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A PRECISE LEVEL SURVEY OF
LANSING, MICHIGAN

Thesis for the Degree of B. S.

O. H. Johnson

T. H. Kay

1911

THESIS.

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A

Precise Level Survey
of
Lansing, Michigan.

by

O. H. Johnson.

T. H. Ray.

1911

This thesis was contributed by

Mr. O. H. Johnson.

under the date indicated by the department
stamp, to replace the original which was de-
stroyed in the fire of March 5, 1916.

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THESIS

SUMMARY.

Precise Level Survey of Lansing, Ingham Co., Michigan.

The reason for taking upon ourselves a task of this magnitude was to find out the difficulties encountered in the field of actual work, and to gain a facility in the use of the instruments of surveying. The object in view is to establish a system of precise levels around the City of Lansing, Michigan, and to locate by means of this system reliable Bench Marks at various points, upon which accurate work may be based. Prior to this time the City of Lansing did not possess such a system. Further, the city is growing so rapidly that such a system of precise levels and Bench Marks is absolutely necessary for further work such as road building, paving, sewer construction, sidewalks, and the extension of the water works system.

The difficulties encountered were numerous, the main one for us being to obtain results which are reliable. This means putting ourselves on a plane equal to that of the U.S. Coast and Geodetic Survey, which consists of men who are employed by the U.S. Government as having large experience and technical training along this line of work. The difficulties encountered in handling the precise level, and the errors caused by those difficulties will be discussed later.

The instrument used in this work was the Coast and Geodetic Survey 1900 Precise Level owned by the Civil Department of the Michigan Agricultural College. The maker was E.G. Fisher of the Mahan Co., St. Louis, Mo. The material used for the castings is a composition of 66 parts of soft cast iron, and 34 parts of grain

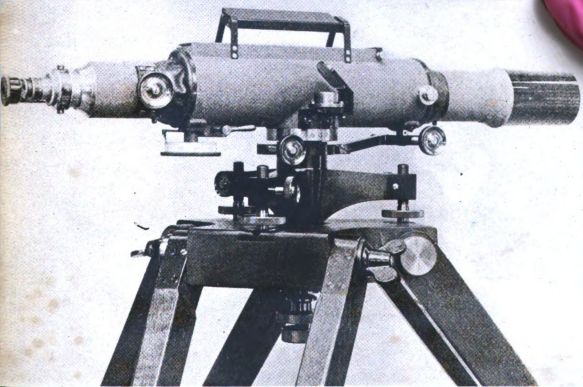


FIG. 2.—THE COAST AND GEODETIC SURVEY LEVEL OF 1900.

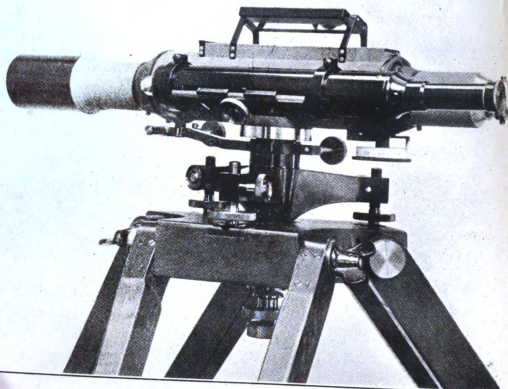


FIG. 1.—THE COAST AND GEODETIC SURVEY LEVEL OF 1900.

nickel, and has a very low coefficient of expansion, .000 004 per degree Centigrade. The screws which pivot the telescope, adjust the position of the level vial, and the slide carrying the spider threads and the level, are made of Prof. Will-Laurie's nickel steel alloy, having a coefficient of only .000 101 per degree Centigrade. From figure (1) it can be seen that the telescope is cut even to allow the level tube being placed as near to the axis of telescope as the cone of the rays for obj. p. by a feature of the objective and the reticle will permit. The outer cylinder supports the telescope by means of pivot screws shown in fig. 1, the points of which enter at a place reinforced by means of a ring which also forms a diaphragm.

The micrometer screw shown in fig. 2 is used to bring the bubble to the center of its run. The end of the micrometer screw carries a steel-hard tip upon which rests the telescope, which is provided with a plate of the same material at the point of contact. The micrometer screw also has a split cylindrical head, graduated into 100 divisions. As the pitch of the screw is 100 threads per inch, the value of one division is 0.001 inches.

The telescope has a vertical travel of about 2 in. above and below its center position. One end of the micrometer screw is fastened to the outer tube a small screw with a lever attached, by means of which the telescope can be lifted from the screw and pressed against a spring above, thus preventing injury, and also the disturbance of the adjustments of the level while the latter is being carried from station to station.

The level tube holds the vial by six retalic contact points, three at each end, 100° apart, the two lower ones being

fastened to the tube itself. The vial is confined longitudinally by cork rings. The level tube is fastened to the telescope at the objective end by means of a square headed vertical clamping screw, while two opposing screws adjust the level laterally.

Two slightly enlarged portions of the telescope tube, which are indicated in Fig. , are turned to equal diameters, and are co-axial with the objective head and draw head bearing. By means of these collars, and suitable shop contrivances the intersection of the vertical spider thread and the middle horizontal thread is so adjusted as to co-incide with the geometric axis of the instrument, thus avoiding error due to the divergence of the line of sight, and the motion of the draw tube. The level vial is also placed parallel to the line of sight in the shop, before the instrument is finally assembled. The objective has a focal length of 41 centimeters. Two Steinheil eyepieces of 8.5 and 12.5 millimeters respectively equivalent focus are provided, having a magnifying power of 45 and 30 diameters. The system of spider threads consists of one vertical and three horizontal lines. The upper and lower threads embrace a distance of 30 centimeters at a distance of 100 meters.

The level reading device, the eye tube of which has been placed at binocular distance from the eye piece of the telescope, thus enables the observer to control both the rod and the level bubble at the same time.

The image of the bubble and the scale divisions near the center of the bubble run are reflected by the mirror above the opening of the outer level tube into two

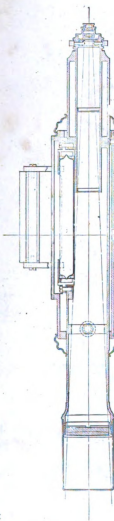
prisms, and are reflected by them into the observer's eye, in a direction parallel to the telescope. The prism has curved surfaces, and together with a lens mounted between them and the eye, reduce the distance between the ends of the bubble and the eye to the normal distance of distinct vision.

The essential features of importance of the precise level are:

1. The instrument is irreversible, and as simple as possible, hence its manipulation is necessarily a program of simple observations.
2. The design of the instrument is such that a change of temperature will not introduce error.
3. The bubble reading device enables the observer to stand erect and make very accurate readings of both rod and bubble almost simultaneously.
4. The instrument has a small surface exposed to the wind.
5. The instrument is heavily designed, which also helps to avoid wind trouble as much as possible.

The rods used are those of the regulation Coast and Geodetic Survey type, being of the cross-section shown in Fig. . They are made of white pine, thoroughly boiled in paraffin and are $3 \frac{1}{8}$ meters long. The rod is divided into meters, decimeters, and centimeters, and millimeters are estimated. The rod is painted alternately black and white for spaces of one centimeter as shown in Fig. . The figures showing the distances on the rod are inverted so that they can be read erect when seen through the telescope.

The rod is also equipped with a spherical bubble by



U.S.C. & G.S. 1907 PRECISE LEVEL.
LONGITUDINAL SECTION

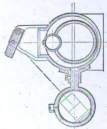


Fig. 12.

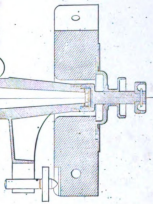


Fig. 13.

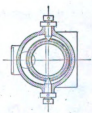
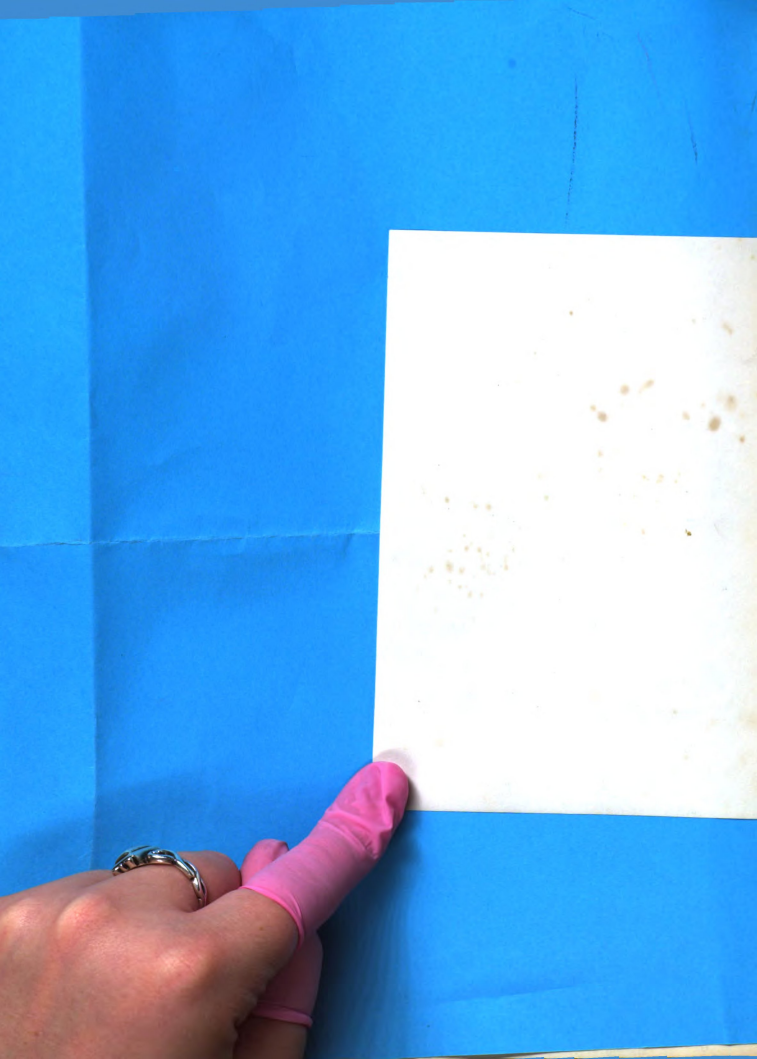


Fig. 14.



which the red can be placed, and a thermometer for recording the temperature.

A cast iron turning plate about six inches in diameter and having a spherical cavity of about 1.5 cm. radius is also used when the turning points are upon the ground.

Method of procedure.

1. All lines were leveled independently in both forward and backward directions.
2. The backward line was run under different atmospheric conditions than the forward line.
3. In all sections upon which the forward and backward readings differ by more than $\frac{1 \text{ mm}}{k}$ (in which k is the distance leveled between adjacent bench marks, in kilometers.) the line was re-run until a check was made.
4. The program of observations were as follows:

The instrument was set up firmly, with the top of the tripod in a horizontal plane, then the lock nut which holds the instrument to the tripod was loosened, and the instrument was leveled by means of three leveling screws, noting when the instrument was level by means of the circular bubble tube on the side of the telescope.

Next, the telescope was tilted upon its vertical axis, the eccentric lever was turned down, allowing the telescope to rest upon the micrometer screw. Then the objective was focused upon the red so that a clear cut image was obtainable, and then the bubble was brought to the center of its run by means of a few turns of the micrometer screw. The bubble was centered closely for a few seconds then the red read, the readings of the three cross wires being taken as rapidly as possible. At the end of the reading notice was taken that

was taken whether the bubble was still in the center of its run. When it was not, the operation was done over until it answered this requirement. As a further check, the average of the three cross wire readings was taken, and it was off more than 1.5 mm. the operation was repeated. This constant difference is due to the fact that the middle cross wire is 1.5 mm. off center.

Care was also taken to make the lengths of back and fore sight equal.

Errors Encountered in Precise Leveling.

1. The attraction of the sun and moon
2. The effect of the spheroidal shape of the earth upon long lines.
3. Error in the parallelism of the level tube with the horizontal.
4. Axis of the telescope not perpendicular to the vertical axis of the instrument.
5. Error in the parallelism of the level tube with the vertical plane through the telescope axis.
6. Parallel between the reflected image of the bubble and the level graduations.
7. Error due to refraction.
8. Error due to defective mounting of lenses.
9. Error due to the wave and of the eye piece glass.
10. Error due to a variation of bar readings.
11. Error due to mistakes in reading rod and recording.
12. Error due to wind.
13. Error due to settlement of instrument.
14. Error due to air vibrations and refraction.
15. Error due to the personal equation.

16. Error due to changes in temperature.

Elimination of errors.

In the first place, some of the above errors exist in the instrument, and are due to improper workmanship. There are due to natural phenomenon. These are numerous, and it is almost impossible to avoid them, neither can they be corrected them because of the lack of knowledge concerning their magnitude.

However, the most important can be obviated, or corrected. As for instance, the effect of temperature upon the instrument was reduced to a minimum, as the instrument was shaded with a large umbrella while being used. The effect of the wind was the greatest difficulty to be overcome, the only way out of the difficulty was to choose a time for the work when the wind was light. This leaves only the error due to unequal back and fore sights to be taken care of. This was done by apportioning the error according to the square root of the distance between bench marks,

In regard to the opinion of different authorities concerning this level the words of Mr. Holton, Member of the American Society of Civil Engineers, are cited. "This level is not superior to a dumpy level, in fact it is so simple that it ceases to possess the virtues of a precise level. In saying this it is not meant that good work can not be done with this instrument, but that it is difficult to determine the errors of adjustment, and a great deal must be taken for granted, which the results of careful work have taught the observers to regard with suspicion. In this instrument the thread error can not be measured accurately, and the thread should ^{regularly} be changed in the field. Also the level tube is not di

measurable, and the resultant error of the instrument must be determined by the so-called peg adjustment, which, although perfect in theory, is found to be very inaccurate in practice.

The problem of adjusting the error of a line during the day is of great importance. Messrs J.B.Johnson, H.M.Wilson and F.J.Hayford have presented long technical discussions upon the subject of error. They all agree upon the following methods of adjusting errors as given below in the order of importance.

1. By the method of Least Squares.
2. By the assumption that the error is directly proportional to the square root of the distance.
3. By the assumption that the error is directly proportional to the distance.

The first method of adjusting errors is in use in a large network of levels often several thousand miles in length. This method is the only reliable one for the case of extensive surveys, and for very precise work.

The second method of adjusting errors is held by most authorities to be sufficiently rigid for level lines of several hundred miles in length. This method is also used for adjusting the error of closure accumulated at the end of a day's circuit.

The third method of adjusting the error, *e.i.* the error is directly proportional to the length of the circuit is also commonly used to adjust the error of closure accumulated during the day. Results secured from the above method seem to stand the test required of them. Prof. J.B.Johnson holds that this method is as reliable as any of the above for short distances. Then too, the matter of adjusting the error should be a case of judgement in some instances. With these ideas in view, and also the fact that with the instrument used, the only errors which are due to observations, unstable supports, and atmospheric

conditions are apt to creep in, this method was used. Any other source of error was not of sufficient magnitude, therefore it was neglected.

The International Geodetic Association have fixed the following limits for probable error of the mean result as follows, per kilometer.

+1 mm. per kilometer is very good.
+ 2 " " " " " fair.
+ 3 " " " " " good
+ 5 " " " " " to large.

The above results are established by men of broad experience, to-gether with the best facilities for doing work of the extreme accuracy.

The limit of the U.S.Coast and Geodetic Survey is + 4 mm. per kilometer, and that of the Mississippi River Survey was + 10 mm. per kilometer. While this last named limit was decided upon as our criterion in accuracy, we have with three exceptions, attained the degree of accuracy equal to that of the U.S.Coast and Geodetic Survey, as shown by the following table.

LINE.	Kilomet.	Act.Error.	E.per K.	Al. Error U.S.C.G.S
B.M.1, to V.S.cor.Hyatt & Logan.	1.2375	-.0018	-.0014	.0044
W.B.Logan, near Hyland to V.S. cor.Franklin & Wash.	1.6590	-.0050	-.0030	.0050
V.S.Wash.& Franklin to B.M.4.	.9402	+.0031	+.0033	.0033
B.M.2, and V.S.on cor.Sheridan & Pennsylvania.	.6766	-.0021	-.0030	.0030
V.S.on Sheridan & Penn.and B.M.7.	1.2405	+.0058	+.0047	.0049
B.M.7, and 9.28 S.Penn.	1.0363	+.0019	+.0010	.0041
9.28 S.Penn. & B.M.8.	.4725	-.0042	-.0030	.0037
B.M.8 to B.M.29.	1.1399	-.0043	-.0043	.0043

	Distance Milo.	Actual Error.	Error per Kilo.	Allowable Error for U.S.C.&G.S.
B.M.10, to B.M.11	1.1299	+ .0031	+ .0027	.0043
B.M.11, to V.S.cor. St. Joe & Logan	.7010	- .0044	- .0030	.0032
V.S.cor. St. Joe & Mich. & B.M.1.	.7773	- .0031	- .0040	.0035
B.M.1, to B.M.13,	1.2347	+ .0043	+ .0035	.0044

DESCRIPTION OF BENCH MARKS.

- P.B.M.1, Seventh brick east of north west corner of Michigan Ave., School, on corner of Michigan and Logan.
- P.B.M.2 Top of the north east corner of bottom step of east entrance to main Blind School Building.
- P.B.M.3, Top of south west corner of concrete foundation of below corner window of the Walker Building, on corner of Franklin and Washington.
- P.B.M.4, Hole on top on north side of water trough on the north east east corner of Case And Franklin.
- P.B.M.5, south east corner of top step of south entrance of the Franklin Ave. School, on corner of Franklin and New York.
- P.B.M.6, On the south west corner of the top of the stepping stone in front of 737 North Pennsylvania.
- P.B.M.7. On the south east corner of the top of the stepping stone in front of 140 South Pennsylvania.
- P.B.M.8, Center of the top of the North West portion of west retaining wall of the Grand Trunk Bridge over the Red River.
- P.B.M.9, The south east corner of the top of the iron pedestal supporting the post which supports the South East corner of the roof on the east end of the Grand Trunk Depot.

P.B.M.10, On the north east corner of the west pier of the Grand Trunk R.R. Bridge over the Grand River, West of Washington.

P.B.M.11. Bolt head north east corner of the north pier of the Logan street bridge over the Grand River.

P.B.M.12, North west corner of the top step of the north entrance to the Logan St. School.

P.B.M.13, South west corner of the top step of west entrance of City Hall.

The above bench marks can be found, marked P.B.M.1, P.B.M.2, etc., (Precise Bench Mark.) as shown above. The Valve Stems of the hydrants were used as turning points when available, and are located on the map accompanying this thesis.

The above precise bench marks are also shown upon the map, together with the line of the precise level survey, and the contours at five foot intervals, which were taken from levels obtained for street intersections obtained from the city engineer. This map and the note book will be found in the pocket at the back of this thesis. All photographs were taken from cuts found in an article on the precise level in the Transactions of the American Society of Civil Engineers.

.7880

.31 .3163

6.08 5590

.81 16.42 1.3780

16.08 17.34 1.6000

4.78 6.09 7.30 .6000

10.1000

LINE BETWEEN E.M. 1 AND V.S. NEAR HIGHLAND ST.

Forward Line.

WIRE SIGHTS		ELEVATIONS.	
Wire Readings		Original	Corrected Datum.
Middle Lower	Upper		
atimeters	Meters	Meters	Feet.

			100.0000	100.0000	158.250	864.855
1	10.00	1.0000	99.9407	99.9408	158.058	864.641
	11.00	1.0000	100.7007	100.7000	159.562	866.147
	11.00	1.0017	99.1003	99.1007	155.300	861.888
	12.00	1.0000	99.5054	99.5050	152.692	859.277
	13.00	1.0010	97.8821	97.8829	151.524	857.909
	14.00	1.0055	98.1051	98.1056	152.035	858.620
	15.00	1.0050	99.4401	99.4407	166.415	863.000
	16.00	1.0010	99.9004	99.9101	164.674	861.259
	17.00	1.0010	99.9004	99.9002	167.253	863.838
	18.00	1.0057	99.7643	99.7643	154.196	860.781
	11.1833					

Check Line.

Check Line.

				99.7643	Sum of S.S. +10.1939
10.00	10.00	11.00	1.0017	99.5007	" " F.S. 8.9320
					Difference + 1.2619
10.00	20.55	21.60	2.0540	99.7024	
					Forward Line.
9.60	11.30	12.74	1.1320	99.4756	Sum of F.S. -11.1263
15.50	16.40	17.40	1.6467	99.1060	" " F.S. -9.2917
					Difference - 1.2336
6.64	7.83	9.00	.7210	97.8863	
					-1.2336
.74	1.77	2.74	.1750	99.6854	+1.2336
					Error - .0016
11.73	3.00	4.20	.8978	100.3879	
9.44	10.68	11.86	1.0600	99.9403	
6.00	7.20	8.34	.7180	100.0000	
			8.9320		

PRECISE MEAS. LINE ON LOGAN ST. AND FRANKLIN AVE.

Forward Line

	BACK SIGHTS Wire Readings Upper Middle Lower Centimeters			Mean Meters.
V.S. on Hyd. on Logan near Hyland.	11.17	13.01	14.18	1.2990
T.P. 1 on ground, 2 000' from Saginaw	5.17	6.41	7.62	.6400
T.P. 2 " " 2 500' " "	5.76	6.91	8.05	.6900
V.S. on Hyd. .E. c r. Logan & Warner	5.20	6.49	7.72	.6470
T.F. 3. on Warner 200' E. of Logan.	21.48	22.75	23.97	2.2735
T.P. 4, " " & Rogers.	25.70	25.22	26.71	2.5210
T.P. 5, 1 00' N.E. of Blind School	1.61	2.98	4.28	.2960
V.S. on Hyd. on N.E. cor. Franklin & Pine.	9.59	10.69	11.70	1.0656
V.S. " " on N.E. " " & Chestnut.	2.39	3.51	4.60	.3500
V.S. " " on N.E. cor. " & Walnut.	2.92	3.93	4.88	.3930
V.S. " " on N.W. cor. " & Seymore.	4.92	6.13	7.22	.6110
V.S. " " on N.W. cor. " & Capitol.	1.10	2.29	3.39	.2390
V.S. " " on N.W. cor. " & Washington.				11.0149

Check Line.

Location	1900	1901	1902	1903
V.S.on Hyd.on N.W.cor. Franklin & Washington.	28.32	25.61	26.83	2.5586
V.S.on Hyd.on N.W.cor. " & Capitol.	11.02	12.10	13.12	1.2080
V.S.on Hyd.on N.W.cor. " & Seymore.	6.11	7.01	7.88	.7000
V.S.on Hyd.on N.E.cor. " & Walnut.	27.61	28.81	29.96	2.8793
V.S.on Hyd.on N.E.cor. " & Chestnut.	16.79	17.88	18.90	1.7866
V.S.on Hyd.on F.E.cor " & Pine.	9.73	11.29	12.70	1.1273
V.S.on Hyd.on N.E.of Blind School Building.	7.02	8.45	9.78	.8423
T.P.4 cor.Warner & Rogers.	30.17	31.41	32.61	3.1396
T.P.3 on ground.500 feet East of Logan.	10.59	11.73	12.52	1.1713

(Continued on Page .)

LINE BETWEEN V.S. NEAR HELLAND ISLAND THE V.S. ON THE
COR. OF BATHINGTON AVE.

Forward Line.

FORE SIGHTS				ELEVATIONS			
Wire Readings				Original Corrected		City	Above
Upper	Middle	Lower	Mean			Datum	Sea Level
CENTIMETERS				Meters.		Feet.	
9.29	10.55	11.72		98.7683	98.7645	154.123	860.781
9.29	10.53	11.72	1.0518	99.0117	99.0119	133.008	861.593
22.61	27.93	29.12	2.7876	96.8641	96.8645	147.923	854.845
13.31	14.47	15.73	1.4453	96.1088	96.1094	145.432	855.073
10.57	11.63	13.17	1.1356	95.8702	95.8710	143.719	855.304
30.19	31.47	32.98	3.1446	94.6929	94.6999	140.882	847.447
44.60	6.07	7.85	.6079	96.6129	96.6141	147.144	855.729
7.79	9.58	11.37	.9556	95.9533	95.9547	144.979	851.564
17.02	18.23	19.53	1.8200	95.1989	95.2005	142.506	846.090
27.63	29.02	29.97	2.8900	92.6689	92.6707	134.802	840.790
8.42	7.82	8.90	.7316	92.3309	92.3329	133.096	839.621
11.37	12.42	13.56	1.2473	91.6946	92.0968	131.010	837.595
24.32	25.61	26.83	2.5586	89.3650	89.3675	123.569	829.951
			30.4143				

Check Line.

1.16	2.26	3.39	.2346	96.3513	96.3577		
11.17	2.23	3.30	.3230	91.6546	91.6550		
4.03	5.72	6.83	.5712	92.3403	92.3412		
2.25	3.41	4.53	.3546	92.1942	92.1951		
2.39	3.51	4.57	.3424	95.1966	95.1966		
9.11	10.53	11.47	1.0313	98.9832	98.9857		
2.72	4.27	5.73	.4126	97.6319	97.6325		
B.M.2.			(1.1166)	97.7505	97.7549	149.805	856.688
28.49	29.10	29.63	2.8799	94.7505	94.7549		
21.33	22.02	22.92	2.1386	98.3112	97.5742		
4.90	6.33	7.7	.6350	96.2660	96.0117		

conditions are apt to creep in, this method was used. Any other source of error was not of sufficient magnitude, therefore it was neglected.

The International Geodetic Association have fixed the following limits for probable error of the mean result as follows, per kilometer.

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W.E. Logan, near Hyland to V.S. cor. Franklin & Wash.	1.0530	-.0050	-.0030	.0050
V.S. Wash. & Franklin to B.M. 4.	.9402	+.0031	+.0033	.0033
B.M. 2, and V.S. on cor. Sheridan & Pennsylvania.	.6766	-.0021	-.0030	.0026
V.S. on Sheridan & Penn. and B.M. 7, and 928 S. Penn.	1.2405	+.0058	+.0047	.0049
928 S. Penn. & B.M. 8.	.4725	-.0042	-.0030	.0037
B.M. 8 to B.M. 29.	1.1399	-.0043	-.0043	.0043

	Distance Kilo.	Actual Error.	Error per Kilo.	Allowable Error for U.S.C.&G.S.
B.M.10, to B.M.11	1.1399	+0.0031	+0.0027	.0043
B.M.11, to V.S.cor. St.Joe & Logan	.7010	-0.0044	-0.0080	.0032
V.S.cor.St.Joe & Mich.& B.M.1.	.7775	-0.0031	-0.0040	.0035
B.M.1, to B.M.13,	1.2347	+0.0043	+0.0035	.0044

DESCRIPTION OF BENCH MARKS.

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- P.B.M.2 Top of the north east corner of bottom step of east entrance to main Blind School Building.
- P.B.M.3, Top of south west corner of concrete foundation of below corner window of the Walker Building, on corner of Franklin and Washington.
- P.B.M.4, Hole on top on north side of water trough on the north east east corner of Case and Franklin.
- P.B.M.5, south east corner of top step of south entrance of the Franklin Ave. School, on corner of Franklin and New York.
- P.B.M.6, On the south west corner of the top of the stepping stone in front of 737 North Pennsylvania.
- B.B.M.7. On the south east corner of the top of the stepping stone in front of 120 South Pennsylvania.
- P.B.M.8, Center of the top of the North West portion of west retaining wall of the Grand Trunk Bridge over the Red River.
- P.B.M.9, The south east corner of the top of the iron pedestal supporting the post which supports the South East corner of the roof on the east end of the Grand Trunk Depot.

P.B.M.10, On the north east corner of the west pier of the Grand Trunk R.R. Bridge over the Grand River, West of Washington.

P.B.M.11. Bolt head north east corner of the north pier of the Logan street bridge over the Grand River.

P.B.M.12, North west corner of the top step of the north entrance to the Logan St. School.

P.B.M.13, South west corner of the top step of west entrance of City Hall.

The above bench marks can be found, marked P.B.M.1, P.B.M.2, etc., (Precise Bench Mark.) as shown above. The Valve Stems of the hydrants were used as turning points when available, and are located on the map accompanying this thesis.

The above precise bench marks are also shown upon the map, together with the line of the precise level survey, and the contours at five foot intervals, which were taken from levels obtained for street intersections obtained from the city engineer. This map and the note book will be found in the pocket at the back of this thesis. All photographs were taken from cuts found in an article on the precise level in the Transactions of the American Society of Civil Engineers.

January 1960.

Major Middle School Year
Contributions Below.

Check 150.

U.S. car light repair and oil.	11.00	11.00	11.00	1.0000
U.S. car.	11.00	11.01	11.00	1.0000
U.S. car.	11.00	11.00	11.00	1.0000
U.S. car. Service.	11.00	11.00	11.00	1.0000
U.S. car. Repair.	11.00	11.00	11.00	1.0000
U.S. car. Accessories.	11.00	11.00	11.00	1.0000
U.S. car. Information.	11.00	11.00	11.00	1.0000
U.S. car. Light.	11.00	11.00	11.00	1.0000
U.S. car. Light and Accessories.	11.00	11.00	11.00	1.0000

LINE BETWEEN P.M. 1 AND V.E. NEAR HYLAND ST.

Forward Line.

WIRE READINGS				ELEVATIONS			
Wire Readings				Per City Above			
Upper	Middle	Lower	Mean	Original	Corrected	Datum	Sea Level
Centimeters			Meters	Meters			Feet.
				100.0000	100.0000	158.350	864.835
7.53	9.01	10.01	.8588	99.9407	99.9408	159.053	864.641
9.01	10.01	11.71	1.0580	100.7307	100.7309	159.562	866.147
14.40	15.07	17.01	1.5317	99.1003	99.1007	155.300	861.885
22.42	23.04	24.55	2.3300	98.7054	98.7059	152.692	859.277
11.03	12.03	13.03	1.3410	97.8921	97.8929	151.324	857.909
4.41	5.71	7.04	.8753	98.1351	98.1356	152.035	858.620
2.10	3.30	4.70	.5630	99.4401	99.4407	166.415	863.000
17.87	19.12	20.31	1.9160	99.9004	99.9101	164.674	861.259
6.57	7.53	9.01	.8700	99.6054	99.6062	157.253	863.838
18.00	19.00	20.00	1.6667	99.7644	99.7643	154.198	860.781
			11.1203				

Check Line.

				99.7643	
10.04	10.63	11.33	1.0617	99.5867	
19.30	20.55	21.69	2.0540	98.7924	
9.60	11.30	12.74	1.1320	99.4355	
15.50	16.49	17.40	1.6467	99.1069	
6.64	7.83	9.06	.7210	97.8863	
.74	1.77	2.74	.1750	99.6804	
11.73	3.00	4.20	.8378	100.3379	
9.44	10.68	11.86	1.0920	99.9403	
6.00	7.20	8.34	.7180	100.0000	
			8.9320		

Check Line.

Sum of F.S. +10.1039
 " " F.S. 8.9320
 Difference + 1.2353

Forward Line.

Sum of F.S. -11.1263
 " " F.S. -9.8917
 Difference - 1.2356

-1.2356

+1.2353

Error - .0013

PRECISE LEVEL LINE ON LOGAN ST. AND FRANKLIN AVE.

Forward Line

	BACK SIGHTS			
	Wire Readings			
	Upper	Middle	Lower	Mean
	Centimeters			Meters.
V.S. on Hyd. on Logan near Hyland.	11.17	13.01	14.19	1.2990
T.P.1 on ground, 2 000' from Saginaw	5.17	6.41	7.62	.6400
T.P.2 " " 2 500' " "	5.76	6.91	8.05	.6900
V.S. on Hyd. .E. cor. Logan & Warner	5.20	6.49	7.72	.6470
T.P.3, on Warner 200' E. of Logan.	21.48	22.75	23.97	2.2733
T.P.4, " " & Rogers.	23.70	25.22	26.71	2.5210
T.P.5, 1 60' N.E. of Blind School	1.61	2.98	4.28	.2960
V.S. on Hyd. on N.E. cor. Franklin	9.59	10.68	11.70	1.0656
& Pine.				
V.S. " " on N.E. " "	2.39	3.51	4.60	.3500
& Chestnut.				
V.S. " " on N.E. cor. " "	2.92	3.93	4.88	.3930
& Walnut.				
V.S. " " on N.W. cor. " "	4.99	6.13	7.22	.6110
& Seymore.				
V.S. " " on N.W. cor. " "	1.10	2.29	3.39	.2290
& Capitol.				
V.S. " " on N.W. cor. " "				
& Washington.				11.0149

Check Line.

V.S. on Hyd. on N.W. cor. Franklin				
& Washington.	24.32	25.61	26.83	2.5586
V.S. on Hyd. on N.W. cor. " "				
& Capitol.	11.02	12.10	13.12	1.2080
V.S. on Hyd. on N.W. cor. " "				
& Seymore.	6.11	7.01	7.88	.7000
V.S. on Hyd. on N.E. cor. " "				
& Walnut.	27.61	28.81	29.96	2.8793
V.S. on Hyd. on N.E. cor. " "				
& Chestnut.	16.79	17.88	18.90	1.7866
V.S. on Hyd. on N.E. cor. " "				
& Pine.	9.73	11.29	12.70	1.1273
V.S. on Hyd. on N.E. of Blind School				
Building.	7.02	8.45	9.78	.8423
T.P.4 cor. Warner &				
Rogers.	30.17	31.41	32.61	3.1396
T.P.3 on ground, 500 feet East of				
Logan.	10.59	11.73	12.52	1.1713

(Continued on Page .)

**LINE BETWEEN V.S. NEAR IRLAND ISLAND THE V.S. ON THE
COR. OF BARRINGTON AVE.**

Forward Line.

FORE SIGHTS Wire Readings				ELEVATIONS.			
Upper	Middle	Lower	Mean	Original	Corrected	City Datum	Above Sea Level
C. MILLERS				Feet.			
9.29	10.53	11.72		98.7683	98.7645	154.128	860.781
9.29	10.53	11.72	1.0813	99.0117	99.0119	178.008	861.523
22.61	27.93	29.13	2.7876	96.8841	96.8845	147.923	854.846
13.31	14.47	15.73	1.4453	96.1093	96.1094	148.436	855.073
10.57	11.68	13.17	1.1856	95.8702	95.8710	143.718	855.304
30.19	31.47	32.88	3.1446	94.6920	94.6920	140.862	847.447
44.60	6.07	7.85	.6070	96.6129	96.6141	147.144	855.796
7.79	9.58	11.32	.9556	95.9533	95.9547	144.970	851.564
17.02	18.22	19.33	1.8200	95.1989	95.2005	142.506	849.090
27.63	29.62	29.97	2.8900	92.6689	92.6707	134.202	840.790
8.42	7.82	8.20	.7310	92.3309	92.3329	135.096	839.621
11.37	12.42	13.56	1.2473	91.6946	92.0968	131.010	837.595
24.32	25.61	26.83	2.8586	89.5680	89.5675	123.569	835.951
			30.4143				

Check Line.

1.10	2.39	3.39	.3240	95.3513	95.3578		
11.17	3.12	3.32	.3230	91.9546	91.9577		
4.33	5.72	6.82	.5712	92.3303	92.3332		
2.15	3.61	4.53	.3240	92.1662	92.1694		
2.39	3.51	4.57	.3236	95.1966	95.1966		
9.11	10.31	11.47	1.3213	95.9532	95.9557		
2.72	4.17	5.73	.4185	97.6312	97.6345		
B.M.2.			(1.1866)	97.7505	97.7549	149.103	856.688
28.49	28.10	29.63	2.8599				
21.33	21.31	21.92	2.1386	95.5717	95.5742		
4.90	6.35	7.7	.6850	96.1060	96.0117		

PRECISE LEVEL LINE ON LOGAN ST. AND FRANKLIN AVE.

Check Line.

	BACK SIGHTS.			
	Wire Readings.			
	Upper	Middle	Lower	Mean.
	Centimeters.			Meters.
V.S. on cor. of Logan & Warner.	13.04	14.19	15.22	1.4170
T.P.2, 2 500 feet North of Saginaw on Logan.	26.35	27.65	28.80	2.7630
T.P.1, 2 000 feet North of Saginaw on Logan.	9.66	11.90	12.08	1.0880
V.S. of Hydrant on Logan St. near Hyland.				
				20.6616

LINE BETWEEN V.S. HEAD WILMARD ST. AND THE V.S. ON THE
COR. OF WASHINGTON AVE.

Check Line.

FORE SIGHTS				ELEVATIONS		
Wire Readings				Original	Corrected	For City
Upper	Middle	Lower	Mean			Datum
Centimeters			Meters		Meters	Feet.
8.46	6.67	7.61	.6645	96.8513	96.8637	
4.91	8.18	7.37	.6153	99.6070	99.6117	
18.11	15.38	14.70	1.3363	98.7693	98.7646	
				111.3873		

Forward Line.

Sum of Fore Sights - 22.143
 " " Back " 11.0143
 Difference - 0.3993

Check Line

Sum of Back Sights + 20.6516
 " " Fore " 11.3873
 Difference + 0.3943

- 0.3993
 + 0.3943
 Error - 0.0050

PRECISE LEVEL LINE ON FRANKLIN AVE.

Forward Line.

	SACCH 115 10		Wire Readings	
	Upper	Wire	Lower	Mean
	Centimeters			Meters
V.S. on Hyd. on N.W. cor. Franklin & Washington.	3.84	4.32	8.17	.4208
L.P.1, on Franklin Ave. on West end of Bridge.	13.89	17.11	15.57	1.7000
V.S. on Hyd. on Franklin, 75 feet East of Turner.	22.62	23.71	24.41	2.8700
L.P.2, on Franklin 150 feet East of Turner.	23.33	24.03	24.40	2.9013
V.S. on Hyd. on N.W. cor. Franklin & Center Ave.	11.82	12.86	13.87	1.2350
V.S. on Hyd. on N.W. cor. Franklin & Cedar St.	2.74	4.04	8.80	.4030
L.P.3, on N.W. cor. of Franklin & Cedar St.	13.07	14.20	15.73	1.4183
V.S. on Hyd. 100 ft. West of Depot on Franklin Ave.	10.03	11.11	12.13	1.1000
V.S. on Hyd. in front of Boiler Shop on Franklin Ave.	7.92	8.34	8.74	.8373
B.M.4, hole in edge of water trough on Case, North Side.				11.8843

Check Line.

B.M.4, on water trough on cor Case & Franklin Ave.	13.89	11.85	12.62	1.1500
V.S. on Hyd. in front of Boiler Shop on Franklin Ave.	4.03	4.94	8.61	.4826
V.S. on Hyd. 100 feet West Of Depot on Franklin Ave.	2.33	4.03	5.20	.4030
L.P.3, on N.W. cor. Franklin Ave. & Cedar St.	21.52	23.71	23.83	2.5708
V.S. on Hyd. on N.E. cor. Franklin & Cedar St.	3.93	3.03	6.04	.5013
V.S. on Hyd. on N.E. cor. Franklin & Cedar St.	3.12	3.64	4.15	.3813
L.P.2, on Franklin, 150 feet East of Turner.	6.32	6.99	7.65	.6080
V.S. on Franklin Ave. 75 feet East of Turner St.	6.33	8.57	7.57	1.1000
L.P.1, on West end of Bridge over the Grand River.	13.07	14.17	15.20	1.4033
B.M.3, top of N.E. cor. of Concrete support of former window of the Walker Bldg.				8.1437

LINE BETWEEN V.S.COR. WASHINGTON AVE. AND B.M. 4.

Forward Line.

Fore Sights				ELEVATIONS.			
Wire Readings				Original Corrected		Per City	Above
Upper	Middle	Lower	Lean	Meters		Datum	Sea Level
Centimeters						Feet.	
				89.3675	89.3675	123.330	839.951
12.80	13.94	14.96	1.3923	89.4115	89.4114	119.904	836.489
4.92	5.61	6.86	.5390	89.5615	89.5615	124.000	839.337
6.92	7.90	7.73	.7676	91.2999	89.9835	129.450	836.043
3.94	4.06	4.17	.4656	93.2199	93.2198	126.003	842.538
3.92	4.92	6.01	.4973	94.0076	94.0069	128.580	845.173
24.52	25.73	26.89	0.5713	91.8383	91.8372	121.400	839.921 Y.B.3
	26.03		2.00003	92.4066	(92.4055)	125.330	839.921 V.S.
2.88	4.04	5.12	.4030	92.8506	92.8493	134.789	841.374
3.72	4.79	5.80	.4770	93.4033	93.4212	136.660	843.447
10.94	11.53	12.09	1.1300 5.1531	93.1616	93.1614	132.613	842.298

Check Line Check Line.

				93.1639	93.1614	136.613	842.298
7.92	8.94	9.74	.8933	93.4999	93.4610		
10.00	11.24	12.43	1.1233	92.8829	92.8511	Forward Line.	
13.02	14.14	15.22	1.4136	91.8425	91.8002	Sum of F.S. + 11.9345	
7.92	8.45	9.31	(.8433)	90.6236	90.6000	" " B.S. 8.1021	
2.74	3.05	3.31	.4033	94.0093	94.0072	Difference + 1.7364	
11.83	12.90	13.91	1.2800	93.2229	93.2200	Check Line.	
23.12	23.62	24.09	2.2000	91.2200	91.2218	Sum of I.S. - 11.9370	
22.82	23.61	24.52	2.1890	89.5642	89.5610	" " B.S. 8.1407	
16.08	17.00	18.51	1.7100	89.8700	89.8604	Difference - 3.7393	
3.45	4.89	5.68	.4273	89.5706	89.5670	Error.	
3.48	4.42	5.33	(.4410)	89.3500	89.3675	+ 3.7364	
			11.170			- 5.1515	
						+ 0.0011 Meters,	

PRECISE LEVEL LINE ON FRANKLIN AND PENNSYLVANIA.

Forward Line.

Station.	FROM STATION First Reading			
	Upper Limb	Lower Limb	Mean	Feet.
B.M. 4, on water trough on N.E. cor. of Case & Franklin	14.91	15.76	16.57	1.5746
T.P. 1, on Franklin Ave. corner of Ballard.	27.25	27.35	27.31	2.7050
T.P. 2, on Franklin Ave. corner of High St.	28.31	28.47	27.89	2.3455
V.S. on Hyd. on N.E. cor. Franklin & High St.				
T.P. 3, on Franklin Ave. corner of Pennsylvania.	13.33	13.35	13.53	1.5333
V.S. on Hyd. on N.E. cor. Franklin & New York Ave.	7.51	7.71	8.00	.7705
B.M. 5, on step of South entrance of Franklin Ave School.	2.78	3.32	3.85	.3313
V.S. on Hyd. on N.E. cor. Franklin & New York.	5.34	4.91	5.92	.4690
T.P. 4, on Pennsylvania 250 feet south of Franklin Ave.	3.31	4.31	5.65	.4360
V.S. on Hyd. on S.E. cor. Pennsylvania & Porter.	11.02	12.71	14.02	1.0000
V.S. on Hyd. on S.E. cor. Pennsylvania & Sheridan.				10.7000

Check Line.

V.S. on Hyd. on S.E. cor. Pennsylvania & Sheridan	3.00	7.75	8.59	.7750
V.S. on Hyd. on S.E. cor. Pennsylvania & Porter.	14.02	13.32	15.04	1.5570
T.P. on Pennsylvania 250 feet south of Franklin.	13.03	12.00	10.00	2.0670
V.S. on Hyd. on N.E. cor. Franklin & & New York.				
T.P. 3, on cor. Franklin and High St.	1.00	1.00	2.00	.1850
V.S. on Hyd. on N.E. cor. Franklin & High St.				
T.P. 3, on Franklin Ave. N.E. corner of Ballard Ave.	4.13	4.20	5.75	.4300
B.M. 3, on S.E. cor. Franklin Ave. & Case.				4.0000

LINE BETWEEN B.M. 4 AND V.S. ON SHERIDAN AVE

Forward Line.

BACK SIGHTS				FORE SIGHTS			
Five Readings:				Original	Corrected	Above	Mer City
Upper	Middle	Lower	Mean	Meters		Sea Level	Datum.
Centimeters						Feet.	
				94.1689	94.1814	941.800	135.813
8.01	8.78	9.24	.8713	94.0904	94.0908	944.494	136.109
8.19	8.80	9.49	.8997	94.1471	94.2070	949.198	140.003
8.14	8.71	9.36	(.8716)	94.0414	94.0416	952.412	151.827
8.03	8.67	9.67	.8665	94.3471	94.3475	959.450	153.765
8.38	8.61	8.19	.4596	99.4399	99.4315	963.008	158.493
22.70	3.32	3.83	(.5316)	99.8985	99.9000	964.807	157.923
7.31	7.71	8.09	(.7703)	99.4606	99.4615	963.008	153.493
18.33	19.03	20.61	1.9306	97.9282	97.9286	952.208	151.623
14.33	15.13	17.33	1.5866	96.8316	96.8331	954.441	147.833
5.23	7.70	9.59	.7750	97.5256	97.5264	959.302	149.477
			6.8510				

Check Line

				97.3256	97.3264		
11.03	12.71	14.38	1.2360	96.8316	97.8325	Forward Line	
2.00	4.11	8.47	.4090	97.9798	97.9801	Sum of F.S. +13.7952	
3.67	4.31	8.91	.4693	99.4570	99.4585	" " F.S. C.8310	
						Difference + 4.1640	
17.50	19.12	20.63	1.9100	98.0366	98.0367	Check Line	
27.03	29.65	30.19	2.8623	97.0043	97.0050	Sum of F.S. -9.1463	
27.08	27.72	28.36	2.7720	94.4973	94.4981	" " F.S. 4.9800	
17.37	15.16	12.31	1.3340	93.1593	93.1641	Difference -2.1663	
			4.8800			-4.1663	
						+4.1640	
						-0.0021 M. Error.	

PRECISE LEVEL SURVEY ON PENNSYLVANIA AVE.

Forward Line.

	RACHA TOWEL			Mean Meters
	Wire Readings			
	Upper	Middle	Lower	
Centimeters				
V.S.on Hyd.on Pennsylvania & N.E. cor.of Sheridan.	12.80	14.10	15.28	1.4090
T.P.1.on Pennsylvania, 400 feet South of Sheridan	22.41	22.64	20.81	2.9300
V.S.on Hyd.on N.E.cor.Pennsylvania & May.				
B.M.5, on S.W.cor.stopping stone in Front of 715 Penn				
T.P.2, on Pennsylvania, 100 feet North of Saginaw	20.32	21.61	22.13	2.1700
V.S.on Hyd.on S.E.cor.Penn.& Saginaw.				
T.P.3, on Pennsylvania and Orchard St.	11.62	12.84	11.30	1.9000
V.B.4 on Hyd.on S.E.cor.of Penn.& Linden Grove.				
T.P.4, on Pennsylvania, 100 feet South of Linden Grove	7.18	8.63	9.37	.8300
V.S.on Hyd.on N.E.cor. Penn.& Chilawasco	10.68	11.20	12.07	1.1200
V.S.On Hyd.on N.W.cor. Penn.& Vine.	7.00	8.10	9.31	.8185
V.S.on Hyd.on S.W.cor. Penn.& Jerome	8.52	9.51	10.35	.9400
V.S.on Hyd.on N.E.cor. Penn.& Michigan	6.50	8.01	9.35	.7300
B.M.7, on S.E.cor.stopping stone in Front of 150 S.Penn.				
Check				13.1040

Check Line.

B.M.7, on stopping stone in front of 150 S.Penn.	7.01	8.75	9.69	.8700
V.S.on Hyd.on N.E.cor.Penn. & Michigan	7.02	8.30	10.90	.8065
B.M.of U.S.Topographical Survey, Cor.Mich.(225'A.S.S.S.)				
V.S.of Hyd.on N.W.cor.Penn. & Jerome	5.40	6.75	8.60	.5700
V.S.of Hyd.on N.E.cor.Penn. & Vine.	3.15	4.45	5.00	.4450
V.S.of Hyd.on N.W.cor.Penn. & Mississippi	24.01	25.00	27.55	2.5275
T.P.1, on Pennsylvania N.E.cor. Linden Grove.	17.05	18.03	19.92	1.8210

LINE BARSHE V. S. ON LAMPION, AND A. S.

Forward Line.

FORE SIGHTS				BACK SIGHTS			
Wire Readings				for City			
Upper	Middle	Lower	Mean	Original	Corrected	Later	Above
Centimeters				Meters			
				87.3280	87.3264	149.477	856.062
1.91	2.76	3.58	.9780	99.4654	99.4631	152.211	835.436
11.71	12.45	13.17	(1.9420)	100.1874	100.1831	152.251	835.436
15.02	15.25	15.47	(1.8285)	99.9021	99.9013	157.238	864.513
3.22	3.13	2.57	.8133	100.6121	100.6115	160.256	858.841
9.17	9.32	9.58	(.9375)	101.2535	101.2522	164.722	870.214
10.20	12.48	14.02	1.2453	101.8452	101.8449	163.312	869.904
5.55	5.68	6.19	(.7875)	102.9505	102.9496	167.228	874.513
12.21	12.11	12.25	1.2020	101.7262	101.7279	162.215	870.500
22.91	24.39	25.80	2.4306	100.1528	100.1512	162.742	865.334
3.51	4.70	6.02	.4676	100.2312	100.2293	161.122	867.723
6.82	7.20	9.29	.7856	100.9115	100.9095	161.232	867.812
7.22	6.89	9.29	.4686	100.2722	100.2705	161.452	868.817
7.21	6.75	9.29	.9780	100.2952	100.2935	161.172	867.767
			9.1950				

Check Line.

				100.1952	100.8915		
6.60	6.61	2.76	.7800	100.7222	100.9203	Forward Line	
18.72	19.72	20.72	(1.9755)	99.2995	99.2993	Sum of F.S. + 13.1848	
22.970	2.60	12.45	.9780	100.9105	100.9101	" " B.S. 9.5950	
3.22	17.00	12.25	1.2020	100.9655	100.9630	Difference + 2.5508	
10.31	11.70	13.02	1.1000	100.1305	100.1235		
7.22	9.42	12.25	(.3455)	101.2522	101.2557		
1.99	3.72	5.49	.3755	102.2525	102.2530		

PRECISE LEVEL LINE ON PENNSYLVANIA AVENUE-NORTH.

Check 11-11.

FIG. 11-11-13

Wire Readings

Upper Middle Lower Main
Centimeters Motors

V.S. on Hyd. on N.E. cor. Penn. &

Hyd. on N.E. cor. Penn. &

V.S. on Hyd. on S.E. cor. Penn. &

Hyd. on S.E. cor. Penn. &

V.B. on Hyd. on N.E. cor. Penn. &

.84 .80 10

S.L.F. on S.E. cor. stepping Stone

Hyd. on S.E. cor. Penn. &

T.P.S. on Pennsylvania, N.E. cor. of

Hyd. on S.E. cor. Penn. &

1.40 2.50 2.83 .2438

V.S. on Pennsylvania, and North East

cor. Sheridan.

1.40 2.50 2.83 .2438

7.3335

LINE BETWEEN V.S.ON SHERIDAN AND B.M.5.

Check Line.

FORE SIGHTS				ELEVATIONS		
Wire Readings				Original	Corrected	New City
Upper	Middle	Lower	Mean			
Centimeters				Feet	Feet	Sea Level
1.22	5.72	8.12	.3753	102.9598	102.9530	
15.13	14.77	15.12	1.4740	101.8509	101.8543	
18.99	17.59	18.08	1.7555	100.1008	100.1065	
19.40	20.37	21.26	2.0353	99.2035	99.2033	
27.61	28.29	29.92	2.9173	99.0262	99.0267	
18.01	18.45	20.12	1.9433	97.3232	97.3264	
			10.9235			

Check Line.

Sum of fore sights -10.9035

" " Back " 7.3205

Difference - 3.5830

+ 3.5830

- 3.5847

Error,

+ 0.0017 meters

BRIDGE LEVEL SURVEY ON PENNSYLVANIA AVE.

Forward Line.

STATION	BACK SIGHT			
	Virt. Station		Upper Middle	Lower
			Feet	Feet
B.M. 7, on stepping stone, 100 S. from	18.85	18.18	18.47	1.7100
V.S. on Hyd. H. I. cor. of Pennsylvania				
& Prospect.	2.88	3.81	3.81	.9288
V.S. on Hyd. H. I. cor. of Pennsylvania				
& Indiana	4.17	5.01	4.40	.8430
V.S. on Hyd. H. I. cor. of Pennsylvania				
& Benet	8.87	9.50	10.91	.6366
T.P. 1, on Pennsylvania, 400 feet				
South, P.M.P.E.	9.41	10.74	12.80	1.0733
V.S. on Main and S.E. cor. of				
Pennsylvania	5.11	5.88	5.12	.7630
T.P. 3, on Pennsylvania, 500 feet				
South of Main St.	4.83	5.62	6.87	.8403
V.S. on Hyd. on Pennsylvania in front				
of 950.				5.6380

Check Line.

V.S. on Penn. in front of S. S. South				
Pennsylvania	14.50	14.71	14.83	1.4780
T.P. 1, on Pennsylvania, 400 feet				
North of 950 S. Penn.	22.50	26.10	31.00	5.6085
T.P. 2, on Pennsylvania, corner of				
Main St.	17.48	19.03	20.80	1.3016
T.P. 3, on Pennsylvania, 250 feet				
South of P.M.P.E.	28.02	29.23	30.41	2.3022
V.S. on Hyd. on P.E. cor. Penn. &				
Benet.	18.48	21.41	22.55	3.0386
V.S. on Hyd. on P.E. cor. Penn. &				
Hickory				
V.S. on Hyd. on P.E. cor. Penn. &				
Kalamazoo.	7.60	8.87	10.01	.8850
V.S. on Hyd. on P.E. cor. Penn. &				
Prospect.	9.66	10.40	11.32	1.0050
V.S. on Hyd. on P.E. cor. Penn. &				
Burch.				
B.M. 7, on P.E. cor. stepping stone in				
front of 100 S. Penn.				17.3231

SECTION 5.7.7, 11.12.11, PENNSYLVANIA.

Line

FOUR STAGES Wire Readings			Mean Meters	Original		Der City Bar City	Above Sea Level Feet.
Upper	Middle	Lower		Corrected	Corrected		
Centimeters				Meters			
				100.8952	100.8952	101.110	837.767
8.91	11.12	10.59	1.1860	101.4625	101.4625	102.112	838.697
10.36	10.10	10.13	2.0370	99.5405	99.5405	100.741	833.303
20.16	20.58	20.54	2.9380	97.5635	97.5635	100.255	850.840
10.19	11.09	10.04	1.1373	97.4685	97.4685	102.043	856.528
20.00	20.15	22.00	3.6320	94.8025	94.8025	141.100	847.761
14.50	14.73	14.95	1.4720	93.8071	93.8068	108.864	844.788
			19.1003				

Check Line.

				93.8011	93.8002		
11.04	10.10	10.07	1.1100	94.6455	94.6455	Forward Line.	
1.89	2.91	3.07	.0000	93.7648	93.7648	Sum of F.S. -13.6402	
9.71	11.05	12.55	1.1050	97.3054	97.5625	" " B.S. 5.6380	
0.12	0.48	10.78	.0400	99.5704	99.5705	Difference - 7.0014	
13.64	13.64	14.00	(1.5050)	100.1247	100.1240	Check line.	
4.00	5.00	7.51	.0000	100.3500	100.3551	Sum of B.S. +13.6381	
9.71	8.93	5.11	.0013	101.1214	101.4005	" " F.S. 6.3198	
6.00	7.00	6.51	(.7500)	101.1470	101.1481	Difference + 7.0003	
15.49	16.07	16.00	1.0000	100.8014	100.8025	+7.0002	
			6.6808			-7.0014	
						+0.0019 M.Error.	

PRECISE LEVEL SURVEY ON PENNSYLVANIA AVE. SOUTH.

Vertical Table.

STATIONS.	BACK SIGHTS and INTERMEDIATE SIGHTS				Forn. Meters.
	1.27	1.83	1.34	1.0815	
V.S. on Pennsylvania in Front of No. 547.					
T.P.1, on Pennsylvania, 500 Feet South of C. & D.	1.32	1.87	2.00	1.1000	
T.P.2, on Pennsylvania, 700 Feet South of C. & D.	12.62	12.08	17.82	1.1803	
T.P.3, on Pennsylvania, 1100 Feet South of C. & D.	5.34	6.00	2.00	1.8003	
V.S. on Hydrant in Front of Penn. Pumping Station.					
T.P.4, 100 Feet North of C. & D. R.R. 1100 ft. of Red Cedar.	12.12	10.42	21.14	1.2673	
T.P.5, 300 Feet West of Bridge 2100 Feet N. of C. & D. R.R.	22.72	22.07	31.12	2.0870	
B.M.8, center of Top of S.W. cor. of retaining wall of C. & D. R.R. bridge over Red Cedar River.					7.4006
Check line.					
B.M.9, on C. & D. bridge over Red Cedar Cedar River.	.92	2.24	4.00	.2930	
T.P.5. As Above Described.	4.50	6.35	6.30	.5038	
T.P.4. " " "	22.97	24.21	26.40	2.4000	
V.S. in Front of Pumping Station.					
T.P.3.	20.11	21.74	22.32	2.1796	
T.P.2.	26.85	29.05	29.42	2.1750	
T.P.1.	19.03	19.22	19.30	1.0556	
V.S. on Pennsylvania in front of C. & D. cor.					10.3941

BETWEEN VALVE STEM OF HYDRAULT METER SITE 098 S. FERN. AND E. R. S.

Forward Line.

FOUR SIGHTS			ELEVATIONS				
Upper	Wire Readings	Lower	Mean	Original	Corrected	City	Above
Continents			Below	Station		Water.	Baybessel
				98.9966	98.9966	139.264	844.789
26.05	23.02	27.02	2.0130	98.9915	98.9925	120.824	853.289
24.22	21.14	24.02	2.1306	98.9900	98.9904	121.050	852.741
19.01	17.00	19.11	1.0050	98.9919	98.9917	114.642	856.830
8.12	3.15	6.17	(.0003)	98.9911	98.9935	121.025	852.570
21.47	19.19	24.02	2.5120	98.9922	98.9922	114.891	851.466
4.62	6.00	6.81	.0820	98.9901	98.9901	119.894	856.089
2.12	8.53	4.82	(.0310)	98.9911	98.9931	120.913	835.028
			10.8736				

Check Line.

				98.9931	98.9931		
50.72	47.37	51.12	2.0270	98.9961	98.9901	Forward Line	
19.22	20.53	21.76	2.0213	98.9937	98.9927	Sum of F.S. - 10.8736	
2.24	3.34	4.76	(.0000)	98.9937	98.9937	" " I.S. + 7.4895	
						Difference - 2.8921	
7.14	6.41	6.52	.0080	98.9991	98.9927	Check Line.	
1.77	1.39	4.16	.0070	98.9948	98.9935	Sum of F.S. + 10.8741	
6.22	7.15	7.47	.0716	98.9930	98.9940	" " F.S. - 7.4892	
4.24	5.13	5.41	.0516	98.9930	98.9930	Difference + 2.8949	
			7.4892			-2.9931	
						+2.8949	
						-0.0042 N. Error.	

PRECISE LEVEL SURVEY ALONG THE G.T.R.R.

Forward Line.

STATIONS.	BACK SIGHTS Wire Readings			Mean. Meters.
	Upper	Middle	Lower	
	Centimeters			
B.M.10, on S.E.cor.of Pier of Bridge over Grand River	15.00	16.22	17.40	1.6206
T.P.1, 200 feet east of Washington Ave. 30 ft. N. of tracks.	4.20	5.47	6.69	.5453
B.M.9, top of iron pedestal, S.W.cor. of S.W.post of Dep. Roof.				
T.P.2, 200 ft. east of Depot, South of tracks.	6.40	7.62	8.80	.7603
T.P.3, 200 feet east of Grand St. North of tracks.	9.00	11.02	12.20	1.1003
T.P.4,	17.02	19.19	20.40	1.99170
T.P.4,				
T.P.5,	17.90	19.20	20.47	1.9190
T.P.6,	15.30	15.78	16.23	1.5770
T.P.7,	12.59	13.49	14.36	1.3460
B.M.8, center of top of N.W. por- tion of retaining wall of bridge over Red Cedar				
				10.7278

Check Line.

B.M.8	12.59	13.49	14.36	1.3580
B.M.8.	7.84	9.45	10.99	.9426
T.P.7.	10.62	11.68	13.02	1.2833
T.P.6.	14.00	15.22	16.40	1.5206
T.P.5	9.58	10.82	12.12	1.0860
T.P.4	14.00	15.29	16.62	1.5276
T.P.3	14.10	15.60	16.57	1.5323
T.P.2.	13.52	14.72	15.67	1.4706
B.M.9, on bridge of G.T. over Grand				
T.P.1.	10.53	11.79	12.99	1.1766
B.M.10, on G.T. bridge over Grand.				10.4456

LINE BETWEEN BUNCH PANKS EIGHT AND TEN.

Forward Line.

FORE SIGNS Wire Readings.				ELEVATIONS.			
Upper	Middle	Lower	Mean	Original	Corrected	Per City	Above
Centimeters			Meters	Meters		Datum	Sea Level
				90.8750	90.8778		
11.89	13.17	14.39	1.3150	91.1806	91.1834	129.393	835.908
7.33	7.82	8.20	(.7810)	90.9449	90.9477	128.552	835.157
12.90	14.12	15.09	1.4000	90.3359	90.3289	124.525	833.110
14.18	15.43	16.62	1.5410	89.5455	89.5483	123.963	830.551
14.08	16.11	17.46	1.6020	89.0368	89.0404	122.292	828.877
9.43	10.78	12.01	1.0756	89.8782	89.8820	125.055	831.640
13.13	14.85	16.49	1.4823	90.3149	90.3191	126.489	833.074
12.12	13.69	15.19	1.3666	90.8253	90.8228	127.181	833.766
7.83	9.45	10.93	.9423 10.7318	90.9310	90.9361	129.513	835.008

Check Line.

				90.8750	90.8761	
12.89	13.47	14.76	1.3460	90.5807	90.5317	Forward Line
13.09	14.31	15.50	1.4303	90.2837	90.2847	Sum of B.S. +10.7612
17.95	19.23	20.51	1.9240	89.8203	89.8818	" " F.S. +10.7870
17.85	19.10	20.50	1.9083	89.0580	89.0595	Difference + 0.0560
8.96	10.35	11.60	1.0333	89.5523	89.5543	Check Line
6.58	7.61	8.81	.7823	90.3213	90.3238	Sum of F.S. +10.5084
7.26	8.51	9.05	(.8506)	90.9510	90.9538	" " B.S. +10.4450
5.01	6.20	7.52	.6176	91.1340	91.1368	Difference + 0.0000
13.59	14.88	16.10	1.4856 10.5064	90.8750	90.8778	- .0008
						+ .0560
						- .0048 K. Error.

PRECISE LEVEL LINE ON THE G.T.R.R.

Forward Line.

Station.	BACK SIGHTS			
	Wire Readings.			
	Upper	Middle	Lower	Mean.
	Centimeters			Meters.
B.M.8, on B.T. bridge over Grand.	42.10	13.33	14.54	1.3313
E.P.1.	13.03	14.35	15.50	1.4723
T.P.2.	14.91	15.02	17.22	1.6060
T.P.3.	15.10	16.41	17.62	1.6322
T.P.4.	15.30	16.51	17.70	1.6502
T.P.5.	12.76	14.22	15.62	1.4200
T.P.6.	15.11	16.39	17.61	1.6370
T.P.7.	18.55	19.50	20.82	1.9573

B.M.11, bolt head N.E. cor. of Pier
of Logan St. Bridge.

12.6743

Check Line.

B.M.11.	7.86	8.87	9.82	.8850
T.P.7.	10.20	12.22	13.41	1.2173
T.P.6.	45.20	45.03	16.32	1.5015
T.P.5.	13.42	14.88	15.62	1.4560
T.P.4.	15.12	14.33	15.42	1.4813
T.P.3.	13.18	14.53	15.52	1.4560
T.P.2.	13.12	14.50	15.76	1.4480
T.P.1.	15.46	16.02	16.56	1.6020
B.M.10.				

10.9772

LEVEL LINE BETWEEN B.M.ON LOGAN ST BRIDGE & B.M.8.

Forward Line.

FOUR SIGHTS				ELEVATIONS.			
Wire Readings				Original	Corrected	Per City Datum.	Above Sea Level Feet.
Upper	Middle	Lower	Mean				
Contimeters			Meters	Peters			
				90.8750	90.8778	123.823	834.908
11.92	13.13	14.31	1.3113	90.8968	90.8966	123.825	834.970
12.99	14.31	15.53	1.4233	90.9008	90.9004	123.825	834.980
13.00	14.21	15.37	1.4133	91.0275	91.0269	123.008	835.523
13.35	14.59	15.73	1.4533	91.2701	91.2693	123.605	836.120
13.35	14.73	15.79	1.4733	91.4408	91.4478	130.123	836.778
14.59	16.12	17.00	1.6103	91.2585	91.2573	123.866	836.751
10.90	12.21	13.46	1.2100	91.6771	91.6757	130.941	837.526
7.86	8.87	9.82	.8850 10.8022	92.7524	92.7478	134.458	841.043

Check Line.

				92.7424	92.7478
12.33	13.59	14.80	1.3575	91.6771	91.6754
15.05	16.29	17.62	1.6329	91.2627	91.2609
14.49	13.13	14.31	1.3113	91.4527	91.4507
15.12	16.35	17.62	1.6330	91.2757	91.2735
14.02	16.19	17.41	1.6173	91.0897	91.0873
14.99	16.27	17.49	1.6259	90.9207	90.9281
14.59	15.79	16.92	1.5766	90.7721	90.7624
12.97	14.26	15.36	1.4936	90.8205	90.8278

10.2772

Forward Line
Sum of B.S. + 12.6742
" " F.S. - 10.0018
Difference + 1.8714

Check Line.
Sum of F.S. - 21.6455
" " B.S. + 19.9779
Difference = 1.6626

+1.8714
-1.6626
+0.0031 N. Error.

PRECISE LEVEL SURVEY ON LOGAN ST. SOUTH.

Forward Line.

	BACK SIGHTS Wire Readings			Mean- Feet.
	Upper	Middle	Lower	
	Centimeters			
V.S. on N.W. cor, Logan & St. Joe.	42.13	13.12	14.05	1.5100
V.S. on N.E. cor. Logan & Main St.	32.82	30.83	32.26	3.0022
V.S. on N.W. cor. Logan & Williams.				
B.M. 12, on step of Logan St. School				
T.P. 1, between Williams & Isaac	3.76	4.64	5.48	.4626
T.P. 2, on cor. Logan & Isaac	.60	2.03	3.36	.2016
T.P. 3, south of " "	.30	1.18	2.00	.1160
T.P. 4. " " "	1.30	2.10	2.88	.0093
B.M. 11, on Logan St. Bridge.				5.3621
Check Line.				5.3621

Check Line.

B.M. 11.	23.20	24.61	25.80	2.4593
T.P. 4.	22.07	22.54	24.07	2.2526
T.P. 3.	22.52	30.72	31.24	3.0773
T.P. 2.	30.64	31.80	33.96	3.1460
T.P. 1.	12.23	13.67	15.00	1.3350
B.M. 12.				
V.S. on N.W. cor. Logan & Williams				
V.S. on N.E. cor. Logan & Main	2.20	3.02	3.78	.3000
V.S. on N.E. cor. Logan & St. Joseph.				13.3415

LINE BETWEEN B.R. 11 ON LOGAN ST. BRIDGE AND V.S. ON ST. JOSEPH.

Forward Line.

FORE SIGHTS				ELEVATIONS			
Wire Readings.				Original	Corrected	Per City	Above
Upper	Middle	Lower	Mean.				
Centimeters			Meters	Meters		Datum.	Sea Level
				100.1237	100.1265	158.665	885.250
2.25	3.05	3.32	.3940	101.1319	101.1339	161.970	888.555
.63	1.47	2.23	(.1430)	104.0783	104.0710	171.806	872.121
4.73	6.13	7.52	(.6153)	103.5932	103.6017	170.067	873.682
9.52	10.75	11.92	1.0730	103.1415	103.1440	168.565	875.180
27.26	28.20	29.00	2.3830	100.7151	100.7181	160.606	867.121
29.81	30.30	31.08	3.0656	97.8311	97.8346	151.147	857.752
29.62	29.54	29.37	2.9530	94.9241	94.9281	141.246	851.250
23.23	24.62	25.87	2.4600	92.7434	92.7478		
			12.7349				

Check Line.

				92.7436	92.7478	Forward Line.	
1.31	2.12	2.69	.2166	94.9968	94.9967	Sum of F.S. - 12.7349	
2.02	4.20	3.59	.3300	97.6685	97.6699	" " F.S. + 5.3301	
						Difference - 7.3337	
3.07	4.30	5.10	.4480	100.3179	100.3184	Forward	
5.85	6.53	7.52	.6163	102.8435	102.8473	Check Line.	
						Sum of B.S. + 12.3415	
4.70	6.12	7.48	(.6100)	103.6015	103.6025	" " B.S. - 5.9381	
						Difference + 7.3784	
.50	1.41	2.21	.1400	104.0715	104.0727	-7.3339	
						+7.3394	
29.33	30.20	31.21	3.0780	161.1335	161.1349	-0.0044 K. Error.	
12.12	13.10	14.04	1.3616	100.1240	100.1265		
			5.9331				

LINE BETWEEN V.S.ON ST.JOSEPH AND B.V.1.

Forward Line.

WIRE SIGHTS				ELEVATIONS			
Upper	Middle	Lower	Mean	Original	Corrected	Per City	Above
Centimeters				Meters		Batum	Sea Lev
						Feet.	
				100.1335	100.2353	152.865	865.250
3.35	4.35	5.33	.4340	100.8335	100.9357	161.057	867.64
.30	1.43	2.35	.1426	103.5712	103.6733	169.262	876.553
22.22	23.51	24.72	2.3510	103.135-	103.1352	165.422	872.057
12.32	13.32	14.45	1.8333	100.5335	100.5371	152.914	866.422
13.42	14.52	15.62	1.4593	100.0413	100.0433	152.739	864.274
7.21	9.37	10.57	.9350	99.8332	99.8333	157.252	864.47
8.04	9.31	10.33	.9130	100.2321	100.2333	165.576	862.101
2.41	2.32	2.33	.2326 9.0333	92.8335	92.9350	152.250	864.033

Check Line.

				99.9333	99.9350	
66.32	7.41	7.89	7.7496	100.2315	100.2332	Forward Line
11.52	12.43	13.30	1.3410	99.8333	99.8335	Sum of F.S.-9.09
6.33	7.35	8.33	.7630	100.0434	100.0441	" " B.S.+8.25
6.55	7.80	8.90	.7720	100.6244	100.6234	Difference -0.13
3.13	3.52	3.84	.3563	102.1347	102.1332	Check Line.
13.57	15.30	16.21	1.8393	103.1324	103.1349	Sum of B.S.+9.51
22.20	22.31	22.47	2.2193	100.8341	100.8371	" " F.S.-9.34
10.71	11.71	1 .95	1.1620 9.3375	100.1234	100.1265	Difference +0.36
						-0.1307
						+0.1276
						-0.0051 N.M

FRANKLIN L. L. DEPART ON HOLLIS ST. SOUTH.

Forward Line.

BACK SIGN S
Time 1.00 min. s
Upper Middle Lower Term.
Continuation of 1.00 min.

V.S. on N.E. cor. Logan & St. Joe.	13.75	11.45	12.45	1.1800
V.S. on N.E. cor. " " Hillsdale	17.51	20.11	20.44	2.6100
V.S. 1, on cor. of " " Lawrence	8.15	9.17	10.51	2.3600
V.S. on cor. of Logan & Malabar	1.75	2.00	2.00	.9100
V.S. 2, 222 West Street " "	9.07	8.02	10.75	.9010
V.S. on N.E. cor. Logan & Washington	6.40	7.75	8.05	.7710
V.S. on S.E. cor. Logan & Allegan	11.45	13.13	15.10	1.9100
V.S. on N.E. cor. Logan & Michigan	8.92	7.41	7.50	.7400
V.S. 1 on Michigan Ave. School.				8.9101

Check line.

V.S. 1.	9.44	9.00	9.00	.9000
V.S. cor. Michigan.	8.00	9.11	10.00	.9100
V.S. cor. Allegan.	7.15	8.13	10.44	.9100
V.S. cor. Washington.	12.51	13.51	14.00	1.9000
V.S. 2.	18.05	19.15	10.37	1.9100
V.S. cor. Malabar.	25.00	25.00	26.01	2.4000
V.S. 1.	4.00	5.00	5.00	.5000
V.S. cor. Hillsdale.	3.43	4.40	5.31	.4300
V.S. cor. St. Joseph.				0.1001

PROF. J. VAN DER WOUDE ON PHYSICAL ASPECT.

Forward Line.

Stations.	BACK STONE Tide Readings			
	Upper	Middle	Lower	Mean.
	Centimeters			Meters.
B.M. 1. on Mich. Ave. School water-table.	2.41	3.68	4.45	.3680
V.S. on cor. Michigan & Butler	1.68	3.68	2.85	.1933
V.S. on N.E. cor. Mich. & Short St.	1.73	3.68	4.12	.3090
V.S. on N.E. cor. Mich. & Spence St.	5.76	6.56	7.64	.6686
V.S. on S.E. cor. Mich. & Pine St.	9.40	10.36	11.36	1.0373
V.S. on S.E. cor. Mich. & Chestnut St.	11.21	12.22	12.17	1.2366
V.S. on S.E. cor. Mich. & Townsend	5.77	6.79	7.68	.6786
V.S. on S.E. cor. Townsend & Ottawa.	.16	1.68	1.97	.1686
V.S. on N.E. cor. Townsend & Spence.	5.88	7.02	8.10	.7666
B.M. 13. top step, south end of west entrance of City Hall.				3.2666

Check Line.

B.M. 11.	7.21	9.22	10.81	.9270
V.S. cor. Ottawa & Spence.	14.41	14.71	15.02	1.4700
V.S. cor. E & Townsend.	15.21	16.16	16.88	1.6086
E.E. cor. Michigan & E	8.21	10.09	11.31	1.0070
V.S. " " & Chestnut.	7.82	9.98	9.97	.8940
V.S. E " & Pine.	9.23	10.30	11.42	1.0370
V.S. " " & Spence	10.21	11.60	12.32	1.1570
V.S. " " & Short.	11.71	12.52	13.70	1.2560
V.S. " " & Butler.	22.53	10.64	11.37	1.0620
E.P. 220 feet West of Butler.	17.15	17.25	12.12	1.7683
B.M. 1.				12.1725

LINE BETWEEN D.M.1. AND D.M.15.07 CITY HALL SQHP.

Forward Line.

TIDE SIGHTS				REDUCTIONS			
Sight Readings				Original	Corrected	Per City	Above
Upper	Middle	Lower	Mean	Meters	Meters	Latent	Sea Level
Centimeters				Feet.			
				180.0000	180.0000	180.000	801.800
11.05	14.71	18.86	14.536	89.9874	89.9873	184.713	801.800
11.08	15.13	19.33	15.180	87.9481	87.9480	181.800	857.700
11.11	15.10	19.33	15.178	88.8053	88.8054	181.003	854.800
8.70	8.80	11.14	9.208	86.8882	86.8880	180.884	818.100
7.20	8.80	9.80	8.933	86.7105	86.7101	180.804	814.100
7.00	8.80	10.41	8.867	87.0400	87.0403	180.800	850.100
14.71	15.50	18.70	1.5560	88.1700	88.1701	181.856	811.000
13.10	14.90	18.01	1.4330	84.9110	84.9170	181.151	807.700
7.01	8.80	10.61	.8670	84.8010	84.8003	180.400	810.000
			10.7000				

Check Line.

				84.8010	84.8000	
8.80	7.00	8.11	.7000	84.7000	84.7000	Forward Line.
						Sum of L.M. = 10.7000
	.81	1.70	.6900	88.1700	88.1700	" " D.M. + 8.8000
						Difference = 5.4000
6.80	7.00	8.40	.7333	87.0000	87.0000	Check Line.
						Sum of L.M. = 10.1700
	1.00	8.10	(.1000)	87.0000	87.0000	" " L.M. = 8.8000
						Difference + 1.3700
11.80	12.80	13.70	1.3100	88.7100	88.7100	
						+8.4000
8.80	7.10	8.10	.7000	86.8000	86.8000	-7.0000
.70	8.00	8.00	.8000	87.0000	87.0000	+8.8000 Error.
.70	1.41	8.70	.1700	88.0000	88.0000	
8.80	8.80	11.80	.9000	89.0000	89.0000	
7.00	7.84	8.80	.7413	86.8000	86.8000	
			6.7000			

PRECISE LEVEL LINE ON THE G.T.R.R.

Forward Line.

Station.	BACK SIGHTS			
	Wire Readings.			
	Upper	Middle	Lower	Mean.
	Centimeters			Meters.
B.M.8, on V.T. bridge over Grand.	42.10	13.33	14.54	1.3316
E.P.1.	13.03	14.35	15.50	1.4323
T.P.2.	14.91	16.02	17.22	1.6060
T.P.3.	15.10	16.41	17.62	1.6332
T.P.4.	15.30	16.51	17.70	1.6503
T.P.5.	12.76	14.22	15.62	1.4200
T.P.6.	15.11	16.32	17.61	1.6376
T.P.7.	18.53	19.50	20.82	1.9573
B.M.11, bolt head N.E. cor. of Pier of Logan St. Bridge.				12.6743

Check Line.

B.M.11.	7.86	8.87	9.82	.8850
T.P.7.	10.20	12.22	13.41	1.2176
T.P.6.	45.02	45.03	16.32	1.5015
T.P.5.	13.40	14.63	15.62	1.4560
T.P.4.	13.12	14.33	15.42	1.4513
T.P.3.	13.18	14.53	15.52	1.4560
T.P.2.	13.18	14.50	15.76	1.4480
T.P.1.	15.46	16.02	16.53	1.6020
B.M.12.				10.9772

LEVEL LINE BETWEEN B.M. ON LOGAN ST BATHING & B.M. 8.

Forward Line.

FORE SIGHTS				ELEVATIONS.			
Wire Readings				Original	Corrected	Per City	Above
Upper	Middle	Lower	Mean	Meters	Meters	Datum.	Sea Level
Centimeters			Meters			Feet.	
				90.8750	90.8778	123.305	834.908
11.92	13.13	14.31	1.3113	90.8968	90.8966	123.305	834.970
12.99	14.31	15.53	1.4233	90.9008	90.9004	123.305	834.980
13.00	14.31	15.57	1.4195	91.0275	91.0369	123.008	835.525
13.36	14.53	15.73	1.4336	91.2701	91.2695	123.605	836.100
13.65	14.73	15.79	1.4716	91.4463	91.4478	123.193	836.778
14.59	16.12	17.00	1.6103	91.2585	91.2573	123.866	836.151
10.90	12.21	13.46	1.3100	91.6771	91.6757	120.941	837.586
7.86	8.87	9.82	.8850	92.7594	92.7478	124.458	841.045
			10.8022				

Check Line.

				92.7404	92.7478
18.33	19.59	20.80	1.9575	91.6771	91.6754
15.05	16.29	17.62	1.6399	91.2627	91.2609
14.49	13.13	14.31	1.3113	91.4527	91.4507
15.12	16.35	17.62	1.6330	91.2757	91.2735
14.02	16.19	17.41	1.6173	91.0897	91.0873
14.59	16.27	17.49	1.6250	90.9907	90.9881
14.59	15.79	16.92	1.5763	90.7721	90.7694
12.97	14.23	15.28	1.4936	90.8305	90.8278

10.9772

Forward Line

Sum of B.S. + 12.6740
 " " F.S. - 10.6018
 Difference + 1.8714

Check Line.

Sum of F.S. - 22.6455
 " " B.S. + 10.9772
 Difference = 1.6683

+1.8714
 -1.6683
 +0.0031 N. Error.

PRECISE LEVEL SURVEY ON LOGAN ST. SOUTH.

Forward Line.

	BACK SIGHTS Wire Readings			Mean. Feet.
	Upper	Middle	Lower	
	Centimeters			
V.S. on N.E. cor, Logan & St. Joe.	43.13	13.12	14.05	1.3100
V.S. on N.W. cor. Logan & Main St.	39.32	30.83	32.26	3.0828
V.S. on N.W. cor. Logan & Williams.				
B.M. 12, on step of Logan St. School				
T.P. 1, between Williams & Isaac	3.76	4.04	5.48	.4626
T.P. 2, on cor. Logan & Isaac	.66	2.43	3.36	.2016
T.P. 3, south of " "	.30	1.18	2.00	.1160
T.P. 4. " " "	1.30	2.10	2.83	.2005
B.M. 11, on Logan St. Bridge.				5.3021
Check Line.				5.3021

Check Line.

B.M. 11.	26.22	24.61	25.80	2.4503
T.P. 4.	22.67	22.54	24.07	2.2526
T.P. 3.	22.53	30.72	31.94	3.0773
T.P. 2.	30.64	31.80	33.00	3.1400
T.P. 1.	12.22	13.67	15.00	1.3350
B.M. 12.				
V.S. on N.W. cor. Logan & Williams				
V.S. on N.E. cor. Logan & Main	2.20	3.02	3.78	.3000
V.S. on N.E. cor. Logan & St. Joseph.				
				13.3415

LINE BETWEEN B.S. 11 ON LOGAN ST. BRIDGE AND V.S. ON ST. JOSEPH.

Forward Line.

FORE SIGHTS				ELEVATIONS			
Wire Readings.				Original Corrected		Per City	Above
Upper	Middle	Lower	Mean.	Meters		Datum.	Sea Level
							Feet.
				100.1337	100.1335	152.065	825.250
2.35	3.05	3.02	.3640	101.1319	101.1339	161.970	833.555
.63	1.47	2.23	(.1480)	104.0733	104.0710	171.903	872.191
4.73	6.10	7.32	(.6183)	103.5032	103.6017	170.067	873.682
9.52	10.75	11.22	1.0730	103.1415	103.1440	133.565	875.150
27.20	28.33	29.00	2.3300	100.7151	100.7181	100.000	867.191
29.61	30.32	31.08	3.0066	97.8311	97.8346	151.147	857.722
29.02	29.54	29.37	2.9530	94.9241	94.9281	141.046	851.250
23.23	24.62	25.37	2.4600	92.7434	92.7478		
			12.7649				

Check Line.

				92.7436	92.7478	Forward Line.	
1.31	2.12	2.59	.2106	94.9065	94.9067	Sum of F.S. - 12.7649	
2.02	4.20	3.52	.8300	97.6685	97.6689	" " F.S. + 5.9001	
						Difference - 7.7650	
3.07	4.50	5.50	.4000	100.3172	100.3184	Forward	
5.85	6.53	7.32	.6163	102.8465	102.8473	Check Line.	
						Sum of B.S. + 15.3415	
4.70	6.12	7.43	(.6100)	103.6015	103.6025	" " F.S. - 5.9001	
						Difference + 7.7764	
.85	1.41	2.21	.1400	104.0715	104.0727	-7.3022	
						+7.3794	
29.32	30.80	32.21	2.0780	101.1335	101.1349	-0.0044 K. Error.	
12.12	13.10	14.04	1.3006	100.1240	100.1256		
			5.9431				

LINE MEASUREMENT V.S.ON ST.JOSEPH AND B.V.1.

Forward Line.

WIRE SIGHTS				ELEVATIONS			
Wire Readings				Original	Corrected	Per City	Above
Upper	Middle	Lower	Mean	Meters	Meters	Datum	Sea Level
Centimeters						Feet.	
				100.1385	100.2132	152.865	865.250
3.95	4.35	5.02	.4040	100.8555	100.8557	161.057	867.647
.50	1.43	2.75	.1406	103.5719	103.5723	169.962	876.554
23.22	23.51	24.72	2.3510	102.1034	102.1889	168.422	872.067
18.50	18.92	19.45	1.8283	100.5665	100.5671	159.914	869.402
13.42	14.52	15.62	1.4503	100.0415	100.0423	153.369	864.274
7.91	9.37	10.57	.9250	99.8998	99.8998	157.262	864.474
6.04	9.31	10.32	.9190	100.2321	100.2323	165.576	862.161
9.41	9.82	9.92	.9086 9.0858	99.9235	99.9250	152.250	864.625

Check Line.

				99.9938	99.9950	Forward Line	
66.93	7.41	7.82	7.7496	100.2215	100.2232	Sum of F.S.-9.082	
11.52	12.43	13.30	1.2410	99.8998	99.8995	" " B.S.+8.952	
						Difference -0.130	
6.32	7.05	8.86	.7630	100.0434	100.0444	Check Line.	
6.53	7.80	8.93	.7720	100.6244	100.6234	Sum of B.S.+0.522	
						" " F.S.-9.307	
3.13	3.52	3.84	.3563	102.1847	102.1862	Difference +0.202	
13.57	15.30	16.91	1.5893	103.1594	103.1549	-0.1567	
						+0.1272	
23.90	22.11	22.47	2.5193	100.8541	100.8571	-0.0051 N. Error	
10.71	11.71	11.65	1.1620 9.8975	100.1234	100.1265		

PRICES L.A.M. MARKET OF 1921 BY TOWN.

Forward Line.

L.A.M. 11213
 Time 11213
 Upper Middle Lower 11213
 Combination 11213

V.S. on N.W. cor. Logan & St. Joe.	10.00	11.00	12.00	1.1000
V.S. on N.W. cor. " " Hillside	17.00	18.00	19.00	2.0000
V.S. 1, on cor. of " " Kenwood	8.00	9.00	10.00	1.0000
V.S. on cor. of Logan & Kalamazoo	1.00	2.00	3.00	.0100
V.S. 2, 100 feet West " "	9.00	10.00	11.00	.0100
V.S. on N.W. cor. Logan & Washington	6.00	7.00	8.00	.7700
V.S. on S.W. cor. Logan & Allegan	11.00	12.00	13.00	1.0000
V.S. on N.W. cor. Logan & Michigan	8.00	9.00	10.00	.7500
V.S. 1 on Michigan Ave. School.				8.0001

Check Line.

V.S. 1.	9.00	10.00	11.00	.9000
V.S. cor. Michigan.	8.00	9.00	10.00	.9100
V.S. cor. Allegan.	7.00	8.00	9.00	.9100
V.S. cor. Washington.	12.00	13.00	14.00	1.0000
V.S. 1.	10.00	11.00	12.00	1.0100
V.S. cor. Kalamazoo.	25.00	26.00	27.00	2.4000
V.S. 1.	4.00	5.00	6.00	.5000
V.S. cor. Hillside.	3.00	4.00	5.00	.4000
V.S. cor. St. Joseph.				0.0001

PLACED IN THE MOUNTAIN OF HYDROLOGICAL ANALYSIS.

Forward Line.

Stations.	BACK STOPS			Mean. Meters.
	Vine Readings			
	Upper Centimeters	Middle	Lower	
B.M. 1. on Mich. Ave. School water-table.	2.41	3.68	4.45	.3660
V.S. on cor. Michigan & Butler	1.00	3.00	2.85	.1333
V.S. on N.E. cor. Mich. & Short St.	1.79	3.00	4.12	.3220
V.S. on N.E. cor. Mich. & Sycamore St.	5.76	6.56	7.64	.6680
V.S. on S.E. cor. Mich. & Pine St.	9.40	10.36	11.86	1.0373
V.S. on S.E. cor. Mich. & Chestnut St.	11.31	12.23	12.17	1.3200
V.S. on S.E. cor. Mich. & Townsend	5.77	6.72	7.68	.6750
V.S. on S.E. cor. Townsend & Ottawa.	.19	1.08	1.97	.1080
V.S. on N.E. cor. Townsend & Seymour.	5.88	7.02	8.10	.7000
M.M. 13. top stop, south end of west entrance of City Hall.				5.2636

Check Line.

B.M. 11.	7.01	9.22	10.81	.9370
V.S. cor. Ottawa & Seymour.	13.41	14.71	15.93	1.4700
V.S. cor. " " Townsend.	15.21	16.16	16.88	1.6086
V.S. cor. Michigan & " "	8.01	10.00	11.31	1.0070
V.S. " " & Chestnut.	7.00	8.88	9.97	.8940
V.S. " " & Pine.	9.93	10.70	11.42	1.0370
V.S. " " & Sycamore	10.21	11.60	12.92	1.1573
V.S. " " & Short.	11.71	12.52	13.50	1.2580
V.S. " " & Butler.	12.53	13.64	14.87	1.3320
V.S. 200 feet west of Butler.	17.15	17.65	18.13	1.7653
B.M. 1.				12.1725

LINE BETWEEN B.M. 1. AND B.M. 15.03 CITY RAIL STAMP.

Forward Line.

TOWER SIGHTS				REDUCTIONS			
Sight Readings				Original	Corrected	Per City	Above
Upper	Middle	Lower	Mean	Meters	Meters	Latent	Sea Level
Centimeters				Feet.			
				143.0000	143.0000	143.000	861.871
11.07	14.71	13.16	1.3276	62.6274	62.6273	154.713	861.140
11.13	14.73	13.73	1.3276	67.3121	67.3120	151.703	857.710
11.14	14.73	13.73	1.3276	62.6274	62.6273	147.003	854.760
8.52	8.52	11.14	.6672	61.6662	61.6662	143.004	818.141
7.32	8.52	8.52	.6672	62.7405	62.7401	147.104	814.117
7.32	8.52	10.41	.6672	67.6412	67.6403	145.803	859.110
14.71	15.50	14.73	1.5276	66.1700	66.1701	143.356	811.061
13. 5	14.02	13.21	1.4276	64.9102	64.9078	141.151	807.710
7.31	8.52	10.61	.6672	64.5012	64.5003	140.403	811.001
			10.7000				

Check Line.

				64.5012	64.5003		
5.32	7.02	8.11	.7663	64.7662	64.7657	Forward Line.	
						Sum of B.M. = 12.6660	
	.54	1.72	.6662	66.1712	66.1707	" " B.M. + 5.1000	
						Difference = 5.4004	
6.55	7.52	8.42	.7512	67.6512	67.6503	Check Line.	
						Sum of B.M. + 12.1700	
	1.02	2.12	(.1662)	67.0112	67.0103	" " B.M. = 6.0000	
						Difference + 5.1667	
11.32	12.82	13.72	1.5012	62.7012	62.7003		
8.32	7.12	8.12	.7662	66.0062	66.0053	+5.4007	
						-5.1662	
.72	2.03	3.25	.1662	67.6662	67.6653	+2.0000 Error.	
.70	1.91	2.70	.1700	68.0400	68.0412		
8.32	8.37	11.12	.9160	63.0160	63.0153		
7.32	7.34	8.33	.7000	63.7000	63.7000		
			6.7420				

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