1922

Missouri School of Mines, Civil Engineering Department survey data. Including the adjustment of the triangulation net on the M.S.M. Campus

Joe Beaty Butler

Roy Oscar Erickson

Wayne Shannon Frame

Department:

MISSOURI SCHOOL OF MINES,

CIVIL ENGINEERING DEPARTMENT SURVEY DATA.

INCLUDING

THE ADJUSTMENT OF THE TRIANGULATION NET

ON THE M.S.M. CAMPUS.

BY

JOE B. BUTLER

(ASSISTANTS R.O.ERICKSON AND W.S.FRAME)

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY, UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

DEGREE OF

CIVIL ENGINEER

Rolla, MO.

1922.

Approved by _____

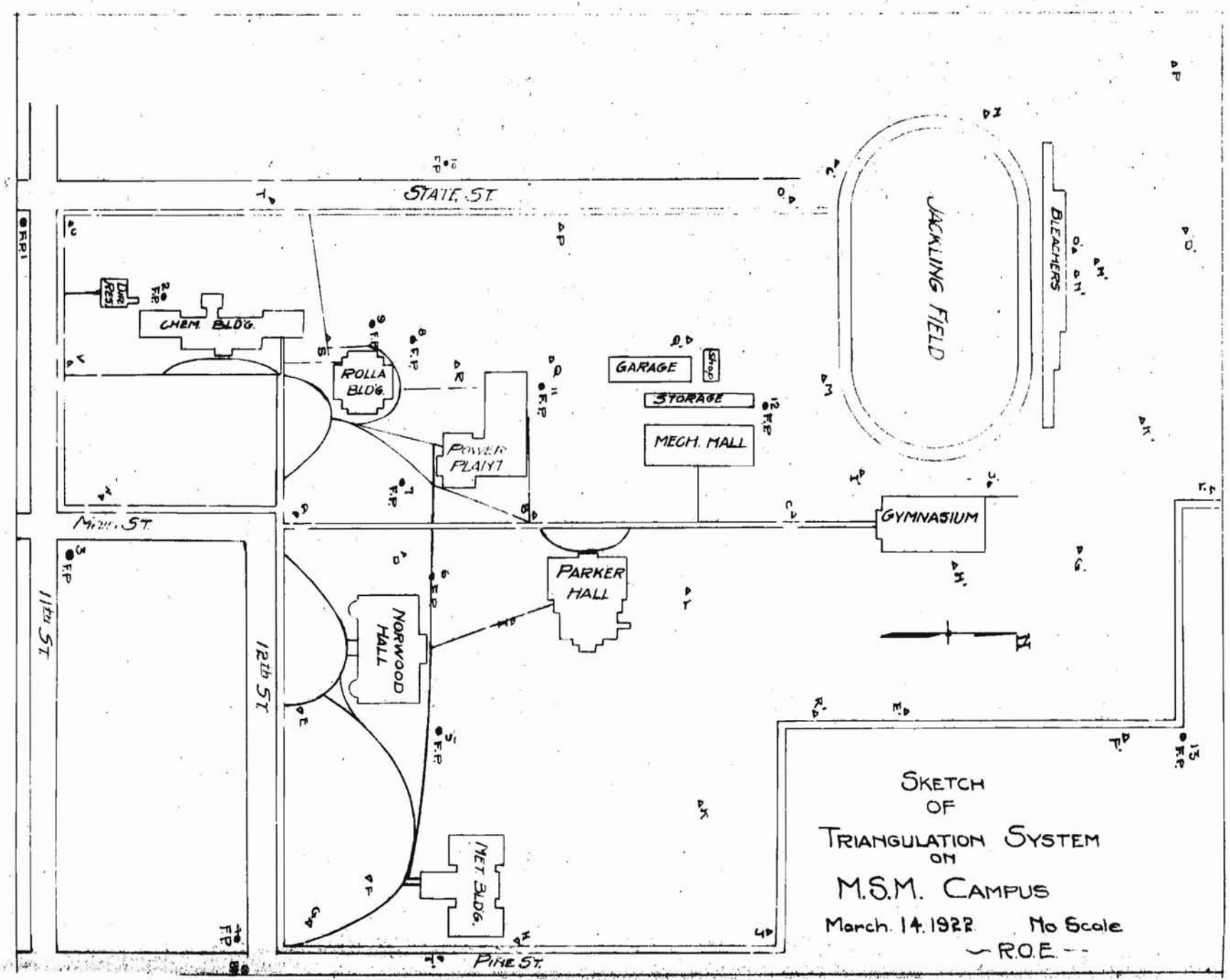
Professor of Civil Engineering.

M.S.M. C.E. Dept. Survey Data.

Part 1, Working Tables.

Part 2, Adjustment Data.

Part 3, Precise Adjustment.


STATE ST.
JACKLING FIELD
BLEACHERS
CHEM. BLD'G.
DYNAMO
ROLLA BLD'G.
POWER PLANT
GARAGE
STORAGE
MECH. HALL
GYMNASIUM
PARKER HALL
NORWOOD HALL
MET. BLD'G.
MINE ST.
11th ST.
12th ST.
PINE ST.
F.P. 1
F.P. 2
F.P. 3
F.P. 4
F.P. 5
F.P. 6
F.P. 7
F.P. 8
F.P. 9
F.P. 11
F.P. 12
F.P. 13
N
SKETCH
OF
TRIANGULATION SYSTEM
ON
M.S.M. CAMPUS
March. 14. 1922. No Scale
~ R.O.E. ~

ANGLES.

-"A"-

WAV	=	24	44	20
S	=	97	52	20
R	=	129	06	00
B	=	174	16	40
D	=	191	35	40
I	=	205	48	20
E	=	262	01	00
VAS	=	73	08	00
R	=	104	21	40
B	=	149	32	20
D	=	166	41	20
I	=	181	02	00
E	=	237	16	40
W	=	335	15	40
SAR	=	31	13	40
B	=	76	24	20
D	=	93	33	20
I	=	107	54	00
E	=	184	08	40
W	=	282	07	40
RAB	=	45	10	40
D	=	62	19	40
I	=	76	40	20
E	=	132	55	00
W	=	230	54	00
BAD	=	17	09	00
I	=	31	29	40
E	=	87	44	20
W	=	185	43	20
DAI	=	14	20	40
E	=	70	35	20
W	=	168	34	20
IAE	=	56	14	40
W	=	154	13	40
EAW	=	97	59	00

-"B"-

ABC	=	180	00	00
L	=	314	14	40
I	=	282	03	00
D	=	350	14	10
CBL	=	34	14	40
I	=	102	03	00
D	=	170	14	10
A	=	180	00	00
LBI	=	67	48	20
D	=	135	29	30
A	=	145	45	20

-"B"-Cont.

IBD	=	68	11	10
A	=	77	57	00
DBA	=	09	45	35

-"C"-

BCM	=	105	20	50
I'	=	146	18	40
E'	=	246	28	30
R'	=	263	29	10
L-	=	315	14	20
D	=	356	16	00
MCI'	=	40	55	50
E'	=	141	05	40
R'	=	158	08	20
L	=	209	53	30
D	=	250	55	10
B	=	254	39	10
I'CE'	=	100	09	50
RS	=	117	12	30
L	=	168	57	40
D	=	208	58	20
B	=	213	43	30
E'CR'	=	17	02	40
L	=	68	47	50
D	=	108	49	30
B	=	113	33	30
R'CL	=	51	45	10
D	=	92	46	50
B	=	96	30	50
LCD	=	41	01	40
B	=	44	45	40
DCB	=	03	44	00

-"D"-

ADR	=	94	17	50
B	=	153	05	10
C	=	159	07	00
I	=	202	10	30
E	=	275	49	00
RDB	=	58	47	20
C	=	84	49	10
I	=	107	52	40
E	=	181	31	10
A	=	365	42	10
BDC	=	08	01	50
I	=	49	05	20
E	=	122	43	50
A	=	306	54	50
CDI	=	43	03	30
E	=	116	42	00
A	=	200	53	00
IDE	=	73	38	30
A	=	157	49	30
EDA	=	84	11	00

-"E"-

AER	=	34	27	50
D	=	35	13	40
F	=	152	51	20
G	=	179	58	00
RED	=	00	45	50
F	=	128	23	30
G	=	155	30	10
A	=	335	32	10
DEF	=	127	37	40
G	=	154	44	20
A	=	334	46	20
FEG	=	37	08	40
A	=	207	08	40
GEA	=	180	02	00

-"F"-

IFT'	=	108	43	30
G	=	173	37	00
E	=	292	04	50
T'FG	=	64	48	40
E	=	183	16	30
I	=	251	11	40
GFE	=	118	27	50
I	=	186	33	00
EFI	=	67	55	10

-"G"-

EGF	=	34	25	30
H	=	99	13	30
T'	=	108	05	10
FGH	=	64	48	00
T'	=	73	39	40
E	=	325	34	30
HGT'	=	08	51	40
E	=	280	46	30
T'GE	=	251	54	50

ANGLES-CONTINUED.

-"H"-

T'HG	=	15	42 30
I	=	98	16 00
L	=	127	41 50
K	=	147	36 40
J	=	187	42 40
GHI	=	82	33 30
L	=	111	59 20
K	=	131	54 10
J	=	172	00 10
T'	=	344	17 30
IHL	=	29	25 50
K	=	49	20 40
J	=	89	36 40
T'	=	261	44 00
LHK	=	19	54 50
J	=	60	00 50
T'	=	232	18 10
KHJ	=	40	06 00
T'	=	212	23 20
JHT'	=	172	17 20

-"I"-

AID	=	07	49 50
B	=	70	33 30
K	=	187	02 10
H	=	237	59 40
G	=	275	09 40
F	=	277	01 10
DIB	=	62	43 30
K	=	179	12 30
H	=	230	09 50
G	=	287	19 50
F	=	309	11 30
A	=	353	10 10
BIK	=	116	28 50
H	=	167	26 30
G	=	204	36 30
F	=	306	27 50
A	=	389	26 40
KIH	=	50	57 30
G	=	68	07 30
F	=	89	58 50
A	=	173	57 50
HIG	=	37	10 10
F	=	39	01 30
A	=	132	00 30
GIF	=	01	51 30
A	=	84	50 30
FIA	=	82	58 50

-"J"-

HJK	=	57	52 20
R'	=	100	36 50
KJR'=		42	40 30
H	=	302	07 40
R'JH	=	259	23 10

-"K"-

HKI	=	79	41 50
L	=	132	32 40
C	=	152	45 00
R'	=	195	21 00
E'	=	204	47 20
J	=	277	58 20
IKL	=	52	40 50
C	=	73	03 10
R'	=	115	39 10
E'	=	125	05 30
J	=	198	16 30
H	=	330	18 10
LKC	=	20	23 20
R'	=	62	58 30
E'	=	73	24 40
J	=	145	35 40
H	=	227	37 20
CKR'	=	42	36 00
E'	=	52	02 30
J	=	125	13 30
H	=	207	15 00
R'KE'=		09	28 30
J	=	82	37 30
H	=	164	39 00
E'KJ	=	73	11 00
H	=	155	13 40
JKH	=	82	01 40

-"L"-

KLH	=	37	42 40
B	=	123	02 00
M	=	208	55 50
C	=	224	01 40
H'	=	257	55 30
E'	=	297	57 20
R'	=	308	16 00
HLB	=	95	19 30
M	=	181	13 10
C	=	196	19 00
H'	=	230	12 40
E'=		270	14 40
R'	=	280	33 20
K	=	332	17 30

-"L" Cont.

BLM	=	85	53 50
C	=	100	59 40
H'	=	134	53 20
E'	=	174	55 30
R'	=	185	14 00
K	=	236	58 00
MLC	=	15	05 50
H'	=	48	59 30
E'	=	89	01 30
R'	=	99	30 10
K	=	151	04 10
CLH'	=	33	53 40
E'	=	73	55 40
R'	=	94	14 30
K	=	135	58 30
H'LE'=		40	02 00
R'=		50	30 40
K	=	102	04 40
E'LR'=		10	18 40
K	=	62	02 40
R'LK	=	51	44 00

ANGLES-CONTINUED.

-"M"-

CMO	=	149	09 00
C'	=	167	44 50
N	=	197	03 50
O'	=	235	02 00
N'	=	239	35 40
M'	=	240	41 00
D'	=	241	26 00
K'	=	263	47 10
J'	=	292	44 20
I'	=	330	02 30
OMC'	=	18	35 50
N	=	47	54 50
O'	=	85	53 00
N'	=	90	26 40
M'	=	91	32 00
D'	=	92	17 00
K'	=	114	38 10
J'	=	143	35 20
I'	=	180	53 30
C	=	210	51 00
C'MN	=	29	19 00
O'	=	67	17 10
N'	=	71	50 50
M'	=	72	56 10
D'	=	73	41 10
K'	=	96	02 20
J'	=	124	59 30
I'	=	162	17 40
C	=	192	15 10
NMO'	=	37	58 10
N'	=	42	31 50
M'	=	43	37 10
D'	=	44	22 10
K'	=	66	43 20
J'	=	95	40 30
I'	=	132	58 40
C	=	162	56 10
O'MN'	=	04	33 40
M'	=	05	39 00
D'	=	06	24 00
K'	=	28	45 10
J'	=	57	43 20
I'	=	95	00 30
C	=	124	58 00

-"M"-

N'MM'	=	01	05 20
D'	=	01	50 20
K'	=	24	11 30
J'	=	53	08 40
I'	=	90	26 50
C	=	120	24 20
M'MD'	=	00	45 00
K'	=	23	06 10
J'	=	52	03 20
I'	=	89	21 30
C	=	119	19 00
D'MK'	=	22	21 10
J'	=	51	18 20
I'	=	88	36 30
C	=	118	34 00
K'MJ'	=	28	57 10
I'	=	66	15 20
C	=	96	12 50
J'MI'	=	37	18 10
C	=	67	15 40
I'MC	=	29	57 30

ANGLES-CONTINUED.

-"N"-

C'NP'	=	196	54	20
D'	=	228	51	10
N'	=	256	15	30
O'	=	258	23	50
N'	=	261	13	30
J'	=	287	47	40
I'	=	307	24	40
M	=	318	40	30
P'ND'	=	31	56	50
M'	=	59	21	10
O'	=	61	29	30
N'	=	64	18	10
J'	=	90	53	20
I'	=	110	30	20
M	=	121	46	10
C'	=	163	05	40
D'NM'	=	27	24	20
O'	=	29	32	40
N'	=	32	21	20
J'	=	58	56	30
I'	=	78	33	30
M	=	89	49	20
C'	=	131	08	50
M'NO'	=	02	08	20
N'	=	04	57	00
J'	=	31	32	10
I'	=	51	09	10
M	=	62	25	00
C'	=	103	44	30
O'NN'	=	02	48	40
J'	=	29	23	50
I'	=	49	00	50
M	=	60	18	40
C'	=	101	36	10
N'NJ'	=	26	35	10
I'	=	46	12	10
M	=	57	28	00
C'	=	98	47	30
J'NI'	=	19	37	00
M	=	30	52	50
C'	=	72	12	20
I'NM	=	11	15	50
C'	=	52	35	20
MNC'	=	41	19	30

-"O"-

C'OM	=	104	43	00
Q	=	173	51	20
R	=	183	48	20
P	=	206	00	00
MOQ	=	69	08	20
R	=	79	05	20
P	=	101	17	00
C'	=	255	17	00
QOR	=	09	57	00
P	=	32	08	40
C'	=	186	08	40
ROP	=	22	11	40
C'	=	176	11	40
POC'	=	154	00	00

ANGLES-CONTINUED.

-"P"-

OPQ'	=	36	21	10
Q	=	98	04	30
R	=	129	19	10
S	=	150	00	50
T	=	188	18	20
Q'PQ	=	61	43	20
R	=	92	58	00
S	=	113	39	40
T	=	151	57	10
O	=	323	38	50
QPR	=	31	14	40
S	=	51	56	20
T	=	90	13	50
O	=	261	55	30
RPS	=	20	41	40
T	=	58	59	10
O	=	230	40	50
SPT	=	38	17	30
O	=	209	59	10
TPO	=	171	41	40

-"Q"-

SQR	=	05	57	20
P	=	93	12	10
Φ	=	142	59	00
Q'	=	151	59	10
L	=	240	19	30
RQP	=	87	14	50
O	=	137	01	40
Q'	=	146	01	50
L	=	234	22	10
S	=	354	02	40
PQO	=	49	46	50
Q'	=	58	47	00
L	=	147	07	20
S	=	266	47	50
OQQ'	=	00	00	10
L	=	97	20	30
S	=	217	01	00
Q'QL	=	88	20	20
S	=	208	00	50
LQS	=	119	40	30

-"R"-

QRD	=	104	50	10
E	=	105	35	20
A	=	128	12	50
S	=	169	36	40
T	=	213	35	50
P	=	298	29	30
O	=	326	58	40
Q'	=	338	20	30
DRE	=	00	45	10
A	=	23	22	40
S	=	64	46	30
T	=	108	45	40
P	=	193	39	20
O	=	222	08	30
Q'	=	233	30	20
Q	=	255	09	50
ERA	=	22	37	30
S	=	64	01	20
T	=	108	00	30
P	=	192	54	10
O	=	221	23	20
Q'	=	232	45	10
Q	=	254	24	40
ARS	=	41	23	50
T	=	85	23	00
P	=	170	16	40
O	=	198	45	50
Q'	=	210	07	40
Q	=	231	47	10
SRT	=	43	59	10
P	=	128	52	50
O	=	157	22	00
Q'	=	168	43	50
Q	=	190	23	20
TRP	=	84	53	40
O	=	113	32	50
Q'	=	124	44	40
Q	=	146	24	10
PRO	=	28	29	10
Q'	=	39	51	00
Q	=	61	30	30
ORQ'	=	11	21	50
Q	=	33	01	20
Q'RQ	=	21	39	30

-"S"-

QSE	=	93	51	20
A	=	102	56	50
W	=	152	00	10
V	=	175	11	20
T	=	246	32	30
P	=	325	08	40
R	=	355	34	20
ESA	=	09	05	30
W	=	58	08	50
V	=	81	20	00
T	=	152	41	10
P	=	231	17	20
R	=	261	43	00
Q	=	266	08	40
ASW	=	49	03	20
V	=	72	14	30
T	=	143	35	40
P	=	222	11	50
R	=	252	37	30
Q	=	257	03	10
WSV	=	23	11	10
T	=	94	32	20
P	=	173	08	30
R	=	203	34	10
Q	=	207	59	50
VST	=	71	21	10
P	=	149	57	20
R	=	180	23	00
Q	=	184	48	40
TSP	=	78	36	10
R	=	109	01	50
Q	=	113	27	30
PSR	=	30	25	40
Q	=	34	51	20
RSQ	=	04	25	40

ANGLES-CONTINUED.

-"T"-

PTQ = 27 27 30
R = 36 07 10
S = 63 06 10
U = 171 49 40
O = 356 26 50
QTR = 08 39 40
S = 35 38 40
U = 144 22 10
O = 328 59 20
P = 332 32 30
RTS = 26 59 00
U = 135 42 30
O = 320 19 40
P = 328 52 50
STU = 108 43 30
O = 293 20 40
P = 296 53 50
UTO = 184 37 10
P = 188 10 20
UTP = 03 33 10

-"U"-

TUV = 91 19 50
T = 360 00 00
VUT = 268 40 10

-"V"-

UVS = 88 35 30
A = 123 13 00
W = 177 18 50
SVA = 34 37 30
W = 88 43 20
U = 271 24 30
AVW = 54 05 50
U = 236 47 00
WVU = 182 41 10

-"W"-

VWS = 68 05 10
A = 101 09 50
SWA = 33 04 40
V = 291 54 50
AWV = 258 50 10

="C""-

NC'D'= 32 18 30
D'= 43 24 10
M'= 45 18 30
N'= 47 23 00
K'= 54 04 20
J'= 83 12 20
I'= 103 39 20
M = 109 21 30
O = 166 01 30
D'C'O'= 11 05 40
M' = 13 00 00
N' = 15 04 30
K' = 21 45 50
J' = 50 53 50
I' = 71 20 50
M = 77 03 00
O =133 43 00
N =227 41 30
O'C'M'= 01 54 20
N' = 03 58 50
K' = 10 40 10
J' = 39 48 10
I' = 60 15 10
M = 65 57 20
O =122 37 20
N =316 35 50
M'C'N'= 02 04 30
K' = 08 45 50
J' = 37 53 50
I' = 58 20 50
M = 64 03 00
O =120 43 00
N =314 41 30
N'C'K'= 06 41 20
J' = 35 49 20
I' = 56 16 20
M = 61 58 30
O =118 38 30
N =312 37 00
K'C'J'= 29 08 00
I' = 49 35 00
M = 55 17 10
O =111 57 10
N =305 55 40

ANGLES-CONTINUED.

-"C""Cont.

J'C'I'= 20 27 00
M = 26 09 10
O = 82 49 10
N = 276 47 40
I'C'M = 05 42 10
O = 62 22 10
N = 256 20 40
MC'O = 56 40 00
N = 250 38 30
OC'N = 193 58 30

-"D"-

P'D'L'= 168 39 40
K'= 193 17 10
J'= 224 33 00
I'= 237 37 00
M = 251 09 50
M'= 252 37 20
N'= 254 05 10
O'= 261 45 20
C'= 280 26 20
N = 296 57 50
L'D'K'= 24 37 30
J'= 55 53 20
I'= 68 57 20
M = 82 30 10
M'= 83 57 40
N'= 85 25 30
O'= 93 05 40
C'= 111 46 40
N = 128 18 10
P'= 191 20 20
K'D'J'= 31 15 50
I'= 44 19 50
M = 57 52 40
M'= 59 20 10
N'= 60 48 00
O'= 68 28 10
C'= 87 09 10
N = 103 40 40
P'= 166 42 50
J'D'I'= 13 04 00
M = 26 36 50
M'= 28 04 20
N'= 29 32 10
O'= 37 12 20

-"D"- Cont.

J'D'C'= 55 53 20
N = 72 24 50
P'= 135 27 00
I'D'M = 13 32 50
M'= 15 00 20
N'= 16 28 10
O'= 24 08 20
C'= 42 49 20
N = 59 20 50
P'= 122 23 00
MD'M' = 01 27 30
N'= 02 55 20
O'= 10 35 30
C'= 29 16 30
N = 45 48 00
P'= 108 50 10
M'D'M'= 01 27 50
O'= 09 08 00
C'= 27 49 00
N = 44 20 30
P'= 107 23 40
N'D'O'= 07 40 10
C'= 26 21 10
N = 42 52 40
P'= 105 54 50
O'D'C'= 18 41 00
N = 35 12 30
P'= 98 14 40
C'D'N = 16 31 30
P'= 79 33 40
ND'P' = 63 02 10

ANGLES-CONTINUED.

-"E'"-

RE'L = 35 21 10
C = 62 38 20
H'= 109 58 20
G'= 133 27 10
F'= 178 39 30
K =339 49 40
LE'C= 37 17 10
H'= 84 37 10
G'= 108 06 00
F'= 153 18 20
K = 314 28 30
R'= 334 38 50
CE'H'= 47 20 00
G'= 70 48 50
F'= 116 01 10
K = 277 11 20
R' =297 21 40
H'E'G'= 23 28 50
F' = 68 41 10
K =229 51 20
R'= 250 01 40
G'E'F'= 45 13 20
K =206 23 30
R' =226 32 50
F'E'K= 161 10 10
R'= 181 20 30
KE'R'= 20 10 20

-"F'"-

E'F'H'= 48 03 00
J'= 63 26 20
G'= 80 06 00
E'=360 00 00
H'F'J'= 15 34 20
G'= 32 04 00
E'=311 58 00
J'F'G'= 16 39 40
E'=296 33 40
G'F'E'=279 54 00

-"G'"-

E'G'H'= 36 45 50
J'= 78 28 50
D'=165 12 10
L'=209 42 30
F'=305 18 20
H'G'J'= 41 43 00
D'=128 26 20
L'=172 56 40

-"G'" Cont.

H'G'F'= 268 32 30
E'= 323 14 10
J'G'D'= 86 43 20
L'= 131 13 40
F'= 226 49 30
E'= 281 31 10
D'G'L'= 44 30 20
F'= 140 06 10
E'= 194 47 50
L'G'F'= 95 35 50
E'= 150 17 30
F'G'E'= 54 41 40

-"H'"-

E'H'R'= 18 01 20
K'= 37 10 20
L'= 55 20 50
G'= 240 14 40
F'= 296 43 10
R'H'K'= 09 09 00
L = 37 19 30
G'= 222 13 20
F'= 278 41 50
E'= 341 58 40
KH'L = 28 10 30
G'= 213 04 20
F'= 269 32 50
E'= 332 49 40
LH'G' = 184 53 50
F'= 241 22 20
E'= 304 39 10
G'H'F'= 56 28 30
E'= 119 45 20
F'H'E'= 63 16 50

ANGLES-CONTINUED.

-"I'"-

J'I'C = 136 41 40
M = 245 48 30
C'= 257 47 30
N = 281 33 50
P'= 309 18 10
O'= 310 37 50
N'= 314 05 00
M'= 316 27 30
D'= 323 39 10
K'= 343 30 10
CI'M = 109 06 40
C'= 121 05 50
N = 144 52 10
P' =172 33 30
O'= 173 56 10
N'= 177 23 20
M'= 179 45 50
D'= 186 57 30
K'= 306 48 30
J'= 223 18 20
MI' C'= 11 59 10
N = 35 45 30
P'= 63 26 50
O'= 64 49 30
N'= 68 16 40
M'= 70 39 10
D'= 77 50 50
K'= 97 41 50
J'= 114 11 40
C'IN= 23 46 20
P'= 51 27 40
O'= 52 50 20
N'= 56 17 30
M'= 58 40 00
D'= 65 51 40
K'= 85 42 40
J'= 102 12 30
NI'P'= 27 41 20
O'= 29 04 00
N'= 32 31 10
M'= 34 53 40
D'= 42 05 20
K'= 61 56 20
J'= 78 26 10

-"I'" Cont.

P'I'O'= 01 22 40
N'= 04 49 50
M'= 07 12 20
D'= 14 24 00
K'= 34 15 00
J'= 51 44 50
O'I'N'= 03 27 10
M'= 05 49 40
D'= 13 01 20
K'= 32 53 20
J'= 49 22 10
N'I'M'= 02 22 30
D'= 09 34 10
K'= 29 25 10
J'= 45 55 00
M'I'D'= 07 11 40
K'= 27 02 40
J'= 43 32 30
D'I'K'= 19 51 00
J'= 36 20 50
K'I'J'= 16 29 50

-"J'"-

I'J'M= = 28 29 40
C' = 57 21 30
N = 81 57 10
O' =105 35 50
N' =108 08 10
M' =112 52 10
D' 130 35 10
K' =153 44 10
G' =206 09 10
MJ'C' = 28 51 50
N = 53 27 30
O' = 77 06 10
N' = 79 38 30
M' = 84 22 30
D' =102 05 30
K' =125 14 30
G' =177 39 30
I' =331 30 20

ANGLES-CONTINUED.

-"J'"-Cont.

C'J'M =	24	35	40
O'=	48	14	20
N'=	50	46	40
M'=	55	30	40
D'=	73	13	40
K'=	96	22	40
G'=	148	47	40
I'=	302	38	30
NJ'O' =	23	38	40
N'=	26	11	00
M'=	30	55	00
D'=	48	38	00
K'=	71	47	00
G'=	124	12	00
I'=	278	02	50
O'J'N'=	02	32	20
M'=	07	16	20
D'=	24	59	20
K'=	48	08	20
G'=	100	33	20
I'=	354	24	10
N'J'M'=	04	44	00
D'=	22	27	00
K'=	45	36	00
G'=	98	01	00
I'=	251	51	50
M'J'D'=	17	43	00
K'=	40	52	00
G'=	93	17	00
I'=	247	07	50
D'J'K'	23	09	00
G'=	75	34	00
I'=	239	24	50
K'J'G'=	52	25	00
I'=	206	15	50
G'J'I'=	153	50	50

-"K""-

L'K'J'=	118	19	50
I'=	128	05	50
M =	144	07	40
N'=	184	09	20
O'=	188	38	40
M'=	190	04	20
D'=	243	55	00
J'K'I'=	09	46	00
M =	24	47	50
N'=	65	49	30
O'=	70	18	50

-"K'"-CONT.

J'K'M'=	71	44	30
D'=	125	35	10
L'=	241	40	10
I'K'M =	16	01	50
N'=	56	03	30
O'=	60	32	50
M'=	61	58	30
D'=	115	49	10
L'=	231	54	10
MK'N' =	40	01	40
O'=	44	31	00
M'=	45	56	40
D'=	99	47	20
L'=	215	52	20
N'K'O' =	04	29	20
M'=	05	55	00
D'=	59	45	40
L'=	175	50	40
O'K'M' =	01	25	40
D'=	55	16	20
L'=	171	21	20
M'K'D'=	53	50	40
L'=	169	55	40
D'K'L'=	116	05	00

-"L'"-

D'L'G'=	262	41	00
K'=	320	42	30
N'=	323	14	00
O'=	326	10	20
G'L'K'=	58	01	30
N'=	60	33	00
O'=	63	29	20
D'=	97	19	00
K'L'N'=	02	31	30
O'=	05	27	50
D'=	39	17	30
N'L'O'=	02	56	20
D'=	36	46	00
O'L'D'=	33	49	40

ANGLES-CONTINUED.

-"M'"-

I'M'M =	19	59	20
C'=	63	00	10
N =	93	57	10
P'=	163	57	30
D'=	203	12	00
K'=	269	01	10
J'=	336	24	40
MN'C' =	43	00	50
N =	73	57	50
P'=	143	58	10
D'=	182	12	40
K'=	249	01	50
J'=	316	25	30
I'=	340	00	40
C'M'N =	30	57	00
P'=	100	57	20
D'=	139	11	50
K'=	206	01	00
J'=	273	24	30
I'=	296	59	50
NM'P' =	70	00	20
D'=	108	14	50
K'=	175	04	00
J'=	242	27	30
I'=	266	02	50
P'M'D'=	38	14	30
K'=	105	03	40
J'=	172	27	10
I'=	196	02	30
D'M'K'=	66	49	10
J'=	134	12	40
I'=	157	48	00
K'M'J'=	67	23	30
I'=	90	58	50
J'M'I'=	23	35	20

-"N'"-

I'N'M =	21	16	30
C'=	67	27	10
N =	101	16	40
P'=	169	53	10
D'=	206	02	20
K'=	265	28	40
J'=	334	03	10

-"N'"Cont.

MN'C' =	46	10	40
N =	80	00	10
P' =	148	36	40
D' =	184	45	50
K' =	344	12	10
J' =	312	46	40
I' =	338	43	30
C'N'M =	33	49	30
P'=	102	26	00
D'=	138	35	10
K'=	198	01	30
J'=	266	36	00
I'=	292	32	50
NN'P' =	68	36	30
D'=	104	44	40
K'=	164	12	00
J'=	232	46	30
I'=	258	43	20
P'N'D'=	36	09	10
K'=	95	35	30
J'=	164	10	00
I'=	190	06	50
D'N'K'=	59	26	20
J'=	128	00	50
I'=	153	57	40
K'N'J'=	68	34	30
I'=	94	31	20
J'N'I'=	25	58	50

-"O'"-

I'O'M =	20	10	00
C'=	66	55	30
N =	101	55	10
P'=	176	55	40
D'=	217	09	40
K'=	273	25	10
J'=	334	58	00
MO'C' =	46	45	30
N =	81	45	10
P'=	156	45	40
D'=	196	59	40
K'=	253	15	10
J'=	314	48	00
I'=	339	50	00

ANGLES-CONTINUED.

-"O'"- Cont.

C'O'N = 34 59 40
P'= 110 00 10
D'= 150 14 10
K'= 206 29 40
J'= 268 02 30
I'= 293 04 30
NO'P' = 75 00 30
D'= 115 14 30
K'= 171 30 00
J'= 233 02 50
I'= 258 04 50
P'O'D'= 40 14 00
K'= 96 28 30
J'= 158 02 20
I'= 183 04 20
D'O'K'= 56 15 30
J'= 117 48 20
I'= 142 50 20
K'O'J'= 61 32 50
I'= 86 34 50
J'O'I'= 25 02 00

-"P'"-

D'P'M'= 34 22 50
N'= 37 56 00
O'= 41 31 20
I'= 43 13 00
N = 85 01 20
M'P'N'= 03 33 10
O'= 07 08 30
I'= 08 50 10
N = 50 38 30
D'= 325 37 10
N'P'O'= 03 35 20
I'= 05 17 00
N = 47 05 20
D'= 322 04 00
O'P'I'= 01 41 40
N = 43 30 00
D'= 318 28 40
I'P'N = 41 48 20
D'= 316 47 00
NP'D'= 274 58 40

-"Q'"-

ERQ'Q = 300 30 20
R = 312 49 00
QQ'R = 12 18 40
P = 59 29 40
RQ'P = 47 11 00

-"R'"-

JR'K = 54 39 20
L = 119 55 50
C = 163 56 20
I' = 179 51 30
H' = 212 14 40
G' = 227 06 30
E' = 264 15 20
KR'L = 65 16 30
C = 109 17 00
I' = 125 12 10
H' = 157 35 20
G' = 172 27 10
E' = 209 36 00
J = 305 20 40
LR'C = 44 00 30
I' = 59 55 40
H' = 92 18 50
G' = 107 10 40
E' = 144 19 30
J = 340 04 10
CR'I' = 15 55 10
H' = 48 18 20
G' = 63 10 10
E' = 100 19 00
J = 196 03 40
I'R'H'= 32 23 10
G' = 47 15 00
E' = 84 23 50
J = 180 08 30
H'R'G'= 14 51 50
E' = 52 00 40
J = 147 45 20
G'R'E'= 37 08 50
J = 132 53 30
E'R'J = 95 44 40

-"T'"-

GT'F = 41 30 40
GT'H =155 25 50
FT'H =113 55 10
FT'G = 318 29 20
HT'G = 204 34 10

BEARINGS.

PRIMARY BEARINGS

AB = N 00 02 00 W
AE = N 87 42 20 E
AR = N 45 12 40 W
AV = S 30 25 40 W
BC = N 00 02 00 W
BI = S 77 59 00 E
CM = N 74 41 10 W
CE'= N 66 24 30 E
EF = N 60 33 40 E
FI = N 51 30 10 W
MD' = N 13 15 10 W
OT = S 00 29 50 W
OC' = N 30 15 10 W
RT = S 40 10 20 W
TU = S 04 07 10 E
UV = N 87 12 40 E
C'D'= N 16 01 20 E
D'E'= S 51 10 20 E
D'I'= S 26 48 00 E

D'I'= S 26 48 00 E is the official bearing, being determined by W.S.Frame during the period of elongation of Polaris at 1 o'clock A.M. Dec. 30,1921 by taking 6 rept. of Angle D'I'Polaris with bubble up and 6 rept. with bubble down. The Berger Precise Transit No.12186, reading to 30", was used .

Angle D'I'-Polaris = 25 23 30
True Bearing Polaris
West Elongation =NNC1 24 33 W
Bearing D'I' =S 26 48 03 E
" " (to 10") S 26 48 00 E

FINAL BEARINGS FROM ADJUSTED ANGLES.

AB = N 00 02 00 W
AC = N 00 02 00 W
AD = N 17 07 00E
AE = N 87 42 20 E
AI = N 31 27 40 E
AR = N 45 12 40 W
AS = N 76 26 20 W
AV = S 30 25 40 W
AW = S 05 41 20 W
BC = N 00 02 00 W
BD = S 09 47 50 E
BI = S 77 59 00 E
BL = N 34 12 40 E
CD = S 03 46 00 E
CL = S 44 47 40 E
CM = N 74 41 10 W
CE'= N 66 24 30 E
CI'= N 33 45 20 W
CR'= N 83 27 10 E
DE = S 67 04 00 E
DI = N 39 17 30 E
DR = N 68 35 10 W
EF = N 60 33 40 E
EG = N 87 40 20 E
ER = N 67 40 50 W
FG = S 57 40 10 E
FT'= N 57 17 10 E
GH = N 06 53 50 E
GT'= N 15 45 30 E
HI = S 89 27 20 W
HJ = N 01 06 00 W
HK = N 41 12 00 W
HL = N 61 06 50 W
HT'= S 08 48 40 E
IK = N 38 29 50 E
JR'= N 80 29 10 W
KL = N 88 49 20 W
KR'= N 25 49 50 ,W

BEARINGS-CONTINUED.

LM = N 59 53 30 W
LE'= N 29 08 00 E
LH'= N 10 54 10 W
LR'= N 39 26 40 E
MN = N 57 30 20 W
MO = S 74 27 50 W
MC'= N 86 56 20 W
MD'= N 13 15 10 W
MI'= N 75 21 20 E
MJ'= N 38 03 10 E
MK'= N 09 06 00 E
MM'= N 14 00 10 W
MN'= N 15 05 30 W
MO'= N 19 39 10 W
NC'= S 16 18 00 E
ND'= N 32 33 10 E
NI'= S 68 53 20 E
NJ'= S 88 30 20 E
NM'= N 59 57 30 E
NN'= N 64 54 30 E
NO'= N 62 05 50 E
NP'= N 00 36 20 E
OP = S 04 15 20 E
OQ = S 36 24 00 E
OR = S 26 27 00 E
OT = S 00 29 50 E
OO'= N 30 15 20 W
PQ = S 86 10 40 E
PR = S 54 56 10 E
PS = S 34 14 30 E
PT= S 04 03 00 W
PQ'= N 32 05 50 E
QR = S 06 34 30 W
QS = S 00 37 10 W
QQ'= N 27 23 40 W
RS = S 03 48 50 E
RT = S 40 10 20 W
RQ'= N 15 05 00 W
ST = S 67 09 20 W
SV = S 04 11 50 E
SW = S 27 23 00 E
TU = S 04 07 10 E
UV = N 87 12 40 E
VW = N 84 31 30 E
C'D'= N 16 01 20 E
C'I'= N 87 22 10 E
C'J'= N 66 55 10 E
C'K'= N 37 47 10 E
C'M'= N 29 01 20 E
C'N'= N 31 05 50 E
C'O'= N 27 07 00 E
D'E'= S 51 10 20 E
D'G'= S 57 34 30 E
D'I'= S 26 48 00 E
D'J'= S 39 52 00 E
D'K'= S 71 07 50 E
D'L'= N 84 14 40 E
D'M'= S 11 47 40 E
D'N'= S 10 19 50 E
D'O'= S 02 39 40 E
D'P'= N 84 25 00 W
E'F'= N 02 25 40 E
E'G'= N 42 46 40 W
E'H'= N 66 15 30 W
E'R'= S 03 46 10 W
F'G'= S 82 31 40 W
F'H'= S 50 27 40 W
F'J'= S 65 52 00 W
G'H'= S 06 00 50 E
G'J'= S 35 42 10 W
G'L'= N 13 04 10 W
H'R'= S 48 14 10 E
I'J'= N 09 33 40 E
I'K'= N06 57 00 W
I'M'= N 33 59 40 W
I'N'= N 36 22 10 W
I'O'= N 39 49 20 W
I'P'= N 41 12 00 W
I'R'= S 80 37 40 E
J'K'= N 16 42 50 W
J'M'= N 57 34 50 W
J'N'= N 62 18 50 W
J'O'= N 64 51 10 W
K'L'= N 44 57 20 E
K'M'= S 46 43 00 W
K'N'= S 40 48 00 W
K'O'= S 45 17 20 W
L'N'= S 47 28 50 W
L'O'= S 50 25 10 W
M'N'= S 00 11 40 E
M'O'= S 46 24 30 W
M'P'= N 50 01 00 W
N'O'= S 89 59 00 W
N'P'= N 46 40 30 W
O'P'= N 42 54 10 W

DISTANCES.

Line	Length.	Line	Length	Line	Length	Line	Length.
A-B =	320.52	H-I =	385.32	P-Q =	207.03	G'H'=	333.44
-C =	657.54	-J =	355.27	-R =	235.15	H'R'=	377.51
-D =	120.13	-K =	304.09	-S =	361.30	I'J'=	173.55
-E =	220.34	-L =	483.29	-T =	397.02	-K'=	453.64
-I =	332.45	-T'=	99.00	-Q'=	205.68	-M'=	399.57
-R =	301.91	I-K =	297.15	Q-R =	133.02	-N'=	376.52
-S =	309.18	J-K =	231.37	-T =	448.59	-O'=	394.91
-V =	350.67	-M =	745.35	-Q'=	211.43	-P'=	718.36
-W =	289.54	-E'=	304.44	R-S =	183.98	J'K'=	290.48
		-R'=	281.19	-T =	341.81	-M'=	398.71
B-C =	337.02	K-L =	223.82	-Q'=	320.14	-N'=	284.58
-D =	308.89	-E'=	277.08	S-T =	251.10	-O'=	310.97
-I =	177.63	-R'=	192.58	-V =	353.37	K'L'=	144.81
-L =	241.77	L-M =	377.05	-W =	379.73	-M'=	206.87
-O =	536.77	-Q =	384.58	-Q'=	482.84	-N'=	283.97
-Q =	200.60	-E'=	397.99	T-U =	266.25	-O'=	247.06
		-R'=	218.72	-V =	361.50	-P'=	438.91
C-D =	544.14	M-N =	408.70	U-V =	238.38	L'M'=	349.40
-J =	552.84	-O =	247.25	V-W =	149.51	-N'=	367.50
-K =	386.08	-Q =	375.96			-O'=	389.61
-L =	193.36	-R =	497.85	C'D'=	561.78	M'N'=	28.01
-M =	196.96	-T =	796.84	-I'=	418.18	-O'=	40.63
-C'=	480.24	-C'=	286.06	-J'=	485.39	-P'=	328.53
-E'=	307.39	-D'=	570.35	-M'=	401.33	N'O'=	29.50
-F'=	497.80	-I'=	136.50	-N'=	376.69	-P'=	345.40
-I'=	104.00	-J'=	261.05	-O'=	362.51	O'P'=	324.54
-R'=	276.97	-K'=	490.06	D'E'=	773.22		
		-M'=	376.99	-F'=	648.00	L-H'=	359.90
D-E =	265.76	-N'=	349.77	-G'=	441.82		
-I =	318.21	-O'=	358.85	-I'=	582.40		
-R =	369.13	-Q'=	216.76	-J'=	455.34		
		M-C'=	212.14	-K'=	220.16		
E-F =	158.58	-D'=	398.66	-L'=	312.03		
-G =	346.68	-F'=	838.70	-M'=	193.33		
-R =	533.86	-I'=	511.18	-N'=	220.86		
-S =	484.79	-J'=	506.17	-O'=	217.50		
		-M'=	293.41	-P'=	211.83		
F-G =	127.91	-N'=	280.55	E'F'=	218.76		
-I =	312.59	-O'=	254.09	-G'=	337.		
-T'=	185.84	-P'=	357.98	-H'=	232.76		
		O-P =	296.94	-R'=	91.56		
G-H =	268.02	-Q =	384.83	F'G'=	243.		
-I =	439.84	-R =	481.45	-H'=	291.60		
-T'=	174.20	-T =	692.23	G'H' =	154.90		
		-C'=	94.42	-J'=	138.90		
		-Q'=	179.20	-L'=	275.16		

ELEVATIONS.

THE ELEVATIONS HERE GIVEN ARE REFERRED TO THE DATUM ELEVATION of the Bench Mark described as follows.
B.M. N.E.Cor.Bolt of Hydrant (No.7) South of Power Plant, Elevation = 1140.81 . This in turn was taken from the Datum of the old B.M. which is 1 Ft.in the ground and encased by a 3" metal pipe and is 4' North of North side of Rolla Bldg.

Elevations of Triangulation Stations are given from top of steel.
Elevations of Hydrants (to avoid confusion) are given top point.

Triangulation Stations		Hydrants.
A= 1136.71	C'= 1147.13	1 = 1124.54
B= 1140.76	D'= 1163.88	2 = 1133.55
C= 1139.50	E'= 1130.54	3 = 1125.83
D= 1139.07	F'= 1147.58	4 = 1126.79
E= 1135.88	G'= 1139.98	5 = 1138.03
F= 1131.54	H'= 1136.57	6 = 1141.79
G= 1125.76	I'= 1147.52	7 = 1141.18
H= 1115.28	J'= 1147.56	8 = 1137.46
I= 1138.65	K'= 1154.52	9 = 1137.64
J= 1124.85	L'= 1160,56	10 = 1122.25
K= 1116.77	M'= 1156.63	11 = 1140.97
L= 1136.68	N'= 1155.29	12 = 1145.91
M= 1147.68	O'= 1155.60	13 = 1152.76
N= 1148.30	P'= 1165.76	
O= 1137.72	Q'= 1135.40	
P= 1122.30	R'= 1124.30	
Q= 1138.20	T'= 1115.45	
R= 1137.77		
S= 1137.71	Elev of USGS B.M. in Knapps Yard	
T= 1124.08	(Elev referred to Sea-Level is	
U= 1122.35	1130. Given to nearest ft.)	
V= 1130.03	is 1124.00 in our system.	
W= 1128.27	1129.946 Elev B.M.	

ELEVATIONS REFERRED TO SEVERAL DATUM PLANES.

ELEVATIONS referred to Station C= Elev. of 100.00

Stations	Hydrants.
A = 97.21	1= 85.04
B =101.26	2= 94.05
D = 99.57	3= 86.33
E = 96.38	4= 87.29
F = 92.04	5= 98.53
G = 86.26	6=102.29
H = 75.78	7=101.68
I = 99.15	8= 97.96
J = 85.35	9= 98.14
K = 77.27	10= 82.75
L = 97.18	11=101.47
M =108.18	12=106.41
N =108.80	13=113.26
O = 98.22	
P = 82.80	
Q = 98.70	
R = 98.27	
S = 98.21	
T = 84.58	
U = 82.85	
V = 90.53	
W = 88.77	
C'=107.63	
D'=124.38	
E'= 91.04	
F'=108.08	
G'=100.48	
H'= 97.07	
I'=108.02	
J'=108.06	
K'=115.02	
L'=121.06	
M'=117.13	
N'=115.79	
O'=116.10	
P'=126.28	
Q'= 95.90	
R'= 84.80	
T'= 75.95.	

ELEVATIONS referred to Station J = Elev. of 100.00

Stations	Hydrants
A = 111.86	1 = 99.69
B = 115.91	2 = 108.70
C = 114.65	3 = 100.98
D = 114.22	4 = 101.94
E = 111.03	55 = 113.18
F = 106.69	6 = 116.94
G = 100.91	7 = 116.33
H = 90.43	8 = 112.61
I = 113.80	9 = 112.79
K = 91.92	10 = 97.40
L = 111.83	11 = 116.12
M = 122.83	12 = 121.06
N = 123.45	13 = 127.91
O = 112.87	
P = 97.45	
Q = 113.35	
R = 112.92	
S = 112.86	
T = 99.23	
U = 97.50	
V = 105.18	
W = 103.42	
C'= 122.28	
D'= 139.03	
E' =105.69	
F'= 122.73	
G'= 115.13	
H'= 111.72	
I'= 122.67	
J'= 123.71	
K'= 139.67	
L'= 135.71	
M'= 131.78	
N'=130.44	
O'= 130.75	
P'= 140.91	
Q'= 110.55	
R'= 99.45	
T'= 90.60	

ELEVATIONS REFERRED TO SEVERAL DATUM PLANES

ELEVATIONS referred to Station S = Elev. 100.00

Stations			Hydrants
A = 99.00	O = 100.01	I'= 109.81	1 = 88.83
B = 103.05	P = 84.59	J'= 109.85	2 = 95.84
C = 101.79	Q = 100.49	K'= 116.81	3 = 88.12
D = 101.36	R = 100.06	L'= 122.85	4 = 89.08
E = 98.17	T = 86.37	M'= 108.92	5 = 100.32
F = 93.83	U = 84.64	N'= 117.58	6 = 104.08
G = 88.05	V = 92.32	O'= 117.89	7 = 103.47
H = 77.57	W = 90.56	P'= 128.05	8 = 99.75
I = 100.94	C'= 109.42	Q'= 97.69	9 = 99.93
J = 87.14	D'= 126.17	R'= 86.59	10 = 84.54
K = 79.06	E'= 92.83	T' = 77.74	11 = 103.26
L = 98.97	F'= 109.87		12 = 108.20
M = 109.97	G'= 102.27		13 = 115.05
N = 110.59	H'= 98.86		

ELEVATIONS referred to Station V = Elev. 100.00

Stations			HYDRANTS
A = 106.68	M = 118.27	G'= 109.95	1 = 94.51
B = 110.73	O = 107.69	H'= 106.54	3 =103.52
C = 109.47	P = 92.27	I'= 117.49	3 = 95.80
D = 109.04	Q = 108.17	J'= 117.53	4 = 96.76
E = 105.85	R = 107.74	K'= 124.49	5 =108.00
F = 101.51	S = 107. 68	L'= 130.53	6 =111.76
G = 95.73	T = 94.05	M'= 126.60	7 =111.15
H = 85.25	U = 92.32	N'= 125.26	8 =107.43
I = 108.62	W = 98.24	O' =125.57	9 =107.61
J = 94.82	C' =117.10	P' =135.73	10 = 92.22
K = 86.74	D'= 133.85	Q'= 105.37	11 =110.94
L = 106.65	E' =100.51	R'= 94.27	12 =115.88
M = 117.65	F' =117.55	T'= 85.42	13 =122.73

ELEVATIONS referred to Station J'= Elev. 100.00

Stations			Hydrants
A = 89.15	N = 100.74	F'= 100.02	1 = 76.98
B = 93.20	O = 90.16	G'= 92.42	2 = 85.99
C = 91.94	P = 74.74	H'= 89.01	3 = 78.27
D = 91.51	Q = 90.64	I'= 99.96	4 = 79.23
E = 88.32	R = 90.31	K'= 106.96	5 = 90.47
F = 83.98	S = 90.15	L'= 113.00	6 = 94 .23
G = 78.20	T = 76.52	M'= 109.07	7 = 93.62
H = 67.72	U = 74.79	N' =107.73	8 = 89.90
I = 91.09	V = 82.47	O'= 108.04	9 = 90.08
J = 77.29	W = 80.71	P'= 118.20	10 = 74.69
K = 69.21	C'= 99.57	Q'= 87.84	11= 93.41
L = 89.12	D'= 116.32	R'= 76.74	12 = 98.35
M = 100.12	E'= 82.98	T'= 67.89	13 = 105.20

HEIGHT OF BUILDING DATA.

No.	OBJECT	Above Sta.	Height.
1.	Chimney of Prof. Harris's Residence.	U	34.0'
2.	East Chimney of Kappa Alpha House	U	33.6'
3.	North Chimney of Prof.Deans Res.	C'	38.9'
4.	Flagpole on Gymnasium	C	69.1'
5.	S.W.Corner of Gymnasium	I'	47.8'
6.	N.W.Corner of Gymnasium	J'	47.8'
7.	Chimney of Prof. Muilenburg's Res.	F'	35.4'
8.	Flagpole on Mechanical Hall	B	48.8'
9.	Campus Flagpole	Base	93.4'
10.	S.W.Chimney of Metallurgy Bldg.	F	48.1'
11.	N.W.Chimney of Metallurgy Bldg.	I	40.0'
12.	Pinnacle on East Corner of Roof of Norwood Hall	F	82.6'
13.	Pinnacle on West Corner of Roof of Norwood Hall	D	75.2'
14.	Pinnacle on Power Plant	D	39.9'
15.	Power Plant Smoke Stack	Base	110.3'
16.	Spire on Rolla Building	S	88.3'
17.	North Ctr. Chimney of Chem. Bldg.	T	66.9'
18.	South Ctr. Chimney of Chem. Bldg.	W	61.8'
19.	Pinnacle on Directors Residence	V	61.3'
20.	Chimney of Sigma Nu House	W	37.3'

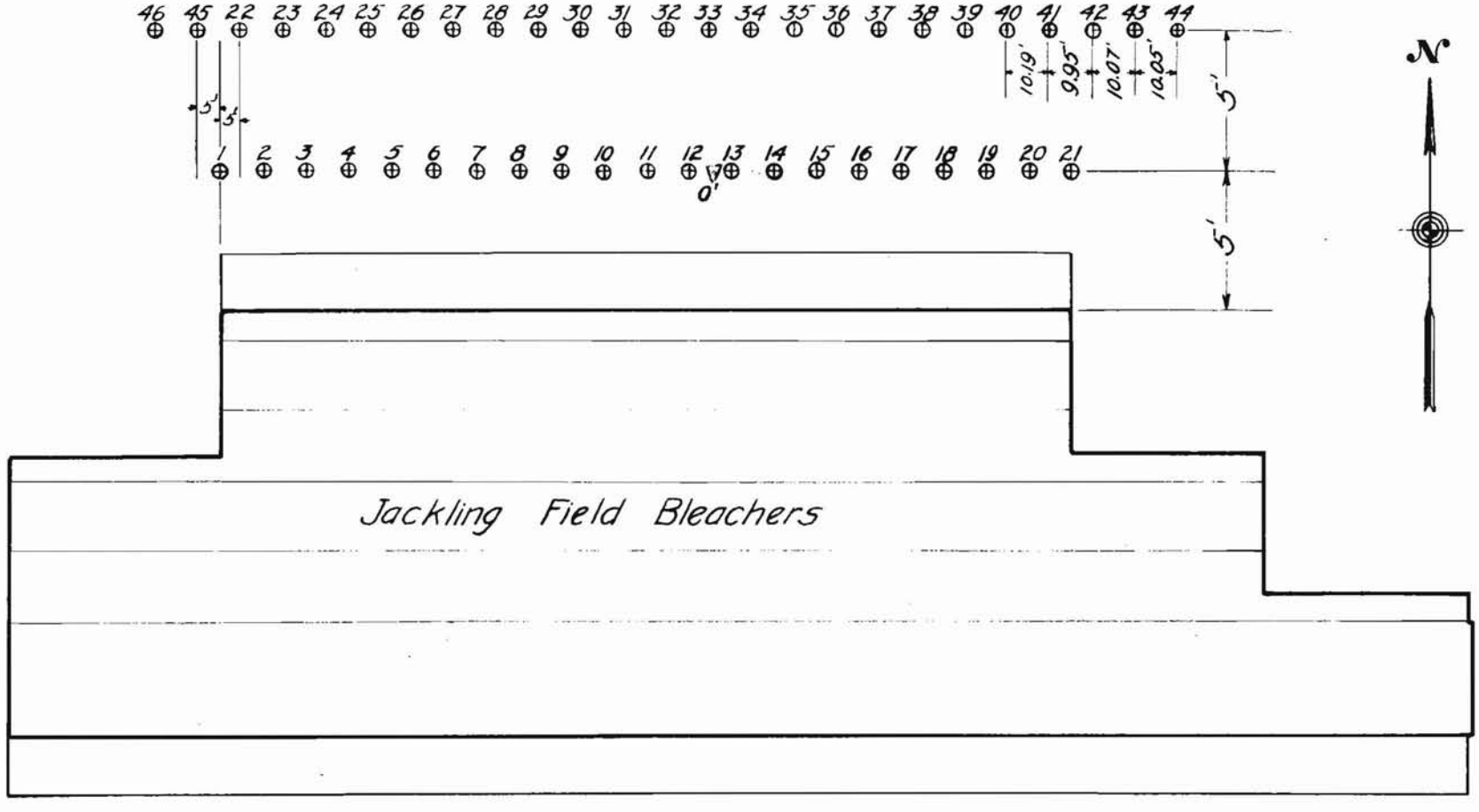
TRUE BEARINGS FROM AZIMUTH STATIONS.

For Polar Observations		For Solar Observations	
1-D'	N 25 44 20 E	1-I'	S 50 47 20 E
2-D'	N 33 35 30 E	2-I'	S 50 00 40 E
3-D8	N 31 21 50 E	3-I8	S 49 13 20 E
4-D'	N 19 04 30 E	4-I'	S 48 22 30 E
5-D'	N 18 42 40 E	5-I'	S 47 30 50 E
6-D'	N 14 17 20 E	6-I'	S 46 37 40 E
7-D'	N 11 48 40 E	7-I'	S 45 42 30 E
8-D'	N 09 17 30 E	8-I'	S 44 45 40 E
9-D'	N 06 43 40 E	9-I'	S 43 46 50 E
10-D'	N 04 08 10 E	10-I'	S 42 46 00 E
11-D8	N 01 31 50 E	11-I'	S 41 43 10 E
12-D'	N 00 55 30 W	12-I'	S 40 38 20 E
13-D'	N 03 41 50 W	13-I'	S 39 31 20 E
14-D'	N 06 17 50 W	14-I8	S 38 22 00 E
15-D'	N 08 52 10 W	15-I'	S 37 10 30 E
16-D'	N 11 24 30 W	16-I'	S 35 56 40 E
17-D'	N 13 54 30 W	17-I'	S 34 40 30 E
18-D'	N 16 21 00 W	18-I'	S 33 22 00 E
19-D'	N 19 57 30 W	19-I'	S 32 01 00 E
20-D'	N 21 03 30 W	20-I'	S 30 37 40 E
21-D'	N23 18 40 W	21-I'	S 29 11 50 E
22-D'	N 25 11 00 W	22-I'	S 49 56 20 E
23-D'	N 22 57 40 E	23-I'	S 49 08 50 E
24-D'	N 20 39 50 E	24-I'	S 48 19 40 E
25-D'	N 18 17 40 E	25-I8	S 47 28 50 E
26-D'	N 15 51 30 E	26-I'	S 46 36 20 E
27-D'	N 13 31 30 E	27-I'	S 45 42 10 E
28-D'	N 10 48 10 E	28-I'	S 44 46 10 E
29-D'	N 08 12 20 E	29-I'	S 43 48 20 E
30-D'	N 05 34 10 E	30-I'	S 42 48 40 E
31-D'	N 02 54 30 E	31-I'	S 41 47 00 E
32-D'	N 00 14 10 E	32-I'	S 40 43 10 E
33-D'	N 02 26 30 W	33-I'	S 39 37 30 E
34-D'	N 05 06 30 W	34-I'	S 38 29 30 E
35-D'	N 07 45 20 W	35-I'	S 37 19 20 E
36-D'	N 10 22 10 W	36-I'	S 36 07 00 E
37-D'	N 12 58 40 W	37-I'	S 34 52 30 E
38-D'	N 15 28 00 W	38-I'	S 33 35 40 E
39-D'	N 17 55 50 W	39-I'	S 32 16 20 E
40-D'	N 20 19 40 W	40-I'	S 30 54 30 E
41-D'	N 22 41 40 W	41-I'	S 29 29 30 E
42-D'	N 24 56 20 W	42-I'	S 28 03 30 E
43-D'	N 27 07 40 W	43-I'	S 26 34 10 E
44-D'	N 29 13 40 W	44-I'	S 25 02 40 E
45-D'	N 27 19 30 E	45-I'	S 50 42 30 E
46-D'	N 29 23 10 E	46-I'	S 51 27 10 E

SKETCHED LOCATION OF AZIMUTH STATIONS

SCALE E&W-1"=40' N&S-1"=6'

Stations are centered points on 1" X1" reinforcing bars driven flush with the ground. Except where noted the spacing between stations is 10'.



Part 2, Adjustment Data.

I. Narration of Adjustment Methods.

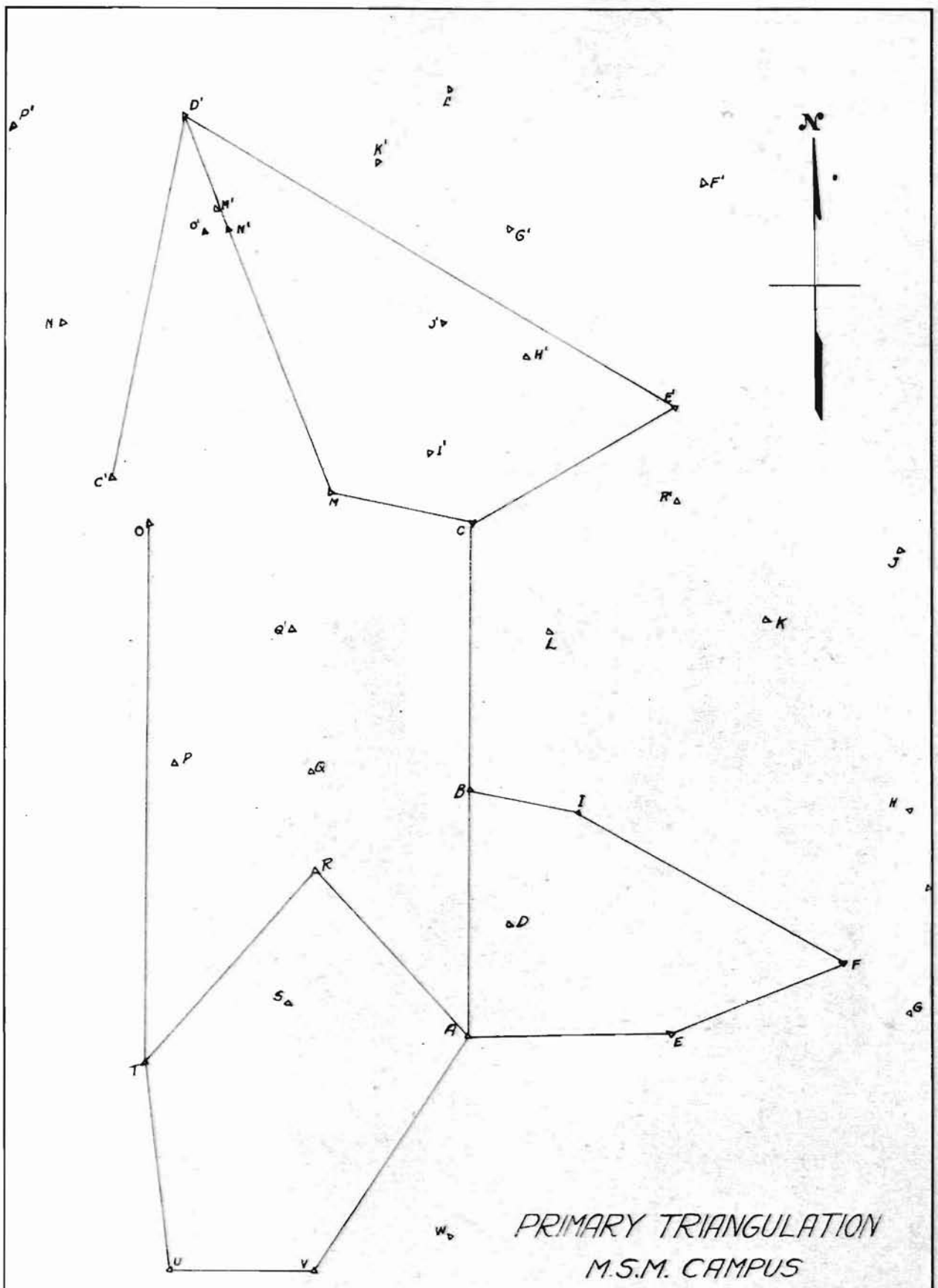
In taking up the adjustment of survey data on the M.S.M. Campus the first thing to determine thethe use for said data. The data is used by the Department to determine whether or not the student in his Field Work has pursued correct methods. No attempt is made to require great precision as the student is just learning to use the instruments and time is not allowed in the courses for him to learn other than the rudiments of Surveying.

With the above in mind it was first decided that the values of adjusted angles would be used to the even 10". As all angle measurements are given equal weight the Method of Least Squares calls for equal distribution of the errors in Station Adjustments. In order to avoid extreme confusion the Primary and Secondary Figures were adjusted to fit Geometrical Angle Perfection. As noted elsewhere the Secondary Angles were adjusted to equal the Primary Angles of which they formed parts. The Final Adjusted Angles were made to conform with both the Primary and Secondary Angles.

When the Adjustment of any angle called for a change in excess of 40" the Field Measurement of that angle was made again. In the Old Triangulation System which is composed of Stations A,B,---E',F' the values of angles are considered correct to 30". But with the New Triangulation Points the values are not no good and are considered correct to 50". As these last values are not very close there is left space for correction as better field angles are obtained. All the various tables that were used as steps in this adjustment are shown so that corrections can be easily traced through.

The Bearings are figured the Primary, Secondary and Final Adjusted angles in the order named. All distances were measured at least twice independently for a check in value of 0.05' or less. The figuring of closures by Latitude and Departures was applied only to the Primary Figures. Elevations are Adjusted to 0.05'.

The Height of Building Data is taken from two independent readings that check to 0.35'. The data on Azimuth Stations is considered accurate to 40".



PRIMARY TRIANGULATION

M.S.M. CAMPUS

No Scale

PRIMARY STATION ADJUSTMENT.

Sta "A"

VAR =	104	21	40	(-5)
RAB =	45	10	40	(0)
BAE =	87	44	20	(-10)
EAV =	123	43	30	(+15)
	360	00	00	

Sta. "B"

ABC =	180	00	00	(-5)
CBI =	102	03	00	(+10)
IBA =	77	57	00	(-5)
	360	00	00	

Sta. "C"

BCM =	105	20	50	(-5)
MCE' =	141	05	40	(+5)
E'CB =	113	33	30	(0)
	360	00	00	

Sta. "E"

AEF =	152	51	30	(-10)
FEA =	207	08	40	(+10)
	360	00	00	

Sta. "F"

EFI =	67	55	10	(0)
IFE =	292	04	50	(0)
	360	00	00	

Sta. "I"

BIF =	306	27	50	(0)
FIB =	153	32	10	(0)
	360	00	00	

Sta. "M"

CMD' =	241	26	00	(0)
D'MC =	119	34	00	(0)
	360	00	00	

Sta. "O"

C'OT =	210	45	00	(0)
TOC' =	149	15	00	(0)
	360	00	00	

Sta. "R"

TRA =	274	37	00	(+10)
ART =	85	23	00	(-10)
	360	00	00	

Sta. "T"

UTO =	184	37	00	(0)
OTR =	39	40	30	(+5)
RTU =	135	42	30	(-5)
	360	00	00	

Sta. "U"

TUV =	91	19	50	(0)
VUT =	268	40	10	(0)
	360	00	00	

Sta. "V"

UVA =	123	13	00	(0)
AVU =	236	47	00	(0)
	360	00	00	

Sta. "C'"

OC'D' =	226	16	30	(0)
D'C'O =	133	43	30	(0)
	360	00	00	

Sta. "D'"

C'D'E' =	293	48	30	(0)
E'D'M =	37	55	10	(0)
MD'C' =	29	16	30	(0)
	360	00	00	

Sta "E'"

CE'D' =	62	35	10	(0)
D'E'C =	297	34	50	(0)
	360	00	00	

N.B. Figures shown in parenthesis ( ) indicate the variation of the above angles from the precise adjusted field angles.

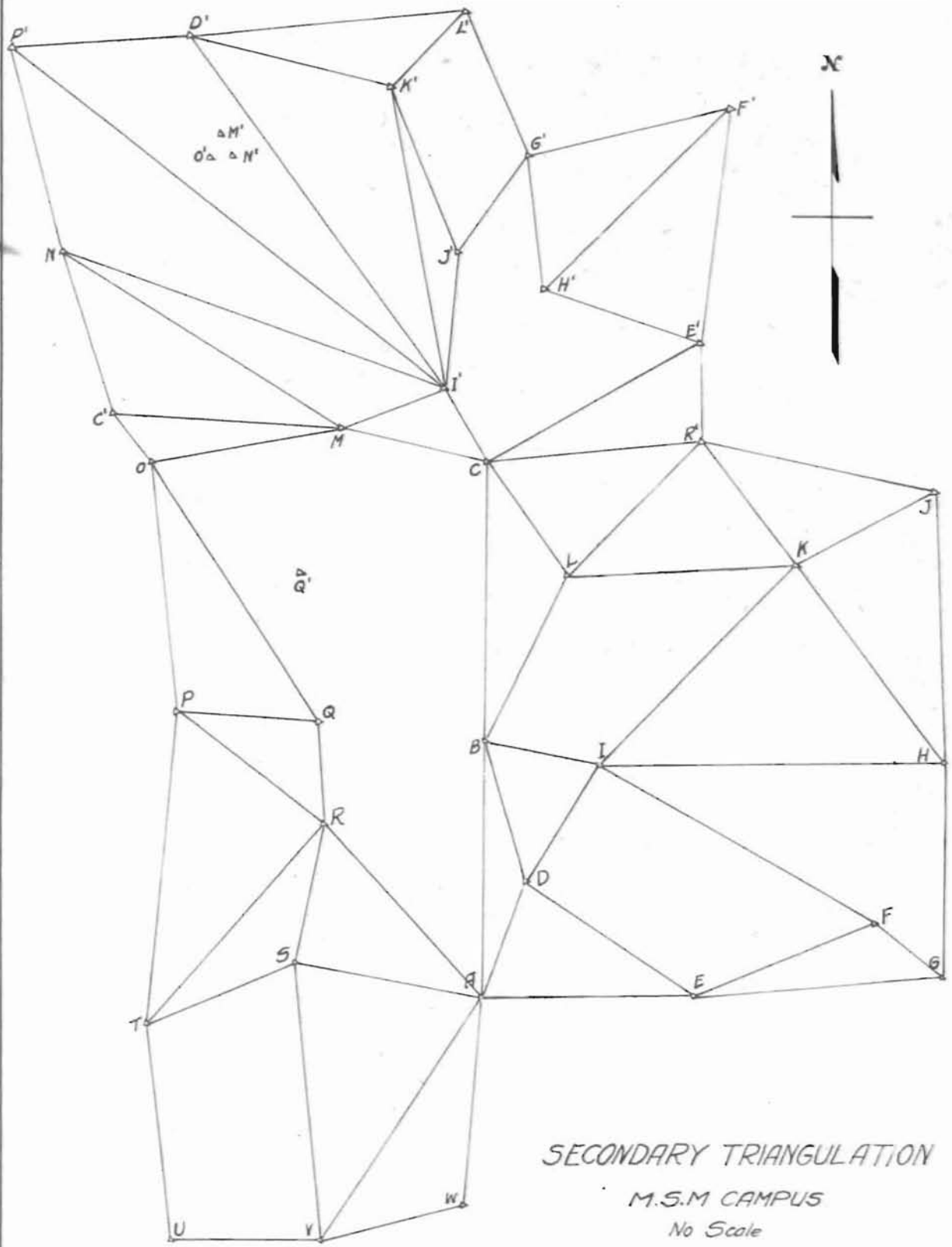
PRIMARY FIGURE ADJUSTMENT.

Figure ABIFEA.			
ABI =	77	57	00
BIF =	153	38	10
IFE =	67	55	10
FEA =	152	51	30
EAB =	87	44	20
	540	00	00

Figure ARTUV.			
RAV =	104	21	40
AVU =	123	13	00
VUT =	91	19	50
UTR =	135	43	30
TRA =	85	23	00
	540	00	00

Figure ARTOC'D'MCB			
BAR =	45	10	40
ART =	274	37	00
RTO =	39	40	30
TOC' =	210	45	00
OC'D' =	133	43	30
C'D'M =	89	16	30
D'MC =	241	26	00
MCB =	105	20	50
CBA =	160	00	00
	1200	00	00

Figure MD'E'C			
CMD' =	118	34	00
MD'E' =	37	55	10
D'E'C =	68	25	10
E'CM =	141	05	40
	360	00	00


P'
D'
L'
K'
M'
O'
N'
F'
G'
J'
H'
E'
I'
C'
M
O
C
R'
J
K
L
Q'
P
Q
B
I
H
R
D
F
S
A
E
G
T
U
V
W
N
SECONDARY TRIANGULATION
M.S.M CAMPUS
No Scale

SECONDARY STATION ADJUSTMENT.

The secondary adjusted angles are made to equal in value the primary angles of which they form a part. The figures in parenthesis ( ) show the variation of the secondary adjusted angles from the adjusted field angles.

Sta. "A"

WAV	=	24	44 20	(0)
VAB	=	73	08 00	(+30)
BAR	=	31	53 40	(+30)
RAB	=	45	10 40	(+20)
BAD	=	17	08 00	(-10)
DAE	=	70	35 20	(-30)
EAW	=	97	59 00	(-30)
		360	00 00	

Sta. "B"

ABC	=	180	00 00	(-40)
CBL	=	34	14 40	(0)
LBI	=	67	48 30	(+10)
IBD	=	68	11 10	(+20)
DBA	=	09	45 50	(+10)
		360	00 00	

Sta. "C"

BCM	=	105	20 50	(+30)
MCI'	=	40	54 50	(x)
I'CE'	=	100	09 50	(x)
E'CR'	=	17	03 40	(+10)
R'CL	=	51	45 10	(0)
LCB	=	44	45 40	(-10)
		360	00 00	

Sta. "D"

ADB	=	153	05 10	(+30)
BDI	=	49	05 20	(-20)
IDE	=	73	38 30	(- 5)
EDA	=	84	11 00	(- 5)
		360	00 00	

Sta. "E"

AED	=	35	13 40	(0)
DEF	=	137	37 40	(0)
FEG	=	27	08 40	(+5)
GEA	=	160	02 00	(-5)
		360	00 00	

Sta. "F"

GFE	=	118	27 50	(+20)
EFI	=	67	55 10	(+10)
IFG	=	173	37 00	(-30)
		360	00 00	

Sta. "G"

EGF	=	34	25 30	(-20)
FGH	=	64	48 00	(+20)
HGE	=	260	46 30	(0)
		360	00 00	

Sta. "H"

GHI	=	82	33 30	(0)
IHK	=	49	20 40	(+10)
KHJ	=	40	06 00	(0)
JHG	=	187	59 50	(-10)
		360	00 00	

Sta. "I"

DIB	=	62	43 30	(0)
BIK	=	116	28 50	(0)
KIH	=	80	57 30	(0)
HIF	=	39	01 30	(0)
FID	=	90	48 40	(0)
		360	00 00	

Sta. "J"

HJK	=	57	52 30	(+10)
KJR'	=	42	44 30	(0)
R'JH	=	259	23 10	(-10)
		360	00 00	

Sta. "K"

HKI	=	79	41 50	(+5)
IKL	=	52	40 50	(+25)
LKR'	=	62	59 30	(+25)
R'KJ	=	82	36 10	(-40)
JKH	=	82	01 40	(-15)
		360	00 00	

SECONDARY STATION ADJUSTMENT CONTINUED.

Sta."L"

BLC	=	100	59 40	(0)
CLR'	=	84	14 30	(0)
R'LK	=	51	44 00	(0)
KLB	=	123	02 00	(0)
		360	00 00	

Sta."M"

CMO	=	149	09 00	(-5)
OMC'	=	18	35 50	(±0)
C'MN	=	39	10 00	(0)
MMI'	=	132	58 40	(x)
I'MC	=	20	27 30	(0)
		360	00 00	

Sta."N"

C'NP'	=	196	64 30	(0)
P'NI'	=	110	30 20	(0)
I'NM	=	11	15 50	(0)
MNC'	=	41	19 30	(0)
		360	00 00	

Sta."O"

C'OM	=	104	43 00	(x)
MOQ	=	69	08 30	(0)
QOP	=	32	08 40	(-5)
POC'	=	154	00 00	(x)
		360	00 00	

Sta."P"

OPQ	=	96	04 30	(+5)
QPR	=	31	14 40	(-5)
RPT	=	56	59 10	(-10)
TPO	=	171	41 40	(+10)
		360	00 00	

Sta."Q"

RQP	=	87	14 50	(-10)
PQC	=	46	43 50	(+10)
OQR	=	222	58 30	(0)
		360	00 00	

Sta."R"

ARS	=	41	23 50	(-5)
SRT	=	43	59 10	(-15)
TRP	=	84	53 40	(+10)
PRQ	=	61	30 30	(0)
QRA	=	129	13 50	(+10)
		360	00 00	

Sta."S"

ASV	=	73	14 30	(-5)
VST	=	71	21 10	(0)
TSR	=	109	01 50	(+5)
RSA	=	107	23 30	(0)
		360	00 00	

Sta."T"

PTR	=	38	07 10	(-15)
RTS	=	26	59 00	(+10)
STU	=	108	43 30	(0)
UTP	=	186	10 20	(+5)
		360	00 00	

Sta."U"

TUV	=	91	19 50	(0)
VUT	=	268	40 10	(0)
		360	00 00	

Sta."V"

UVS	=	88	35 30	(+10)
SVA	=	34	37 30	(+5)
AVW	=	54	05 30	(+5)
WVU	=	182	41 10	(-10)
		360	00 00	

Sta."W"

VWA	=	101	09 50	(0)
AWV	=	258	50 10	(0)
		360	00 00	

SECONDARY STATION ADJUSTMENT CONTINUED.

Sta."C'"

NC'M =	109 21 30	( )
MC'O =	56 41 10	( )
OC'N =	193 57 20	( )
	360 00 00	

Sta."D'"

P'D'L' =	168 39 40	( )
L'D'K' =	24 37 30	( )
K'D'I' =	44 19 50	( )
I'D'P' =	122 23 00	( )
	360 00 00	

Sta."E'"

R'E'C =	62 38 20	(+5)
CE'H' =	47 30 00	(0)
H'E'F' =	68 41 10	(+10)
F'E'R' =	181 20 30	(-15)
	360 00 00	

Sta."F'"

H'F'G' =	32 04 00	(-5)
E'F'H' =	48 02 00	(+10)
G'F'E' =	279 54 00	(-5)
	360 00 00	

Sta."G'"

H'G'J' =	41 43 00	
J'G'L' =	131 13 40	
L'G'F' =	95 35 50	
F'G'H' =	91 27 30	
	360 00 00	

Sta."H'"

G'H'F' =	56 28 30	(+10)
F'H'E' =	63 16 50	(0)
E'H'G' =	240 14 40	(-10)
	360 00 00	

Sta."I'"

CI'M =	109 06 40	(+5)
MI'N =	35 45 30	(+5)
NI'P' =	27 41 20	(0)
P'I'D' =	14 34 00	(-5)
D'I'K' =	19 51 00	(-35)
K'I'J' =	18 39 50	(0)
J'I'C =	136 41 40	(+20)
	360 00 00	

Sta."J'"

I'J'K' =	153 44 10	(0)
K'J'G' =	52 35 00	(0)
G'J'I' =	153 50 50	(0)
	360 00 00	

Sta."K'"

D'K'L' =	116 05 00	(0)
L'J'K' =	118 19 50	(-10)
J'K'I' =	08 46 00	(+10)
I'K'D' =	116 48 10	(0)
	360 00 00	

Sta."L'"

K'L'D' =	39 17 30	(-10)
D'L'G' =	302 41 00	(+10)
G'L'K' =	58 01 30	(0)
	360 00 00	

Sta."P'"

I'P'N =	41 48 30	(+5)
D'P'I' =	43 13 00	(+5)
NP'D' =	274 58 40	(-10)
	360 00 00	

Sta."R'"

JR'K =	54 39 20	(+20)
KR'L =	65 18 30	(+20)
LR'G =	44 00 30	(+10)
GR'E' =	100 00 00	(-20)
E'R'K =	95 44 40	(-30)
	360 00 00	

SECONDARY FIGURE ADJUSTMENT.

Fig. AWV
AWV = 101 09 50
WVA = 54 05 50
WAV = 24 44 20
180 00 00

Fig. AVS
AVS = 34 37 30
VSA = 72 14 30
SAV = 73 08 00
180 00 00

Fig. SVUT
TSV = 71 21 10
SVU = 88 35 30
VUT = 91 19 50
UTS = 108 43 30
360 00 00

Fig. TRS
STR = 28 59 00
TRS = 43 59 10
RST = 109 01 50
180 00 00

Fig. RAS
SRA = 41 23 50
RAS = 31 13 40
ASR = 107 22 30
180 00 00

Fig. TPR
TPR = 58 59 10
PRT = 84 53 40
RTP = 36 07 10
180 00 00

Fig. RPQ
RPQ = 31 14 40
PQR = 87 14 50
QRP = 61 30 30
180 00 00

Fig. QPO
QPO = 98 04 30
POQ = 33 08 40
OQP = 49 46 50
180 00 00

Fig. OC'M
OC'M = 56 41 10
C'MO = 18 35 50
MOC' = 104 43 00
180 00 00

Fig. MC'N
MC'N = 109 31 30
C'NM = 41 19 30
NMC' = 29 19 00
180 00 00

Fig. NI'M
NI'M = 35 45 30
I'MN = 132 58 40
MNI' = 11 15 50
180 00 00

Fig. MI'C
CMI' = 29 57 30
MI'C = 109 06 40
I'CM = 40 55 50
180 00 00

Fig. ARQOMCB.
BAR = 45 10 40
ARQ = 128 12 50
RQO = 232 58 30
QOM = 69 08 20
OMC = 149 09 00
MCD = 105 20 50
CBA = 180 00 00
900 00 00

Fig. I'NP'
I'NP' = 110 30 30
NP'I' = 41 48 20
P'I'N = 27 41 30
180 00 00

Fig. I'P'D'
I'P'D' = 43 13 00
P'D'I' = 133 33 00
D'I'P' = 14 84 00
180 00 00

Fig. H'G'F'
H'G'F' = 91 27 30
G'F'H' = 33 04 00
F'H'G' = 56 28 30
180 00 00

Fig. CI'J'G'H'E'
E'CI' = 100 09 50
CI'J' = 136 41 40
I'J'G' = 153 50 50
J'G'H' = 41 43 00
G'H'E' = 240 14 40
H'E'C = 47 20 00
720 00 00

Fig. H'F'E'
E'H'F' = 63 16 50
H'F'E' = 48 02 00
F'E'H' = 68 41 10
180 00 00

Fig. CE'R'
CE'R' = 62 38 20
E'R'C = 100 19 00
R'CE' = 17 02 40
180 00 00

Fig. LCR'
LCR' = 51 45 10
CR'L = 44 00 30
R'LC = 84 14 20
180 00 00

Fig. LR'K
LR'K = 65 16 30
R'KL = 62 59 30
KLR' = 51 44 00
180 00 00

Fig. KR'J
KR'J = 54 39 20
R'JK = 43 44 30
JKR' = 82 36 10
180 00 00

SECONDARY FIGURE ADJUSTMENT CONTINUED.
(AND SUPPLEMENTARY FIGURE ADJUSTMENT.)

Fig. BCL

BCL	=	44	46 40
CLB	=100	52	40
LBC	=	34	14 40
	180	00	00

Fig ABD

ABD	=	09	45 50
BDA	=153	05	10
DAB	=	17	09 00
	180	00	00

Fig. BLKI

BLK	=123	03	00
LKI	=	53	40 50
KIB	=116	38	50
IBL	=	67	48 20
	360	00	00

Fig ADE

ADE	=	84	11 00
DEA	=	35	13 40
EAD	=	70	35 20
	180	00	00

Fig EFG

EFG	=118	27	50
FGE	=	34	25 30
GEF	=	27	06 40
	180	00	00

Fig. IKH

IKH	=	79	41 50
KHI	=	49	20 40
HIK	=	50	57 30
	180	00	00

SUPPLEMENTARY FIGURE ADJUSTMENT

Fig KJH

KJH	=	57	52 20
JHK	=	40	06 00
HKJ	=	82	01 40
	180	00	00

Fig. J'I'K'

J'I'K'	=	16	29 50
I'J'K'	=153	44	10
I'K'J'	=	09	46 00
	180	00	00

Fig GT'H

GT'H	=	15	43 30
HT'G	=	08	51 40
GHT'	=155	25	50
	180	00	00

Fig. DBI

DBI	=	68	11 10
BID	=	62	43 30
IDB	=	49	05 20
	180	00	00

Fig D'K'I'

K'D'I'	=	44	19 50
I'K'D'	=115	49	10
D'I'K'	=	19	51 00
	180	00	00

Fig. IHGF

FIH	=	39	01 30
IHG	=	83	33 30
HGF	=	64	48 00
GFI	=173	37	00
	360	00	00

D'K'L' Figure.

K'L'D'	=	39	17 30
D'K'L'	=116	05	00
L'D'K'	=	34	37 30
	180	00	00

Fig DIFE

EDI	=	73	38 30
DIF	=	90	48 40
IFE	=	67	55 10
FED	=127	37	40
	360	00	00

Fig. J'K'L'G'

J'G'L'	= 131	13	40
G'L'K'	=	59	01 30
L'K'J'	= 118	19	50
K'J'G'	=	52	26 00
	360	00	00

FINAL ADJUSTED ANGLES.

Sta. "A"			
WAV	=	34	44 20
VAG	=	73	08 00
GAT	=	31	13 40
TAB	=	45	10 40
BAD	=	17	02 00
DAI	=	14	30 40
IAW	=	53	14 40
EAW	=	97	59 00
		360	00 00

Sta. "B"			
ABC	=	180	00 00
CBE	=	34	14 40
EBI	=	67	48 20
IBD	=	68	11 10
DBA	=	09	45 50
		360	00 00

Sta. "C"			
BCM	=	105	20 30
MCI'	=	40	55 50
I'CH'	=	130	00 50
H'CR'	=	17	02 40
R'CL	=	51	45 10
LCD	=	41	01 40
DCB	=	03	44 00
		360	00 00

STA. "D"			
ADR	=	94	17 50
RDB	=	58	47 20
BDC	=	00	01 50
CDI	=	43	03 30
IDE	=	73	35 30
EDA	=	84	11 00
		360	00 00

Sta. "E"			
AER	=	34	27 50
RED	=	00	45 50
DEF	=	127	37 40
FEG	=	37	08 40
GEA	=	160	08 00
		360	00 00

Sta. "F"			
EGF	=	34	25 30
FGH	=	64	48 00
HGT'	=	09	51 40
T'GE	=	251	54 50
		360	00 00

Sta. "G"			
IFT'	=	105	48 20
T'FG	=	64	48 40
GFE	=	118	37 50
EFI	=	67	55 10
		360	00 00

Sta. "H"			
T'HG	=	16	42 30
GHI	=	82	33 30
IHL	=	29	35 50
LHK	=	13	54 50
KHJ	=	40	08 00
JHT'	=	178	17 20
		360	00 00

Sta. "I"			
AID	=	37	48 50
DIB	=	62	43 30
BIK	=	118	38 50
KIH	=	50	57 30
HIG	=	37	10 00
GIF	=	01	51 30
FIA	=	52	56 50
		360	00 00

Sta. "J"			
AJK	=	57	52 20
KJR'	=	42	44 30
R'JH	=	259	23 10
		360	00 00

Sta. "K"			
HKI	=	73	41 50
IKL	=	52	40 50
LKG	=	30	28 30
GKR'	=	43	36 00
R'KE'	=	09	36 30
E'KJ	=	73	11 00
JKH	=	82	01 40
		360	00 00

Sta. "L"			
KLH	=	37	43 40
HLB	=	95	19 20
BLM	=	85	53 50
MLG	=	15	05 50
GLH'	=	33	53 40
H'LE'	=	40	02 00
E'LR'	=	10	18 40
R'LK	=	51	44 00
		360	00 00

FINAL ADJUSTED ANGLES.

Sta. "M"

CMO =	149	09	00
OMC' =	16	35	50
C'MN =	29	19	00
NMO' =	37	58	10
O'MN' =	04	33	40
N'MM' =	01	05	30
M'MD' =	00	45	00
D'MK' =	22	21	10
K'MJ' =	28	57	10
J'MI' =	37	18	10
I'MC =	39	57	30
	360	00	00

Sta. "N"

C'NP' =	190	54	30
P'ND' =	31	56	50
D'NM' =	27	24	30
M'NO' =	03	08	30
O'NN' =	03	48	40
N'NJ' =	20	35	10
J'NI' =	19	37	00
I'NM =	11	15	50
MNC' =	41	19	30
	360	00	00

Sta. "O"

C'ON =	104	43	00
MOQ =	69	08	30
QOR =	00	57	00
ROP =	33	11	40
POC' =	154	00	00
	360	00	00

Sta. "P"

OPQ' =	36	31	10
Q'PQ =	61	43	30
QPR =	31	14	40
RPS =	30	41	40
SPT =	38	17	30
TPO =	171	41	40
	360	00	00

Sta. "Q"

SQR =	05	57	30
RQP =	87	14	50
PQO =	49	46	50
OQQ' =	09	00	10
Q'QL =	88	26	30
LQS =	119	40	30
	360	00	00

Sta. "R"

QRD =	104	50	10
DRE =	00	45	10
ERA =	22	37	30
ARS =	41	23	50
SRT =	43	59	10
TRP =	84	53	40
PRO =	38	29	10
ORQ' =	11	21	50
Q'RQ =	21	39	30
	360	00	00

Sta. "S"

QSE =	93	51	30
ESA =	09	05	30
ASW =	49	03	30
WSV =	23	11	10
VST =	71	21	10
TSP =	78	36	10
PSR =	30	25	40
RSQ =	04	25	40
	360	00	00

Sta. "T"

PTQ =	27	37	30
QTR =	08	39	40
RTS =	38	59	00
STU =	108	43	30
UTO =	184	37	10
OTP =	03	33	10
	360	00	00

Sta. "U"

TUV =	91	19	50
VUT =	268	40	10
	360	00	00

FINAL ADJUSTED ANGLES.-

Sta."V"

UVS	=	88	35	30
SVA	=	34	37	30
AVW	=	54	05	50
WVU	=	182	41	10
		360	00	00

STA."W"

VWS	=	68	05	10
SWA	=	33	04	40
AWV	=	258	50	10
		360	00	00

Sta."C"

MOC'N	=	193	58	30
MC'D'	=	32	18	30
D'C'O'		11	03	40
O'C'M'		01	54	30
M'C'N'		02	04	30
N'C'K'		06	41	20
K'C'J'		39	08	00
J'C'I'		20	27	00
I'C'M	=	05	42	10
MC'O	=	56	40	00
		360	00	00

Sta."D"

P'D'L'	=	168	39	40
L'D'K'	=	24	37	30
K'D'J'	=	31	15	50
J'D'I'	=	13	04	00
I'D'M	=	13	32	50
MD'N'	=	01	27	30
M'D'N'	=	01	27	50
N'D'O'	=	07	40	10
O'D'C'	=	18	41	00
C'D'N	=	16	31	30
ND'P'	=	63	02	10
		360	00	00

Sta."E"

R'E'L	=	35	21	10
LE'C	=	37	17	10
CE'H'	=	47	30	00
H'E'G'	=	33	38	50
G'E'F'	=	45	13	20
F'E'K	=	161	10	10
KE'R'	=	20	10	30
		360	00	00

Sta."F"

E'F'H'	=	48	02	00
H'F'J'	=	15	24	20
J'F'G'	=	16	39	40
G'F'E'	=	279	54	00
		360	00	00

Sta."G"

E'G'H'	=	36	45	50
H'G'J'	=	41	43	00
J'G'D'	=	86	43	30
D'G'L'	=	44	30	30
L'G'F'	=	95	35	50
F'G'E'	=	54	41	40
		360	00	00

Sta."H"

E'H'R'	=	18	01	30
R'H'K	=	09	09	00
KH'L	=	23	10	30
LH'G'	=	184	53	50
G'H'F'	=	56	28	30
F'H'E'	=	83	16	50
		360	00	00

Sta."I"

J'I'C	=	136	41	40
CI'M	=	109	06	40
MI'C'	=	11	59	10
C'I'N	=	23	48	30
NI'P'	=	27	41	30
P'I'O'	=	01	23	40
O'I'N'	=	03	27	10
N'I'M'	=	02	22	30
M'I'D'	=	07	11	40
D'I'K'	=	19	51	00
K'I'J'	=	16	29	50
		360	00	00

FINAL ADJUSTED ANGLES.

Sta. "J"

I'J'M =	28	29	40
MJ'C' =	28	51	50
C'J'N =	24	35	40
NJ'O' =	23	38	40
O'J'N' =	02	32	20
N'J'M' =	04	44	00
M'J'D' =	17	43	00
D'J'K' =	23	09	00
K'J'G' =	53	25	00
G'J'I' =	153	50	50
	360	00	00

Sta. "K"

L'K'J' =	118	13	50
J'K'I' =	09	46	00
I'K'M =	16	01	50
MK'N' =	40	01	40
N'K'O' =	04	09	20
O'K'M' =	01	35	40
M'K'D' =	53	50	40
D'K'L' =	116	05	00
	360	00	00

Sta. "L"

D'L'G' =	362	41	00
G'L'K' =	58	01	30
K'L'N' =	02	31	30
N'L'O' =	02	56	30
O'L'D' =	33	49	40
	360	00	00

Sta. "M"

I'M'M =	19	58	20
MM'C' =	43	00	50
C'M'N =	30	57	00
NM'P' =	70	00	20
P'M'D' =	38	14	30
D'M'K' =	66	49	10
K'M'J' =	67	23	30
J'M'I' =	33	35	30
	360	00	00

Sta. "T"

GT'F =	41	30	40
FT'H =	113	55	10
HT'G =	204	34	10
	360	00	00

Sta. "N"

I'N'M =	31	16	30
M N'C' =	46	10	40
C'N'N =	33	49	30
N N'P' =	68	36	30
P'N'D' =	36	09	10
D'N'K' =	59	26	20
K'N'J' =	68	34	30
J'N'I' =	25	56	50
	360	00	00

Sta. "O"

I'O'M =	30	10	00
M O'C' =	46	45	30
C'O'N =	34	59	40
N O'P' =	75	00	30
P'O'D' =	40	14	00
D'O'K' =	56	15	30
K'O'J' =	61	33	50
J'O'I' =	35	02	00
	360	00	00

Sta. "P"

D'P'M' =	34	33	50
M'P'N' =	03	33	10
N'P'O' =	03	35	20
O'P'I' =	01	41	40
I'P'N =	41	46	30
N P'D' =	274	58	40
	360	00	00

Sta. "Q"

PQ'Q =	300	30	20
QQ'R =	13	18	40
RQ'P =	47	11	00
	360	00	00

Sta. "R"

JR'K =	54	39	20
KR'L =	65	16	30
LR'C =	44	00	30
CR'I' =	15	55	10
I'R'H' =	33	33	10
H'R'G' =	14	51	50
G'R'E' =	37	08	50
E'R'J =	95	44	40
	360	00	00

HEIGHT OF BUILDING METHODS.

The height of building data was obtained by the method of Problem D10,Pages114 and 115 of Pence and Ketchums Surveying Manual (fourth edition 1915). The field notes for the same are on file in the C.E.Dept.Office.

AZIMUTH STATION ADJUSTMENT.

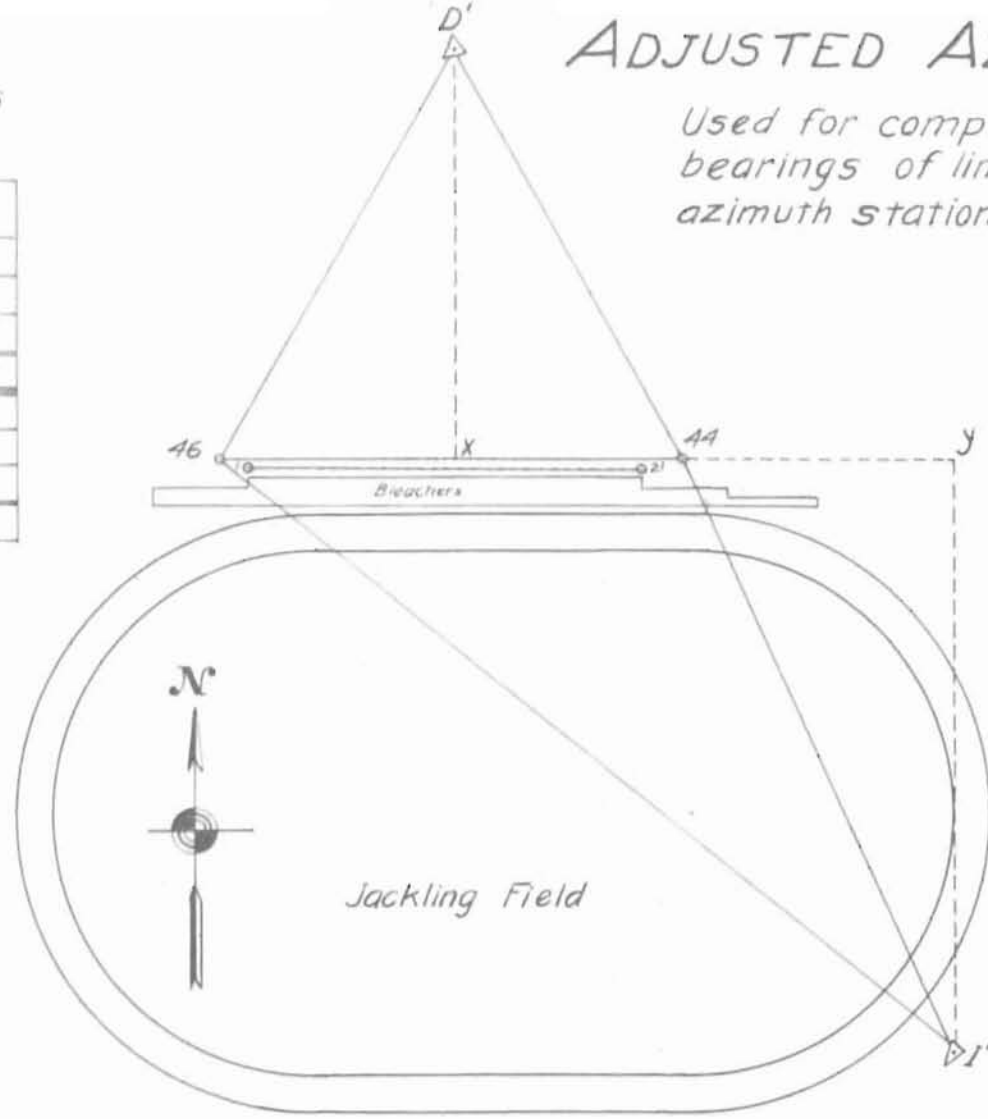
As shown in sketch page 23 the azimuth stations are spaced at regular intervals at 5 and 10 ft. above the Jackling Field Bleackers. The wokk of getting bearings from these 46 points to Stations D' and I' was greatly lessened by making the precise survey as shown by sketch page 39, and by computing the bearings by first solving the angles each line makes with D'I' (by getting first the angle with D'44 and I'44). All the computations are filed in the C.E.Dept office.

ADJUSTED AZIMUTH NOTES

Used for computing the true bearings of lines from the azimuth stations.

ADJUSTED ANGLES

Angle	Adjusted Value
46-44-D'	61°04'49
D'-46-44	60°18'19"
44-D'-46	58°36'52"
Δ 46-D'-44 =	180°00'00"
46-44-1'	114°44'07"
46-1'-44	26°24'02"
44-46-1'	38°51'51"
Δ 46-1'-44 =	180°00'00"



DISTANCES

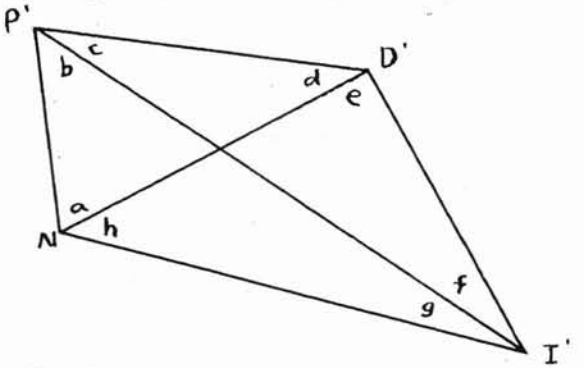
Line	Corrected Distance
46-D'	246.34
44-D'	244.48
44-1'	338.91
46-1'	490.65
44-46	240.26

Line	Computed Distance
46-X	122.03
X-44	118.23
D'-X	213.99
1'-y	307.83
44-y	141.81
46-y	382.04

ADJUSTMENT OF A QUADRILATERAL

Method of Correlatives.

(Geodetic Quadrilateral)



In the plain quadrilateral as shown in above figure, there are seven angle conditions and three side conditions that must be satisfied to make such afigure geometrically possible. These ten conditions can all be covered by thre angle equations and one side equation.

1. The sum of the eight corner angles must be exactly 360°. This furnishes one angle condition.

2. The opposite angles where the diagonals cross must be equal. This furnishes two angle conditions.

3. In each of the four triangles formed among the stations, such as NP'D', the sum of the three angles must be exactly 180°. This furnishes four angle conditions.

The three side conditions arise from the fact that each unknown side is contained in two different triangles, so that each side may be found by two independent computations which must give identical results. Thus the unknown side NI' may be computed from the known side P'D', through the triangles ND'I' and DI'P',or through the triangles NP'I' and ND'P', and the two values thus obtained must be the same. These three conditions are not independent, however,for if any one of them is satisfied, the other two are also satisfied. All seven angle conditions may be satisfied without satisfying any of the side conditions.

The seven angle conditions are so involved, however,that if any three independent ones are satisfied,the other four are also satisfied. The first three are independent,so all the angle conditions will be satisfied if we have:

1. $a+b+c+d+e+f+g\ h=360^\circ$.

$$a+b=e+f \qquad 1.$$

$$c+d=g+h$$

In the side equation we have from the figure:

$$P'D' = P'N\frac{\sin a}{\sin d} = NI'\frac{\sin g}{\sin b}\cdot\frac{\sin a}{\sin d},$$

also,

$$P'D' = D'I'\frac{\sin f}{\sin c} = NI'\frac{\sin h}{\sin e}\cdot\frac{\sin f}{\sin c},$$

whence,

$$\frac{P'D'}{NI'} = \frac{\sin a \sin g \sin f \sin h}{\sin b \sin d \sin c \sin e},$$

or,

$$\frac{\sin a \sin c \sin e \sin g}{\sin b \sin d \sin f \sin h} = 1.$$

When this is true, the side conditions will all be satisfied, and we will have for :

$$2.\ \frac{\sin a \sin c \sin e \sin g}{\sin b \sin d \sin f \sin h} = 1 \qquad 2$$

This may be written in logarithmic form,

$$\Sigma \log \sin (a,c,e,g) - \Sigma \log \sin (b,d,f,h) = 0.$$

Letting M_a, M_b, etc. represent the measured values of the angles a, b, etc., and l_1, l_2, l_3, l_4, represent the discrepancies in these equations due to the errors in the measured angles, we have:

$$\Sigma(M_g \ldots M_h) - 360^\circ = l_1$$

$$(M_a + M_b) - (M_e + M_f) = l_2$$

$$(M_c + M_d) - (M_g + M_h) = l_3$$

$\log \sin(M_a, M_c, M_e, M_g) - \log \sin(M_b, M_d, M_f, M_h) = l_4$

In order to satisfy the conditional equations (1) and (2), the corrections v_a, v_b, etc., in which v_a, v_b, etc., represent the numerical change in seconds required in A, B, etc., which when added algebraicaly to the measured values M_a, M_b, etc., must reduce these equations to zero.

Hence we have:

3. $v_a+v_b+v_c+v_d+v_e+v_f+v_g+v_h=-l_1$;

$v_a+v_b \quad -v_e-v_f \quad =-l_2 \quad 3$

$v_c+v_d \quad -v_g-v_h=-l_3$

$d_a v_a - d_b v_b + d_c v_c - d_d v_d + d_e v_e - d_f v_f + d_g v_g - d_h v_h = -l_4$

v_a etc., are expressed in seconds.

d_a etc., are the tabular differences for one second for the log sin M_a etc.

Angles over 90° the tabular difference must be considered negative, since the sin will decrease as the angle increases in value.

Derivation for Correlatives

A conditional equation expresses a relation that must exist among dependent quantities. In geodetic work the conditional equation may in general be expressed in the form:

$a_1x+a_2y\ldots\ldots\ldots a_ut=E_a$

$b_1x+b_2y\ldots\ldots\ldots b_ut=E_b$ 4.

$\ldots\ldots\ldots\ldots\ldots\ldots$

$m_1x+m_2y\ldots\ldots\ldots m_ut=E_m$

where x,y,t,etc.,are the most probable values of the unknown quantities, and u is the number of such quantities.

$x=M_1$(weight p_1)

$y=M_2$(weight p_2)

$t=M_u$(weight p_u)

Let v_1,v_2,v_u,etc.,represent the corresponding residuals in the given equations. We may then write:

$x=M_1+v_1$

$y=M_2+v_2$ 5.

$\ldots\ldots\ldots$

$t=M_u+v_u$

Substituting in equation 4,gives the conditional equations:

$$a_1v_1+a_2v_2.....+a_uv_u=Ea-\Sigma aM$$
$$b_1v_1+b_2v_2.....+b_uv_u=Eb-\Sigma bM \qquad 6.$$
$$.....$$
$$m_1v_1+m_2v_2.....+m_uv_u=Em-\Sigma mM$$

The values of v_1,v_2,etc.,are indeterminate,and an infinite number of sets of values will satisfy the equations. The values in any one set are not independent,as they must be such as will satisfy the above equations.

If v_1,v_2,etc.,in equation 6, are assumed to vary, thru all possible values,due to any one set of values,dv_1,dv_2,etc.,and all possible sets of values dv_1,dv_2,etc.,are taken in turn,the most probable set of values v_1,v_2,etc.,for the given set of observations will eventually be reached.

The values dv_1,dv_2,etc.,in any one set cannot be independent,as the dependent quantities can not be varied independently.

differentiating equations 6, we have:

$$a_1dv_1+a_2dv_2.....+a_udv_u=0$$
$$b_1dv_1+b_2dv_2.....+b_udv_u=0 \qquad 7.$$
$$.....$$
$$m_1dv_1+m_2dv_2.....+m_udv_u=0$$

The Relations that must Exist among the Quantities dv_1, dv_2, etc.

Since the number of equations is less than the number of quantities dv_1, dv_2, etc., it follows that an infinite number of sets of simultaneous values of dv_1, dv_2, etc., is possible. Inorder to involve equation 7, simultaneously in an algebraic discussion, it is necessary to replace them by a single equivalent equation; meaning an equation so formed that the only values which will satisfy it are those which will individualy satisfy the original equations which it replaces.

This is done by writing:

$$\left.\begin{aligned} &K_1(a_1dv_1+a_2dv_2.....+a_udv_u)\\ &+K_2(b_1dv_1+b_2dv_2.....+b_udv_u)\\ &\quad.....\\ &+K_n(m_1dv_1+m_2dv_2.....+m_udv_u) \end{aligned}\right\} =0$$

K_1, K_2, etc., are independent constants which may have any possible values assigned to them at pleasure. Equation 8, must by agreement remain true for all possible sets of values K_1, K_2, etc., its component members remaining indâvidualy equal to zero.

These component members are identical with the first members of the original conditional eqoations, so that no set of values d v_1,dv_2,etc., can satisfy equation 8, unless it can satisfy each of equation 7.

In order to determine the most probable values of v_1,v_2,etc.,we must have the most probable values of the observed quantities that render the sum of the weighted squares of the residual errors a minimum.

$p_1v_1^2+p_2v_2^2.....+p_uv_u^2$=a minimum.

In accordance with the principals of the calculus FOR THE CASE OF DEPENDENT QUANTITIES the first derivative of this expression must equal zero for every possible set of values dv_1,dv_2,etc. Hence, by differentiating, and omitting the factor 2, we have:

$p_1v_1dv_1+p_2v_2dv_2.....+p_uv_udv_u=0$ 9.

in which dv_1,dv_2,etc., must be simultaneous values. Since these values are also simultaneous in equation 8, we may combine this equation with equation 9, and write:

$$p_1v_1dv_1+p_2v_2dv_2.....+p_uv_udv_u=$$

$$= \begin{cases} k_1(a_1dv_1+a_2dv_2....+a_udv_u) \\ +k_2(b_1dv_1+b_2dv_2....+b_udv_u) \\ ..... \\ +k_m(m_1dv_1+m_2dv_2....+m_udv_u) \end{cases}$$

and by rearranging the terms, we have:

$$\left.\begin{array}{l} (p_1v_1-(k_1a_1+k_2b_1....+k_mm_1))dv_1 \\ +(p_2v_2-(k_1a_2+k_2b_2....+k_mm_2))dv_2 \\ ..... \\ +(p_uv_u-(k_1a_u+k_2b_u....+k_mm_u))dv_u \end{array}\right\} =0. \qquad 10.$$

Since k_1,k_2,etc.,are independent and arbitrary constants, it is evedent that this equation can not be true unless its component members are each equal to zero, so that

$(p_1v_1-(k_1a_1+k_2b_1....+k_mm_1))dv_1=0;$

etc.; etc.;

from which we have:

$$p_1v_1=k_1a_1+k_2b_1....+k_mm_1$$

$$p_2v_2=k_1a_2+k_2b_2....+k_mm_2 \qquad 11.$$

.....

$$p_uv_u=k_1a_u+k_2b_u....+k_mm_u$$

as the general equations of condition for the most probable values of v_1,v_2, etc.

Now it is evident that equations 11, can not be solved for v_1, v_2, etc., until definite values have been assigned to k_1, k_2, etc. In any particular case the m conditional equations 6, must be numericaly satisfied in order to satisfy the rigid geometrical conditions of the case, while the u conditional equations 11, must be satisfied in order to have the most probable values for v_1, v_2, etc. In the general discussion of the problem the values of k_1, k_2, etc., have been entirely arbitrary, since the numerical requirements of equations 6, vanish in differentiation. There is but one set of values for the m unknown quantities k_1, k_2, etc., and the u unknown quantities v_1, v_2, etc., that will satisfy the m plus u equations consisting of equations 6, and 11. The auxiliary quantities k_1, k_2, etc., are called the correlatives of the corresponding conditional equations 6, and the quantities v_1, v_2, etc., are the most probable values of the residual errors in the observation equations. Substituting in equations 6, the values of v_1, v_2, etc., due to equations 11, we have:

$$k_1\Sigma\frac{a^2}{p}+k_2\Sigma\frac{ab}{p}.....+k_m\Sigma\frac{am}{p}=E_a-\Sigma aM$$

$$k_1\Sigma\frac{ab}{p}+k_2\Sigma\frac{b^2}{p}.....+k_m\Sigma\frac{bm}{p}=E_b-\Sigma bM \qquad 12.$$

.....

$$k_1\Sigma\frac{am}{p}+k_2\Sigma\frac{bm}{p}.....+k_m\Sigma\frac{m^2}{p}=E_m-\Sigma mM$$

in which

$$\Sigma\frac{a^2}{p}=\frac{a_1^2}{p_1}+\frac{a_2^2}{p_2}.....+\frac{a_u^2}{p_u}$$

$$\Sigma\frac{ab}{p}=\frac{a_1b_1}{p_1}+\frac{a_2b_2}{p_2}.....+\frac{a_ub_u}{p_u}$$

etc., etc.

It is evident that k_1, k_2, etc., can be found by solving the simultaneous equations 12. Then from equations 11, we have:

$$v_1=k_1\frac{a_1}{p_1}+k_2\frac{b_1}{p_1}.....+k_m\frac{m_1}{p_1}$$

$$v_2=k_1\frac{a_2}{p_2}+k_2\frac{b_2}{p_2}.....+k_m\frac{m_2}{p_2} \qquad 13.$$

.....

$$v_u=k_1\frac{a_u}{p_u}+k_2\frac{b_u}{p_u}.....+k_m\frac{m_u}{p_u}$$

and from equations 5,

$$x=M_1+v_1$$
$$.....\qquad 14.$$
$$t=M_u+v_u$$

in which x, t, etc., are the most probable values of the quantities whose observed values were M_1, M_u, etc.

Using l_1, l_2, etc., as representing the discrepancies due to errors in the measured angles, and rewriting equation 12, we have:

$$k_1\Sigma\frac{a^2}{p}+k_2\Sigma\frac{ab}{p}+k_3\Sigma\frac{ac}{p}+k_4\Sigma\frac{ad}{p}=-l_1$$

$$k_1\Sigma\frac{ab}{p}+k_2\Sigma\frac{b^2}{p}+k_3\Sigma\frac{bc}{p}+k_4\Sigma\frac{bd}{p}=-l_2$$

$$k_1\Sigma\frac{ac}{p}+k_2\Sigma\frac{bc}{p}+k_3\Sigma\frac{c^2}{p}+k_4\Sigma\frac{cd}{p}=-l_3 \qquad 15.$$

$$k_1\Sigma\frac{ad}{p}+k_2\Sigma\frac{bd}{p}+k_3\Sigma\frac{cd}{p}+k_4\Sigma\frac{d^2}{p}=-l_4$$

and from equations 13, and 5, we have:

$$v_a=k_1\frac{1}{p_a}+k_2\frac{1}{p_a}+k_4\frac{d_a}{p_a}$$

$$v_b=k_1\frac{1}{p_b}+k_2\frac{1}{p_b}-k_4\frac{d_b}{p_b}$$

$$v_c=k_1\frac{1}{p_c}+k_3\frac{1}{p_c}+k_4\frac{d_c}{p_c}$$

$$v_d=k_1\frac{1}{p_d}+k_3\frac{1}{p_d}-k_4\frac{d_d}{p_d}$$

$$v_e=k_1\frac{1}{p_e}-k_2\frac{1}{p_e}+k_4\frac{d_e}{p_e} \qquad 16.$$

$$v_f=k_1\frac{1}{p_f}-k_2\frac{1}{p_f}-k_4\frac{d_f}{p_f}$$

$$v_g=k_1\frac{1}{p_g}-k_3\frac{1}{p_g}+k_4\frac{d_g}{p_g}$$

$$v_h=k_1\frac{1}{p_h}-k_3\frac{1}{p_h}-k_4\frac{d_h}{p_h}$$

in which p_a, represents the weight of M_a, p_b, the weight of M_b, and so on.

Then in the case of equal weights, we have from equations 3, and 15 :

$$8k_1+((d_a+d_c+d_e+d_g)-(d_b+d_d+d_f+d_h))k_4 = -l_1$$

$$4k_2+(d_a-d_b-d_e+d_f)k_4 = -l_2$$

$$4k_3+(d_c-d_d-d_g+d_h)k_4 = -l_3 \qquad 17.$$

$$((d_a+d_b+d_e+d_g)-(d_b+d_d+d_f+d_h))k_1$$
$$+(d_a-d_b-d_c+d_f)k_2+(d_c-d_d-d_g+d_h)k_3+\Sigma d^2k_4 = -l_4$$

and from equation 16, we have:

$$v_a=k_1+k_2+d_ak_4$$
$$v_b=k_1+k_2-d_bk_4$$
$$v_c=k_1+k_3+d_ck_4$$
$$v_d=k_1+k_3-d_dk_4$$
$$v_e=k_1-k_2+d_ek_4$$
$$v_f=k_1-k_2-d_fk_4$$
$$v_g=k_1-k_3+d_gk_4$$
$$v_h=k_1-k_3-d_hk_4$$

Having found the values of v_a, v_b, etc., we have in any case for the most probable values of the angles a, b, etc.,

$a=M_a+v_a$; $e=M_e+v_e$;

$b=M_b+v_b$; $f=M_f+v_f$; 19.

$c=M_c+v_c$; $g=M_g+v_g$;

$d=M_d+v_d$; $h=M_h+v_h$.

Referring to equation 8a, and solving for l_1, l_2, l_3, l_4, we have:

$l_1 = -14"$,

$l_2 = -4.3"$,

$l_3 = -3.3"$,

$l_4 = +769.8$;

Solving equation 17, we have first,

$d_a - d_c - d_e - d_g = 106.9$

$d_b - d_d - d_f - d_h = 100.5$

$d_a - d_b - d_e - d_f = 79.8$

$d_c - d_d - d_g - d_h = -24.2$

whence by substituting these results in the equation we have:

$8k_1 - 11.6k_4 = 14$

$4k_2 - 79.8k_4 = 4.3$

$4k_3 - 24.2k_4 = 3.3$

$-11.6k_1 - 79.8k_2 - 24.2k_3 + 10835.72k_4 = -769.8$

Having four independent equations and four unknowns it is evident that k_1, k_2, k_3, k_4, can be found by solving the above equations simultaneously.

From which we find :

$k_1 = 1.6197$ $\qquad$ $k_3 = 0.2813$

$k_2 = 2.2679$ $\qquad$ $k_4 = -.06987$

Now by equation 18, the adjustments are as follows:

$k_1 - k_2 - d_a k_4 = -1.4500$ = adjustment for angle a

$k_1 - k_2 - d_b k_4 = -6.5995$ = " " " " b

$k_1 - k_3 - d_c k_4 = -0.1121$ = " " " " c

$k_1 - k_3 - d_d k_4 = +2.8626$ = " " " " d

$k_1 - k_2 - d_e k_4 = -2.3716$ = " " " " e

$k_1 - k_2 - d_f k_4 = 6.1211$ = " " " " f

$k_1 - k_3 - d_g k_4 = -2.9764$ = " " " " g

$k_1 - k_3 - d_h k_4 = +1.7248$ = " " " " h

The above adjustments should be added to the measured angles algebraically as shown in equation 12.

After the above adjustments are made they should be checked by their log sines; the sum of which, according to equation 2, should be equal to zero.

These corrected angles are according to the theory of least squares, the most probable angles for the quadrillateral under consideration.

Quadrilateral Adjustment by Method of Least Squares

Measured Ang's		p	Log sin	d	d^2	Adjustments		Adjusted Angles	Check log sines
a	31° 56' 37.5"	1	9.72352665	33.8	1142.44	$K_1 + K_2 + d_a K_4$	+1.450"	31° 56' 38.950"	9.72355315
b	41° 48' 15"	1	9.82385665	23.5	552.25	$K_1 + K_2 - d_b K_4$	+6.599"	41° 48' 21.599"	9.8238721
c	43° 12' 56.7"	1	9.83553041	22.4	501.76	$K_1 + K_3 + d_c K_4$	-0.112"	43° 12' 56.588"	9.8355301
d	63° 02' 00"	1	9.95000950	10.7	114.49	$K_1 + K_3 - d_d K_4$	+2.863"	63° 02' 2.863"	9.9500126
e	59° 21' 00"	1	9.93464860	12.5	156.25	$K_1 - K_2 + d_e K_4$	-2.372"	59° 20' 57.628"	9.9346456
f	14° 23' 56.8"	1	9.39563186	82	6724.0	$K_1 - K_2 - d_f K_4$	+6.121"	14° 24' 02.921"	9.3956820
g	27°41' 22.5"	1	9.66715495	40.2	1616.04	$K_1 - K_3 + d_g K_4$	-2.274"	27° 41' 20.226"	9.6671458
h	78°33' 37.5"	1	9.99128562	4.3	18.49	$K_1 - K_3 - d_h K_4$	+1.725"	78° 33' 39.225"	9.9912863
	359°59' 46"		l_4 = 769.8	ΣD^2 =	10825.72			360° 00' 00"	l_4 = 0

a+b = 73° 44' 52.5"
c+f = 73° 44' 56.8"
l_2 = - 4.3"

c+d = 106° 14' 56.7"
g+h = 106° 15' 00"
l_3 = - 3.3

$d_a + d_c + d_e + d_g$ = 108.9
$d_b + d_d + d_f + d_h$ = 120.5
$d_a - d_b - d_e + d_f$ = 79.8
$d_c - d_d - d_g + d_h$ = -24.2

-359° 59' 60"
359° 59' 46"
l_1 = - 14"

$8K_1 - 11.6K_4 = 14$
$4K_2 + 79.8K_4 = 4.3$
$4K_3 - 24.2K_4 = 3.3$
$-11.6K_1 + 79.8K_2 - 24.2K_3 + 10825.72K_4 = -76$

K_1 = +1.6197
K_2 = +2.8679
K_3 = +0.2813
K_4 = -0.08987

Rigorous Adjustment of a Quadrilateral

	Measured Angles	Angle equation adjustment: For 360°	For Opp Angles		Adjusted Values	Log sin A, B, etc.	d	Side Equation Adjustment		Adjusted Ang.	Check Log. Sines
a	31°56'37.5"	+1.75"	+1.075"	A	31°56'40.325"	9.7235362	33.7	+x + x₁	-1.372"	31°56'38.953"	9.7235315
b	41°48'15.0"	+1.75"	+1.075"	B	41°48'17.825"	9.8238633	23.5	+x - x₁	+3.77"	41°48'21.595"	9.8238721
c	43°12'56.7"	+1.75"	+.825"	C	43°12'59.275"	9.8355362	22.4	-x + x₂	-2.69"	43°12'56.585"	9.8355801
d	63°02'00"	+1.75"	+.825"	D	63°02'02.575"	9.9500123	10.7	-x - x₂	+0.29"	63°02'02.865"	9.9500126
e	59°21'00"	+1.75"	-1.075"	E	59°21'00.675"	9.9346494	12.4	+x + x₃	-3.04"	59°20'57.636"	9.9346456
f	14°23'56.8"	+1.75"	-1.075"	F	14°23'57.475"	9.3956374	82	+x - x₃	+5.44"	14°24'02.915"	9.3956820
g	27°41'22.5"	+1.75"	-.825"	G	27°41'23.425"	9.6671587	40.2	-x + x₄	-3.20"	27°41'20.225"	9.6671458
h	78°33'37.5"	+1.75"	-.825"	H	78°33'38.425"	9.9912860	4.3	-x - x₄	+0.80"	78°33'39.225"	9.9912863
	359°59'46.0"				360°00'00"	l = +815				360°00'00"	l = 0

$d_a = 33.7$
$d_d = 10.7$
$d_e = 12.4$
$d_h = 4.3$
61.1
168.1
$C = -107.0$

$d_b = 23.5$
$d_c = 22.4$
$d_f = 82.0$
$d_g = 40.2$
168.1

$\frac{C}{4} = -26.75$

$d_a = 33.7$
$d_b = 23.5$
$C_1 = 57.2$

$d_e = 12.4$
$d_f = 82.0$
$C_3 = 94.4$

$d_c = 22.4$
$d_d = 10.7$
$C_2 = 33.1$

$d_g = 40.2$
$d_h = 4.3$
$C_4 = 44.5$

$\frac{C^2}{4} = 2862.25$

$C_1^2 = 3271.84$
$C_2^2 = 1095.61$
$C_3^2 = 8911.36$
$C_4^2 = 1980.25$
18121.31

$\frac{-815}{18121.3} = -0.04497$

$+x = -26.75 \times -.04497 = +1.20$
$+x_1 = 57.2 \times -.04497 = -2.57$
$+x_2 = 33.1 \times -.04497 = -1.48$
$+x_3 = 94.4 \times -.04497 = -4.24$
$+x_4 = 44.5 \times -.04497 = -2.00$

Measurement of the Base Line

The line between the triangulation points P'and D' was chosen for the base line, being the one most favorably situated for this purpose; and to avoid excessive slopes was measured as a broken line P'xD'.

Measurements were made with a K.&E.tape graduated to hundredths, which had been recently standardized by the U.S.Bureau of Standards.

The method was as follows:

(1).Stakes were set along the line of measurement by transit, approximately one half tape length apart.

(2).The angles P'D'x and D'P'x,were measured by repition and the triangle balanced to 180°.

(3).Elevations were taken on these stakes with a level.

(4).The slope distances between tacks in these stakes were careful measured, noteing the temperature, and useing a constant tension of ten pounds.

(5).Corrections were made for absolute length. for sag, for temperature, and for vertical and horizontal alignment,the final result being taken as the true length of the base line.

In the quadrilateral P'D'I'N,we assumed the angles to have been measured with equal care. The base line P'D',was measured with a standard steel tape, and corrections made for temperature, sag, and tension. In adjusting this quadrilateral, the following conditions, or equations of condition must be satisfied:

(1).Angle equations,

$a+b+c+d+e+f+g+h=360^{\circ}$

$a+b=e+f$

$c+d=g+h$

(2).Side equation,

(log sin a + log sin c + log sin e + log sin g)-
(log sin b + log sin d + log sin f + log sin h)=0.

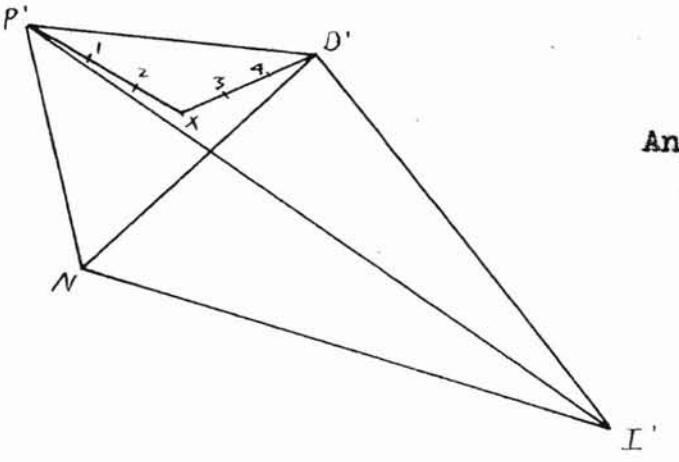
A provisional adjustment is first made that will satisfy the angle equations. This adjustment is as follows:

(1). If $a+b+c+d+e+f+g+h$, fails to equal 360°,each angle is corrected by adding or subtracting one eighth of the discrepancy as the case may be.

(2). If $a+b$, fails to equal $e+f$, increase each member of the smaller sum and decrease each member of the larger sum by one fourth of the discrepancy.

The same fact applies to the condition if c+d, fails to equal g+h.

COMPUTATIONS FOR BROKEN BASE LINE



Angle xD'P'=17°35'10"

" D'P'x=17°16'15"

NOTES

Line	nSlope Dist.	Diff. in Elev.
P'-1	52.292'	1.036'
1-2	33.580'	0.552'
2-x	26.065'	1.018'
x-3	26.400'	0.696'
3-4	36.765'	0.157'
4-D'	46.805'	0.153'

Temperature of tape=5°C.

Tension on tape=10 lbs.

Weight of tape per foot=0.014 lbs.

(1) Correction for absolute length.

$Ca = \frac{Lc}{l}$. L= uncorrected length.
c= correction to measuring unit.
l= uncorrected length of measuring unit.

Correction for 10 lb. pull, supported at 0-100 = -0.045'

then $c = \frac{0.045}{100} = -0.00045'$. l= 1.

then Ca = Lc.

C

Corrections	Corrected Values
Ca(P'-1)=52.292x-.00045=-.023	(P'-1) = 52.269'
Ca (1-2)=33.580x-.00045=-.015	(1-2) = 33.565'
Ca (2-x)=26.065x-.00045=-.012	(2-x) = 26.053'
Ca (x-3)=26.400x-.00045=-.012	(x-3) = 26.388'
Ca (3-4)=36.765x-.00045=-.016	(3-4) = 36.749'
Ca(4-D')=46.805x-.00045=-.021	(4-D') = 46.784'

(2) Corrections for temperature.

$Ct = LK(t_1-t_2)$ K= coefficient of expansion for tape.
t_1= standard temperature
t_2= actual temperature.

K= .0000063 t_1= 62°F t_2= 5°C=41°F

then $K(t_1-t_2)$=.0000063(62-41)=.0001323

Corrections	Corrected Values
Ct(P'-1)=52.269x.00013=-.0069	(P'-1) = 52.262'
Ct (1-2)=33.569x.00013=-.0044	(1-2) = 33.561'
Ct (2-x)=26.053x.00013=-.0034	(2-x) = 26.050'
Ct (x-3)=26.308x.00013=-.0035	(x-3) = 26.305'
Ct (3-4)=36.749x.00013=-.0049	(3-4) = 36.744'
Ct(4-D')=46.784x.00013=-.0061	(4-D') = 46.778'

(3) Corrections for sag.

$$Cs = \frac{L}{24}\left(\frac{wl}{t}\right)^2$$

l=length of a span
L=uncorrected length x (n)=ln
w=weight of a unit length of tape=.014lbs
t=tension=10lbs.
n=number of spans=1

then $Cs = \frac{l^3 x .014^2}{2400} = .000000087(1)^3$

Corrections	Corrected Values
Cs(P'-1)= -.0120	(P'-1) = 52.250'
Cs (1-2)= -.0030	(1-2) = 33.558'
Cs (2-x)= -.0014	(2-x) = 26.049'
Cs (x-3)= -.0015	(x-3) = 26.383'
Cs (3-4)= -.0041	(3-4) = 36.740'
Cs(4-D')= -.0084	(4-D') = 46.770'

(4) Correction for grade.

$Cg = \frac{h^2}{2L}$. h= difference in elevation
L= uncorrected distance

Corrections	Corrected Values
Cg(P'-1)= -.0100	(P'-1)= 52.240'
Cg (1-2)= -.0050	(1-2)= 33.553'
CgCg(2-x)= -.0190	(2-x)= 26.030'
Cg (x-3)= -.0090	(x-3)= 26.374'
Cg (3-4)= -.0003	(3-4)= 36.740'
Cg (4-D')=-.0002	(4-D')= 46.770'

Distance P'x = (P'-1)+(1-2)+(2-x)= 111.823'

Distance xD' = (x-3)+(3-4)+(4-D')= 109.884'

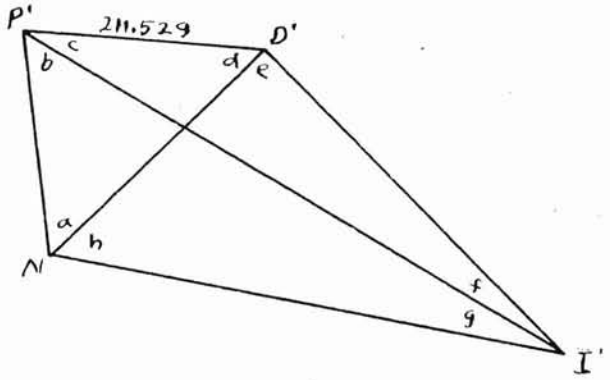
(5) Correction for horizontal alignment.

$c = \sqrt{a^2+b^2+2ab.\cos\theta}$ c= length of base line
a= P'x = 111.823
b= xD' = 109.884
θ= xD'P' D'P'x =34°51'25"

$c = \sqrt{12504.583+12074.493+2x111.823x109.884x\cos 34°51'25"}$

c= 211.529' = true length of base line.

Having found the corrected angles for the quadrilateral, and also the corrected length of the base line, we can now solve the remaining sides of the figure by the law of sines.



Solving for P'N in triangleP'D'N

log P'N=log sin 63°2' 2.863"= log 211.529-log sin 31°56' 38.950"

log 211.529	=2.3253700	
log sin 63°02'2.86"	2.9500186-10	
	12.2753886-10	
log sin 31°56'38.950"	9.7235315-10	
log P'N	2.5518571	P'N= 356.329 ft.

Solving for P'I' in triangle D'I'P'

log D'I'=log sin63°12'56.566"=log 211.529-log sin 14°24'02.921"

log 211.529	2.3253700	
log sin 63°12'56.566"	9.9385391-10	
	12.1609091-10	
log sin 14°24'02.921"	9.3956820-10	
log D'I'	2.7652181	D'I'= 582.396

Solving for NI' in triangle ND'I'

log NI'-log sin 59°20'57.628"=log D'I'-log sin 78°33'39.225"

log D'I' 2.7652181

log sin 59°20'57.628" 9.9346456-10

12.6998637

log sin 78°33'39.225" 9.9912863-10

log NI' 2.7085774 NI'=511.184 ft.

Solving for P'I' in triangle P'I'D'

log P'I'-log sin(d+e)=log 211.529-log sin 14°24'02.921"

(d+e)= 122°23'00.491"

log sin 122°23'00.491" 9.9265906-10

log 211.529 2.3253700

12.2519606

log sin 14°24'02.921" 9.3956820-10

log P'I' 2.8562786 P'I'= 718.255 ft.

Solving for ND' in triangle P'D'N

log ND'-log sin(b+c)=log 211.529-log sin 31°56'38.950"

~~log~~ (b+c)= 85°01'18.187"

log sin 85°01'18.187" 9.9983586-10

log 211.529 2.3253700

12.3237286

logsin 31°56'38.950" 9.7235315-10

log ND' 2.6001971 ND'= 398.288 ft.