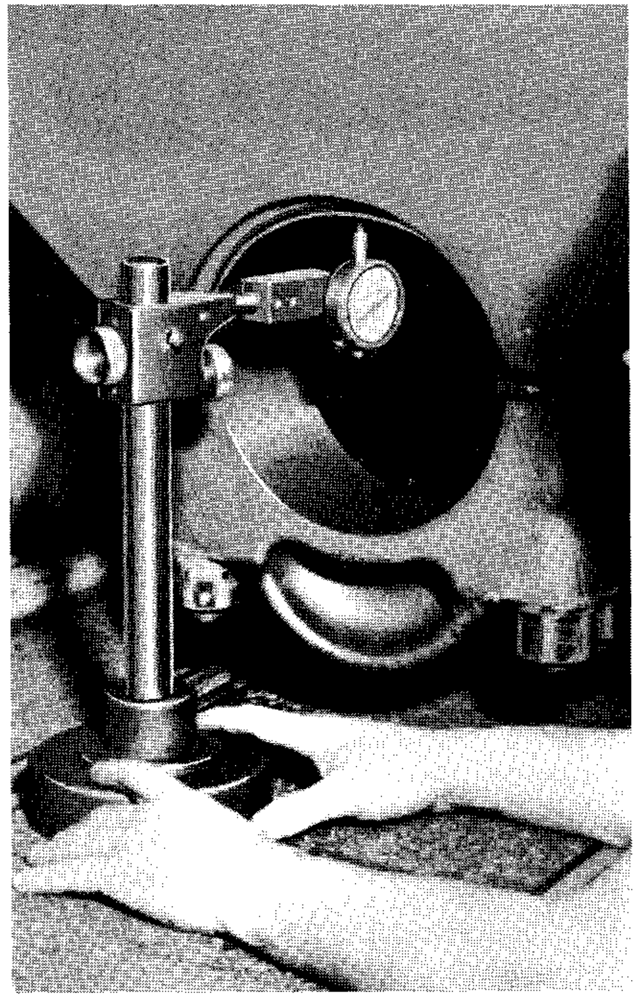

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Fig. 5 – Bore Alignment Measurement Using Dial Indicator

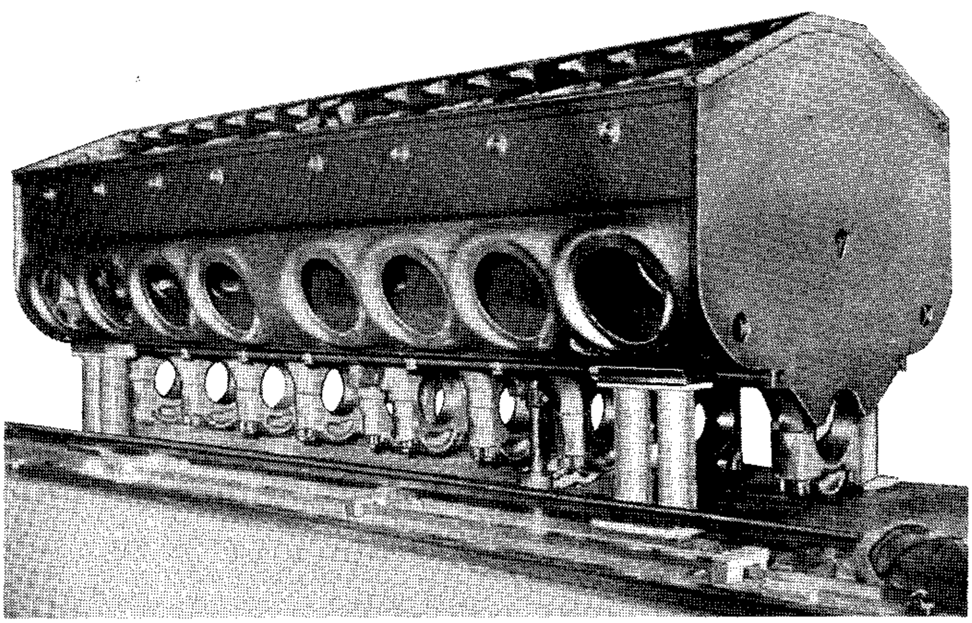

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Fig. 4 – Crankcase Supported On Precision Granite Table

independent sets of dial indicator readings. Any discrepancies between individual readings which are in excess of .0005" must be resolved. Record the final corrected readings on the computation worksheet for Granite Table Inspection (sample provided in the Appendix Section).

Before mathematically computing the alignment functions on the worksheet it is very important to understand each of the functions from a physical standpoint. The following definitions are provided along with an appropriate figure to explain each alignment concept.

1. Case Line –
   The relative vertical position of the crankcase portion of the main bearing bores, Fig. 6.
2. Cap Line –
   The relative vertical position of the main bearing cap portion of the main bearing bores, Fig. 6.
3. Vertical Bow –
   The maximum deviation of the center of any one main bearing bore from a line drawn through the centers of the generator and accessory end main bearing bores is the crankcase vertical bow. The 16 cylinder crankcase shown in Fig. 7 has a maximum bow of -.003" or -3 mils sag. Positive bow is referred to as crown.
4. Step/Effective Step –
   The difference in vertical position between two adjacent main bearing bores (case or cap line), Fig. 8.
5. Slope Change –
   The relative vertical position of two adjacent effective steps (case or cap line), Figs. 9 and 10.
6. Case And Cap Tilt –
   The difference between the accessory and generator positions of any one main bearing bore, Fig. 11.

An explanation on how to use the computation worksheet (for use with the granite table) follows. A master worksheet, as well as a completed example sheet is provided in the Appendix Section.

NOTE: For ease in calculating data, record as mils: where .001" equals 1.0 mil.

1. Column A indicates the main bearing position number for 16 and 20 cylinder engines. The example sheet provided is for a 16 cylinder crankcase.
2. Columns B and C are case line dial indicator readings taken at the accessory and generator end respectively of each main bearing bore. The following sign convention must be used: Towards topdeck is pos. (+), away from topdeck is neg. (–).

NOTE: Dial indicator readings are recorded as positive (+) when gauge travel is towards the topdeck and negative (–) when gauge travel is away from the topdeck. Because of the inverted position of the gauge dial indicator, plus (+) gauge readings are recorded as minus values.

3. Column D is the average ordinate for case line for each main bearing bore. This is found by calculating the average of column B and C, or [Acc. + Gen.]/2 = AVG.
   Example: $[(-2.5) + (-1.2)]/2 = -1.8$ mils.
4. Column E is the STEP between two adjacent main bearing bore averages. Step is calculated algebraically to determine sign convention using the following equation:
   $Y_2 - Y_1$ = Step 1,2 $Y_3 - Y_2$ = Step 2,3 etc.
   Example: $(-1.5) - (-1.8) = +0.3$,
   $(-0.3) - (-1.5) = +1.2$ etc.
5. Column F is a constant factor used to adjust step when the span between main bearing bores is not 16.625" for the purpose of calculating EFFECTIVE STEP. This is only necessary on 16 and 20 cyl. engines because the span distance between the two center main frames is 1/2 the distance between any two intermediate main frames, therefore, the factor is 2.
6. Column G is the effective step which is the product (x's) of Column E and its corresponding factor in Column F.
7. Column H is the case line SLOPE CHANGE or the algebraic difference between two adjacent effective steps (Column G).
   Example: $x_2 - x_1$ or $(+1.2)\ \ (+0.3) = +0.9$,
   $(+0.6) - (+1.2) =\ 0.6$ etc.
8. Column I is the algebraic difference between the case line readings at the generator end (Column C) and the case line readings at the accessory end (Column B) which equals case line tilt (per gauge length), or $Z_G - Z_A$ or $(-1.2) - (-2.5) = +1.3$.

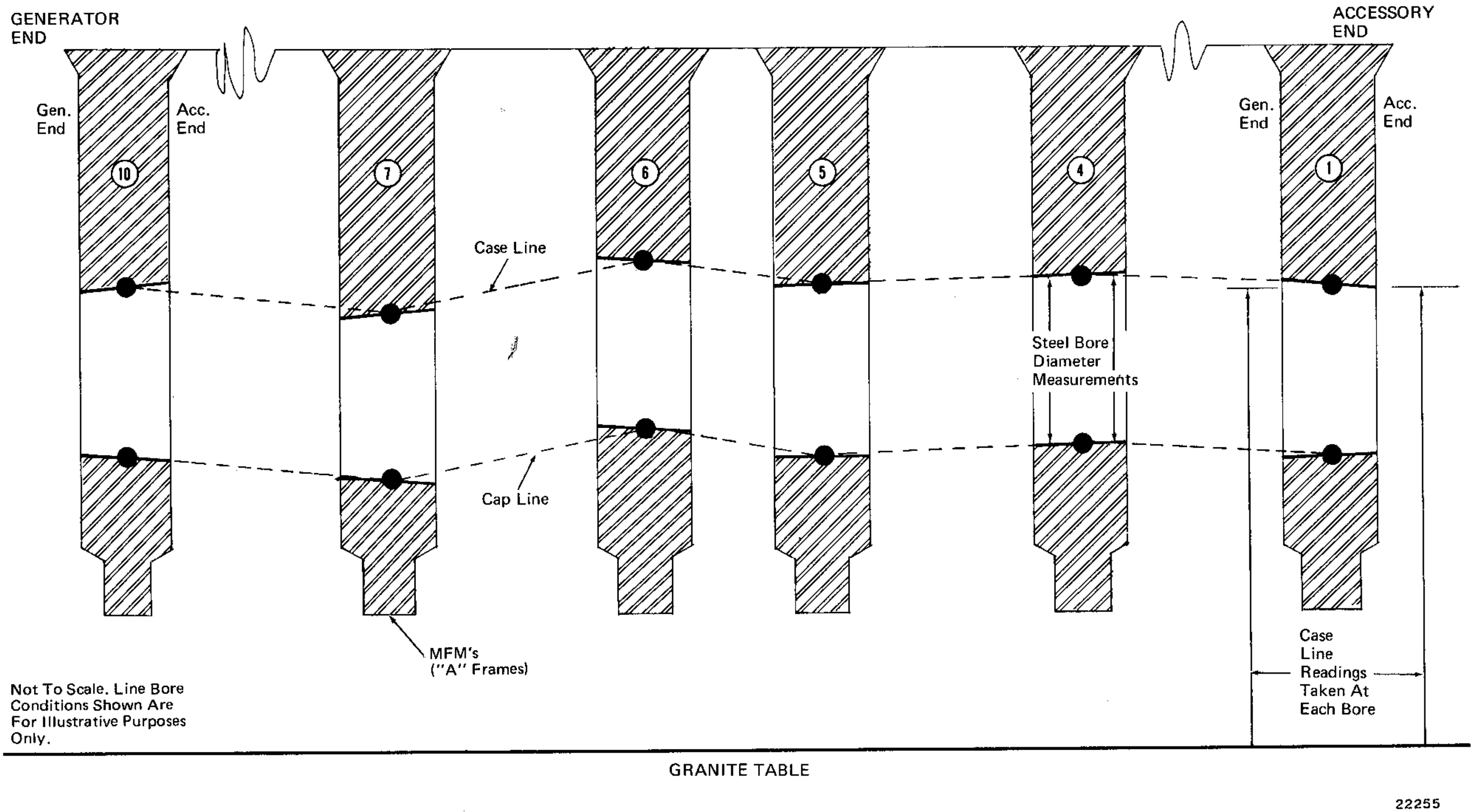

Fig. 6 – Relative Vertical Position Of Case Line And Cap Line

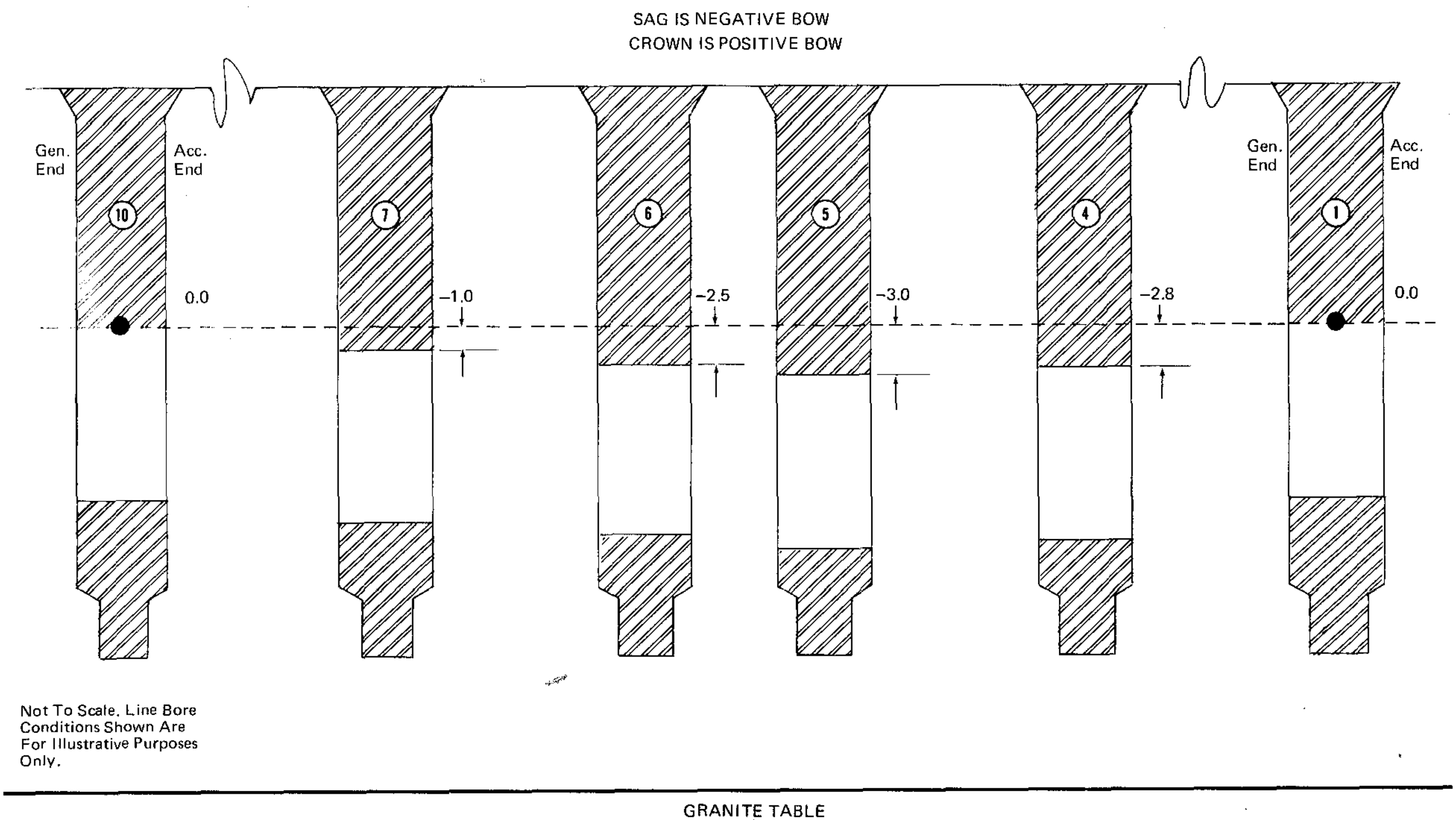

Fig. 7 – Vertical Bow

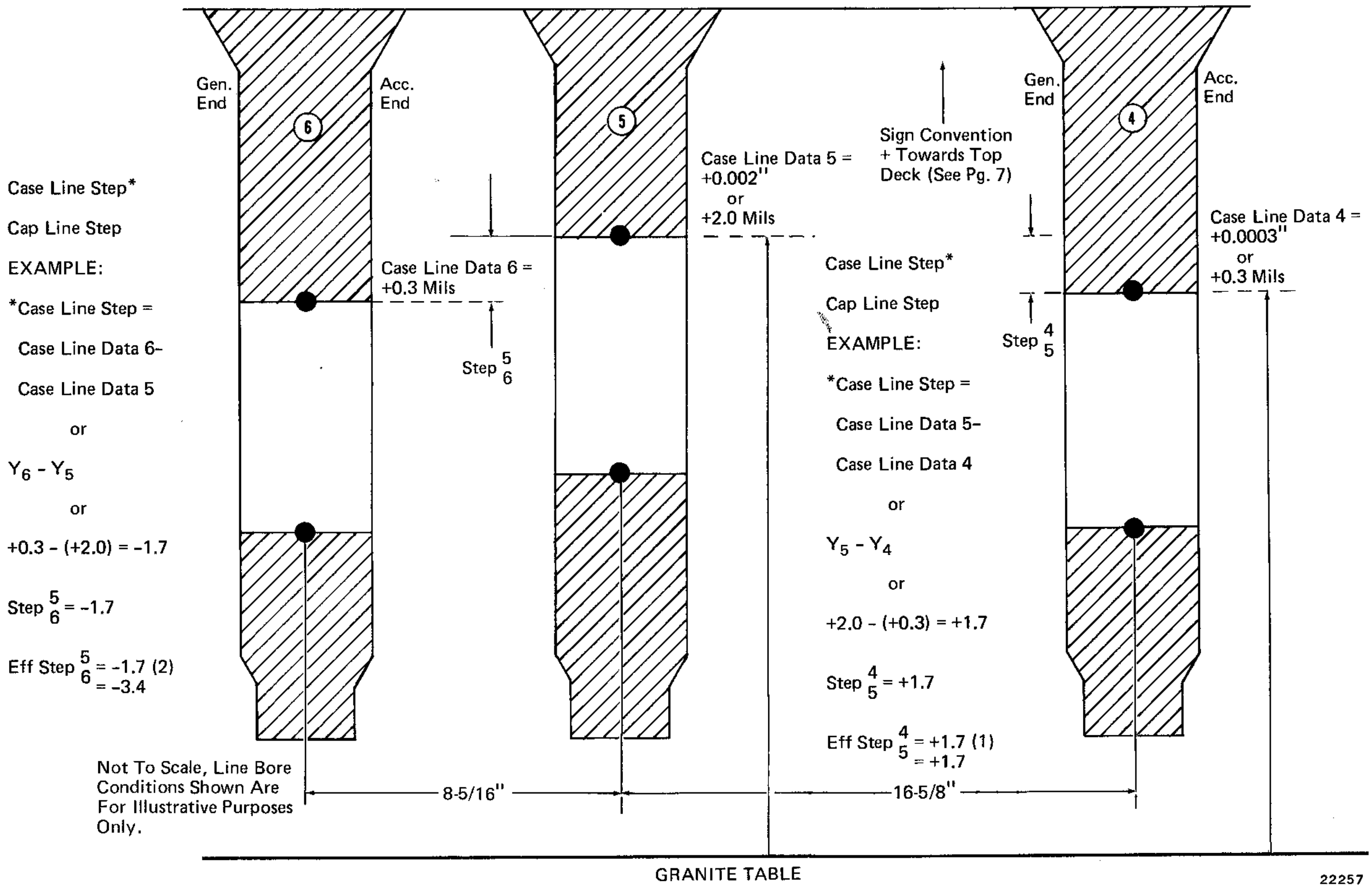

Fig. 8 – Step And Effective Step

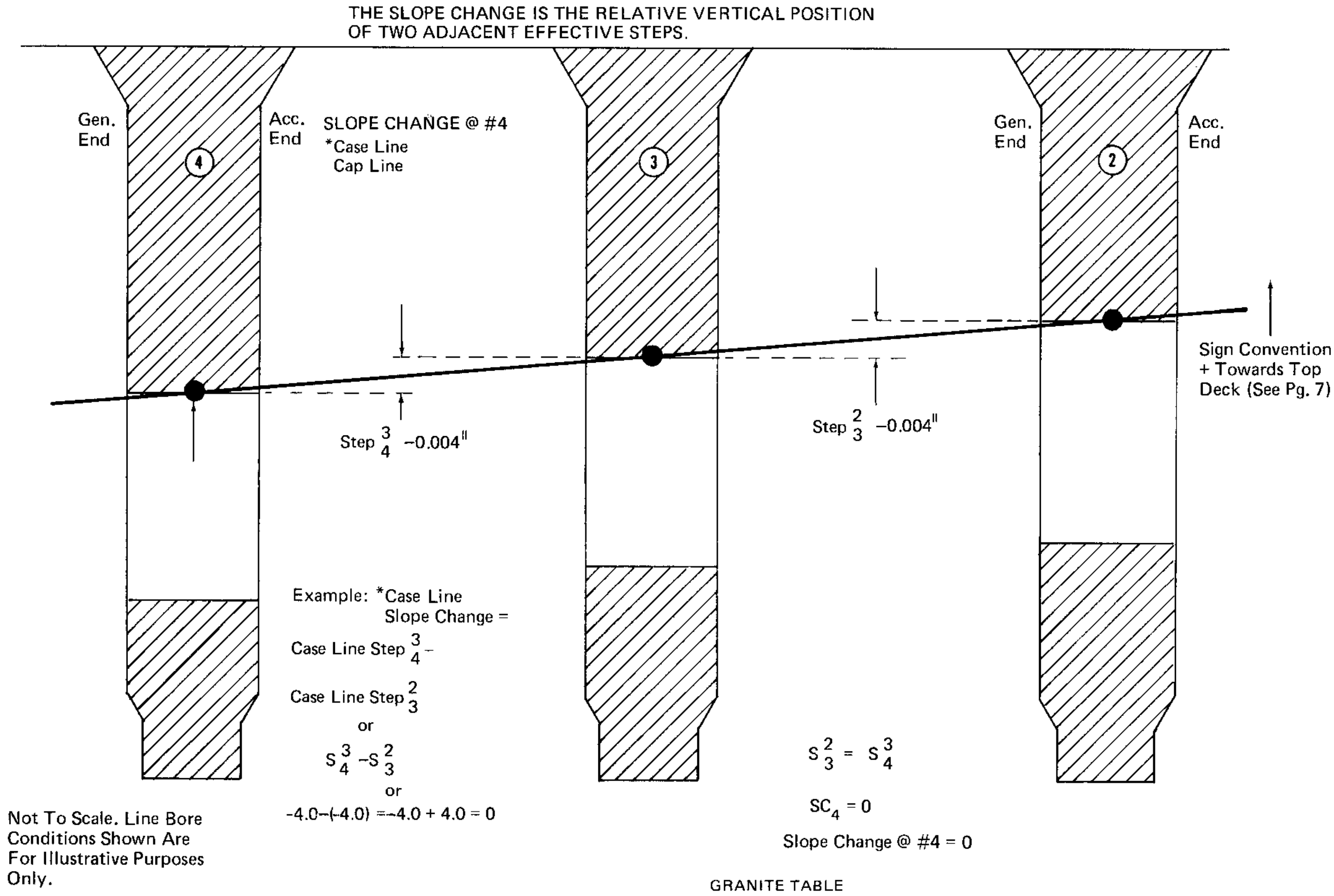

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Fig. 9 – Slope Change Vs. Step (Zero Slope Change Illustrated)

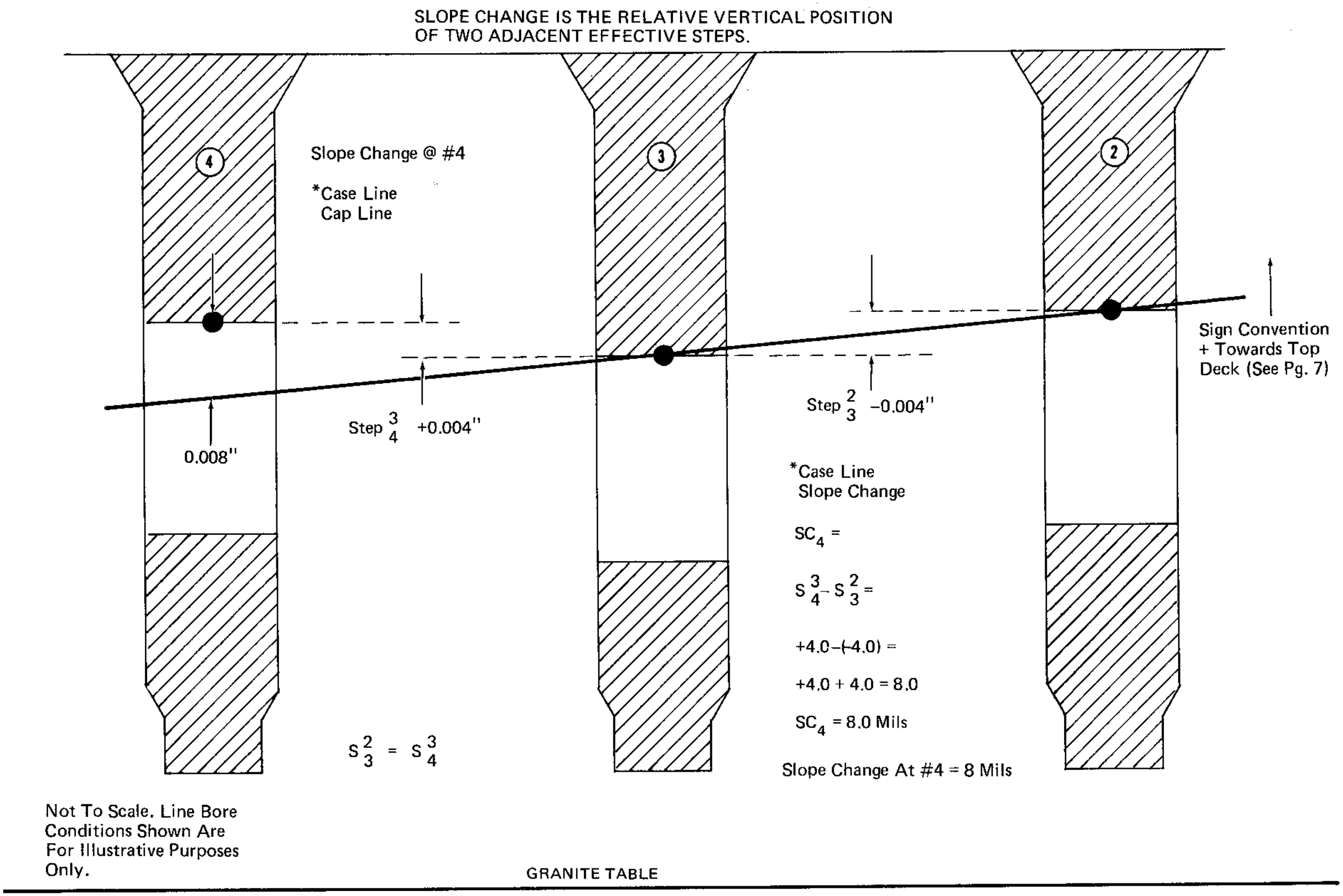


Fig. 10 – Slope Change Vs. Step (8 Mils Change Illustrated)

Case Tilt
Case Line Data, Gen. -
Case Line Data, Acc.
or
$Z_G - Z_A$ or
3.6 -3.4 = +0.2

Cap Tilt =
Case Tilt + *Steel Bore Diff.
or
+0.2 + (-.6) = -0.4

*Steel Bore Difference =
Acc. End Steel Bore - Gen. End Steel Bore
or
+1.4 - (+2.0) = -0.6

Not To Scale. Line Bore Conditions Shown Are For Illustrative Purposes Only.

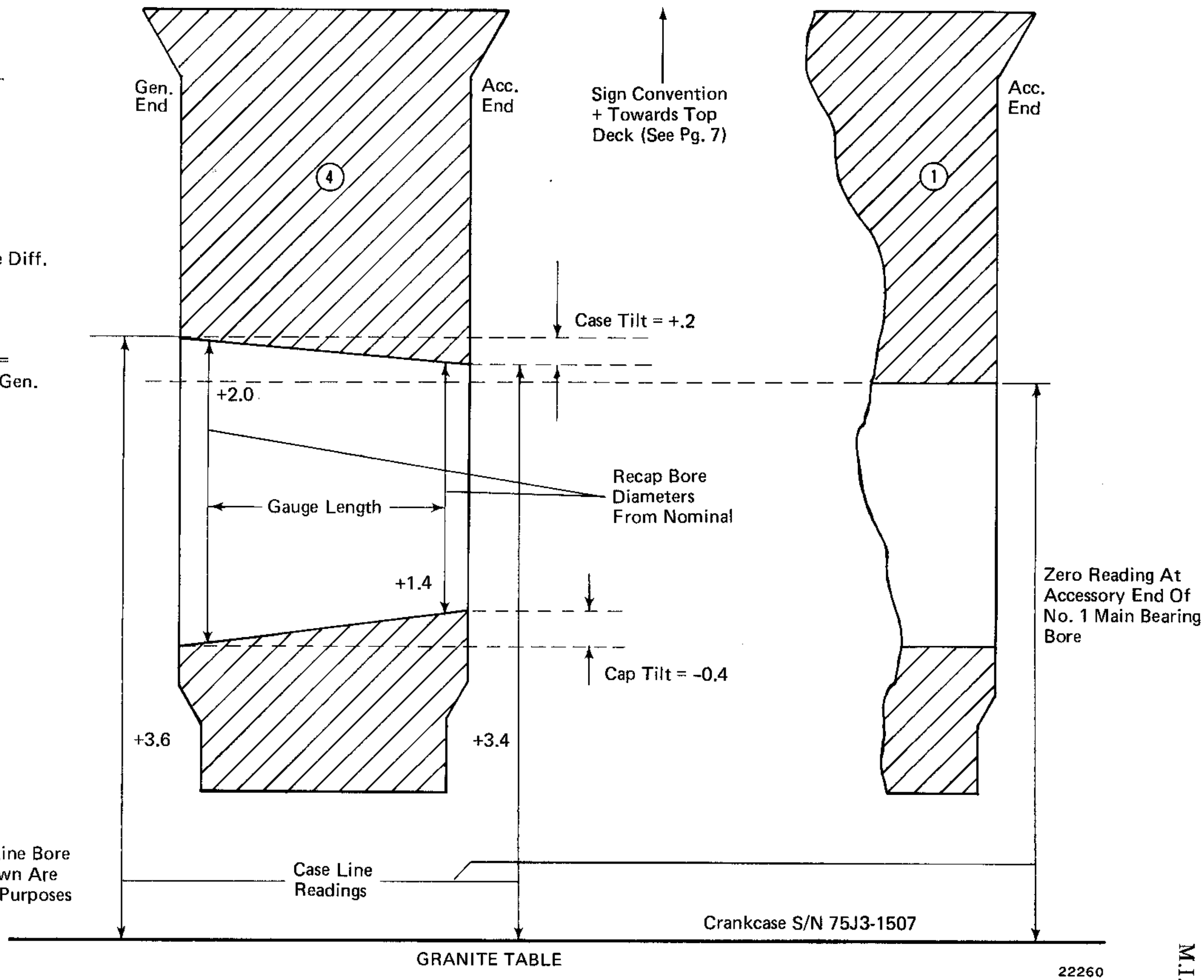


Fig. 11 - Case And Cap Tilt

9. Columns J and K are vertical recap steel bore variations from the nominal bore diameter of 8.2500", taken at the accessory end and generator end respectively. The following sign convention is used: pos.(+) = Larger than nominal and neg.(-) = Smaller than nominal. Example: A vertical steel bore dia. of 8.2511" is expressed +1.1 mils; 8.2488" is -1.2 mils.

10. Column L is the steel bore difference, which is the accessory end steel bore size minus the generator end steel bore size.
Example: (+1.1) - (+1.3) =-0.2.

11. Column M is the CAP TILT per gauge length. It is equal to the algebraic sum of Columns I and L or case line tilt plus steel bore difference. Example: (+1.3) + (-0.2) = +1.1.

12. Columns N and O are the cap line calculations for the accessory end and generator end respectively. It is the algebraic difference between the case line dial indicator readings and the steel bore variation from nominal; or Column B - Column J = Column N etc. and Column C - Column K = Column O etc.
Example: (-2.5) - (+1.1) = -3.6 and
(-1.2) - (+1.3) = -2.5 etc.

13. Column P is the average ordinate for cap line at each main bearing bore and is calculated the same as the average ordinate for case line (Column D).

14. Columns Q through T are used to calculate CAP LINE step, effective step and slope change. The calculations are identical to those used to find case line, step, effective step and slope change respectively in Columns E, F, G, and H.

The main bearing line bore graph (master and example sheets provided in Appendix) is used to determine vertical bow. The numerical values listed in Columns D <u>or</u> P on the worksheet are used as the data points on the graph. A scale must be assigned to the horizontal lines on the graph so that they include the range of values from either Column D or P. Plot the data points on the graph under the appropriate main bearing position number. Draw a straight line to connect the two end data points and from the line of reference determine the max. vertical sag (-) or crown (+).

B. GRANITE MEASURING BAR METHOD

NOTE: This procedure should only be used to determine steel bore alignment when a precision granite table is not available.

The granite measuring bar 8467738 and gauge assembly 8467737 are used to determine cap line data, after the recap operation has determined that the steel bore diameters are within acceptable limits. The bar, Fig. 12, consists of a 42" long piece of polished granite with a square cross section and a fluid level attached to one end. The level is used to establish horizontal attitude transversely in the bore. The bar is supported by three pairs of ball-head legs spaced in such a manner that only two pairs of legs are in use per each run (the span distance between the center MFM's is one half the distance between intermediates and thus requires an additional set of legs).

The gauge assembly consists of a standard clockwise dial type instrument with an automatic revolution counter. The numerical values obtained in this bore alignement check are merely relative; meaning that there is no prior setting of the gauge in a master fixture. Gauge travel adjustments are not necessary as this has been pre-established in the design make-up of the bar and gauge assembly. <u>Close attention must be paid, however, to the number of sweeps the pointer makes around the dial or the revolution counter, so that consistent numerical data can be obtained.</u>

PROCEDURE:

The crankcase should be resting on its exhaust deck and should be as level as reasonably possible. The main bearing caps should be applied and torqued per Section II, E 3.

The measuring bar is then placed in the first three consecutive main bearing bores starting at the No. 1 MFM. It is suggested that the bar supporting legs be consistently located in the center of the MFM's in which they are placed.

The gauge assembly is placed on top of the bar at the accessory end of the No. 1 MFM. The gauge is then moved from side to side within the bore until a maximum reading is obtained, Fig. 12. Two readings are taken and recorded per bore with the data points located 1/2" in from the accessory and generator end faces. After the readings have been obtained for the first three

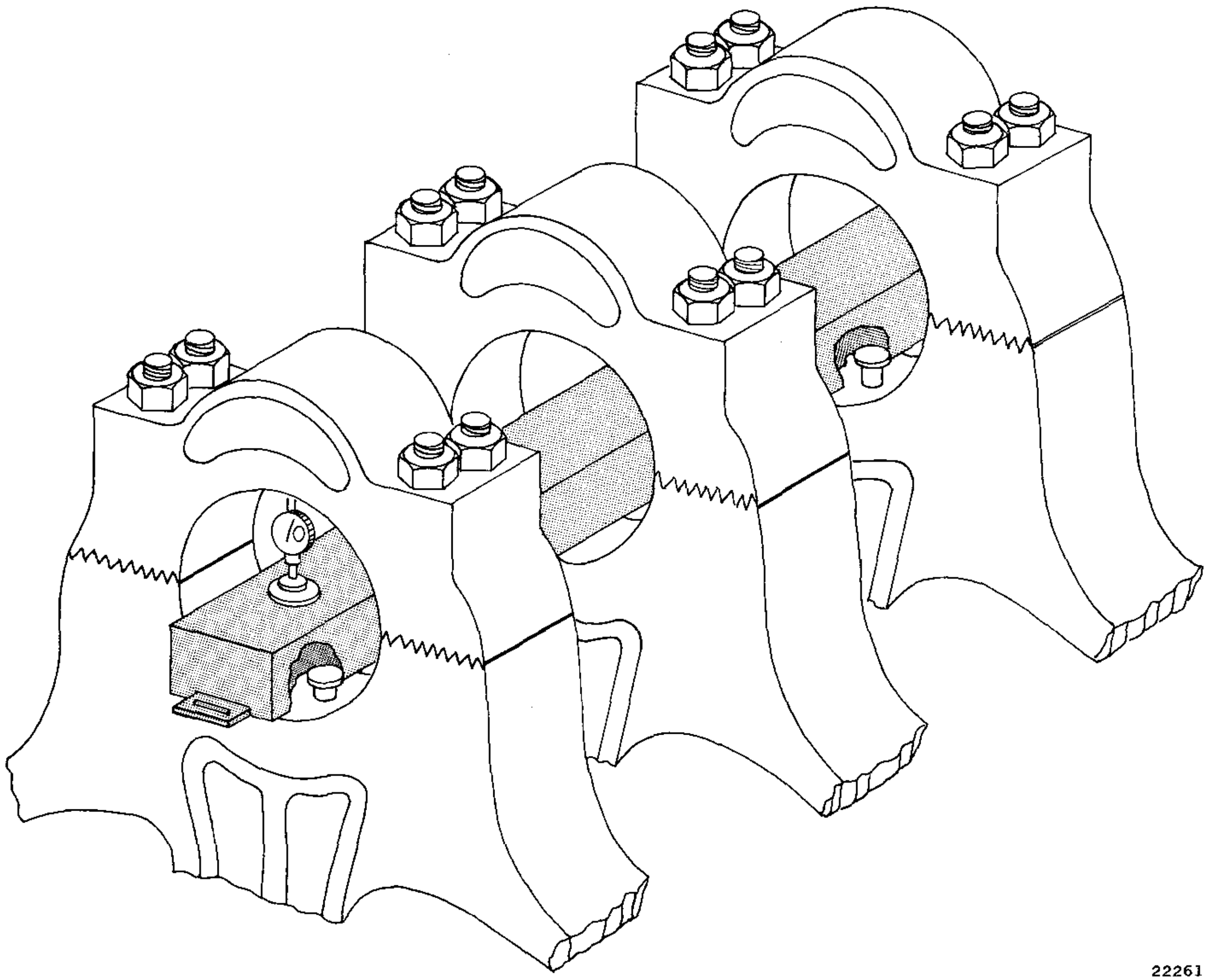


Fig. 12 – Granite Measuring Bar In Place

bores, the bar is then moved to the next adjacent MFM and leveled; meaning that the bar should now span MFM's 2, 3, and 4. This will provide the second run of readings (starting at the accessory end of the No. 2 MFM), and this sequence is followed through the remaining bores of the crankcase. The readings obtained are recorded on the computation worksheet (for measuring bar) provided in the Appendix.

NOTE: It is vitally important that at least two truly independent sets of readings are taken per crankcase with the measuring bar method to insure repeatable, and thus accurate, results. Of the two sets of readings, any discrepancies between individual readings which are in excess of .0005" (.5 mils) must be resolved.

An explanation on how to use the computation worksheet (for use with the measuring bar) follows. A master worksheet, as well as a completed example are provided in the Appendix.

NOTE: For ease in calculating data, record as mils; where .001" equals 1.0 mil.

1. Column A indicates run numbers for 16 or 20 cylinder crankcases. Each run number determines the location of the measuring bar within the crankcase.

2. Column B is the main bearing position numbers for a 16 and 20 cylinder crankcase per run.

3. Columns C and D are the CAP LINE dial indicator readings for the accessory and generator ends respectively.

4. Column E is the average ordinate for each main bearing bore. This is found by calculating the average of Columns C and D, or

[acc. + gen.]/2 = AVG.
Example: [(4.7) + (5.5)]/2 = 5.1 mils.

5. Column F is the STEP between two adjacent main bearing bores' averages per run. Step is calculated algebraically to determine sign convention using the following equation:
$Y_2 - Y_1$ = Step 1,2 $Y_3 - Y_2$ = Step 2,3 etc.
Example: (4.0) - (5.1) = -1.1,
(4.3) - (4.0) = 0.3 etc.

6. Column G is a constant factor used to adjust step when the span between main bearing bores is not 16.625" for the purpose of calculating EFFECTIVE STEP. This is only necessary on 16 and 20 cylinder engines because the span distance between the two center main frames is one half the distance between any two intermediate main frames; therefore, the factor of 2 is used.

7. Column H is effective step which is the product (x's) of Column F and its corresponding factor in Column G.

8. Column I is the uncorrected cap line slope change value which is defined as the algebraic difference between two adjacent effective steps (Column H).
Example: (0.3) - (-1.1) = 1.4 mils.

9. Column J is a slope change correction used to adjust for sag or crown present within the measuring bar. This correction value equals twice the amount of sag (neg. -) or crown (pos. +) found in the bar.

NOTE: The bar correction factor is provided with each measuring bar assembly and should be checked annually at Electro-Motive. Contact your service representative to make necessary arrangements to have this function performed.

10. Column K is the corrected SLOPE CHANGE value obtained by determining the algebraic sum of Column I and the bar correction value in Column J.
Example: (1.4) + (-0.6) = 0.8 mils.

11. The back side of the computation worksheet, Fig. A-4 Part 2 of 2, begins with Column L which provides the main bearing position numbers for 16 and 20 cylinder engines.

12. Column M is the same corrected slope change data taken from Column K on the front side of the computation worksheet.

13. Columns N and O are intermediate steps required to obtain the main bearing line bore graph. The values are obtained by calculating the cumulative sum of the slope change figures in Column L, starting at the center of the engine and working towards the top and bottom of each Column. As shown on the example worksheet provided, the corrected slope change value for the No. 6 main bearing (-2.2) is algebraically added to the corrected slope change value for the No. 5 main bearing (0.9). The total (-1.3) is then algebraically added to the No. 4 main bearing corrected slope change value (-0.6); equals (-1.9) etc.

The exact same procedure is followed for the readings obtained in Column O. As shown on the sample worksheet, the corrected slope change value of the No. 6 main bearing (-2.2) is again algebraically added to the cumulative value for the No. 5 main bearing in Column N (-1.3). The total (-3.5) is then added algebraically to the cumulative value of the No. 4 main bearing (-1.9) etc.

14. The figures obtained in Column O are used to plot data points on the main bearing line bore graph, Fig. A-5, as shown in the example provided.

A scale must be assigned to the horizontal lines so that they include the range of values from Column O. Plot the data points on the graph under the appropriate main bearing position number. The center mains on 16 and 20 cyl. crankcases will always be zero data points. A straight line is then drawn through the two end points and from this line of reference the vertical bow or crown is determined.

The sample computation shows the maximum vertical height of the case occurs at the No. 6 main bearing (7.7 mils) and the crankcase is crowned.

SECTION IV

ENGINE REBUILD AND LOAD TESTING

Position the crankcase in such a manner as to facilitate main bearing cap removal and crankshaft installation. Apply new main bearings and the crankshaft in accordance with the procedure outlined in the appropriate Engine Maintenance Manual. Tighten all main bearing cap nuts per Section II, Item C 4. Assemble the engine with new or requalified material and install in an appropriate test cell facility (engine application will so dictate) and prepare for break-in or load test. Be sure to properly fill the engine's lube oil system and pre-lube prior to start up.

It is recommended that the break-in or load test procedure used, includes a "feel over" check of the crankshaft/main bearing system before advancing engine speed and load.

APPENDIX

NOTE: The following limits apply only when the main bearing stud stretch is .025" ± .006".

TABLE 1
STEEL BORE DIAMETER LIMITS
(DIMENSIONS IN INCHES)

	REMACHINED		REUSE WITHOUT ANY BORE REMACHINING
	AS LINE BORED*	AFTER CAP RE-APPLICATION	
ANY ONE DIAMETER (MAX.)	8.2530	8.2540	8.2540
(MIN.)	8.2490	8.2480	8.2470
Max. variation between accessory end diameter and gen. end diameter in any one steel bore	NO REQUIRE-MENT	.0025	.003

*Reference only. Dimensions obtained after cap reapplication are to be used for qualification.

TABLE 2
LINE BORE ALIGNMENT LIMITS
(DIMENSIONS IN INCHES)

CASE LINE & OR CAP LINE		REMACHINED		REUSE W/O REMACHINING
		MAX. BOW (-) OR CROWN (+)		MAX. BOW
20 cyl.		-.011	+.016	.020
16 cyl.		-.007	+.010	.012
12 cyl.		-.005	+.007	.008
8 cyl.		-.005	+.007	.008
6 cyl.		-.005	+.007	.008
Max. slope change – Thousandths/16.625"	Case Line	±.005*		±.007*
	Cap Line	±.0065		±.0085

*Reference only. Cap line dimensions are to be used for qualification.

DATE ______

ENGINE SERIAL NO.

CRANKCASE SERIAL NO.

Main Bearing Number	Case Line Indicator Readings Acc. End	Case Line Indicator Readings Gen. End	Average (Acc. & Gen.)/2	Step, Case Line	Factor	Effective Step, Case Line	Slope Change, Case Line	Case Tilt	Bore Variation From Normal, Acc. End	Bore Variation From Normal, Gen. End	Steel Bore Difference, (Acc. - Gen.)	Cap Tilt	Cap Line Calculations, Acc. End	Cap Line Calculations, Gen. End	Average (Acc. - Gen.)/2	Step, Cap Line	Factor	Effective Step, Cap Line	Slope Change, Cap Line
1					1												1		
2 1					1												1		
3 2					1												1		
4 3					1												1		
5 4					1												1		
6 5					2												2		
7 6					1												1		
8 7					1												1		
9 8					1												1		
10 9					1												1		
11 10					1												1		
12																			
A (20 Cyl. / 16 Cyl.)	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
									(COLUMNS)										

22262

Fig. A-1 – 16 & 20 Cylinder Crankcase Line Bore Computation Worksheet For Use With The Granite Table

ENGINE SERIAL NO. 76D3-1505

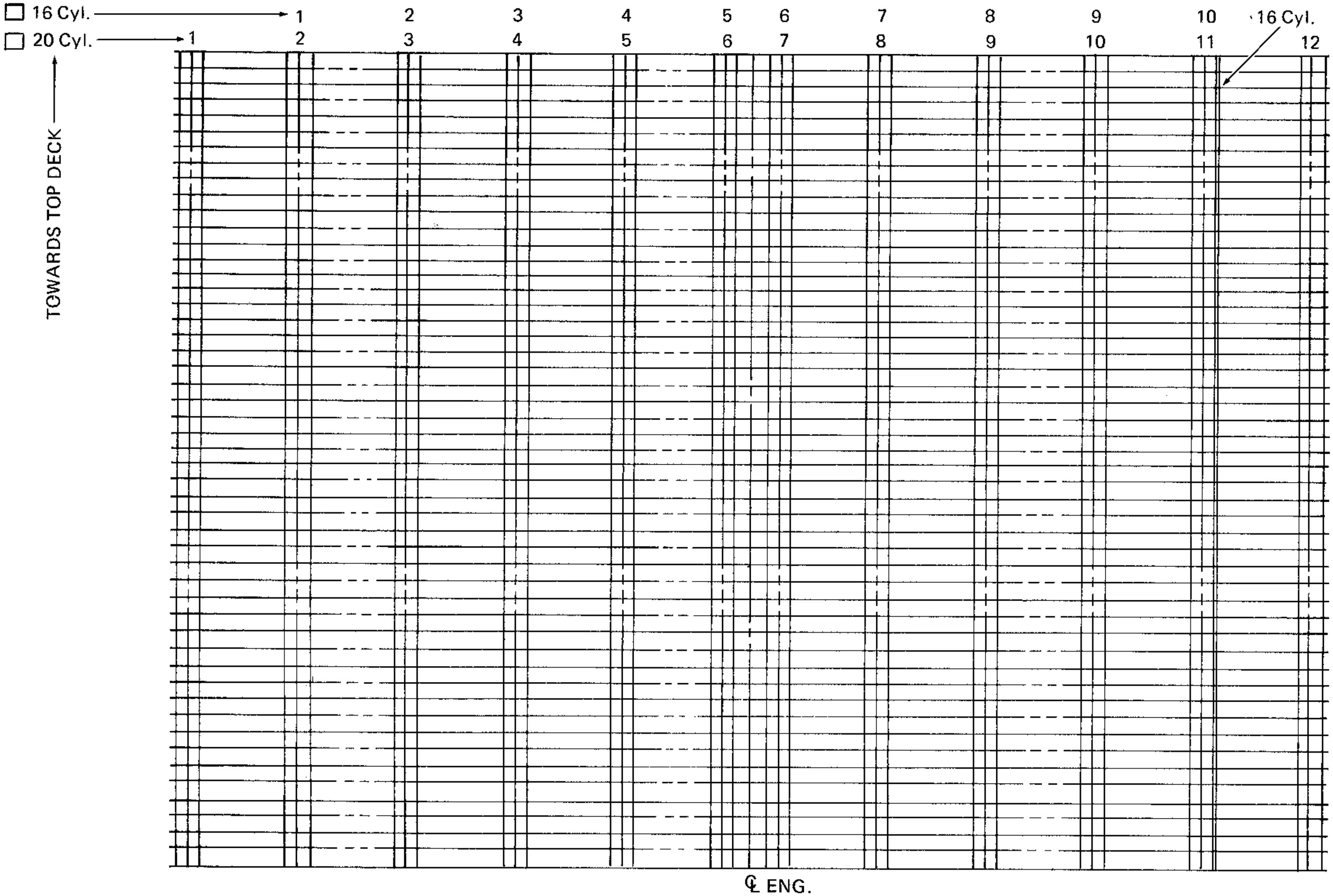
DATE ______

CRANKCASE SERIAL NO. 76A13

Main Bearing Number	Case Line Indicator Readings Acc. End	Case Line Indicator Readings Gen. End	Average (Acc. & Gen.) / 2	Step, Case Line	Factor	Effective Step, Case Line	Slope Change, Case Line	Case Tilt	Bore Variation From Normal, Acc. End	Bore Variation From Normal, Gen. End	Steel Bore Difference, (Acc. - Gen.)	Cap Tilt	Cap Line Calculations, Acc. End	Cap Line Calculations, Gen. End	Average (Acc. - Gen.) / 2	Step, Cap Line	Factor	Effective Step, Cap Line	Slope Change, Cap Line
1																			
					1												1		
2 1	-2.5	-1.2	-1.8					1.3	1.1	1.3	-.2	1.1	-3.6	-2.5	-3.0				
				.3	1	.3										2.4	1	2.4	
3 2	-1.7	-1.3	-1.5				.9	.4	-.6	-1.2	.6	1.0	-1.1	-.1	-.6				-2.3
				1.2	1	1.2										.1	1	.1	
4 3	-.6	-.1	-.3				-.6	.5	.3	0.0	.3	.8	-.9	-.1	-.5				1.8
				.6	1	.6										1.9	1	1.9	
5 4	0.0	.5	.3				1.1	.5	-1.1	-1.2	.1	.6	1.1	1.7	1.4				-2.0
				1.7	1	1.7										-.2	1	-.2	
6 5	2.0	2.0	2.0				-.5	0.0	.9	.6	.3	.3	1.1	1.4	1.2				1.6
				.6	2	1.2										.7	2	1.4	
7 6	2.8	2.4	2.6				.9	-.4	.5	.9	-.4	-.8	2.3	1.5	1.9				1.8
				2.1	1	2.1										3.2	1	3.2	
8 7	5.4	4.1	4.7				-3.8	-1.3	-.5	-.2	-.3	-1.6	5.9	4.3	5.1				-5.4
				-1.7	1	-1.7										-2.2	1	-2.2	
9 8	2.8	3.3	3.0				1.1	.5	-.2	.5	-.7	-.2	3.0	2.8	2.9				.8
				-.6	1	-.6										-1.4	1	-1.4	
10 9	2.4	2.4	2.4				-1.5	0.0	1.0	.9	.1	.1	1.4	1.5	1.5				-.5
				-2.1	1	-2.1										-1.9	1	-1.9	
11 10	.5	0.0	.3					-.5	.7	.7	0.0	-.5	-.2	-.7	-.4				
					1												1		
12																			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
20 Cyl. — 16 Cyl.								(COLUMNS)											

22263

Fig. A-2 – 16 & 20 Cylinder Crankcase Line Bore Computation Worksheet
For Use With The Granite Table



ENG. SERIAL NO. ____________________

C'CASE SERIAL NO. ____________________

DATE ____________

INSPECTOR ____________

Fig. A-3 – Main Bearing Line Bore Graph

22264

ENG. SERIAL NO. 76C3-1518 CASE SERIAL NO. 76A-115
INSPECTOR ______ DATE ______
MODEL SD45 TYPE 20-645E3

A		B		C	D	E	F	G	H	I	J	K
Run No. 20 Cyl.	Run No. 16 Cyl.	Bearing No. 20 Cyl.	Bearing No. 16 Cyl.	Cap Line Dial Indicator Rdgs. Acc. End	Cap Line Dial Indicator Rdgs. Gen. End	Average (A + G) /2	Step	Factor (Constant)	Effective Step	Uncorrected Slope Change	Bar Correction	Corrected Slope Change
1		1		4.7	5.5	5.1						
		2		3.7	4.4	4.0	-1.1	1	-1.1	1.4	-.6	.8
		3		3.6	5.0	4.3	.3	1	.3			
2	1	2	1	4.3	5.0	4.6						
		3	2	3.7	4.8	4.2	-.4	1	-.4	.4	-.6	-.2
		4	3	4.1	4.3	4.2	0.0	1	0.0			
3	2	3	2	3.9	5.0	4.4						
		4	3	4.1	4.1	4.1	-.3	1	-.3	0.0	-.6	-.6
		5	4	3.8	3.9	3.8	-.3	1	-.3			
4	3	4	3	4.5	4.7	4.6						
		5	4	4.3	3.8	4.0	-.6	1	-.6	1.5	-.6	.9
		6	5	4.7	5.2	4.9	.9	1	.9			
5	4	5	4	4.1	3.7	3.9						
		6	5	4.7	5.2	4.9	1.0	1	1.0	-1.6	-.6	-2.2
		7	6	4.5	4.7	4.6	-.3	2	-.6			
6	5	6	5	5.0	5.4	5.2						
		7	6	4.9	5.0	4.9	-.3	2	-.6	-.3	-.6	-.9
		8	7	3.2	4.4	3.8	-.9	1	-.9			
7	6	7	6	4.7	4.9	4.8						
		8	7	3.3	4.5	3.9	-.9	1	-.9	1.4	-.6	.8
		9	8	4.1	4.8	4.4	.5	1	.5			
8	7	8	7	3.6	4.6	4.1						
		9	8	4.4	5.0	4.7	.6	1	.6	-.7	-.6	-1.3
		10	9	3.7	5.5	4.6	-.1	1	-.1			
9	8	9	8	4.9	5.6	5.2						
		10	9	4.1	5.4	4.7	-.5	1	-.5	-.6	-.6	-1.2
		11	10	3.4	3.9	3.6	-1.1	1	-1.1			
10		10		3.9	5.7	4.8						
		11		3.6	4.2	3.9	-.9	1	-.9	1.8	-.6	1.2
		12		4.9	4.8	4.8	.9	1	.9			

22265A

Fig. A-4 - 16 & 20 Cylinder Line Bore Computation Worksheet For Use With Granite Measuring Bar 8467738 (Sheet 1 of 2)

ENGINE SERIAL NO. 76C3-1518 CASE SERIAL NO. 76A-115

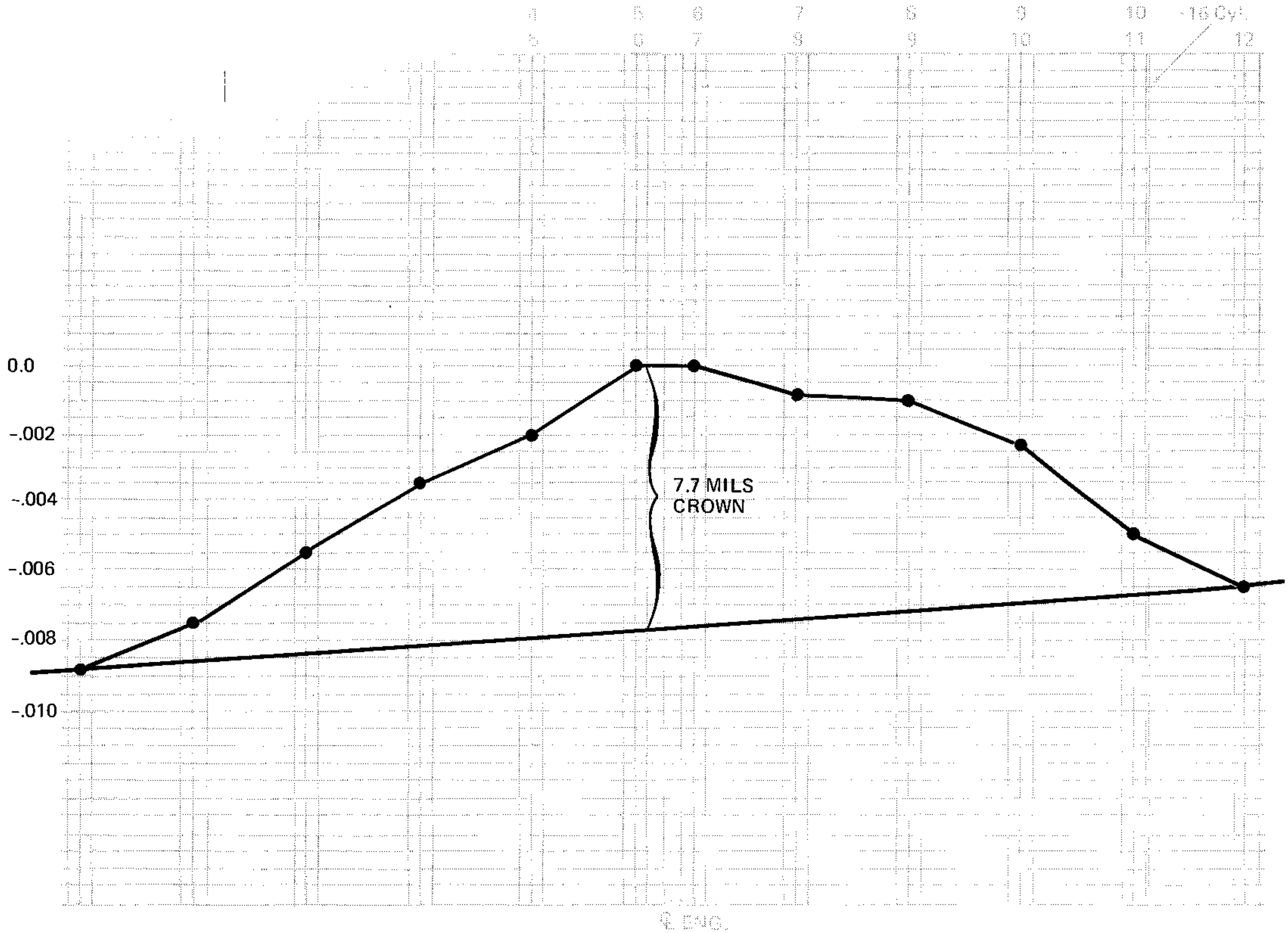
INSPECTOR ______________ DATE ______________

MODEL SD45 TYPE 20-645E3

Bearing No. 20 Cyl.	Bearing No. 16 Cyl.	L Slope Change Corrected	M Cum. Sum of Change From Engine ℄ Step I	N Cum. Sum Of Change From Engine ℄ Step II	O Vertical Bow/Crown Data (From Line Bore Graph, Fig. A5)	P
1				-8.8	0.0	
			-1.3			
2	1	.8		-7.5	1.1	
			-2.1			
3	2	-.2		-5.4	3.0	
			-1.9			
4	3	-.6		-3.5	4.7	
			-1.3			
5	4	.9		-2.2	5.6	
			-2.2			
6	5	-2.2		0.0	7.7	
— ENGINE ℄ —						
7	6	-.9		0.0	7.6	
			-.9			
8	7	.8		-.9	6.5	
			-.1			
9	8	-1.3		-1.0	6.1	
			-1.4			
10	9	-1.2		-2.4	4.4	
			-2.6			
11	10	1.2		-5.0	1.7	
			-1.4			
12				-6.4	0.0	

22265B

Fig. A-4 – 16 & 20 Cylinder Line Bore Computation Worksheet For Use With Granite Measuring Bar 8467738 (Sheet 2 of 2)



ENG. SERIAL NO. 76C3-1518 DATE

C'CASE SERIAL NO. 76A-115 INSPECTOR

Fig. A-5 – Main Bearing Line Bore Graph

22266

Equipment:

	Part No.
Dial Bore Gauge	8275258
Master (8.2500" Nominal)	9321276
Serration Gauge -- Includes Master	9081052
Precrush Plates	8488128
Texaco Threadtex Lubricant #2303 (70 lb. Pail)	8307731
Granite Inspection Table	Contact EMD Service Department For Supplier Information
Support Blocks	File Drawing #778
Dial Indicator Gauge – Case Line Readings - Table Method	File Drawing #891
Measuring Bar	8467738
Dial Indicator Gauge	8467737