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EVALUATION OF AIRBORNE GRAVIMETER OPERATIONAL TEST

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Foreword

Under Contract DA-49-013-eng-2326, an operational test of the LaCoste-Romberg airborne gravimeter was made by the FLAG Corporation for the Army Map Service over a triangular course in southern Texas and Louisiana where there is good ground gravity control. Observations were made in both directions over each leg of the course at a flight level of approximately 12,000 feet and both the observed gravity values determined and the ground control gravity values were projected to the 12,000 foot level for comparative purposes on the basis of the normal gradient of gravity. The average agreement between the two sets of values reported by FLAG is ± 5.7 mgals.

Under Contract DA-49-018-eng-2435, the University of Wisconsin was charged "to perform sufficient checks and computations to determine the adequacy of the gravity meter readings, reductions, and computations of gravity values made by FLAG under Contract DA-49-013-eng-2326, to enumerate all discrepancies detected in the data and to recommend acceptance or rejection thereof."

Before undertaking the above evaulation, Mr. Strange of the University of Wisconsin visited Dr. Lucien LaCoste of FLAG at Austin, Texas to ascertain firsthand what procedures and methods were used in reducing the observed gravity values and he also visited Dr. L. L. Nettleton of FLAG at Houston, Texas to determine the reliability of the ground control used, the procedures used in projecting the ground control upward and what degree of smoothing, if any, had been applied in comparing values. With this background, the evaluation study was undertaken on the basis of the same reduction theory used by FLAG for determining the observed gravity values and the comparative upward projected ground control values. However, the data were reduced, using a digital procedure rather than an analog one, as used by FLAG in obtaining the observed gravity values. This was done for the following reasons:

1: By using a different computational method for reducing the data, the effect of the computational method on results obtained could be ascertained;

2: As the two methods should give results in substantial agreement, any significant errors in the original values could be detected;

3: Eventually a digital procedure will have to be adopted if the gravimeter is not to be tied up as a computer for reducing the values.

Summary

The results for three lines of airborne gravimeter measurements made by FLAG Corporation over a triangular course in southern Texas and Louisiana were examined as to method of reduction used and the reliability of the numerical results, which were obtained by analog procedures, checked using a digital method of computation. A comparison of the FLAG values with upward continued ground values of gravity to flight level at 12,000 feet as determined by FLAG was also examined as to the reliability of the method used and the numerical results compared with those obtained using digital procedures. No significant numerical errors were found in the data prepared by FLAG, and the corrections and procedures used by FLAG in reducing data and evaluating their results were found to be both reasonable and adequate. On the basis of the checks made covering three flight lines of measurements (six flight lines were made by FLAG), it is recommended that the gravity meter readings, reductions and computations submitted by FLAG be accepted.

The results obtained, using the digital method of computation in contrast to the analog procedure used by FLAG to obtain observed gravity values showed a somewhat larger deviation of the digitally computed values from the upward continued ground values. The average differences from the upward continued values were 6.8 mgals using digital procedures and 5.7 mgals using the analog procedures. This difference of 1.1 mgals can be attributed to the higher degree of smoothing that is obtained with the analog method, particularly where there are large corrections as for changes in course heading. Regardless of computation procedure, it appears that the airborne

gravity meter readings can be reduced to yield observed gravity values at a specified level that will be reliable to between 5 and 8 mgals. However, it should be noted that the sign of the deviations from the upward continued values at any one place using the two procedures were frequently out of phase. As a result, the average difference in values using the two procedures actually approached 6 mgals. Further study is being made as to the cause of these out of phase relationships.

Introduction

The primary objective of the present evaluation study of the airborne gravimeter operational test conducted by the FLAG Corporation for the Army Map Service was to determine the reliability of the results reported.

In carrying out the investigation the data reported by FLAG were examined first from the standpoint of whether the corrections applied in reducing the data were theoretically correct and whether any significant corrections had been omitted. Once satisfied on these points the data were examined from the standpoint of whether the corrections had been applied in a logical and consistent manner. Finally, the numerical values for the corrections and final results were checked for accuracy.

In checking the theory and logic behind the corrections applied by FLAG to the gravimeter values obtained, particular attention was given to the "additional" horizontal corrections applied. The remainder of the corrections are of a standard nature and represent those in general use for marine gravimetric measurements. The additional horizontal corrections were for long period horizontal accelerations of the airplane that were not being taken out by the accelerometers. The theory and logic used for determining these accelerations and their effect were found to represent good first approximations and to be as near correct as could be established with the data available. Increased accuracy for these corrections, however, should be possible in the future once the gravimeter output is changed to give digital rather than analog values so that a Fourier analysis can be applied.

As certain portions of the data reduction procedure required the mechanical following of record traces obtained on the plane to obtain (1) vertical velocities from the hypsometer record and (2) data for the additional horizontal corrections, Mr. Strange spent several days at Austin rerunning original hypsometer records through the differentiating and filter circuits and the horizontal acceleration records through the horizontal accelerometer and associated averaging circuits to determine the degree to which the original results could be reproduced. All results for two lines of measurement were checked using digital computations and desk calculators beyond this stage. The two lines chosen were Baton Rouge to Houston and Baton Rouge to Shreveport. These lines were chosen because the additional horizontal accelerations were a maximum on the Baton Rouge to Houston run and a minimum on the Baton Rouge to Shreveport run. In addition, an IBM program was prepared to perform the digital reductions and one line, Houston to Baton Rouge, reduced using this program.

Examination of Theory of Reductions

The only reduction requiring examination as to theory is the additional horizontal corrections. Questions as to theory of the Eotvos corrections have been adequately treated by Nettleton et al., (1960) and Thompson and LaCoste, (1960).

The horizontal accelerometer equation of motion is

$$\ddot{x} + 2R\, w_o\, \dot{x} + w_o^2\, x = \ddot{y} \tag{2}$$

where x = accelerometer motion

y = plane motion

w_o = 2π times the natural frequency

and R = damping coefficient ($R = 1$ for critical damping)

For a sine wave the solution of this equation gives

$$x = \frac{1}{\left(\frac{w_o}{w}\right)^2 - 1 + j\ 2R\left(\frac{w_o}{w}\right)}\ y \qquad (3)$$

Equation (3) yields for the ratio of the magnitudes of x and y

$$\frac{|x|}{|y|} = \frac{1}{\sqrt{\left[\left(\frac{w_o}{w}\right)^2 - 1\right]^2 + 2R\left(\frac{w_o}{w}\right)^2}} \qquad (4)$$

If there is critical damping $R = 1$

$$\frac{|x|}{|y|} = \frac{1}{1 + \left(\frac{w_o}{w}\right)^2} \qquad (5)$$

Next must be considered the zeroing servo connected with the accelerometer. The equation connecting the input to this servo with its output is

$$u = x - \frac{w_1\ w_2}{(w_1 + s)(w_2 + s)}\ x \qquad (6)$$

where x is the same as in equation (2) and is input to servo

u = output from the servo

w_1 and w_2 = the time constants of the two stages of the servo circuit

For sine waves equation (6) becomes

$$u = \left[1 - \frac{1}{\left(1 + j\frac{w}{w_1}\right)\left(1 + j\frac{w}{w_2}\right)}\right] x \qquad (7)$$

If we take $w_1 = w_2 = w_o$ equation (7) becomes

$$u = \left[1 - \frac{j\left(\frac{w_o}{w}\right)^2}{\left(1 - j\frac{w_o}{w}\right)^2}\right] x = \left[\frac{1 - 2j\frac{w_o}{w}}{\left(1 - j\frac{w_o}{w}\right)^2}\right] x \qquad (8)$$

From (8) the ratio of the magnitudes of u and x can be shown to be

$$\frac{|u|}{|x|} = \frac{\sqrt{1 + 4\left(\frac{w_o}{w}\right)^2}}{1 + \left(\frac{w_o}{w}\right)^2} \qquad (9)$$

Using (9) and (5) we then get

$$\frac{|u|}{|y|} = \sqrt{\frac{1 + 4\left(\frac{w_o}{w}\right)^2}{\left[1 + \left(\frac{w_o}{w}\right)^2\right]^2}} \qquad (10)$$

If $\frac{w_o}{w}^2 << 1$

equation (10) can be approximated by

$$\frac{|u|}{|y|} = 1 \qquad (11)$$

It can be seen from equation (10) that for low frequencies (small values of w) equation (11) is no longer a good approximation and the output no longer accurately represents the plane motion y. In this case a correction is needed.

Provided the low frequency (long period) portion of the horizontal accelerations is confined to one frequency the error will be a certain percentage of the original value. This is the assumption made by FLAG.

The above equations were first worked out by Dr. Lucien LaCoste of FLAG and were checked by University of Wisconsin personnel.

Method of Reduction

Actual original data obtained in flight consisted of three records:

1) Averaged beam position B_a (Record 6 of FLAG)

2) Hypsometer record h (Record 8 of FLAG)

3) Horizontal Acceleration traces A_c and A_L (Record 1 of FLAG)

These records are used as beginning points in all calculations.

Two operations performed on these original records could not be done adequately for digital computations. These were 1) determination of vertical accelerations (h) from the hypsometer record and 2) calculation of the additional horizontal corrections: $A^2_{c}/_{2g}$, $A^2_{c2}/_{2g}$, and A_c from the horizontal accelerations observed by the cross horizontal accelerometer (A_c record) and $A^2_{L}/_{2g}$, $A^2_{L2}/_{2g}$, and $A^2_{L_2}$ from the A_L horizontal longitudinal accelerometer record.

The general reduction equation is $g = S_a + E + F + D + H + d/dt$

$$(\vec{B}_a - \vec{h}^{\cdot}) \qquad (1)$$

where

S_a = spring tension adjustment on gravimeter

E = Eotvos correction

F = Free Air reductions flight level to standard level (12,000 ft.)

D = correction for instrumental drift

H = additional horizontal corrections

$\vec{B}_a$ = average beam position

$\vec{h}^{\cdot}$ = average vertical velocity

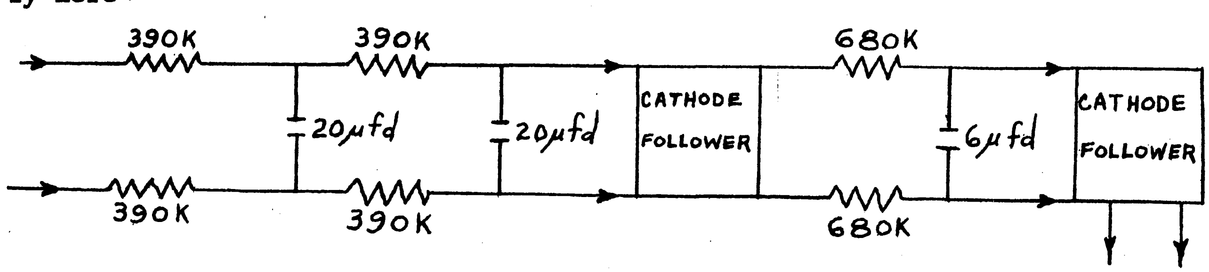
As there was no method for checking either S_a or D, these two terms were accepted as correct. At points where changes in spring setting were made problems arose, however, because the $\vec{B}_a$ curve had been averaged across spring tension changes. This factor had to be taken into consideration when applying the spring tension correction. Examination of Record 7 of FLAG results, where gravity remained constant while a discontinuous change in spring tension setting was made showed the manner in which the averaged beam trace reacter to a discontinuous change in spring tension setting. Study of this curve indicated that the best way to numerically allow for the time lapse before the averaged curve assumed a new slope after changing the spring tension setting was to introduce a 20 second lag.

Values of E and F were taken from the FLAG reports after suitable numerical checks were made.

In obtaining $\vec{h}$ and H, the first step is a purely mechanical operation. A pen of a recorder is made to follow a trace by manual adjustments as described in the FLAG report. The process of following the trace results in mechanical and/or electrical changes in the system which produces the desired output trace or traces.

To check the reproducibility of the $\vec{h}$ curves, the record for h obtained on the flights from Baton Rouge to Houston and Houston to Baton Rouge were used. As mentioned by FLAG in their report, the $\vec{h}$ curve had not been filtered correctly in the original data reductions.

To make the filtering on the $\vec{h}$ record exactly similar to that given to the B_a curve in the meter, the filtering circuit should have been identical to that shown on Fig. 14 of the FLAG report which is reproduced schematically here.



This gives to a close approximation filtering with time constants of $w_1 = .168\ sec^{-1}$, $w_2 = .122\ sec^{-1}$, and $w_3 = .025\ sec^{-1}$. When filtering the h curve FLAG used the above circuit with the leg containing the 680K resistors and 6μfd capacitor unintentionally omitted. This omitted the filtering with the time constant of $w_3 = .025\ sec^{-1}$. To check the reproducibility of the records obtained by FLAG, the $\vec{h}$ record was run through this "incorrect" filter. A comparison of results showed that there is no significant difference between the two records. This verifies that FLAG's results for $\vec{h}$ are completely reproducible.

An examination of the $\vec{B}_a - \vec{h}$ curve picked at ten second intervals showed that there remained a small amount of the vertical acceleration unremoved. Since the vertical acceleration had a predominant period of about one minute and gravity was to be obtained as averages over three minutes this residual vertical acceleration averaged out and had a negligible effect on the results. This, it should be noted is in marked contrast to the horizontal acceleration corrections which are always of negative sign and therefore will not average out. A run with the correct filtering circuit was also made to see what differences would be obtained in removing the vertical accelerations. Surprisingly; at least initially, the results, gave an even poorer removal of the vertical accelerations. Although this record was almost identical in character to the others obtained, the amplitude of the predominant frequency was reduced slightly thus giving poorer results. Actually, this should have been expected because the predominant period of the vertical acceleration is about one minute and the effect of the addition of a filter with a time constant of 40 sec would be expected to cut the amplitude. The "correct" filter assumes that the hypsometer has the same degree of sensitivity as the beam. Actually, if the hypsometer is not as sensitive to vertical heights changes as the meter element is to vertical velocities, the hypsometer itself will act as a filter on its output. This, in turn, means that the hypsometer results should need less final filtering to be comparable to the meter results.

The important points leading to a decision as to which of the filtered curves to use were 1) Empirically, the hypsometer records required a different filter than the beam record to give best removal of vertical accelerations.

This was based upon examination of the $\vec{B}_a$, h, $\vec{h}$, and $\vec{B}_a - \vec{h}$ records. 2) Their difference is rather small as the predominant vertical accelerations have a period of one minute and later averaging is done over three minutes. As a result the remaining vertical accelerations are averaged out later. Spot checks show that final gravity results differ only by two to three milligals in a random manner regardless of which $\vec{h}$ curve is used.

On the basis of the above, it was decided to use the "incorrect" filtered $\vec{h}$ curves.

The $\vec{B}_a$ and $\vec{h}$ curves were first picked at ten second intervals and $\vec{h}$ subtracted from $\vec{B}_a$. In matching the records, it was found that the timing lines placed on the $\vec{h}$ curve were slightly inaccurate. This was ascertained as follows: The peaks and valleys which appear on the $\vec{h}$ curve would be expected to exactly match short period peaks and valleys appearing on the $\vec{B}_a$ curve. They did not do so but were shifted by small amounts up to about 5 seconds. This was partially due to the fact that the filter used on the $\vec{h}$ curve was not exactly similar to that used on the $\vec{B}_a$ curve so that the two curves were shifted slightly different amounts during filtering. In addition, slipping of the paper in the recorder sometimes occurs causing shifts. In carrying out the subtraction $(\vec{B}_a - \vec{h})$, the curves were shifted by eye until the valleys and peaks of the $\vec{h}$ curve coincided with those of the $\vec{B}_a$ curve over a segment of the record. The timing lines corresponding to these positions of coincidence were used for picking the ten second values on the $\vec{h}$ curve.

The $\vec{B}_a - \vec{h}$ curve shows short period changes. This is demonstrated by the 10 second values for the Baton Rouge to Houston shown in Figure 1. An examination of this curve with the $\vec{h}$ curve shows this to be primarily a result of the inability of the hypsometer record to completely represent the vertical accelerations of the plane. In addition, there were no doubt some inaccuracies due to inability of getting the timing exactly accurate. This type of error would be accentuated where steep slopes are involved. Since averages over one minute were desired, it was possible to remove these short period variations by averaging.

At half minute intervals the simple average of the value at the point and the three values at 10 second intervals immediately on each side (7 values in all) was computed. These average values were plotted and straight lines drawn between them. The average slope over a one minute interval was determined from the curve, assuming that the average slope over the interval would be the slope of a straight line drawn between the end points. Since the $\vec{B}_a - \vec{h}$ curve being used had been previously averaged asymmetrically with respect to time, it had been shifted with respect to the timing lines on the record. In order to determine the amount of this shift, reference was made to FLAG Record No. 6 containing both the B_a and $\vec{B}_a$ curves. By examining the relative time locations of the same peak on the two curves, it was determined that the amount of shift was approximately constant and equal to 20 seconds. The $\vec{B}_a$-$\vec{h}$ curve was accordingly shifted by this amount. The $\vec{B}_a$-$\vec{h}$ curves shown in Figure 1 are plotted as they appear after shifting the curve to its correct position on the time axis.

The additional horizontal corrections H_c and H_L used by FLAG and shown on Form C of the FLAG results, were double averaged. However, in the checking method described here, single time averages were needed. These were computed from $A_c^2/2g$, $A_{c2}^2/_{2g}$, $A_L^2/_{2g}$, $A_{L2}^2/2g$ curves. Each of these curves was picked at thirty second intervals where they were smooth, and 10 second intervals where large corrections appeared. Once averaged H_c and H_L values were computed using the formula $H_c = \frac{1}{2g}(A_c^2 - A_{c2}^2)$ A_c^2/A_{c2}^2, etc. Before getting minute averages, it was again necessary to determine the amount of shift of the H_c and H_L curves to get the accurate time intervals. This was done by comparing similar peaks on the single averaged H_c and double averaged H_c curves and on the single averaged H_L and double averaged H_L curves from the FLAG report. It was found that the shift was approximately 30 seconds and this value used throughout in determining the correct intervals.

With these corrections equation (1) was used to get three minute averages of g. Next nine minute averages were taken by averaging three adjacent values. To be equivalent to FLAG results, more averaging is required. Any averaging of the B curve by FLAG was equivalent to averaging final gravity values. Three averagings of the B curve were made by FLAG before taking nine interval averages. The time constants used by FLAG were considered to be approximately equivalent to taking the averages of adjacent values twice to give the final values used. This averaging was done to give the final digital gravity results. To see what this averaging does, the schematic below is provided. The original one minute (three mile) averages given below are (1), (2), (3), (4), and (5)

1 min. avg.	3 min. avg.	First additional avg.	Final Gravity value chosen for (3)
(1)			
(2) -------	$\frac{(1) + (2)+(3)}{3}$	$\frac{(1) + 2(2)\ 2\ 2(3) + (4)}{6}$	
	-------		
(3) -------	$\frac{(2) + (3) + (4)}{3}$	-------	$\frac{(1)+3(2)+4(3)+3(4)+(5)}{12}$
	-------	$\frac{(2) + 2(3) + 2(4) + (5)}{6}$	
(4) -------	$\frac{(3) + (4) + (5)}{3}$		
(5)			

It can be seen that the average obtained for interval (3) is dependent on five, one minute averages, and is to some extent dependent on g obtained over 15 miles. However, 5/6 of the result depends only on a 9 mile average of g.

It might at first glance seem that taking the double averages after three minute averages differs from the FLAG procedure of taking the short period averages first, then the three minute averages. However, the following sketch shows that the two operations are numerically identical.

1 min. avg.	3 min. avg.	First additional avg.	Final Gravity value chosen for (3)
(1)			
	$\frac{(1) + (2)}{2}$		
(2)		$\frac{(1) + 2(2) + (3)}{4}$	
	$\frac{(2) + (3)}{2}$		$\frac{(1) + 3(2) + 4(3) + 3(4) + (5)}{12}$
(3)		$\frac{(2) + 2(3) + (4)}{4}$	
	$\frac{(3) + (4)}{2}$		
(4)		$\frac{(3) + 2(4) + (5)}{4}$	
	$\frac{(4) + (5)}{2}$		
(5)			

Results

The results of the numerical calculations are shown in Tables 1 and 3 of Appendix. Final gravity values, the comparison with upward continued values and the FLAG values are given in tables 2 and 4 of the Appendix. These comparisons are also shown graphically in Figures 2 and 3

Remarks on Results

Examination of Tables 2 and 4 show that the digital procedure used gives values comparable in accuracy to those obtained by FLAG. Although the digital results obtained differ on the average from FLAG values by 6.0 milligals, their deviation from the upward continued values is not significantly different from FLAG's results. This would seem to indicate that the overall accuracy of the data as quoted by FLAG is correct and that the difference between the two methods is primarily due to the way in which the data are handled, especially the manner in which averaging is performed.

On the Baton Rouge to Houston line the average difference for the University of Wisconsin values and the upward continued values was 5.8 mgals. The FLAG values showed an average difference of 4.5 mgals from the upward continued values. On the Baton-Rouge to Shreveport line, the average difference for the University of Wisconsin from the upward continued values was 7.6 mgals. The average difference for the FLAG values was 5.4 mgals.

Status of High Speed Computer Reductions

In addition to the above study which was carried out using a desk calculator, an IBM program for the Control Data Corp., 1604 computer was prepared to analyze the data flown by FLAG. This computer is a high speed machine; 4.75 minutes being required for the reduction of one, 200 mile flight. Basic input data were the Ba, H, $A_c^2/2g$, $A_c^2 2/_{2g}$, $A_L^2/2g$ and $A_{L2}^2/2g$ analog curves. The first four curves were picked every 10 seconds and the last two were picked each minute. This information was then put on cards. At each control point, the control number, latitude, longitude and altitude were also put on a card. The total drift was also entered into the program along with the flight altitude. This is all the information required.

The following operations are performed by the program:

From the latitudes and longitudes, distances between the points are computed using the method given in "Formulas and Tables for computation of geodetic position on the international ellipsoid", Special Publication 200, U.S.C. & G.S. 1935. Velocities are computed for the midpoints of these line segments from control point to control point. Velocities are interpolated every 10 seconds from these computed velocities. This method gave values which agreed to 1:1000 with that determined by FLAG. From altitudes given at the control points, altitudes are interpolated every 10 seconds. Using the given latitude, the velocity of a point in space at 12,000 feet altitude is computed. The method used is that given in Hosmer (1929). These velocities are printed at one minute intervals.

The Eotvos correction is computed every 10 seconds. It is printed with the interpolated altitude at intervals of 10 seconds. The digital curves Ba, H, $A_c^2/2g$, $A_{c2}^2/2g$, $A_L^2/2g$, $A_{L2}^2/2g$ are read into the computer and are printed at intervals of 10 seconds. The spring tension changes are likewise read into the computer. Hc and HL are computed and averaged over $\pm$ 10 seconds.

DEL G is computed by the formula

DEL G = SA(I -4) + EOTVOS (I) + Hc + H1 + Drift + F(I)

Where:

SA(I) = Spring Tension at Time (I)

EOTVOS (I) = Eotvos Corr. at Time (I)

F = Free Air Corr. for Changes in Altitude to 1200 ft.

The Spring tension changes are fed in with a 40 sec delay to agree with the reaction of the Beam to these changes:

DEL G is averaged over $\pm$ 20 sec. and $\pm$ 90 seconds.

DEL G 1 = $\pm$ 20 Sec. Ave.

DEL G 2 = $\pm$ 90 Sec. Ave.

The Hypsometer curve is subtracted from the beam curve. B-H is then averaged over $\pm$ 20 sec. and $\pm$ 90 seconds.

(B-H) 1 = $\pm$ 20 Sec. Ave.

(B-H) 2 = $\pm$ 90 Sec. Ave.

The unaveraged DEL G, DEL G 1, and DEL G 2 are printed.

The unaveraged B-H, (B-H) 1 and (B-H) 2 are printed.

The slope of (B-H) 2 is computed using the average slope over ± 60 seconds. This slope then is averaged over ± 50 seconds.

Gravity is now equal to the averaged slope + DEL G 2.

The final Gravity value equals Gravity averaged over ± 120 seconds.

DEL G 2 is plotted on profile 1 symbol "D".

The averaged Slope of (B-H) 2 is plotted on profile 1 symbol "1".

Gravity is plotted on profile #1 symbol "2".

A listing of Final averaged gravity is printed, and a profile is plotted (Profile #2).

Listings of the data are on the left of each of the profiles.

A comparison of results for the Houston-Baton Rouge line obtained using the above machine program gave results but differed on the average by 5.5 mgals from the upward projected ground values. The analog procedure used by FLAG for this line gave agreement to 5.2 mgals. However, as observed with the hand calculated comparisons on the other two lines the departures were in large measure out of phase with the FLAG results so that the actual difference with FLAG was close to 5.1 mgals on the average.

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APPENDIX

TABLE 1

REDUCTIONS FOR OBSERVED GRAVITY AT 12,000 FT. ELEVATION

BATON ROUGE TO HOUSTON

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \dot{\vec{h}})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1032-38	4.5	3.5	-875.8	-867.8	-891.2	7502.6	- 14	- 1	0	978.3000		
1038-44	4.5	3.6	-869.1	-861.0	-884.2	7502.6	- 8	- 3	- 65.5	.2509	978.263	
1044-50	4.5	3.6	-869.6	-861.5	-884.8	7502.6	- 3	- 1	- 85.4	.2374	.242	978.245
1050-56	4.5	3.9	-861.9	-853.5	-876.5	7502.6 7400.0	- 3	- 1	- 53.8	.2376	.232	.236
1056-62	4.5	3.9	-858.0	-849.6	-872.5	7400.0	- 4	- 1	- 10.5	.2210	.238	.237
1062-68	4.5	3.9	-859.9	-851.5	-874.5	7400.0	- 3	- 1	+ 24.6	.2551	.239	.239
1068-74	4.5	4.2	-865.2	-856.5	-879.6	7400.0	- 2	- 1	+ 15.2	.2416	.238	.242
1074-80	4.5	4.2	-890.4	-881.7	-905.5	7400.0	-126	-10	+150.9	.2184	.251	.246
1080-86	4.5	4.7	-873.7	-864.5	-887.8	7400.0 7451.2	- 81	- 3	+133.4	.2851	.243	.247
1086-92	4.5	5.3	-907.8	-898.0	-922.2	7451.2	- 17	- 4	+ 8.2	.2252	.252	.246
1092-98	4.5	5.5	-905.7	-895.7	-919.9	7451.2	- 9	- 3	+ 16.4	.2447	.238	.244
1098-1104	4.5	5.4	-904.4	-894.5	-918.7	7451.2	- 11	- 3	+ 17.6	.2451	.248	.245
1104-10	4.5	5.4	-881.8	-871.9	-895.4	7451.2	- 6	- 6	+ 2.3	.2551	.248	.244
1110-16	4.5	5.7	-902.7	-892.5	-916.6	7451.2	- 8	- 4	- 4.7	.2269	.233	.232

TABLE 1 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	7 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1116-22	4.5	5.7	-899.8	-889.6	-913.6	7451.2	- 9	- 3	- 18.7	978.2159	978.220	978.224
1122-28	4.5	5.7	-905.5	-895.3	-919.5	7451.2	- 25	- 1	+ 3.5	.2182	.225	.225
1128-34	4.5	6.2	-876.3	-865.6	-889.0	7451.2	- 40	- 4	+ 15.2	.2424	.229	.226
1134-40	4.5	6.5	-889.2	-878.2	-902.2	7451.2	- 16	- 4	- 11.7	.2263	.223	.223
1140-46	4.5	6.2	-902.7	-892.0	-916.1	7451.2	- 7	- 3	- 32.8	.2013	.218	.217
1146-52	4.5	6.6	-888.7	-877.6	-901.3	7451.2	- 3	- 4	- 25.7	.2262	.210	.213
1152-58	4.5	6.7	-907.6	-896.4	-920.6	7451.2	- 3	- 8	- 25.7	.2029	.216	.212
1158-64	4.5	6.4	-890.5	-879.6	-903.3	7451.2	- 6	-19	- 12.9	.2190	.208	.209
1164-70	4.5	6.6	-915.5	-904.4	-928.8	7451.2	- 21	- 8	0	.2024	.203	.203
1170-76	4.5	7.3	-895.6	-883.8	-907.7	7451.2	- 11	-45	- 9.4	.1871	.196	.201
1176-82	4.5	7.7	-918.2	-906.0	-930.5	7451.2	- 30	-15	+ 15.2	.1999	.207	.205
1182-88	4.5	7.6	-894.2	-882.1	-905.9	7451.2	- 32	- 5	+ 17.6	.2349	.214	.212
1188-94	4.5	7.8	-892.5	-880.2	-904.0	7451.2	- 15	- 2	- 31.6	.2076	.217	.214
1194-1200	4.5	8.2	-901.0	-888.3	-912.3	7451.2	- 9	- 2	- 28.1	.2088	.211	.211
1200-06	4.5	8.4	-916.3	-904.4	-928.8	7451.2	- 23	- 2	+ 9.4	.2160	.206	.205

TABLE 1 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1206-12	4.5	8.3	-918.0	-905.2	-929.6	7451.2	- 45	- 3	+ 10.5	978.1931	978.201	978.200
1212-18	4.5	8.8	-919.1	-905.8	-930.3	7451.2	- 23	- 3	- 10.5	.1934	.196	.195
1218-24	4.5	8.8	-916.1	-902.8	-927.2	7451.2	- 23	- 7	- 2.3	.2007	.188	.188
1224-30	4.5	8.6	-925.1	-912.0	-936.6	7451.2	- 38	- 9	- 5.8	.1708	.181	.183
1230-36	4.5	9.3	-933.2	-919.4	-944.2	7451.2	- 25	- 6	- 12.9	.1720	.181	.184
1236-42	4.5	9.7	-912.1	-897.9	-922.1	7451.2	- 7	- 4	- 28.1	.1990	.191	.190
1242-48	4.5	9.6	-915.9	-901.8	-926.1	7451.2 7400.0	- 4	- 2	- 26.9	.2102	.200	.197
1248-54	4.5	9.6	-901.3	-887.2	-911.2	7400.0	- 7	- 3	+ 11.7	.1995	.201	.200
1254-60	4.5	10.1	-878.1	-863.5	-886.8	7400.0	- 15	- 7	+ 2.3	.2035	.202	.199
1260-66	4.5	10.6	-884.8	-869.7	-893.2	7400.0	- 17	-11	+ 14.0	.2018	.193	.194
1266-72	4.5	10.8	-877.1	-861.8	-885.1	7400.0	- 13	-13	- 23.4	.1745	.189	.193
1272-78	4.5	10.6	-869.6	-854.5	-877.6	7400.0	- 8	- 9	- 23.4	.1910	.199	.199
1278-84	4.5	10.2	-850.0	-835.3	-857.9	7400.0	- 7	- 4	- 18.7	.2214	.209	.205
1284-90	4.5	10.8	-868.6	-853.3	-876.3	7400.0	- 5	- 3	- 9.4	.2153	.203	.203
1290-96	4.5	11.4	-896.7	-880.8	-904.6	7400.0	- 4	- 7	- 19.9	.1735	.197	.196

TABLE 1 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1296-1302	4.5	11.5	-876.7	-860.7	-883.9	7400.0	- 7	-11	- 5.9	978.2012	978.190	978.191
1302-08	4.5	11.4	-868.7	-852.8	-875.8	7400.0	- 8	- 9	- 19.9	.1963	.186	.184
1308-14	4.5	11.6	-861.7	-845.6	-868.4	7400.0	- 28	- 8	- 43.0	.1616	.172	.184
1314-20	4.5	10.9	-868.2	-852.8	-875.8	7400.0	- 76	-11	+ 23.4	.1576	.206	
1320-26	4.5	9.8	-899.6	-885.1	-909.0	7400.0	- 89	-10	+199.0	.3000		
1326-32	AUTOPILOT OUT											
1332-38	AUTOPILOT OUT											
1338-44	AUTOPILOT OUT											
1344-50	4.5	10.6	-864.8	-849.7	-872.6	7400.0	- 45	- 1	- 35.1	.1553		
1350-56	4.5	10.3	-850.6	-835.8	-858.4	7400.0	- 30	- 1	- 15.2	.2044	.193	
1356-62	4.5	10.5	-851.5	-836.5	-859.1	7400.0	- 13	- 1	- 15.2	.2207	.206	.202
1362-68	4.5	11.0	-865.1	-849.6	-872.5	7400.0	- 11	- 2	- 31.6	.1919	.204	.199
1368-74	4.5	11.3	-893.2	-877.4	-901.1	7400.0	- 9	- 5	+ 4.7	.1986	.185	.192
1374-80	4.5	11.6	-897.4	-881.3	-905.1	7400.0	- 7	-10	- 22.2	.1647	.196	.193
1380-86	4.5	11.9	-874.5	-858.1	-881.3	7400.0	- 30	-10	+ 36.3	.2240	.196	.197

TABLE 1 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B_a} - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1386-92	4.5	12.4	-882.7	-865.8	-889.2	7400.0	- 39	- 5	+ 22.2	978.1980	978.201	978.195
1392-98	4.5	12.9	-906.3	-888.9	-912.9	7400.0	- 20	- 6	+ 10.5	.1806	.184	.190
1398-1404	4.5	12.6	-913.3	-886.2	-910.1	7400.0	- 17	- 9	+ 1.2	.1741	.193	.195
1404-10	4.5	12.3	-884.2	-867.4	-890.8	7400.0	- 18	-11	+ 36.3	.2255	.211	.207
1410-16	4.5	12.8	-846.7	-829.4	-851.8	7400.0	- 16	-13	+ 7.0	.2352	.216	.208
1416-22	4.5	13.2	-865.7	-848.0	-870.9	7400.0	- 16	-10	- 24.6	.1875	.193	.196
1422-28	4.5	12.7	-891.0	-873.8	-897.4	7400.0	- 16	-10	- 30.4	.1552	.188	.187
1428-34	4.5	13.2	-895.5	-877.8	-901.5	7400.0	- 17	-15	+ 46.8	.2223	.178	.183
1434-40	4.5	13.6	-918.2	-900.1	-924.4	7400.0	- 25	-16	+ 14.0	.1576	.189	.184
1440-46	4.5	13.6	-911.4	-893.3	-917.4	7400.0	- 34	-14	+ 44.5	.1881	.179	.184
1446-52	4.5	14.1	-933.1	-914.5	-939.2	7400.0	- 23	-15	+ 60.8	.1926	.186	.186
1452-58	4.5	14.4	-901.5	-882.6	-906.4	7400.0	- 27	-18	+ 21.2	.1788	.194	.191
1458-64	4.5	15.4	-919.2	-899.3	-922.6	7451.3	- 25	-11	+ 9.4	.2111	.192	.190
1464-70	4.5	16.2	-947.0	-926.3	-951.3	7451.3	- 12	- 4	- 7.0	.1860	.184	.181
1470-76	4.5	15.9	-976.5	-956.1	-981.9	7451.3	- 13	-16	+ 7.0	.1564	.163	.172

TABLE 1 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
1476-82	4.5	15.9	-941.2	-920.8	-945.7	7451.3 7554.0	- 19	-35	- 39.8	978.1448	978.177	978.175
1482-88	4.5	16.0	-941.2	-920.7	-945.6	7554.0	- 20	-15	- 53.8	.2285	.185	.188
1488-94	4.5	16.1	-941.2	-920.6	-945.5	7554.0	- 27	-15	- 95.3	.1808	.206	.194
1494-1500	4.5	16.1	-920.5	-900.0	-924.3	7554.0 7502.6	- 20	- 4	- 87.8	.2100	.180	.187
1500-06	4.5	16.0	-947.0	-926.5	-951.5	7502.6	- 14	- 1	- 95.9	.1492	.183	.180
1506-12	4.5	16.3	-893.0	-872.2	-895.8	7502.6	- 82	- 8	- 35.1	.1909	.170	.174
1512-18	4.5	16.1	-909.5	-888.9	-912.9	7502.6	- 75	-12	- 42.1	.1697	.168	.166
1518-24	4.5	15.8	-907.3	-887.0	-910.9	7502.6	- 75	-23	- 62.0	.1407	.158	.162
1524-30	4.5	17.0	-901.7	-880.2	-904.0	7502.6 7451.3	- 49	-34	- 36.3	.1640	.162	.167
1530-36	4.5	17.6	-906.1	-884.0	-907.9	7451.3	-122	-21	+ 72.5	.1819	.187	.178
1536-42	4.5	17.7	-889.6	-868.4	-891.8	7451.3	-102	- 7	+ 56.2	.2157	.180	.179
1542-48	4.5	17.8	-884.4	-862.1	-885.4	7451.3	- 76	- 2	- 55.0	.1419	.171	
1548-54	4.5	18.0	-908.2	-885.7	-909.6	7451.3	- 60	- 2	- 33.9	.1558		

c.u. = counter units

TABLE 2

COMPARISON OF FINAL GRAVITY VALUES AT 12,000 FEET

BATON ROUGE TO HOUSTON

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences: Digital vs Upward con't.	Absolute Differences: Analog vs Upward con't.
1044-50	978.245	978.240	978.242	3	2
1050-56	.236	.235	.241	5	6
1056-62	.237	.236	.241	4	5
1062-68	.239	.237	.240	1	3
1068-74	.242	.242	.237	5	5
1074-80	.246	.245	.235	11	10
1080-86	.247	.246	.232	15	14
1086-92	.246	.243	.229	17	14
1092-98	.244	.240	.226	18	14
1098-1104	.245	.236	.223	22	13
1104-10	.244	.233	.220	24	13
1110-16	.232	.228	.218	14	10
1116-22	.224	.223	.217	7	6
1122-28	.225	.221	.216	9	5
1128-34	.226	.220	.216	10	4
1134-40	.223	.219	.215	8	4
1140-46	.217	.216	.214	3	2
1146-52	.213	.213	.213	0	0
1152-58	.212	.210	.212	0	2
1158-64	.209	.209	.210	1	1

TABLE 2 con't.

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences Digital vs Upward con't.	Absolute Differences Analog vs Upward con't.
1164-70	978.203	978.208	978.206	3	2
1170-76	.201	.209	.204	3	5
1176-82	.205	.212	.204	1	8
1182-88	.212	.213	.204	8	9
1188-94	.214	.212	.205	9	7
1194-1200	.211	.208	.204	7	4
1200-06	.205	.203	.202	3	1
1206-12	.200	.197	.199	1	2
1212-18	.195	.194	.196	1	2
1218-24	.188	.192	.196	8	4
1224-30	.183	.192	.196	13	4
1230-36	.184	.192	.196	12	4
1236-42	.190	.195	.196	6	1
1242-48	.197	.197	.196	1	1
1248-54	.200	.198	.196	4	2
1254-60	.199	.196	.194	5	2
1260-66	.194	.193	.193	1	0
1266-72	.193	.195	.193	0	2
1272-78	.199	.199	.195	4	4
1278-84	.205	.202	.196	9	6
1284-90	.203	.199	.196	7	3
1290-96	.196	.194	.196	0	2

TABLE 2 con't.

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences Digital vs Upward con't.	Analog vs Upward con't.
1296-1302	978.191	978.189	978.196	5	7
1302-08	.184	.188	.195	11	7
1308-14	.184	.187	.193	9	6
1314-20	---	.191	.191	-	-
1320-26	---	.193	.190	-	-
1326-32	Auto Pilot Out				
1332-38	Auto Pilot Out				
1338-44	Auto Pilot Out				
1344-50	---	.192	.189	-	-
1350-56	---	.198	.190	-	-
1356-62	.202	.198	.190	12	8
1362-68	.199	.197	.189	10	8
1368-74	.192	.196	.187	5	9
1374-80	.193	.195	.186	7	9
1380-86	.197	.195	.186	11	9
1386-92	.195	.193	.187	8	6
1392-98	.190	.193	.186	4	7
1398-1404	.195	.194	.184	11	10
1404-10	.207	.195	.182	25	13
1410-16	.208	.195	.182	26	13
1416-22	.196	.194	.182	14	12
1422-28	.187	.191	.182	5	9

TABLE 2 con't.

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences Digital vs Upward con't.	Absolute Differences Analog vs Upward con't.
1428-34	978.183	978.188	978.182	1	6
1434-40	.184	.186	.182	2	4
1440-46	.184	.183	.181	3	2
1446-52	.186	.181	.181	5	0
1452-58	.191	.177	.180	11	3
1458-64	.190	.174	.179	11	5
1464-70	.181	.169	.178	3	9
1470-76	.172	.166	.177	5	11
1476-82	.177	.167	.174	3	7
1482-88	.188	.173	.174	14	1
1488-94	.194	.176	.174	20	2
1494-1500	.187	.175	.174	13	1
1500-06	.180	.171	.172	8	1
1506-12	.174	.170	.172	2	2
1512-18	.166	.171	.170	4	1
1518-24	.162	.175	.170	8	5
1524-30	.167	.178	.172	5	6
1530-36	.178	.176	.172	6	4
1536-42	.179	.168	.170	9	2

Average differences FLAG (Analog) vs Upward continued values 5.4 mgls.

Average differences University of Wisconsin (Digital) vs Upward continued values 7.6 mgls.

TABLE 3

REDUCTIONS FOR OBSERVED GRAVITY AT 12,000 FT. ELEVATION

BATON ROUGE TO SHREVEPORT

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
2592-98	4.5	11.8	-592.3	-576.0	-591.6	7143.2 7040.5	- 5	0	+ 30.5	978.2739	978.254	978.250
2598-2604	4.5	11.7	-598.3	-582.1	-597.8	7040.5	- 3	0	+ 50.3	.1989	.240	.244
2604-10	4.5	11.7	-603.7	-587.5	-603.4	7040.5 7091.8	- 1	0	+ 98.3	.2476	.241	.245
2610-16	4.5	12.1	-602.3	-585.7	-601.5	7091.8	0	0	+ 79.6	.2778	.255	.251
2616-22	4.5	12.6	-608.7	-591.6	-607.6	7091.8 7143.2	0	0	+ 44.5	.2381	.256	.252
2622-28	4.5	12.6	-608.1	-591.0	-607.0	7143.2	- 1	0	+ 14.0	.2533	.243	.251
2628-34	4.5	12.6	-616.4	-599.3	-615.5	7143.2 7245.9	- 1	0	- 50.3	.2370	.264	.258
2634-40	4.5	12.7	-609.6	-592.4	-608.4	7245.9	- 9	0	- 35.1	.3022	.263	.267
2640-46	4.5	13.0	-635.6	-618.1	-634.8	7245.9	- 8	0	- 62.0	.2501	.278	.267
2646-52	4.5	13.1	-616.4	-598.8	-614.0	7245.9	- 3	0	- 55.0	.2829	.257	.263
2652-58	4.5	13.1	-656.5	-638.9	-654.2	7245.9	- 3	0	- 59.7	.2380	.263	.258
2658-64	4.5	13.5	-643.4	-625.4	-640.3	7245.9	- 1	0	- 43.3	.2701	.247	.256
2664-70	4.5	13.6	-647.9	-629.8	-646.8	7245.9	0	0	- 76.1	.2320	.267	.261

TABLE 3 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{\dot{h}})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
2670-76	4.5	13.7	-619.5	-601.3	-617.5	7245.9 7194.5	0	0	- 31.6	978.2990	978.260	978.262
2676-82	4.5	13.7	-646.6	-628.4	-646.3	7194.5	0	0	- 7.0	.2502	.261	.262
2682-88	4.5	13.7	-642.6	-624.4	-642.4	7194.5	- 43	0	+ 16.4	.2344	.263	.268
2688-94	4.5	13.6	-606.5	-588.4	-604.7	7194.5	- 18	0	+ 24.6	.3054	.282	.279
2694-2700	4.5	13.8	-584.7	-566.4	-581.8	7194.5	- 5	0	- 10.5	.3062	.289	.286
2700-06	4.5	13.7	-623.0	-604.8	-621.2	7194.5	- 3	0	- 24.6	.2547	.287	.287
2706-12	4.5	14.0	-601.3	-582.8	-598.6	7194.5	- 3	0	- 2.3	.2996	.285	.287
2712-18	4.5	14.3	-586.8	-568.0	-583.5	7194.5	- 2	0	- 17.6	.3004	.296	.291
2718-24	4.5	14.5	-608.1	-589.1	-604.1	7194.5	0	0	- 11.7	.2877	.293	.295
2724-30	4.5	14.9	-587.6	-568.2	-583.9	7194.5	- 3	0	- 26.9	.2897	.299	.297
2730-36	4.5	14.7	-584.7	-565.5	-581.0	7194.5	- 6	0	+ 2.3	.3188	.299	.300
2736-42	4.5	14.7	-603.1	-583.9	-599.9	7194.5	- 6	0	- 8.2	.2894	.305	.299
2742-48	4.5	15.0	-606.5	-587.0	-604.3	7194.5 7143.2	- 3	0	+ 24.6	.3080	.289	.295
2748-54	4.5	15.0	-599.9	-580.4	-596.3	7143.2	- 2	0	+ 15.2	.2691	.300	.295
2754-60	4.5	15.6	-599.0	-578.9	-594.7	7143.2	- 11	0	+ 76.1	.3226	.291	.297
2760-66	4.5	15.7	-617.1	-596.9	-613.1	7143.2	- 8	0	+ 50.2	.2813	.308	.303

TABLE 3 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{H})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
2766-72	4.5	15.5	-615.0	-595.0	-612.2	7245.9	- 1	0	+ 81.9	978.3209	978.307	978.311
2772-78	4.5	15.9	-627.6	-607.2	-623.6	7143.2 7245.9	- 1	0	+ 14.0	.3190	.325	.320
2778-84	4.5	16.0	-611.3	-590.8	-606.7	7245.9	0	0	- 14.0	.3340	.328	.325
2784-90	4.5	16.2	-608.6	-587.9	-603.7	7245.9	0	0	- 18.7	.3325	.322	.322
2790-96	4.5	16.3	-619.9	-599.1	-615.3	7245.9	0	0	- 38.6	.3010	.323	.322
2796-2802	4.5	16.6	-624.1	-603.0	-619.3	7245.9	- 2	0	+ 2.3	.3354	.318	.325
2802-08	4.5	16.8	-626.0	-604.7	-621.1	7245.9	- 9	0	- 5.8	.3190	.337	.332
2808-14	4.5	16.8	-632.6	-611.3	-627.8	7245.9	- 3	0	+ 31.6	.3557	.338	.341
2814-20	4.5	17.0	-635.6	-614.1	-630.9	7245.9	- 3	0	+ 18.7	.3397	.348	.343
2820-26	4.5	17.3	-634.3	-612.5	-629.5	7245.9 7297.2	- 2	0	+ 25.7	.3491	.336	.341
2826-32	4.5	17.2	-628.2	-606.5	-623.3	7297.2	- 60	0	- 15.2	.3177	.343	.341
2832-38	4.5	16.9	-627.9	-606.5	-623.1	7297.2	- 9	0	- 11.7	.3624	.338	.343
2838-44	4.5	17.4	-653.8	-631.9	-648.9	7297.2	- 3	0	- 19.9	.3342	.351	.349
2844-50	4.5	17.6	-618.1	-596.0	-612.4	7297.2	0	0	- 36.3	.3575	.355	.354
2850-56	4.5	17.8	-632.0	-609.7	-626.6	7297.2	- 4	0	- 1.2	.3744	.357	.355
2856-62	4.5	18.3	-637.6	-614.8	-631.9	7297.2	- 28	0	- 8.2	.3381	.349	.348

TABLE 3 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4. X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min gals.	11 Final Grav Average gals.
2862-68	4.5	18.3	-662.7	-639.9	-657.3	7297.2	- 7	0	- 7.0	978.3349	978.336	978.343
2868-74	4.5	18.4	-658.5	-635.6	-652.9	7297.2	0	0	- 18.7	.3346	.347	.348
2874-80	4.5	18.4	-633.9	-611.0	-627.9	7297.2	- 4	0	+ 5.8	.3801	.358	.359
2880-86	4.5	18.8	-658.1	-634.8	-652.2	7297.2	- 11	0	+ 16.4	.3594	.370	.363
2886-92	4.5	18.8	-632.1	-608.8	-625.5	7297.2	- 20	0	+ 10.5	.3712	.354	.354
2892-98	4.5	18.9	-662.9	-639.5	-656.9	7297.2	- 5	0	- 11.7	.3326	.340	.343
2898-2904	4.5	18.9	-682.3	-658.9	-676.8	7297.2	- 2	0	- 11.7	.3157	.343	.346
2904-10	4.5	18.9	-649.2	-625.8	-642.8	7297.2	- 13	0	+ 29.3	.3797	.359	.360
2910-16	4.5	18.8	-646.1	-622.8	-639.7	7297.2	- 2	0	+ 17.6	.3811	.380	.373
2916-22	4.5	18.7	-656.6	-633.4	-650.8	7297.2	- 1	0	+ 25.7	.3801	.377	.378
2922-28	4.5	19.3	-633.0	-609.2	-625.9	7297.2	- 10	0	0	.3703	.379	.380
2928-34	4.5	19.5	-644.7	-620.7	-637.7	7297.2 7348.6	- 13	0	+ 32.8	.3883	.389	.388
2934-40	4.5	20.0	-597.1	-572.6	-588.3	7348.6	- 7	0	- 37.4	.4076	.401	.395
2940-46	4.5	20.1	-614.3	-589.7	-605.7	7348.6	- 3	0	- 42.1	.4068	.396	.396
2946-52	4.5	20.2	-625.2	-600.5	-616.7	7348.6	- 4	0	- 63.2	.3737	.393	.394
2952-58	4.5	19.7	-607.7	-583.5	-599.2	7348.6	- 3	0	- 56.2	.3992	.395	.396

TABLE 3 con't.

Time Interval	1 Drift c.u.	2 Free Air Cor. c.u.	3 Eotvos Cor. c.u.	4 1+2+3 c.u.	5 4 X 1.027 mgals.	6 Spring Tension mgals.	7 Additional Horizontal Correction mgals. H_c	 H_1	8 Slope Cor. 11.7 X $(\vec{B}_a - \vec{h})$ mgals.	9 Grav Aver 1 min 5+6+7+8+ 971.907 gals.	10 Grav Aver 3 min. gals.	11 Final Grav Average gals.
2958-64	4.5	20.0	-629.0	-604.5	-620.8	7348.6	- 1	0	- 24.6	978.4112	978.403	978.399
2964-70	4.5	20.7	-610.2	-585.0	-600.8	7348.6	- 2	0	- 56.2	.3986	.397	.395
2970-76	4.5	21.0	-629.7	-604.2	-620.7	7348.6	- 16	0	- 48.0	.3729	.382	.385
2976-82	4.5	21.1	-625.6	-600.0	-619.3	7348.6 7297.2	- 14	0	- 37.4	.3869	.382	.384
2982-88	4.5	21.1	-622.5	-596.9	-613.0	7297.2	- 3	0	- 17.6	.3850	.389	.389
2988-94	4.5	20.9	-635.4	-610.0	-626.5	7297.2	- 5	0	+ 19.9	.3946	.395	.397
2994-3000	4.5	20.8	-639.6	-614.3	-630.9	7297.2	- 4	0	+ 33.9	.4052	.407	.405
3000-06	4.5	20.9	-630.3	-604.9	-621.3	7297.2	- 1	0	+ 37.4	.4213	.411	.410
3006-12	4.5	21.0	-637.0	-611.5	-618.0	7297.2	- 5	0	+ 24.6	.4078	.412	.410
3012-18	4.5	21.9	-662.7	-636.3	-653.6	7297.2	- 3	0	+ 57.3	.4069	.407	.410
3018-24	4.5	22.1	-645.6	-619.0	-638.8	7297.2	0	0	+ 38.6	.4060	.414	.415

c.u. = counter units

TABLE 4

COMPARISON OF FINAL GRAVITY VALUES AT 12,000 FEET

BATON ROUGE TO SHREVEPORT

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences: Digital vs Upward con't.	Absolute Differences: Analog vs Upward con't.
2592-98	978.250	978.229	978.242	8	13
2598-2604	.244	.236	.244	0	8
2604-10	.245	.240	.246	1	6
2610-16	.251	.244	.248	3	4
2616-22	.252	.247	.249	3	2
2622-28	.251	.250	.250	1	0
2628-34	.258	.252	.251	7	1
2634-40	.267	.253	.252	15	1
2640-46	.267	.255	.254	13	1
2646-52	.263	.255	.257	6	2
2652-58	.258	.253	.259	1	6
2658-64	.256	.250	.262	6	12
2664-70	.261	.250	.265	4	15
2670-76	.262	.254	.268	6	14
2676-82	.262	.259	.272	10	13
2682-88	.268	.267	.276	8	9
2688-94	.279	.274	.277	2	3
2694-2700	.286	.279	.278	8	1
2700-06	.287	.282	.280	7	2
2706-12	.287	.285	.282	5	3

TABLE 4 con't.

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences: Digital vs Upward con't.	Absolute Differences: Analog vs Upward con't.
2712-18	978.291	978.287	978.284	7	3
2718-24	.295	.291	.287	8	4
2724-30	.297	.296	.289	8	7
2730-36	.300	.300	.291	9	9
2736-42	.299	.302	.293	6	9
2742-48	.295	.302	.296	1	6
2748-54	.295	.303	.298	3	5
2754-60	.297	.306	.301	4	5
2760-66	.303	.310	.304	1	6
2766-72	.311	.311	.308	3	3
2772-78	.320	.314	.310	10	4
2778-84	.325	.317	.314	11	3
2784-90	.323	.320	.320	3	0
2790-96	.322	.322	.326	4	4
2796-2802	.325	.326	.332	7	6
2802-08	.332	.332	.338	6	6
2808-14	.341	.337	.341	0	4
2814-20	.343	.339	.344	1	5
2820-26	.341	.340	.346	5	6
2826-32	.341	.341	.347	6	6
2832-38	.343	.341	.347	4	6
2838-44	.349	.344	.346	3	2

TABLE 4 con't.

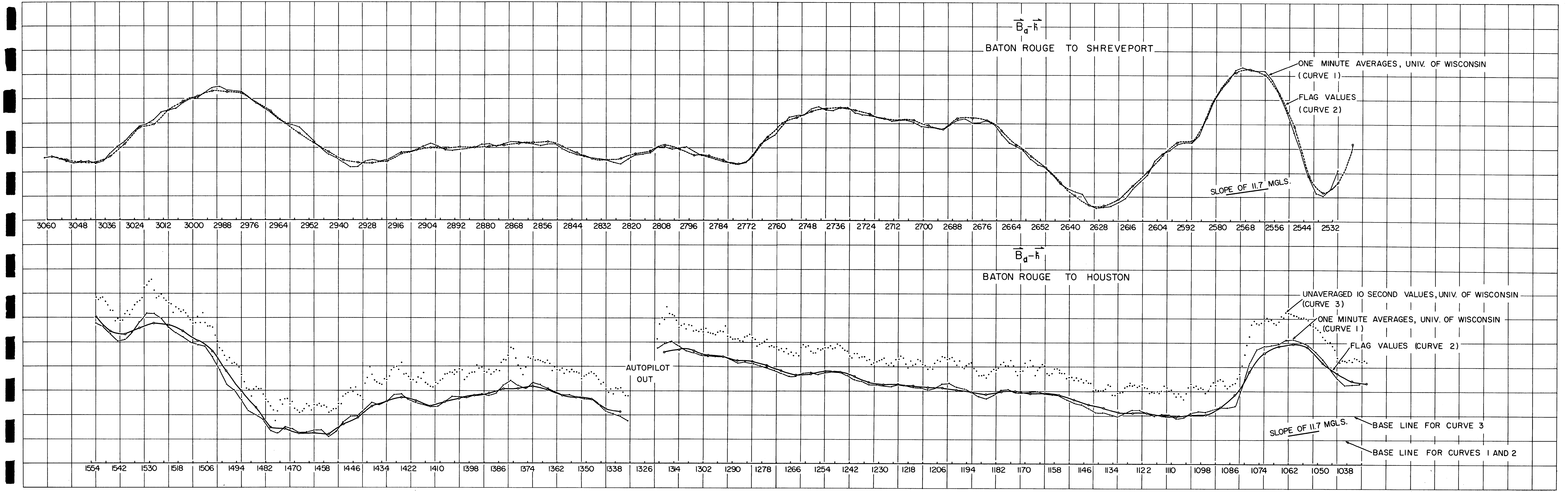
Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences: Digital vs Upward con't.	Absolute Differences: Analog vs Upward con't.
2844-50	978.354	978.349	978.346	8	3
2850-56	.355	.354	.350	5	4
2856-62	.348	.357	.352	4	5
2862-68	.343	.356	.352	9	4
2868-74	.348	.354	.350	2	4
2874-80	.359	.354	.355	4	1
2880-86	.363	.355	.358	5	3
2886-92	.354	.355	.360	6	5
2892-98	.343	.358	.363	20	5
2898-2904	.346	.361	.367	21	6
2904-10	.360	.366	.368	8	2
2910-16	.373	.367	.370	3	3
2916-22	.378	.368	.374	4	6
2922-28	.380	.369	.378	2	9
2928-34	.388	.374	.382	6	8
2934-40	.395	.383	.384	11	1
2940-46	.396	.390	.386	10	4
2946-52	.394	.392	.387	7	5
2952-58	.396	.392	.388	8	4
2958-64	.399	.393	.390	9	3
2964-70	.395	.395	.391	4	4
2970-76	.385	.397	.394	9	3

TABLE 4 con't.

Time Interval	Univ. of Wis. Final Gravity Values (Digital) gals	FLAG Final Gravity Values (Analog) gals	Upward Continued Gravity Values gals	Absolute Differences Digital vs Upward con't.	Absolute Differences Analog vs Upward con't.
2976-82	978.385	978.397	978.396	11	1
2982-88	.389	.399	.398	9	1
2988-94	.397	.401	.400	3	1
2994-3000	.405	.405	.406	1	1
3000-06	.410	.409	.410	0	1
3006-12	.410	.412	.412	2	0
3012-18	.410	.414	.414	4	0
3018-24	.415	.417	.416	1	1

Average difference FLAG (Analog) vs Upward continued values 4.5 mgls.

Average difference University of Wisconsin (Digital) vs Upward continued values 5.8 mgls.



$\vec{B}_a - \vec{h}$
BATON ROUGE TO SHREVEPORT
ONE MINUTE AVERAGES, UNIV. OF WISCONSIN (CURVE 1)
FLAG VALUES (CURVE 2)
SLOPE OF 11.7 MGLS.
3060 3048 3036 3024 3012 3000 2988 2976 2964 2952 2940 2928 2916 2904 2892 2880 2868 2856 2844 2832 2820 2808 2796 2784 2772 2760 2748 2736 2724 2712 2700 2688 2676 2664 2652 2640 2628 2616 2604 2592 2580 2568 2556 2544 2532
$\vec{B}_a - \vec{h}$
BATON ROUGE TO HOUSTON
UNAVERAGED 10 SECOND VALUES, UNIV. OF WISCONSIN (CURVE 3)
ONE MINUTE AVERAGES, UNIV. OF WISCONSIN (CURVE 1)
FLAG VALUES (CURVE 2)
AUTOPILOT OUT
SLOPE OF 11.7 MGLS.
BASE LINE FOR CURVE 3
BASE LINE FOR CURVES 1 AND 2
1554 1542 1530 1518 1506 1494 1482 1470 1458 1446 1434 1422 1410 1398 1386 1374 1362 1350 1338 1326 1314 1302 1290 1278 1266 1254 1242 1230 1218 1206 1194 1182 1170 1158 1146 1134 1122 1110 1098 1086 1074 1062 1050 1038

FIG. 1

ARMY MAP SERVICE

EVALUATION OF AIRBORNE GRAVITY METER TEST

RESULTS OF COMPARISON

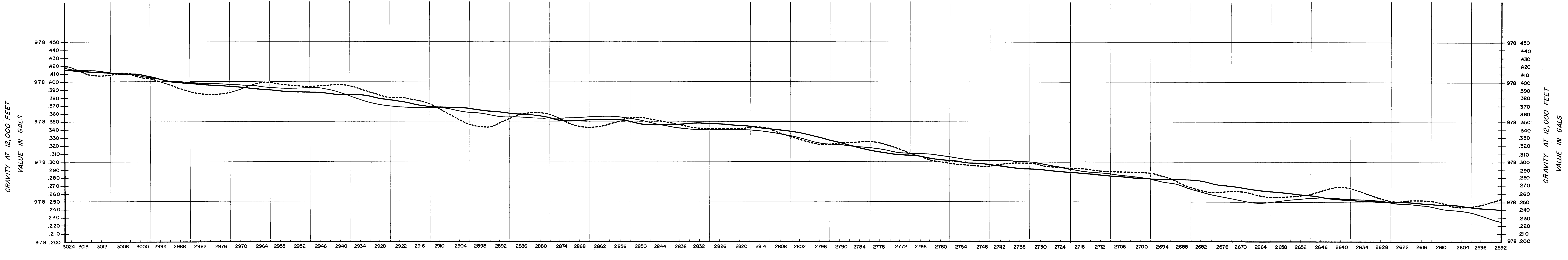
BATON ROUGE TO SHREVEPORT

UNIVERSITY OF WISCONSIN

GEOPHYSICS AND POLAR RESEARCH CENTER

JANUARY 5, 1961

FIG. 2



ARMY MAP SERVICE
EVALUATION OF AIRBORNE GRAVITY METER TEST
RESULTS OF COMPARISON
BATON ROUGE TO HOUSTON

UNIVERSITY OF WISCONSIN
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JANUARY 5, 1961

FIG. 3

LEGEND

UPWARD CONTINUED GRAVITY RESULTS ———
FLAG GRAVITY RESULTS ———
UNIV. OF WISCONSIN GRAVITY RESULTS - - - - -