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FINAL REPORT

WIND TUNNEL ANALYSIS OF THE EFFECTS OF PLANTINGS AT HIGHWAY GRADE SEPARATION STRUCTURES: SUPPLEMENT

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DEPARTMENT OF CIVIL ENGINEERING
DEPARTMENT OF AEROSPACE ENGINEERING
DEPARTMENT OF LANDSCAPE ARCHITECTURE
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Table 1. Particle Properties

This table lists the properties of the particles tested for snowdrift simulation.

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Constant Data		Name Date of Test Course No. Section

Column No														
Item	Material	ρ_p	D_p	U_f/u_{*t}	U_o **	A_1	u_{*t}							
Units		particle density	particle Diameter	*	Bridge Ht	***	threshold friction speed							
Ref.		gm/cm^3	μm		FPS		cm/S							
1.	tea	0.2	500	6.00	3.55	0.123	11.0							
2.	shell35	1.1	69	0.90	5.64	0.225	17.5							
3.	shell28	1.1	268	5.96	5.96	0.121	18.5							
4.	glass M	2.5	101	2.8	6.61	0.144	20.5							
5.	"2332.5	3.99	49	1.3	6.93	0.172	21.5							
6.	snow	0.7	150	2.55	7.00	0.153	14.0							
7.														
8.														
9.	* Ratio of particle terminal speed to threshold friction speed													
10.	** Reference air speed at initiation of particle motion in the wind tunnel.													
11.														
12.	*** Threshold friction speed coefficient													
13.														
14.														
15.														
16.														
17.														
18.														
19.														
20.														
21.														
22.														
23.														
24.														
25.														

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Table 2. Basic experiment data log

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Constant Data		Name Date of Test Course No. Section

Column No	Run #	Δp	Config.	Mat'l	Pa	T	Date	Start time	q		Free Stream Speed		
Item	Run Number	Transd. Voltage			Barom. Pressure	Ambient Temp.			Dynamic Pressure	Air Density ρ	U_∞		
Units		Volts			inHg	°F			PSF	slugs/ft^3	FPS	COMMENTS	
Ref.													
1.	1	0.93	1-0°	Glass ML	29.05	60	10/12/78	935	0.494	.00230	20.73	Bare model calib.	
2.	2	0.88	1-0°	Glass ML	29.04	54	10/12/78	242	0.467	.00233	20.02	Bare model calib	
3.	3	1.21	"	"	29.04	54	10/12/78	442	0.643	.00233	23.49	Bare model calib.	
4.	1	0.76	"	"	29.34	57	10/13/78		0.404	.00234	18.58	Bare model ceiling	
5.	1	0.88	"	"2332.5	29.40	53	10/14/78	1149	0.467	.00236	19.89	Bare model calib.	
6.	1	0.99	"	"	29.34	46	10/17/78	833	0.526	.00239	20.98	Bare model calib.	
7.	2	0.925	"	"	29.29	54	10/17/78	1119	0.491	.00235	20.44	Bare model calib.	
8.	1	0.56	"	Shell28	29.28	50	10/18/78	845	0.297	.00237	15.84	Invalid, left off spire	
9.	2	0.60	"	"	29.27	53	10/18/78	940	0.319	.00235	16.47	Bare model calib.	
10.	3	0.80	"	"	29.33	60	10/18/78	2:36	0.425	.002325	19.12	Bare model calib.	
11.	1	0.73	"	"	29.28	49	10/19/78	8:44	0.388	.00237	18.09	Bare model calib.	
12.	2	0.89	"	Shell35	29.25	56	10/19/78	10:22	0.473	.00234	20.12	Bare model calib.	
13.	3	0.57	"	Tea	29.14	67	10/19/78	---	0.303	.00228	16.30	Bare model calib.	
14.	1	1.24	"	2332.5	28.69	56	10/25/78	10:47	0.658	.00229	23.97	Benson plant test	
15.	1	1.06	"	"	29.50	55	10/31/78	1:53	0.563	.00236	21.84	Plan DOT-1	
16.	2	RUN ABORTED,		No Spires				4:08				Plan DOT-1	
17.	1	1.07	1-0°	2332.5	29.45	50	11/1/78	9:51	0.568	.00238	21.85	Plan DOT-1	
18.	1	0.96	"	"	29.23	66	11/2/78	4:06	0.510	.00229	21.10	Bare Model, guardrail	
19.	1	0.95	"	"	29.34	54	11/6/78	1:28	0.504	.00235	20.71	DOT-1 with guardrail	
20.	1	1.32	"	"	29.28	46	11/7/78	8:29	0.701	.00235	24.43	Bare model calib.	
21.	2(1)	0.95	"	"	29.20	56	11/7/78	2:14	0.504	.00233	20.80	Plan DOT-2	
22.	3(2)	0.98	"	"	29.20	58	11/7/78	3.54	0.520	.00232	21.17	Plan A-0	
23.	1	1.07	"	"	28.84	56	11/9/78	10:06	0.568	.00230	22.22	Plan B-0	
24.	1	1.06	"	"	28.96	55	11/10/78	9:47	0.563	.00232	22:04	Plan C-0	
25.	2	1.13	"	"	28.82	60	11/10/78	1:15	0.600	.00228	22.92	Plan D-0	

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Constant Data		Name Date of Test Course No. Section

Column No	Run #	Δp	config.	mat'l	Pa	T	Date	Start time	q	ρ	U_∞	COMMENTS
Item												
Units		Volts			in Hg	°F			PSF	slugs/ft3	FPS	
Ref.												
1.	3	0.980	1-0°	GL-2332.5	28.94	62	11/10/78	3:44	.520	.002285	21.34	Vortex generators
2.	4	0.960	"	"	29.00	60	11/10/78	7:00	.510	.00230	21.06	Plan E-0
3.	5	0.945	"	"	29.05	58	11/10/78	8:20	.502	.00231	20.84	Plan F-0
4.	1	0.71	"	"	28.89	55	11/13/78	9:51	0.377	.00231	18.06	Bare model calib.
5.	1	0.96	"	"	29.37	43	11/14/78	3:13	0.510	.00241	20.58	Plan G-0
6.	1	0.955	"	"	29.41	35	11/15/78	9:42	0.507	.00245	20.35	Plan H-0
7.	2	0.950	"	"	29.36	38	11/15/78	1:13	0.5045	.00243	20.38	Plan I-0
8.	3	0.960	"	"	29.35	42	11/15/78	3:28	0.510	.00241	20.57	Plan J-0
9.	1	0.540	"	"	29.31	40	11/16/78	11:12	0.287	.00242	15.41	Bare model calib.
10.	2	0.960	"	"	29.15	37	11/16/78	7:16	0.510	.00242	20.54	Plan K-0
11.	1	0.965	"	"	29.11	40	11/17/78	10:30 p	0.512	.00240	20.67	Plan L-0
12.	1	0.92	"	"	29.19	39	11/18/78	10:06a	0.489	.00241	20.13	Illinois
13.	1	0.92	"	"	29.76	30	11/20/78	10:43	0.489	.00250	19.76	Plan M-0
14.	1	0.897	"	"	29.57	27	11/22/78	7:30	0.476	.00250	19.51	Plan N-0
15.	1	0.918	"	"	29.30	34	11/23/78	6:50	0.487	.00244	19.97	Plan O-0
16.	1	0.84	1-20°	"	29.28	6	12/7/78	10:18	0.446	.00259	18.56	Bare model calib.
17.	1	0.875	"	"	29.26	8	12/9/78	1:33	0.465	.00258	18.99	Plan DOT-1
18.	1	0.86	"	"	28.96	25	12/15/78	8:55	0.457	.00246	19.26	Bare model calib.
19.	1	0.93	"	"	28.86	36	12/19/78	8:45	0.494	.00240	20.29	Plan A-20
20.	2	0.85	"	"	28.79	38	12/19/78	11:24	0.451	.00238	19.46	Plan B-20
21.	3	0.895	"	"	28.73	36	12/19/78	2:42	0.475	.00239	19.95	Plan C-20
22.	1	0.985	"	"	28.65	32	12/20/78	10:42	0.523	.00240	20.88	Plan D-20
23.	1	0.930	"	"	28.60	36	12/21/78	3:16	0.494	.00238	20.39	Plan D-20
24.	1	0.925	"	"	28.99	32	12/22/78	4:58	0.491	.00243	20.11	Plan E-20
25.	1	0.890	"	"	29.32	18	12/27/78	11:27	0.473	.00253	19.34	Plan F-20

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Constant Data		Name Date of Test Course No. Section

Column No													
Item	Run #	Δp	config.	mat'l.	Pa	T	Date	Start time	q	ρ	U_∞	COMMENTS	
Units		Volts			in Hg	°F			psf	slugs/ft^3	FPS		
Ref.													
1.	2	0.895	1-20°	2332.5	29.18	28	12/27/78	3:37	0.475	.00246	19.64	Plan G-20	
2.	3	0.840	"	"	29.16	26	12/27/78	7:58	0.446	.00247	18.99	Plan H-20	
3.	1	0.915	"	"	29.00	32	12/28/78	10:40	0.486	.00243	20.00	Plan I-20	
4.	2	0.895	"	"	28.95	35	12/28/78	3:17	0.475	.00241	19.86	Plan J-20	
5.	1	0.900	"	"	28.48	10	1/5/79	4:29	0.478	.00250	19.56	Plan K-20	
6.	1	0.915	"	"	29.09	8	1/16/79	4:45	0.486	.00256	19.48	Plan L-20	
7.	1	0.750	Fence	"	28.73	18	1/20/79	6:57	0.398	.00248	17.93	Fence, solid-wood	
8.	2	0.450	"	"	28.73	16	1/20/79	≈ 8:35	0.239	.00249	13.86	Fence, solid-paper	
9.	1	0.460	"	"	28.79	24	1/22/79	8:41	0.244	.00245	14.12	Fence, Solid-gap "	
10.	2	0.490	"	"	28.79	24	1/22/79	2:43	0.260	.00245	14.57	" " cloth	
11.	1	0.400	"	"	29.16	8	1/29/79	4:47	0.212	.00257	12.86	50% fence	
12.	1	0.45	"	"	29.22	0	1/31/79	9:42	0.239	.00262	13.51	Standard bush	
13.	2	0.4	"	"	29.22	2	1/31/79	4:49	0.212	.00261	12.77	25% fence	
14.	1	0.63	"	"	29.16	3	2/3/79	10:32	0.335	.00260	16.05	1/2 bush	
15.	1	0.43	"	"	28.94	26	2/6/79	8:35	0.228	.00245	13.64	Fence, solid-gap	
16.	1	1.04	1-40°	"	29.43	5	2/9/79	1:33	0.552	.00261	20.58	Bare model calib.	
17.	1	0.965	"	"	29.46	21	2/12/79	1:32	0.512	.00252	20.15	Plan DOT 1	
18.	1	0.945	"	"	29.34	21	2/13/79	10:41	0.502	.00251	19.98	Plan F-40	
19.	2	0.90	"	"	29.21	25	2/13/79	2:29	0.478	.00248	19.62	Plan G-40	
20.	1	0.95	"	"	28.85	33	2/14/79	1:30	0.504	.00241	20.45	Plan J-40	
21.	1	0.96	"	"	29.14	16	2/15/79	≈ 11:05	0.510	.00252	20.10	HI-SP &Time lapse-	
22.	2	0.94	"	"	29.22	15°	2/15/79	2:41	0.499	.00254	19.84	bare Bare model calib.	
23.	1	0.92	"	"	29.76	-5°	2/16/79	1:08	0.489	.00270	19.04	Plan A-40	
24.	1	1.01	"	"	29.34	6°	2/19/79	8:41	0.536	.00260	20.33	Plan I-40	
25.	2	0.99	"	"	29.17	37°	2/19/79	2:32	0.526	.00242	20.85	Plan D-40	

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Constant Data														
										Name Date of Test Course No. Section				
Column No	RUN #	Δp	Config.	Mat'l.	Pa	T	Date	Start time	q	ρ	U_∞	COMMENTS		
Item														
Units		Volts			in Hg	°F			PSF	slugs/ft^3	FPS			
Ref.														
1.	1	0.92	1-40	2332.5	29.00	40	2/20/79	11:32	0.489	.00239	20.22	Plan G-40		
2.	2	0.93	"	"	28.91	38	2/20/79	3:43	0.494	.00239	20.32	Bare model calib.		
3.	1	0.87	"	"	29.17	26	2/21/79	1:53	0.462	.00247	19.33	Plan F-40		
4.	1	0.88	"	"	28.87	35°	2/22/79	1:36	0.467	.00240	19.72	Plan FM-40		
5.	1	0.89	"	"	29.13	23	2/23/79	10:32	0.473	.00249	19.50	1/2 bush, plan FM-40		
6.	1	0.93	"	"	29.51	15	2/24/79	10:55	0.494	.00256	19.64	time lapse-only ~~2.4FR/S-off 10:44 bar~~		
7.	1	0.73	2-0	"	28.79	24	3/24/79	11:40	0.388	.00245	17.78	Bare model calib.		
8.	1	1.03	"	"	29.25	32	3/26/79	10:47	0.547	.00245	21.13	Bare model calib.		
9.	1	0.83	"	"	29.39	26	3/27/79	9:27	0.441	.00249	18.81	Bare model calib.		
10.	2	0.94	"	"	29.28	37	3/27/79	3:20	0.499	.00243	20.28	Plan D-0		
11.	1	0.92	"	"	28.80	43	3/28/79	10:47	0.489	.00236	20.35	Plan G-0		
12.	1	0.80	"	"	28.55	57	4/12/79	9:49	0.425	.00228	19.32	Bare model with BERM		
13.	1	0.91	"	"	28.85	49	4/13/79	10:04	0.483	.00234	20.34	Plan G-0 with BERM		
14.	1	0.305	new 50% fence	"	29.14	51	5/1/79	8:43	0.162	.00235	11.74	8MPH	50% fence	
15.	1	0.431	"	"	28.60	73	5/8/79	10:59	0.229	.00221	14.39	9.8MPH	" "	cont
16.	1	0.5365	"	"	28.86	69	5/10/79	8:51	0.285	.00225	15.92	10.85MPH	"	"
17.	1	0.562	Wall	"	29.26	53	5/23/79	9:17	0.298	.00235	15.93	Acoustic wall		
18.	2	0.363	"	"	29.26	53	5/23/79	10:16	0.193	.00235	12.81	"	"	
19.	3	0.984	"	"	29.26	53	5/23/79	10:57	0.193	.00235	21.08	" "	cont.	
20.														
21.														
22.														
23.														
24.														
25.														

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Table 3. Experiment comment log.

Run 10-12-1
Bare model calibration.
Material collects under bridge about half-bridge width (upwind lane) from start of test - later, material collects from upwind edge of lanes, first on upwind lane, more material collects on upwind lane.
Drift depth on road about 3 mm.

Run 10-12-2
Bare model calibration
Same comments as 10-12-1, somewhat slower speed

Run 10-12-3
Bare model calibration.
Same comments as 10-12-1, 2, higher speed

Run 10-13-1
Ceiling test, unsuccessful with insufficient material and variable release rate, Material deposited under bridge (upwind lane).

Run 10-14-1
Bare model calibration.
Drift deposition with new material ($\rho_p = 4$, $D_p = 50$) appears to be identical to runs 10-12-1, 2, 3 ($\rho_p = 2.5$, $D_p = 100$).

Run 10-17-1
Bare model calibration.
Drift patterns same.

Run 10-17-2
Bare model calibration.
Drift patterns same.

Run 10-18-1
Bare model calibration.
Drift deposition with new material ($\rho_p = 1.1$, $D_p = 260$)
Same as other two materials even though boundary layer spires inadvertently not inserted. Test repeated (10-18-2).

Run 10-18-2
Bare model calibration.
Drift patterns same.

Run 10-18-3
Bare model calibration.

Run 10-19-1
Bare model calibration.

Run 10-19-2
Bare model calibration attempt with light ($\rho_p = 1.1$) small ($D_p = 60$) material. Unsuccessful as most particles go into suspension.

Run 10-19-3
Bare model calibration attempt with very light ($\rho_p \cong 0.2$, $D_p \cong 500$) material. Unsuccessful.

Run 10-25-1
Test of Jeff Benson's miniature trees, bushes, etc.
Realistic drifts. Dramatic effect of changes in barrier shape and porosity.

Run 10-31-1
Test of packing material as simulated bushes - placed upwind of road about 30H but not on fill. This material is used from here on as it seems to be a reasonable material and is easy to install.

Run 10-31-2
DOT planting arrangement number 1. Run aborted because boundary layer spires omitted inadvertently.

Run 11-1-1
DOT planting arrangement number 1. Because of proximity of bushes on fill to upwind lane, material deposits immediately on broad range of upwind lane (about 4 bridge widths). Away from bridge the planting is far enough upwind (13H) to significantly delay accumulation on road. Eventually more accumulation on downwind lane.

Run 11-2-1
Test of bare model with guardrails in median. Not greatly changed from bare model. Upwind guard rail causes deeper drifting under bridge on upwind lane. Both guard rails alter drift pattern locally on downwind lane, under bridge and near outboard end of rail.

Run 11-6-1
DOT planting arrangement #1 with guardrails. Immediate deposition on upwind lane is slightly different from 11-1-1 due to guardrail. Lateral extent slightly less, longitudinal extent greater. Lateral position of deposition seems to occur just upwind of upwind guardrail,still significantly worse than bare model.

Run 11-7-1
Bare model calibration
Extension of calibration speed range (high speed).
Drift deposits same as before.

Run 11-7-2
DOT plant plan #2, with guardrails.
Results essentially same as run 11-6-1.

Run 11-7-3
Planting plan A, with guardrails
Excellent results, still material one-half bridge width deposited under bridge immediately.

Run 11-9-1
Planting plan B,
Unsuccessful, material deposited immediately on both lanes because of proximity to road and height of planting arrangement.

Run 11-10-1
Planting plan C
Fairly successful, although some material on upwind lane immediately at considerable distance from bridge, as well as underneath bridge about two-thirds bridge width.

Run 11-10-2
Planting plan D.
Less successful than Plan A or Plan C because downwind leg of planting arrangement (within 150 ft right-of-way) too close to highway (11H) and deposition takes place immediately away from the bridge on the upwind lane, slight deposition under bridge.

Run 11-10-3
Bare model with bridge vortex generators.
Unsuccessful. Vortex generators had no effect.

Run 11-10-4
Planting plan E.
Not as successful as plan A. More material immediately deposited under bridge, upwind lane, 1.5 bridge widths.

Run 11-10-5
Planting plan F
Initial deposit under bridge about the same as plan E.

Run 11-13-1
Bare model calibration.
Lower speed.

Run 11-14-1
Planting plan G with deflectors on lee fill-slope fairly successful. Immediate deposition under bridge only one-third bridge width. Outboard edge of deflector causes deposition on roadway. Downward leg of planting is further from roadway than plan D (17H) and thus more successful in delay of drifting on outboard portion of road.

Run 11-15-1
Planting plan H
Same as plan G without deflectors but with bridge side shields. Successful except for immediate deposition under bridge of one-half bridge width.

Run 11-15-2
Planting plan I
Same as plan G with larger deflectors placed on crown of fill. Only slightly more effective than plan H under bridge. Some deposition away from bridge due to outboard end of deflectors.

Run 11-15-3
Planting plan J
Same as plan H without bridge side shields plus an additional downwind row of bushes 11.5 heights upwind of upwind lane. Successful except for immediate deposition 60% bridge width under bridge on upwind lane.

Run 11-16-1
Bare model calibration - lowest speed.

Run 11-16-2
Planting plan K
Same as plan J plus large deflector in slightly different position than plan I plus bridge side shields on bridge. Very successful test with almost no immediate deposition.

Run 11-17-1
Planting plan L, same as plan K with bridge side shields but without large deflectors. Camera malfunction, no B&W photographs. Results not as good as Run 11-16-2, material collected immediately under bridge.

Run 11-18-1
Illinois photograph simulation
Camera malfunction, no B & W photographs, results primarily similar to Illinois photograph except not enough bushes on one side of fill.

Run 11-20-1
Planting plan M
Only 3 B & W photographs, overall results similar to Run 11-23-1.

Run 11-22-1
Planting plan N
Same as plan J with base ogive under upwind end of bridge. Very successful test. Almost no immediate deposition anywhere.

Run 11-23-1
Planting plan O
Same as plan M with base ogive. Immediate deposition under bridge (one-half bridge width) probably because planting on fill too close.

Run 12-7-1

Bare model calibration @ 20° wind angle. Snowing, small amount in wind tunnel. Cold (6°F), previous low temperature was 27°F; as a result, bridge contracted during test and pulled apart at joint. Downwind road lane also gapped at joint. Not a serious problem. Material deposits immediately downwind of windward bridge slope on upwind lane (bridge fill deposit). Quick deposition of material and windward side of bridge on both upwind and downwind lanes. Also on leeward side of bridge and downwind lanes. Drift connection is earlier but not as wide.

Run 12-9-1

DOT - 1 Planting plan. Immediate deposition over large area downwind of windward bridge slope and under bridge on upwind lane. Eventually, almost no deposition on lanes on windward side of bridge but very wide drift on leeward side, mostly on upwind lane.

Run 12-15-1

Bare Model calibration essentially identical to Run 12-7-1.

Run 12-19-1

Plan A-20 (same as A-o) with long ogive. During run on upwind side of upwind lane some material collects and then erodes periodically. Early deposit one bridge width downwind of windward bridge slope on upwind lane (bridge fill deposit). Eventually some deposit on windward side of bridge.

Run 12-19-2

Plan B-20 (same as A-20 plus large deflectors on bridge fill shoulder). Windward deflector caused immediate drifting on windward side of upwind lane. Unsuccessful.

Run 12-19-3

Plan C-20 (same as J-0). Rather successful. Bridge fill deposit on upwind lane only one-third bridge width.

Run 12-20-1

Plan D-20 (same as C-20 but shorter ogive). Boundary layer spires inadvertently omitted.

Run 12-21-1

Plan D-20. Little Difference from C-20, slightly wider fill deposit.

Run 12-22-1

Plan E-20 (Same as D-20 plus fill shoulder deflector). Deflector concentrates bridge fill deposit and shifts it further leeward and increases its width; unsuccessful.

Run 12-27-1

Plan F-20 (same as D-0 plus ogive). Bridge fill deposit about same as C-20.

Run 12-27-2

Plan G-20 (same as H-0 without bridge side shields but with ogive). Successful, about same as C-20 and F-20.

Run 12-27-3

Plan H-20 (same as G-20 but with 1/2 bush thickness). Fill deposit drift may be slightly wider and upwind lane windward side of bridge may fill faster.

Run 12-28-1

Plan I-20 (same as M-0 plus ogive). Fairly successful. Bridge fill deposit widens with time.

Run 12-28-2

Plan J-20 (same as I-20 but 1/2 bush thickness). Results similar to I-20.

Run 1-5-1

Plan K-20 (same as D-20 but bush adjacent to secondary road trimmed to secondary road elevation). Bridge fill deposit narrower than D-20 but drift on secondary road larger!

Run 1-16-1

Plan L-20 (same as K-20 but without ogive). Still very narrow (1/3 bridge widgh) bridge fill deposit.

Run 1-20-1

Test of solid barrier fence (30H long) on bare floor. On this and rest of barrier tests simultaneous photographs of plan and elevation views were taken. Strong effect of fence ends. Material collected both leeward and windward sides.

Run 1-20-2

Test of solid barrier fence on sandpaper (most succeeding tests on sandpaper). Leeward drift to 15H in center.

Run 1-22-1

Test of solid barrier fence with bottom gap. Pattern different from 1-20-2 only in early stages.

Run 1-22-2

Test of solid barrier fence with bottom gap on cloth. Plan view impossible to see with cloth.

Run 1-29-1

Test of 50% porous horizontal slat fence. Equilibrium drift not reached. Leeward drift only from to 2H to 14.4H downwind of fence.

Run 1-31-1

Test of standard width bushing (fiber material). Leeward drift length of 13.4H and windward drift length of 9H.

Run 1-31-2

Test of 25% porous horizontal slat fence. Assymetric drift because of uneven gap. Drift length windward of 4H and leeward drift of 15.9H.

Run 2-3-1

Test of 1/2 width bush barrier. Windward drift asymmetric. Leeward drift planform shape similar to full bush width, length = 14H. Longest portion of windward drift length = 10.6H.

Run 2-6-1

Test of solid fence barrier. Results similar to Run 1-22-1.

Run 2-9-1

Model 1 reinserted at 40° wind direction. Bare model calibration. Initial narrow drift downwind of bridge fill on upwind lane. Later drift across both lanes upwind of bridge. Strong shear under bridge keeping patch clear.

Run 2-12-1

Plan DOT-1. Wide initial drift on upwind lane similar to 0° and 20° tests.

Run 2-13-1

Plan F-40. Eventually twin narrow drifts on upwind lane either side of bridge.

Run 2-12-2

No black and white photos due to camera failure. Slides were taken. Rerun later.

Run 2-14-1

Same situation as run 2-13-2.

Run 2-15-1

Time-lapse and high-speed photography by ISU film production unit. Not terribly successful.

Run 2-15-2

Same situation as Run 2-13-2

Run 2-16-1

Plan A-40. Not a successful plan.

Run 2-19-1

Plan I-40. Eventual narrow drift downwind side of bridge. Good plan.

Run 2-19-2

Plan D-40. Good plan similar to I-40.

Run 2-20-1

Plan G-40. Good plan similar to I-40.

8mm color time-lapse by S. Ring at 2.2 frames/second.

Run 2-20-2

Bare model calibration. Similar to Run 2-9-1

Run 2-21-1

Plan F-40. Good plan.

Run 2-22-1

Plan FM-40. Good plan.

Run 2-23-1

Plan FM-40 with 1/2 bush width. Similar to Run 2-22-1.

Run 2-24-1

Bare model. No black and white stills. 8mm color time-lapse by S. Ring at 2.4 frames/second.

Run 3-24-1

Model 2 inserted into wind tunnel at 0° wind direction. Bare model calibration. Main difference from model 1 is wider initial deposit on upwind lane due to exaggerated fill depth. Model is thus effectively distorted horizontally (aerodynamically) in a few places as well as vertically.

Run 3-26-1

Bare model calibration. Higher speed.

Run 3-27-1

Bare model calibration. Intermediate speed.

Run 3-27-2

Plan D-0. Effective horizontal distortion most evident with simulated bush. Immediate deposit on upwind lane.

Run 3-28-1

Plan G-0. Horizontal distortion not as critical with this plan since farther upwind from roadway. Fairly successful test.

Run 4-12-1

Test of safety berm on model 2. Berm creates deep drift on upwind roadway.

Run 4-13-1

Test of safety berm on model 2 with plan G-0. Effect of berm seems to diminish with control. Berm-caused drift not as deep.

Run 5-1-1

Test of new 50% fence. Tested for 8 hours 16 minutes at 8 mph. Cornice formation evident.

Run 5-8-1

Continuation of Run 5-1-1 for 5 hours 52 minutes at 9.8 mph.

Run 5-10-1

Continuation of Run 5-8-1 for 1 hour 49 minutes at 10.85 mph. Drift equilibrium achieved. Good cross-section comparison with full-scale.

Run 5-23-1

Test of acoustic wall. Almost all material deposited upwind.

Run 5-23-2

Test of acoustic wall at lower speed.

Run 5-23-3

Continuation of Run 5-23-2 at higher speed.

Table 4. Photography log

DEPARTMENT OF AEROSPACE ENGINEERING - IOWA STATE UNIVERSITY of Science and Technology

Constant Data		Name Date of Test Course No. Section

Column No													
Item	RUN NO.	START TIME	SIGN PHOTO TIME	FIRST PHOTO RUN TIME	END PHOTO TIME	RUN TIME MIN	FILM NO.	NUMBER PHOTOS	NEGATIVE NUMBERS	COLOR FILM NO.	SLIDE NO'S.		
Units							(B & W)	(B & W)					
Ref.													
1.	10/12/1	9:35	8:45	9:39	9:51	16	1	7	13-19	1	12-15		
2.	10/12/2	2:42	2:13	2:43	2:57	15	2	6	0-7	"	16-17		
3.	10/12/3	4:42	4:40	4:43	4:51	9	2	12	8-19				
4.	10/13/1	1:55	1:51		1:57	2	2	2	20-21				
5.	10/14/1	1:49	11:43	11:50	12:14	25	2	13	22-34	1,2	18-21,2-12		
6.	10/17/1	8:33	8:30	8:36	8:51	18	2,3	10	35-37,3-9				
7.	10/17/2	11:19	11:17	11:21	11:38	19	3	10	10-19				
8.	10/18/1	8:45	8:35	8:47	9:01	16	3	10	20-29				
9.	10/18/2	9:40	9:38	9:45	9:63	23	3	4	30-33				
10.	10/18/3	2:36	2:33	2:37	2:46	10	4	8	1-8		"		
11.	10/19/1	8:44	8:42	8:46	8:54	10	4	6	9-14				
12.	10/19/2	10:22	10:19	10:33	10:44	22	4	4	15-18				
13.	10/19/3	4:04	3:58	4:06	4:12	8	4	4	19-22				
14.	10/25/1	10:47				23(EST)	6	8	0A-7A	3	24A-33		
15.	10/31/1	2:53		2:55	3:05	12	5	3	2-4				
16.	10/31/2	4:08	5:07	5:11	5:17	9	5	4	5-8				
17.	11/1/1	9:51	9:49	9:54	10:20	29	5	9	9-17				
18.	11/2/1	4:06	4:05	4:10	4:30	24	5	6	18-21,23,24				
19.	11/6/1	1:28	1:25	1:33	2:01	33	5	7	25-31	4	1-7		
20.	11/7/1	8:29	8:28		8:43	14	6	7	9-15	4	8-13		
21.	11/7/2	2:14	2:07	2:12	2:46	28	6	13	16-28				
22.	11/7/3	3:54	3:49	3:54	4:27	33	7	11	0-10	4	14-17		
23.	11/9/1	10:06	10:02		10:27	21	7	5	11-15	4	18-24		
24.	11/10/1	9:47	8:58	9:52	10:11	23	7	8	16-23	4	25-28		
25.	11/10/2	1:15	1:13	1:21	1:32	17	7	7	24-30	4	29-34		

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Constant Data		Name Date of Test Course No. Section

Column No													
Item	RUN NO.	START TIME	SIGN PHOTO TIME	FIRST PHOTO RUN TIME	END PHOTO TIME	RUN TIME	FILM NO.	NUMBER PHOTOS	NEGATIVE NUMBERS	COLOR FILM NO.	SLIDE NUMBER		
Units							(B & W)	(B & W)					
Ref.													
1.	11/10/3	3:40	3:40	3:44	3:59	19	8	8	2-9	5	1-4	sign says 11/10/2	
2.	11/10/4	7:00	6:51	7:00	7:19	19	8	7	10-16	5	5-8	"	"
3.	11/10/5	8:20	8:21	8:26	8:52	32	8	11	17-27	5	9-12		
4.	11/13/1	9:51	9:49		10:29	38	8	8	28-35	5	13-16		
5.	11/14/1	3:13	3:09	3:16	3:45	32	9	8	3-10	5	17-20		
6.	11/15/1	9:42	9:42	9:48	10:19	37	9	9	11-19	5	21-24		
7.	11/15/2	1:13	1:13	1:17	1:47	34	9	9	20-28	5	25-28		
8.	11/15/3	3:28	3:26	3:31	4:02	34	10	9	1A-9A	5	29-34		
9.	11/16/1	11:21	11:20	11:24	12:15	54	10	12	11A-22A	5,6	35-36,4-11		
10.	11/16/2	7:16	7:16	7:20	7:40	24	10	13	23A-35A	6	12-13		
11.	11/17/1	10:30	camera	failure		?	11	0	0	6	14-20		
12.	11/18/1	10:06	"	"		?	11	0	0	6	21-25		
13.	11/20/1	10:43	"	"	11:12	29	11	3	2-4	6	26-30		
14.	11/22/1	7:30	7:25	7:31	7:57	27	12	16	2-17	6,7	31-37,0-4	sign says 11/23/1	
15.	11/23/1	6:50	no sign	6:53	7:12	22	12	13	18-30	7	5-15		
16.	12/7/1	10:18	10:15	10:25	10:49	31	13	17	5-21	8	8-12		
17.	12/9/1	1:33	1:28	1:35	2:03	30	13	13	22-34	8	15-24		
18.	12/15/1	8:55	8:53	9:02	9:16	21	14	7	3-9	8	25-36		
19.	12/19/1	8:45	8:43	8:49	9:02	17	14	9	10-18	9	1-9		
20.	12/19/2	11:24	11:16	11:28	11:38	14	14	8	19-26	9	10-17		
21.	12/19/3	2:42	2:30	2:50	3:04	22	14	7	27-33	9	18-22		
22.	12/20/1	10:42	10:32	10:39	10:51	9	15	7	3-9				
23.	12/21/1	3:16	3:16	3:22	3:40	24	15	10	10-19	9	23-34		
24.	12/22/1	4:58	3:58	5:01	5:16	18	15	11	20-30	10	2-7		
25.	12/27/1	11:27	11:24	11:29	11:49	22	16	13	1-13	10	8-14		

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Constant Data		Name Date of Test Course No. Section

Column No														
Item	RUN NO.	START TIME	SIGN PHOTO TIME	FIRST PHOTO RUN TIME	END PHOTO TIME	RUN TIME	FILM NO.	NUMBER PHOTOS	NEGATIVE NUMBERS	COLOR FILM NUMBER	SLIDE NUMBERS			
Units						MIN	(B & W)	(B & W)						
Ref.														
1.	12/27/2	2:37	2:34		2:55	18	16	11	14-24	10	15-19			
2.	12/27/3	7:58	7:54		8:20	22	16	10	25-34					
3.	12/28/1	10:40	10:37	10:42	11:03	23	17	9	1-3,6-11	10	20-27			
4.	12/28/2	3:17	3:14	3:19	3:38	21	17	10	12-21	10	28-34			
5.	1/5/1	4:29	4:24	4:33	4:49	20	17	11	22-32	11	1-8			
6.	1/10/1	4:45	4:42	4:46	5:06	21	18	16	2-17					
7.	1/20/1	6:57	5:14	6:54	7:20	26	19,21	18,18	0-17,2-19					
8.	1/20/2	8:25	8:18	8:26	9:19	54	19,21	17,17	18-34,20-36					
9.	1/22/1	8:41	8:35	8:41	9:57	76	23,22	20,20	2-21,1-20					
10.	1/22/2	2:43	2:34	2:52	3:48	65	23,22	12,12	22-33,24-35	11a	1-10			
11.	1/29/1	4:47	4:42	4:48	6:38	111	24,25	33,33	0A-32A,0-32	12	1-7			
12.	1/31/1	9:42	9:35	9:41	10:31	49	26,27	18,18	1-18,0-17					
13.	1/31/2	4:49	4:45	4:50	6:20	91	26,27	17,17	19-35,21A-37A					
14.	2/3/1	10:32	10:19	10:33	11:14	42	28,29	11,11	0,2-11,1-10					
15.	2/6/1	8:35	8:29	8:36	10:55	140	28,29	22,23	12-33,11-33					
16.	2/9/1	1:33	2:02	1:42	1:59	26	30	10	1-10	13	2-13 sign after			
17.	2/12/1	1:32	1:23	1:38	2:01	29	30	7	11-17	13	15-24			
18.	2/13/1	10:41	10:38	10:53	11:16	35	30	10	18-27	13	25-38			
19.	2/13/2	2:29	camera	failure						14	1-10			
20.	2/14/1	1:30	"	"						14	11-21			
21.	2/15/1	11:05	time lapse and high speed											
22.	2/15/2	2:41	camera	failure						14	22-25			
23.	2/16/1	1:08	1:06	1:13	1:36	28	31	9	2A-10A	14	26-32			
24.	2/19/1	8:41	8:38	8:46	9:08	27	31	8	11A-18A	15	2-12			
25.	2/12/2	2:32	2:29	2:38	3:00	28	31	8	19A-26A	15	13-19			

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Constant Data		Name Date of Test Course No. Section

Column No														
Item	RUN NO.	START TIME	SIGN PHOTO TIME	FIRST PHOTO RUN TIME	END PHOTO TIME	RUN TIME	FILM NO. (B&W)	NUMBER PHOTOS (B&W)	NEGATIVE NUMBERS	COLOR FILM NO.	SLIDE NO'S.			
Units						MIN								
Ref.														
1.	2/20/1	11:32	11:22	11:43	12:09	37	31	10	27A-36A	15	21-29			
2.	2/20/2	3:43	3:41	3:49	4:13	30	32	12	2-13	15	30-35			
3.	2/21/1	1:53	1:26	1:56	2:33	40	32	13	14-26	15,16	36-38,1-4			
4.	2/22/1	1:36	1:30	1:43	2:11	35	32	10	27-36	16	5-14			
5.	2/23/1	10:32	10:28	10:42	11:11	39	33	12(+20)	2-13(+14,15 20-37)	16,17	15-23,2-12			
6.	2/24/1	time-lapse								17	13-21			
7.	3/24/1	11:40	11:06	11:48	12:33	53	34	21	2-22					
8.	3/26/1	10:47	10:43	10:54	11:20	33	34	13	23-35	18	9-18			
9.	3/27/1	9:27	9:15	9:37	10:07	40	35	12(+5)	1-12(+13-17)	18	19-27			
10.	3/27/2	3:20	3:10	3:23	3:50	30	35	8	19-26	18	28-32			
11.	3/28/1	10:47	10:45	10:53	11:38,12:13	86	35,36	11(+4),7	27-37,3-9 (+10-13)	18,19	33-37,1-14			
12.	4/12/1	9:49		10:05	10:44	55	37	14(+18)	6-19(+20-37)	19	17-24			
13.	4/13/1	10:04	10:00	10:09	11:14	70	38	14(+18)	2-15(+16-33)	19,20	26-31,1-7			
14.	5/1/1	8:43	8:25	8:43	2:49,4:59	496	39,40, 41	10(+24),4, 14(+17)	27,29-37, 3-6(3-26),	20,21	11-22,12-28			
15.									4-17(21-37)					
16.	5/8/1	10:59	10:52	10:59	4:51	352	40,42	10,10(+7)	7-16,5-14 (+15-21)					
17.	5/10/1	8:51	8:46	9:13	10:40	109	40,42	5(+2),5(+1)	17-21(+22,					
18.									23),22-26					
19.									(+27-37)	22	3-15			
20.	5/23/1	9:17	9:14	9:19	9:49	32	43	5	8-12					
21.	5/23/2	10:16	10:15	10:21	10:54	38	43	6	13-18					
22.	5/23/3	10:57	10:56	11:00	11:07	10	43	4(+11)	19-22(+23-33)					
23.														
24.														
25.														

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Table 5. Figures of Merit

The first column after the run number lists the dimensionless time at which the drift area A = 20 in^2. The second column lists dimensionless time at A = 50 in^2 and the third column lists the accumulated area A at the same dimensionless time for which the uncontrolled model reached 100 in^2 of drift accumulation. The first column is divided by the best run number in that group (largest time, run 11-15-2 for 0° wind direction, all three columns). The second column is treated similarly. The third column is divided into the smallest area in that column. These three numbers are then averaged to obtain the figure of merit. The most effective controls are those with figures of merit near 1.0. For zero degrees, the figure of merit for uncontrolled model tests averages 0.30. For the seven best controlled plans the average figure of merit is 0.82. For the twenty degree wind direction the numbers are 0.39 and 0.985 (three best) and for 40° the figures of merit are 0.405 and 0.93, respectively for the uncontrolled and five best controlled plans. For model 2 the areas used were 40, 100, and 200 in^2 instead of 20,50, and 100. The relative values of figures of merit for model 2 are not as valid as for model one because of the horizontal aerodynamic distortion.

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Constant Data		Name Date of Test Course No. Section

Column No														
Item	Run No	$\hat{\hat{t}}$ @ A=20 in^2	$\hat{\hat{t}}$ @ A=50 in^2	A @ $\hat{\hat{t}}$ = 3130	Figure of Merit		Run No.	$\hat{\hat{t}}$ @ A=20 in^2	$\hat{\hat{t}}$ @ A=50 in^2	A @ $\hat{\hat{t}}$ =3130(0°) or 2860(20°)	Figure of Merit			
Units														
Ref.														
1.	10/12/1	1614	2344	84.5	0.32		11/15/2	3957	5219	8.9	1.00			
2.	10/12/2	1809	2305	100.2	0.33		11/15/3	3300	4670	18.0	0.74			
3.	10/12/3	936	1418	157.3	0.19		11/16/1	1917	2552	77.4	0.36			
4.	10/17/1	1680	2240	100	0.31		11/16/2	3178	3805	18.4	0.67			
5.	10/17/2	1690	2233	99.9	0.31									
6.	10/14/1	1665	2372	84.5	0.33									
7.	10/18/1	1469	1945	126.8	0.27		11/20/1	3760	4540	14.7	0.81			
8.	10/18/2	----	------	------	------		11/22/1	3360	4900	17.2	0.77			
9.	10/18/3	1251	1829	118.1	0.25		11/23/1	3390	4280	10.0	0.86			
10.	10/19/1	865	1546	130.6	0.19		12/7/1	1700	2150	100	0.42			
11.	11/1/1	2200	3340	44.1	0.47		12/9/1	540	3190	41.2	0.46			
12.	11/2/1	1660	2220	100.1	0.31		12/15/1	1400	1897	111.3	0.36			
13.	11/6/1	2540	3460	37.0	0.52		12/19/1	1650	2760	54.1	0.51			
14.	11/7/1	1814	2447	82.4	0.35		12/19/2	1347	1736	162.5	0.32			
15.	11/7/2	1500	3120	52.6	0.38		12/19/3	2560	3360	30.8	0.74			
16.	11/7/3	2480	3300	42.0	0.49		12/20/1	1889	2872	49.6	0.56			
17.	11/9/1	40	1100	149.3	0.03		12/21/1	3040	4090	17.5	0.99			
18.	11/10/1	2660	3410	33.0	0.53		12/22/1	1900	2951	47.0	0.57			
19.	11/10/2	2440	3600	38.6	0.51		12/27/1	2030	3330	39.1	0.64			
20.	11/10/3	981	2004	89.2	0.24		12/27/2	1820	2730	59.9	0.52			
21.	11/10/4	1960	3520	46.9	0.45		12/27/3	1960	3000	47.6	0.58			
22.	11/10/5	2300	4320	28.5	0.57		12/28/1	3000	4080	18.3	0.97			
23.	11/13/1	1951	2543	80	0.36		12/28/2	2480	3310	30.2	0.73			
24.	11/14/1	3326	4658	15.6	0.77		1/5/1	2790	3910	22.0	0.60			
25.	11/15/1	3460	5060	17.1	0.79		1/16/1	3030	4060	17.0	0.996			

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Constant Data		Name Date of Test Course No. Section

Column No													
Item	Run No.	$\hat{\hat{t}}$ @ A=20 in^2	$\hat{\hat{t}}$ @ A=50 in^2	A @ $\hat{\hat{t}}$ =3655(40°) 2680(0°Dist)	FIGURE of MERIT								
Units													
Ref.		(40)	(100)	(200)									
1.	2/9/1	2685	3262	70	0.44								
2.	2/12/1	1480	5020	30.0	0.51								
3.	2/13/1	4320	5400	9.0	0.98								
4.	2/16/1	850	3220	70.9	0.30								
5.	2/19/1	4080	4660	13.5	0.81								
6.	2/19/2	4450	5280	12.5	0.89								
7.	~~2/20/1~~	~~4440~~	~~5600~~	~~9.0~~	~~0.999~~								
8.	2/20/2	2280	2890	100	0.37								
9.	2/21/1	4060	5200	12.1	0.86								
10.	2/22/1	3870	4760	13.6	0.79								
11.	~~2/23/1~~	~~4230~~	~~5150~~	~~10.2~~	~~0.92~~								
12.	3/24/1	1770	2436	114	0.57								
13.	3/26/1	1951	3030	80	0.71								
14.	3/27/1	1567	2559	90	0.60								
15.	3/27/2	14	2848	97	0.38								
16.	3/28/1	1409	5651	60	0.87								
17.	4/12/1	2073	2882	89.5	0.69								
18.	4/13/1	2311	5240	65	0.95								
19.													
20.													
21.													
22.													
23.													
24.													
25.													

Aero. E.

Table 6. Full Scale Extrapolation

In order to extrapolate to full scale conditions, first the modified Richardson numbers are equated, i.e.,

$$\left.\frac{\rho}{\rho_p}\ \frac{U^2}{gh}\ \left(1 - \frac{U_o}{U}\right)\right|_{\text{Model}} = \left.\frac{\rho}{\rho_p}\ \frac{U^2}{gh}\ \left(1 - \frac{U_o}{U}\right)\right|_{\text{Full Scale}}$$

This establishes the full scale - model scale wind speed ratio U/U_m. In the following table, the values of Richardson number for each experimental run are listed in column 9. The reference height wind speed (16 feet above surface) is listed for the model in column 4, the ratio U/U_m is listed in column 5, and the full-scale reference wind speed is listed in column 7.

The time scale is determined by equating model and full scale values of the rest of the combined mass-rate-roughness parameter, i.e.,

$$\left.\frac{\Delta A}{UL\Delta t}\ \left[A_1^{\ 2}\ \frac{D_p}{h}\ \left(\frac{U}{U_o}\right)^2\right]^{3/7}\right|_{\text{Model}} = \left.\frac{\Delta A}{UL\Delta t}\ \left[A_1^{\ 2}\ \frac{D_p}{h}\ \left(\frac{U}{U_o}\right)^2\right]^{3/7}\right|_{\text{Full Scale}}$$

The resulting values of time-scale ratio, $\Delta t/\Delta t_m$, are tabulated in column 6. The equivalent full-scale storm duration for each run (corresponding to the last photographic data point) is tabulated in column 11. In order to determine the full-scale real time from the dimensionless time values in the figures in the main report, it is necessary to multiply the dimensionless time values by the ratio listed in column 10.

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Constant Data										Name Date of Test Course No. Section				
			19	15				$\frac{\rho}{\rho_p}\frac{U^2}{gh}(1-\frac{U_o}{U})$						
Column No	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			
Item	Run No.	Particle Material	ρ_M	U_M	$\frac{U}{U_M}$	$\frac{\Delta t}{\Delta t_m}$	U	$A_1 \frac{2D}{h} \frac{\rho}{\rho_p}(\frac{U}{U_o})^2$		$\Delta t/\Delta\hat{t}$	Full Scale Duration			
Units			slugs/ft^3	$.9U_\infty$			FPS	Model			HR.MIN.			
Ref.							Full Scale			MIN.				
1.	10/12/1	ML	.00230	18.66	4.70	13.14	87.71	.000412	.0124	0.0570	3:30			
2.	-2	ML	.00233	18.02	4.69	13.14	84.48	.000385	.0115	0.0618	3:17			
3.	-3	ML	.00233	21.14	4.86	13.07	102.80	.000529	.0172	0.0402	1:58			
4.	10/14/1	2332.5	.00236	17.90	3.78	18.50	67.65	.000237	.00698	0.1173	7:43			
5.	10/17/1	2332.5	.00239	18.88	3.85	18.45	72.68	.000264	.00812	0.0999	5:32			
6.	10/17/2	2332.5	.00235	18.40	3.80	18.49	69.86	.000251	.00747	0.1092	5:51			
7.	10/18/1	Shell128	.00237	14.26	6.91	9.65	98.49	.000549	.0153	0.0502	2:34			
8.	10/18/2	Shell128	.00235	14.82	6.96	9.64	103.12	.000592	.0169	0.0451	3:42			
9.	10/18/3	Shell128	.002325	17.21	7.19	9.59	123.79	.000799	.0246	0.0302	1:36			
10.	10/19/1	Shell128	.00237	16.28	7.16	9.60	116.64	.000715	.0218	0.0344	1:36			
11.	10/19/2	Shell135	.00234	18.11	7.39	9.97	133.75	.000821	.0288	0.0258	3:39			
12.	10/19/3	Tea	.00228	14.67	17.69	4.23	259.56	.002987	.1118	0.00605	0:34			
13.	10/25/1	2332.5	.00229	21.57	3.875	18.43	83.59	.000344	.01090	0.0729	7:04			
14.	10/31/1	2332.5	.00236	19.66	3.86	18.44	75.90	.000286	.00889	0.0906	3:41			
15.	11/1/1	2332.5	.00238	19.67	3.88	18.43	76.25	.000286	.00898	0.0896	8:57			
16.	11/2/1	2332.5	.00229	18.99	3.78	18.50	71.73	.000267	.00790	0.1028	7:24			
17.	11/6/1	2332.5	.00235	18.64	3.81	18.48	70.98	.000257	.00773	0.1052	10:07			
18.	11/7/1	2332.5	.00235	21.99	3.94	18.39	86.58	.000358	.01171	0.0675	4:19			
19.	11/7/2	2332.5	.00233	18.72	3.80	18.49	71.06	.000259	.00775	0.1049	8:37			
20.	11/7/3	2332.5	.00232	19.05	3.80	18.48	72.45	.000269	.00807	0.1005	10:10			
21.	11/9/1	2332.5	.00230	20.00	3.83	18.47	76.54	.000296	.00906	0.0888	6:28			
22.	11/10/1	2332.5	.00232	19.84	3.84	18.46	76.12	.000291	.00894	0.0900	7:05			
23.	11/10/2	2332.5	.00228	20.63	3.83	18.46	79.11	.000315	.00972	0.0824	5:14			
24.	11/10/3	2332.5	.002285	19.21	3.78	18.50	72.67	.000273	.00811	0.1000	5:52			
25.	11/10/4	2332.5	.00230	18.95	3.78	18.50	71.69	.000266	.00789	0.1030	5:52			

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Constant Data										Name Date of Test Course No. Section				
									$\frac{\rho}{\rho_p}\frac{U^2}{gh}(1-\frac{U_o}{U})$					
Column No	(1)	(2)	(3)(9)	(4) (5)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			
Item	Run *	Particle Material	ρ_M	U_M	$\frac{U}{U_M}$	$\frac{\Delta t}{\Delta t_m}$	U	$A_1 \frac{2D}{h} p(\frac{U}{U_o})^2$		$\Delta t/\Delta\hat{t}$	Full Scale Duration			
Units			slugs/ft^3	$.9U_\infty$			Full Scale FPS	Model		MIN	HR,MIN.			
Ref.														
1.	11/10/5	2332.5	.00231	18.76	3.78	18.50	70.96	.000260	.00772	0.1053	9:52			
2.	11/13/1	2332.5	.00231	16.25	3.65	18.60	59.26	.000195	.00528	0.1580	11:47			
3.	11/14/1	2332.5	.00241	18.52	3.85	18.45	71.26	.000254	.00779	0.1044	9:50			
4.	11/15/1	2332.5	.00245	18.32	3.87	18.44	70.87	.000248	.00769	0.1057	11:22			
5.	11/15/2	2332.5	.00243	18.34	3.85	18.45	70.69	.000249	.00766	0.1063	10:27			
6.	11/15/3	2332.5	.00241	18.51	3.85	18.45	71.22	.000254	.00779	0.1044	10:27			
7.	11/16/1	2332.5	.00242	13.87	3.54	18.68	49.05	.000142	.00350	0.2448	16:49			
8.	11/16/2	2332.5	.00242	18.49	3.85	18.45	71.26	.000253	.00778	0.1045	7:23			
9.	11/17/1	2332.5	.00240	18.60	3.84	18.46	71.50	.000256	.00784	0.1037	?			
10.	11/18/1	2332.5	.00241	18.12	3.83	18.47	69.37	.000243	.00737	0.1108	?			
11.	11/20/1	2332.5	.00250	17.78	3.88	18.43	68.94	.000234	.00728	0.1122	8:54			
12.	11/22/1	2332.5	.00250	17.56	3.87	18.44	67.87	.000228	.00703	0.1164	8:18			
13.	11/23/1	2332.5	.00244	17.97	3.84	18.46	69.06	.000239	.00730	0.1119	6:46			
14.	12/7/1	2332.5	.00259	16.70	3.88	18.43	64.77	.000206	.00637	0.1293	9:31			
15.	12/9/1	2332.5	.00258	17.09	3.90	18.42	66.57	.000216	.00675	0.1216	9:13			
16.	12/15/1	2332.5	.00246	17.33	3.82	18.47	66.25	.000222	.00669	0.1227	6:28			
17.	12/19/1	2332.5	.00240	18.26	3.83	18.47	69.89	.000247	.00748	0.1091	5:14			
18.	12/19/2	2332.5	.00238	17.51	3.77	18.50	66.08	.000227	.00665	0.1236	4:19			
19.	12/19/3	2332.5	.00239	17.96	3.80	18.48	68.34	.000239	.00712	0.1149	6:47			
20.	12/20/1	2332.5	.00240	18.79	3.85	18.45	72.40	.000261	.00806	0.1006	2:46			
21.	12/21/1	2332.5	.00238	18.35	3.82	18.47	70.04	.000249	.00750	0.1086	7:23			
22.	12/22/1	2332.5	.00243	18.10	3.84	18.46	69.54	.000242	.00739	0.1103	5:32			
23.	12/27/1	2332.5	.00253	17.41	3.88	18.43	67.52	.000224	.00695	0.1178	6:45			
24.	12/27/2	2332.5	.00246	17.68	3.84	18.46	67.93	.000231	.00705	0.1160	5:32			
25.	12/27/3	2332.5	.00247	17.09	3.82	18.48	65.22	.000216	.00647	0.1273	6:47			

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Constant Data										Name Date of Test Course No. Section				
									$\frac{\rho}{\rho_p}\frac{U^2}{gh}(1-\frac{U_o}{U})$					
Column No	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			
Item	Material	Particle	ρ_M	U_M	$\frac{U}{U_M}$	$\frac{\Delta t}{\Delta t_m}$	U	$A_1 \frac{2D_p}{h}(\frac{U}{U_o})^2$		$\Delta t/\Delta\hat{t}$	Full Scale			
Units			slugs/ ft^3	$.9U_\infty$			Full Scale FPS	Model		Min	Duration Hr, Min			
Ref.														
1.	12/28/1	2332.5	.00243	18.00	3.84	18.46	69.07	.000240	.00729	0.1121	7:05			
2.	12/28/2	2332.5	.00241	17.87	3.82	18.48	68.18	.000236	.00710	0.1152	6:28			
3.	1/5/1	2332.5	.00250	17.60	3.87	18.44	68.06	.000229	.00707	0.1157	6:09			
4.	1/16/1	2332.5	.00256	17.53	3.91	18.41	68.49	.000227	.00717	0.1139	6:27			
5.	1/20/1	2332.5	.00248											
6.	1/20/2	2332.5	.00249											
7.	1/22/1	2332.5	.00245											
8.	1/22/2	2332.5	.00245											
9.	1/29/1	2332.5	.00257											
10.	1/31/1	2332.5	.00262											
11.	1/31/2	2332.5	.00261											
12.	2/3/1	2332.5	.00260											
13.	2/6/1	2332.5	.00245											
14.	2/9/1	2332.5	.00261	18.52	4.00	18.35	74.01	.000254	.00843	0.0959	7:57			
15.	2/12/1	2332.5	.00252	18.14	3.91	18.41	70.95	.000244	.00772	0.1055	8:54			
16.	2/13/1	2332.5	.00251	17.98	3.90	18.42	70.04	.000239	.00753	0.1082	10:45			
17.	2/13/2	2332.5	.00248	17.66	3.86	18.45	68.10	.000231	.00709	0.1155				
18.	2/14/1	2332.5	.00241	18.41	3.84	18.46	70.74	.000251	.00767	0.1062				
19.	2/15/1	2332.5	.00252	18.09	3.91	18.41	70.70	.000242	.00768	0.1059				
20.	2/15/2	2332.5	.00254	17.86	3.91	18.41	69.85	.000236	.00745	0.1094				
21.	2/16/1	2332.5	.00270	17.14	3.98	18.36	68.27	.000217	.00711	0.1149	8:34			
22.	2/19/1	2332.5	.00260	18.30	3.98	18.37	72.79	.000248	.00812	0.0999	8:16			
23.	2/19/2	2332.5	.00242	18.77	3.87	18.44	72.59	.000261	.00809	0.1003	8:36			
24.	2/20/1	2332.5	.00239	18.20	3.82	18.47	69.47	.000245	.00739	0.1104	11:23			
25.	2/20/2	2332.5	.00239	18.29	3.82	18.47	69.90	.000248	.00749	0.1089	9:14			

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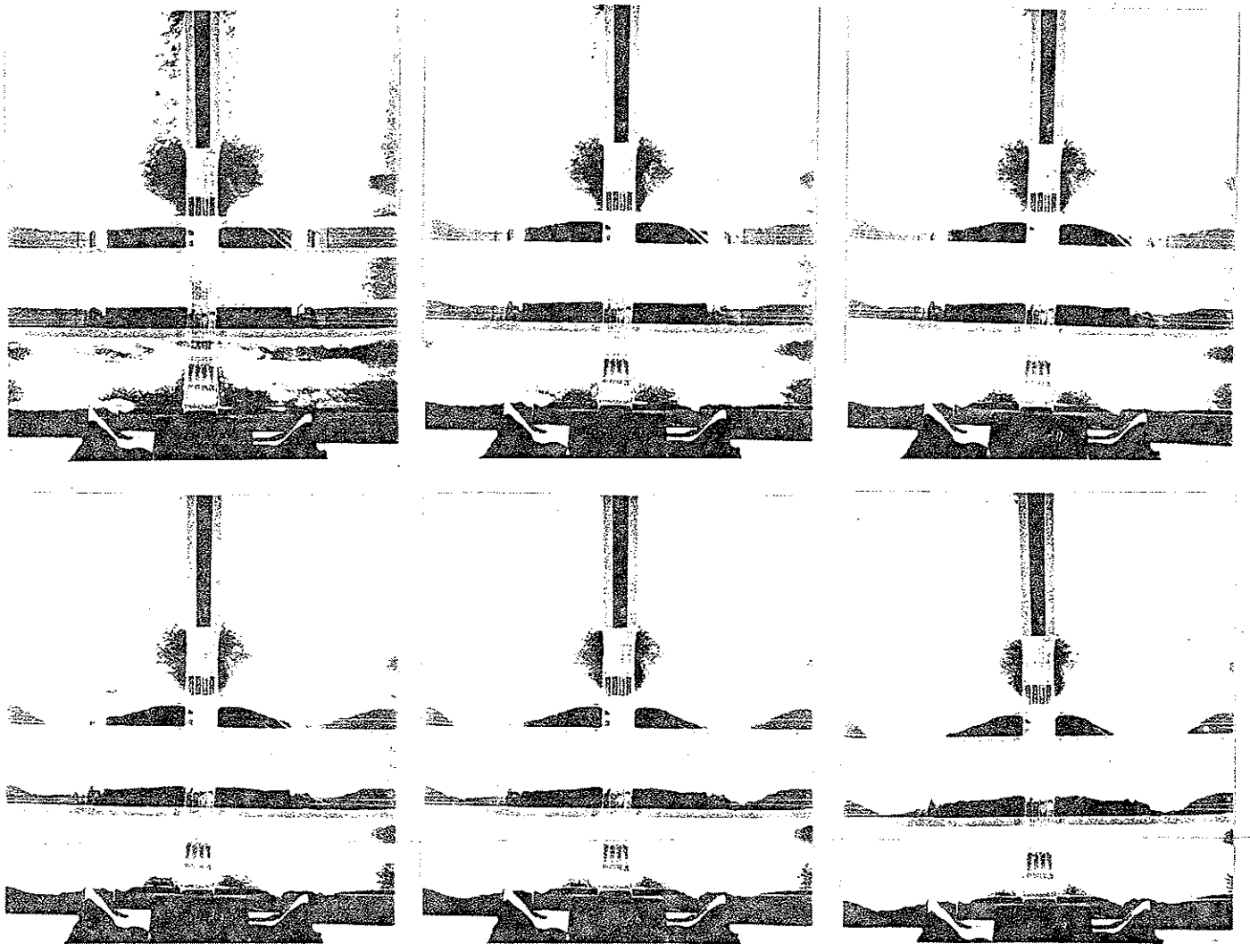
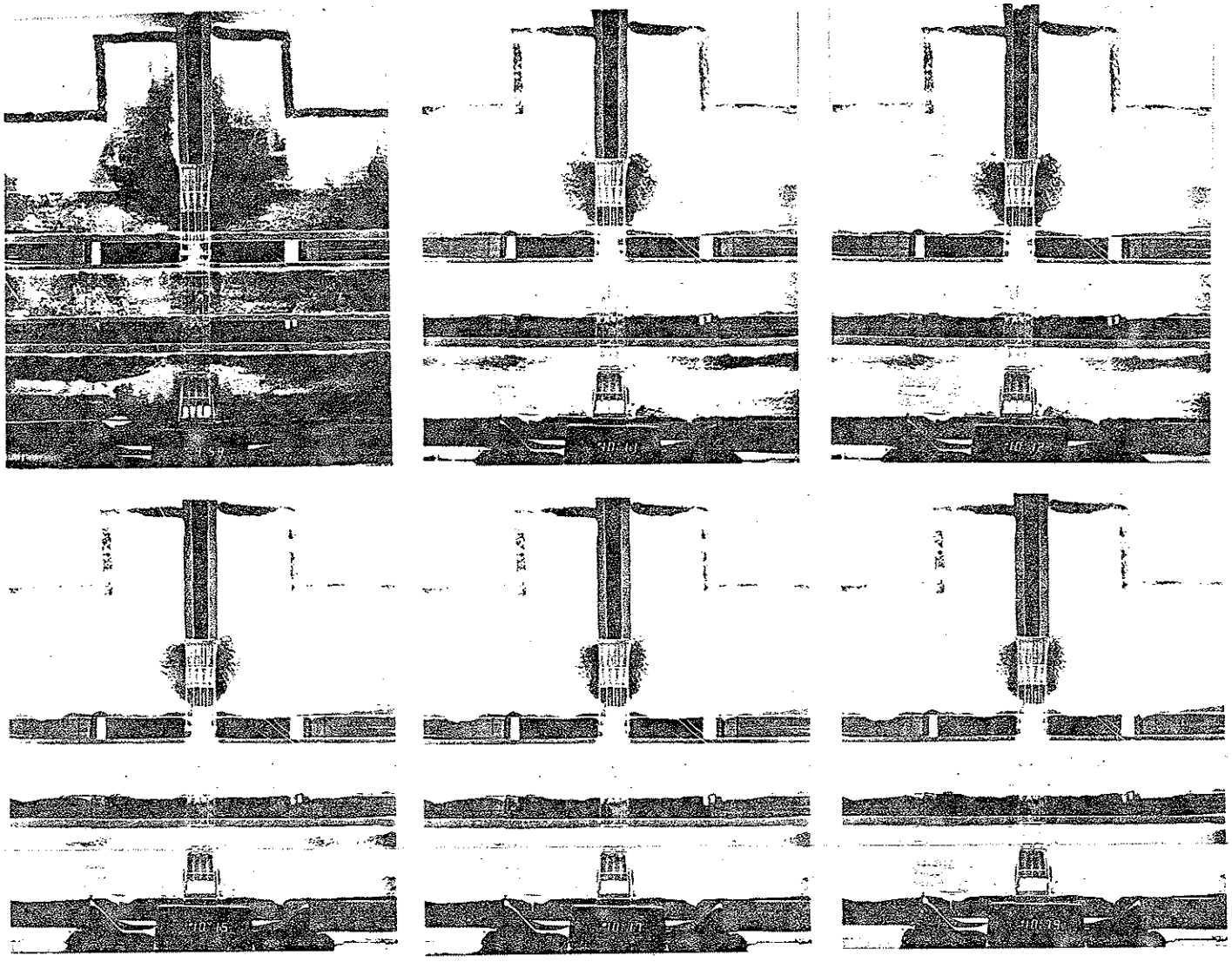
Constant Data										Name Date of Test Course No. Section				
									$\frac{\rho}{\rho_p}\frac{U^2}{gh}\left(1-\frac{U_o}{U}\right)$					
Column No	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			
Item	RUN #	Particle Material	ρ_M	U_M	$\frac{U}{U_M}$	$\frac{\Delta t}{\Delta t_m}$	U	$A_1 \frac{2D_p}{h}\left(\frac{U}{U_o}\right)^2$		$\Delta t/\Delta\hat{t}$	Full Scale			
Units			slugs/	$.9U_\infty$			Full	Model		Min	Duration			
Ref.			ft^3	$.95U_\infty$			Scale FPS				Hr, Min			
1.	2/21/1	2332.5	.00247	17.40	3.83	18.46	66.71	.000224	.00678	0.1210	12:18			
2.	2/22/1	2332.5	.00240	17.75	3.80	18.49	67.48	.000233	.00695	0.1179	10:47			
3.	2/23/1	2332.5	.00249	17.55	3.86	18.45	67.69	.000228	.00698	0.1174	12:00			
4.	2/24/1	2332.5	.00256	17.68	3.92	18.41	69.22	.000231	.00733	0.1113				
5.	3/24/1	2332.5	.00245	16.89	2.70	27.37	45.52	.0000948	.00299	0.2899	24:11			
6.	3/26/1	2332.5	.00245	20.07	2.81	27.22	56.31	.000134	.00473	0.1779	14:58			
7.	3/27/1	2332.5	.00249	17.87	2.75	27.29	49.23	.000106	.00354	0.2421	18:12			
8.	3/27/2	2332.5	.00243	19.27	2.77	27.26	53.40	.000123	.00421	0.2010	13:38			
9.	3/28/1	2332.5	.00236	19.33	2.74	27.31	52.88	.000124	.00413	0.2054	39:09			
10.	4/12/1	2332.5	.00228	18.35	2.66	27.42	48.84	.000112	.00347	0.2474	25:08			
11.	4/13/1	2332.5	.00234	19.32	2.72	27.33	52.64	.000124	.00408	0.2081	31:53			
12.	5/1/1	2332.5	.00235											
13.	5/8/1	2332.5	.00221											
14.	5/10/1	2332.5	.00225											
15.	5/23/1	2332.5	.00235											
16.	5/23/2	2332.5	.00235											
17.	5/23/3	2332.5	.00235											
18.														
19.														
20.														
21.														
22.														
23.														
24.														
25.														

Part 7. Photographic Sequences

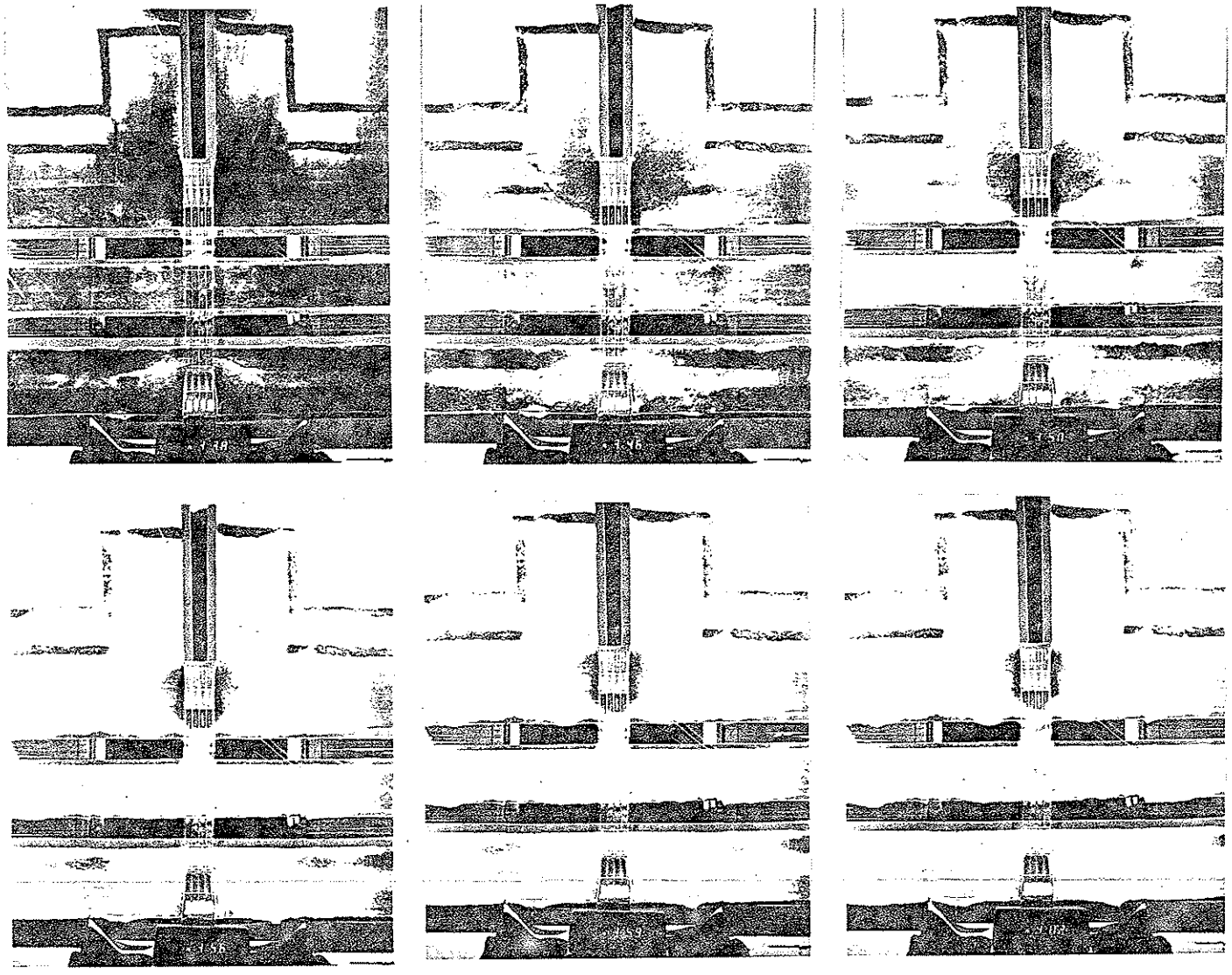
The following pages illustrate typical photographic sequences of some of the experimental runs. The values of ΔT listed are values of dimensionless time. Comparisons of photographs from one run with photographs with another run at the same wind direction should be done at the same values (as nearly as possible) of dimensionless time.



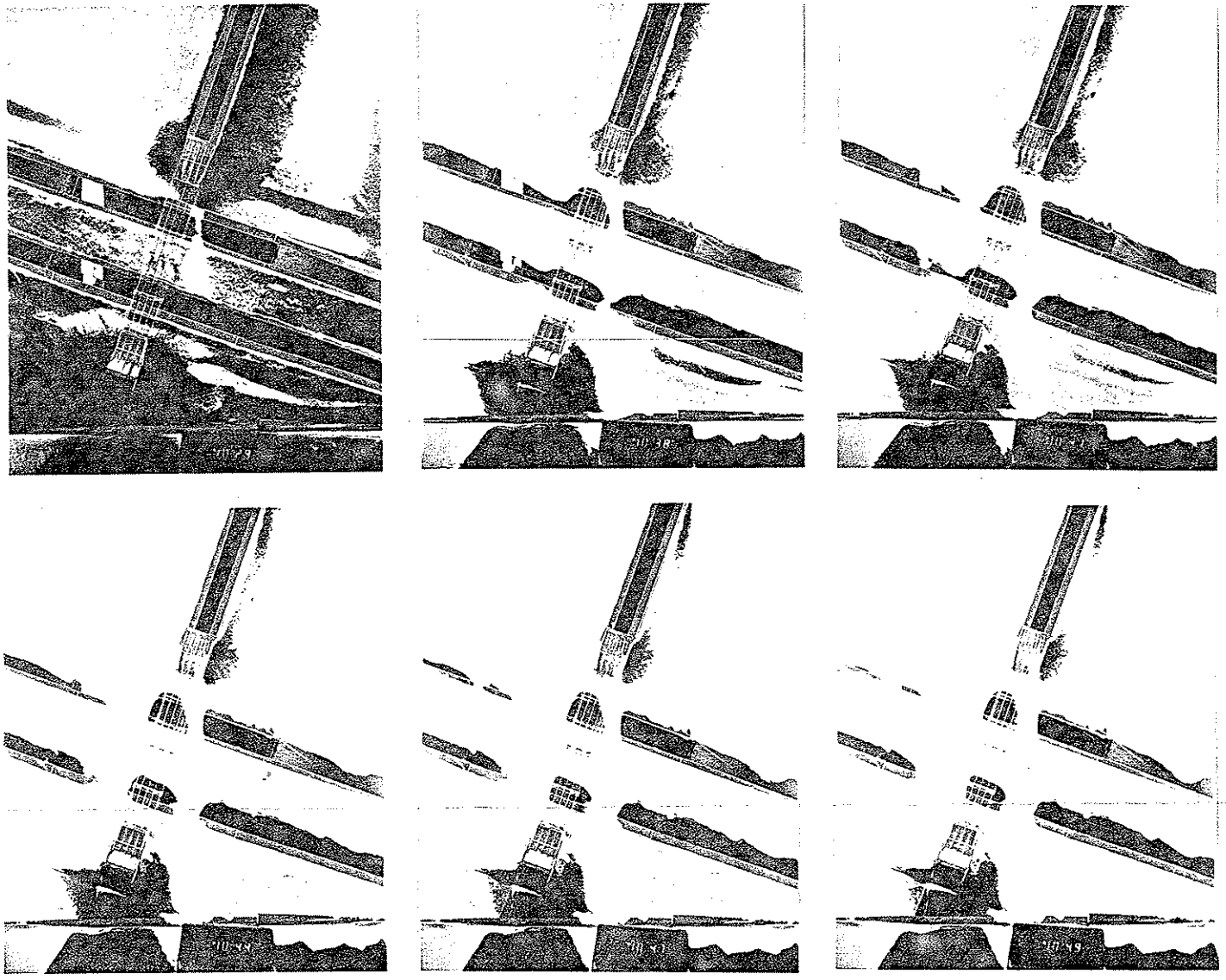
RUN 11-13-1 BARE, ΔT = 2472, 3061, 3414, 3767, 4120, 4473



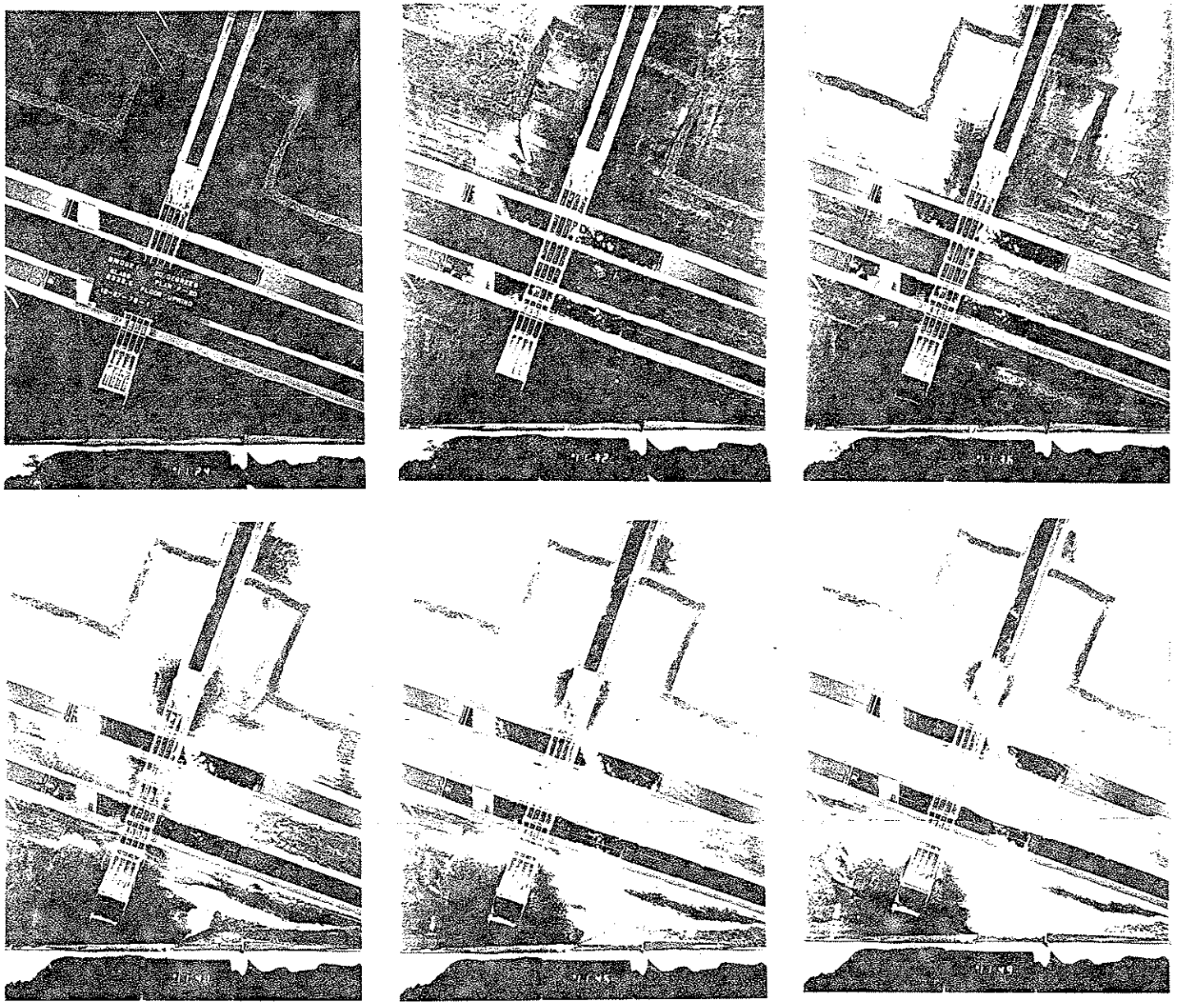
RUN 11-15-1 H-0, ΔT = 2791, 5059, 5234, 5767, 6106, 6455



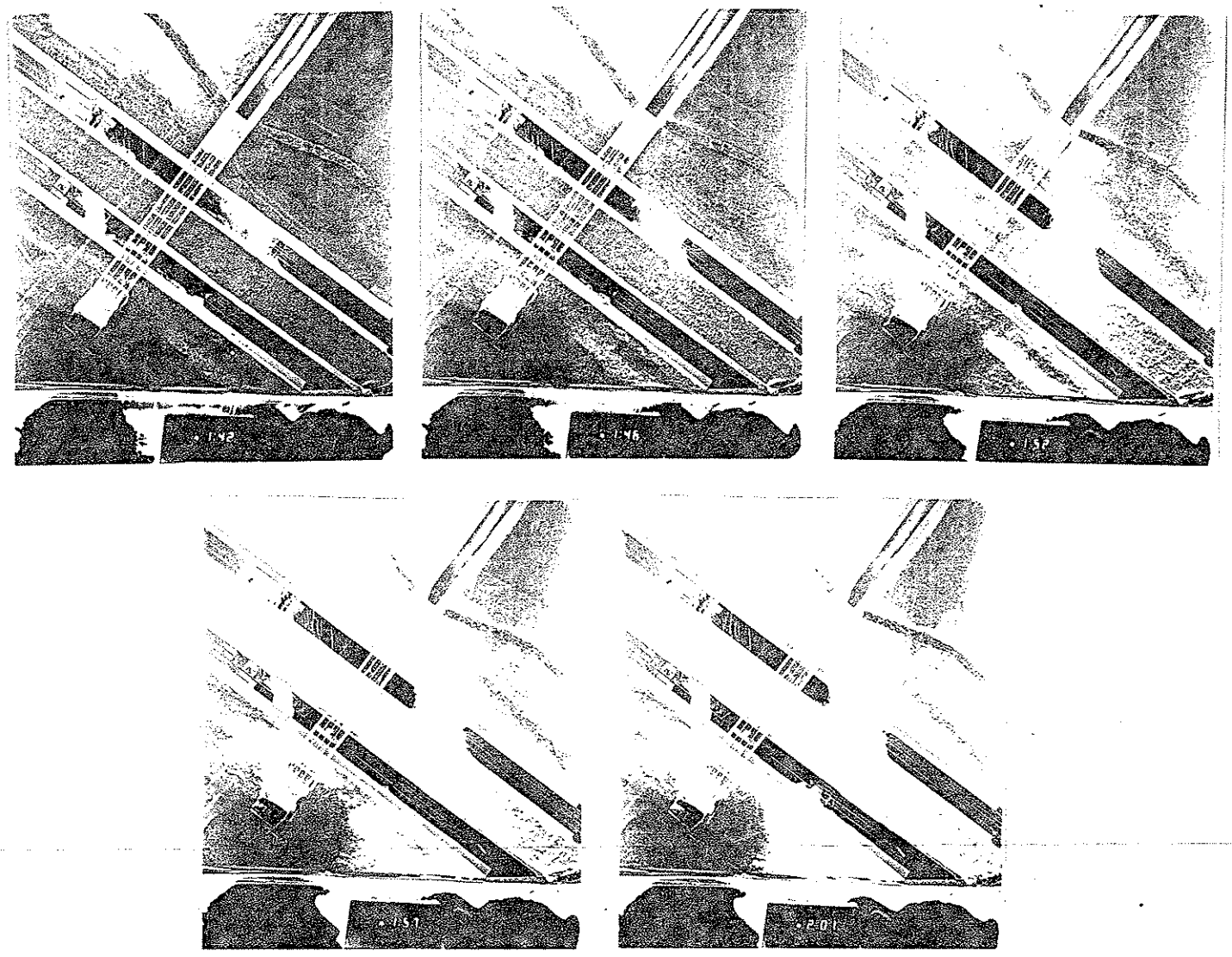
RUN 11-15-3 J-0, ΔT = 1767, 3181, 3888, 4948, 5478, 6009



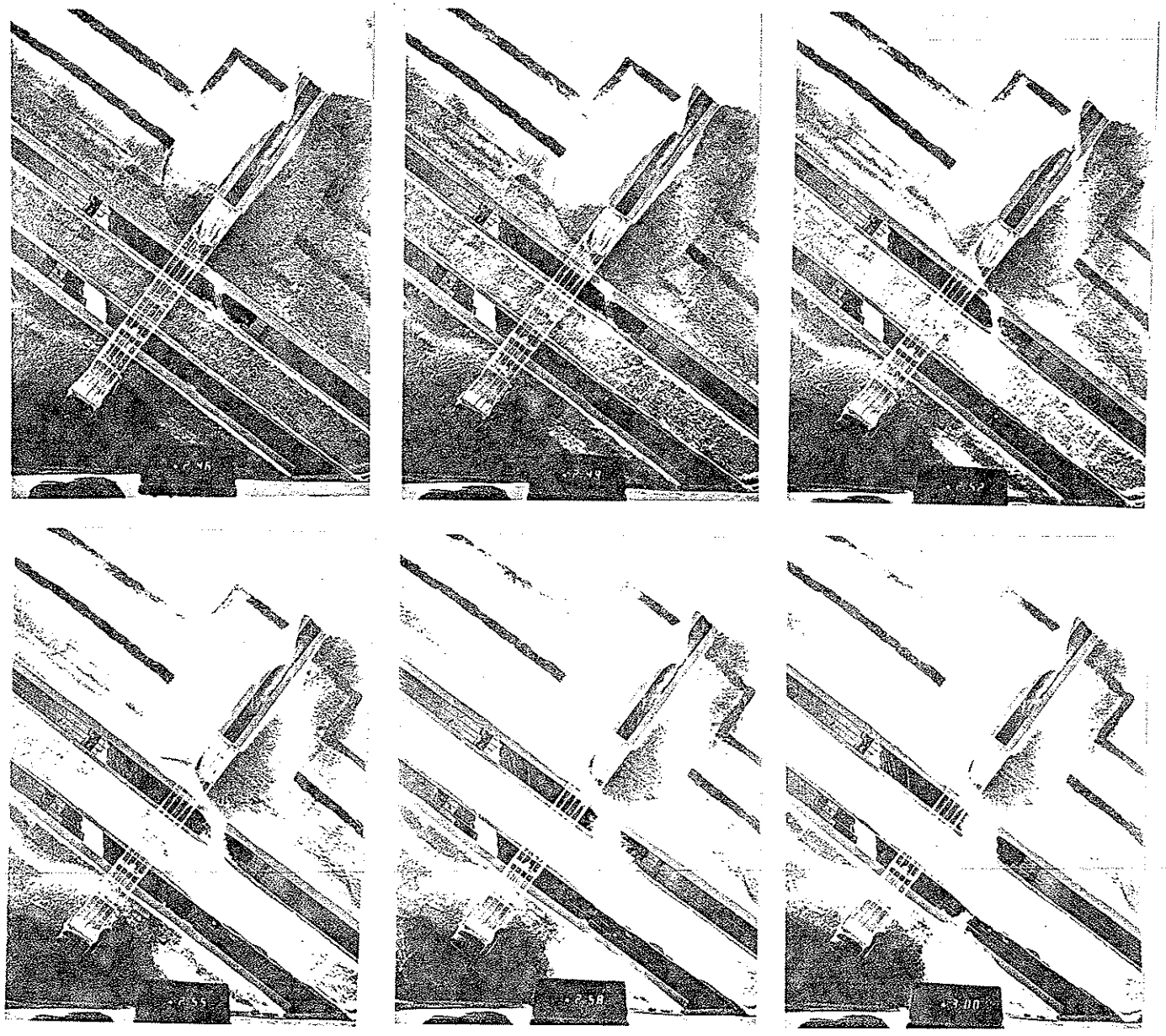
RUN 12-7-1 BARE, ΔT - 1568, 2851, 3278, 3706, 4134, 4419



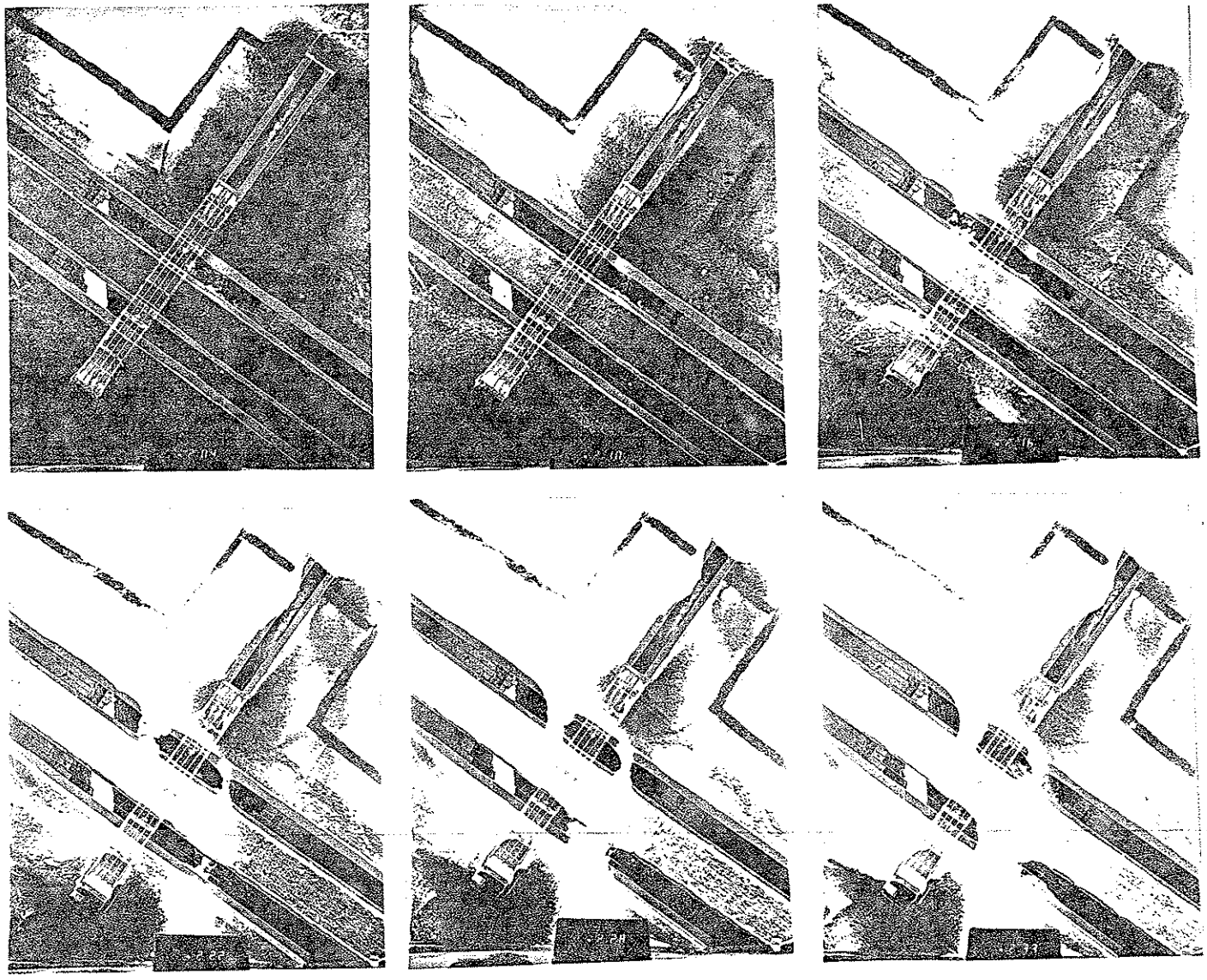
RUN 12-27-1 F-20, ΔT = 782, 1408, 2190, 2816, 3442



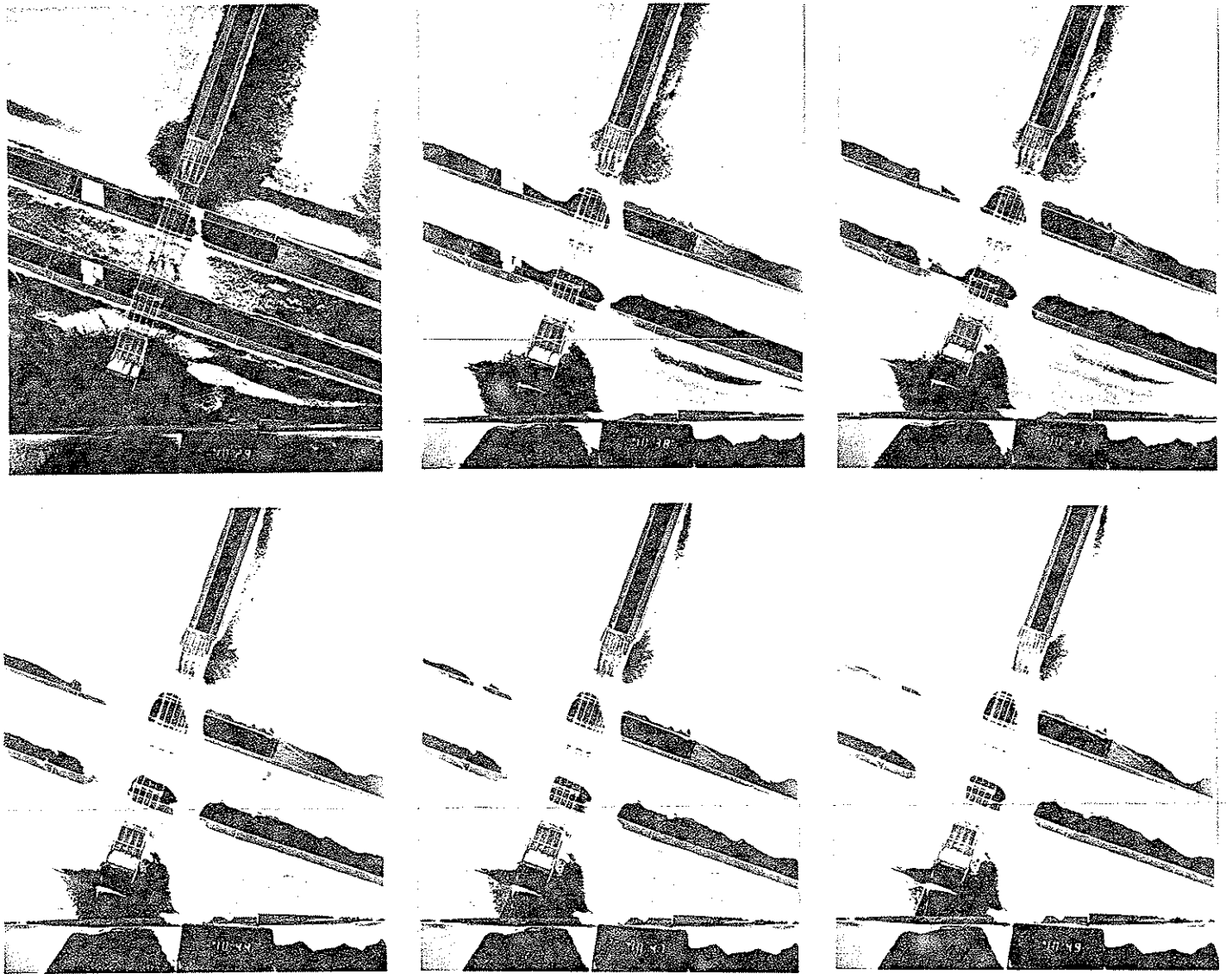
RUN 2-12-1 DOT-1, ΔT = 1745, 2443, 3490, 4363, 5061



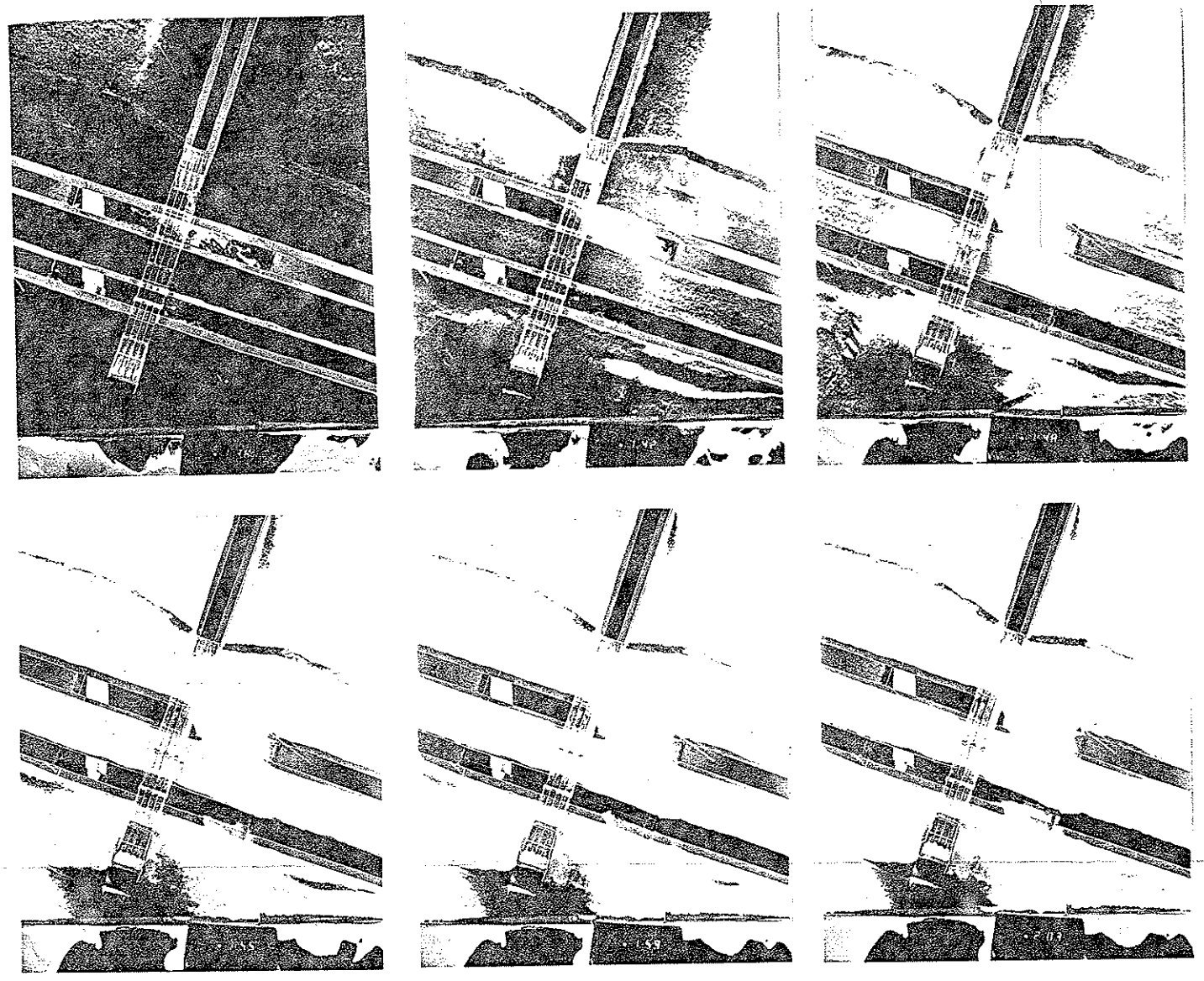
RUN 2-19-2 D-40, ΔT = 2574, 3125, 3677, 4229, 4780, 5148



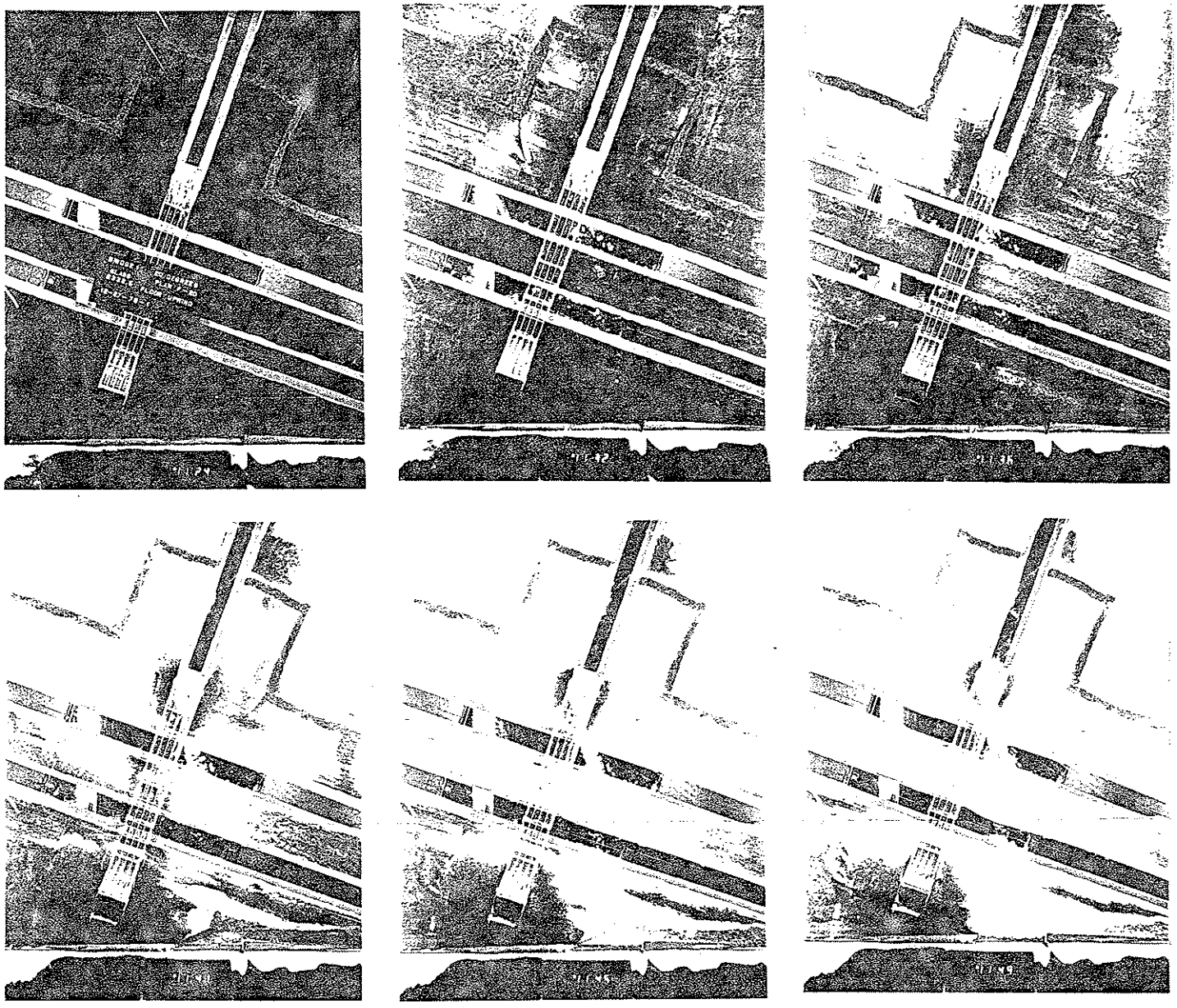
RUN 2-21-1 F-40, ΔT = 1678, 2594, 3509, 4424, 5340, 6102



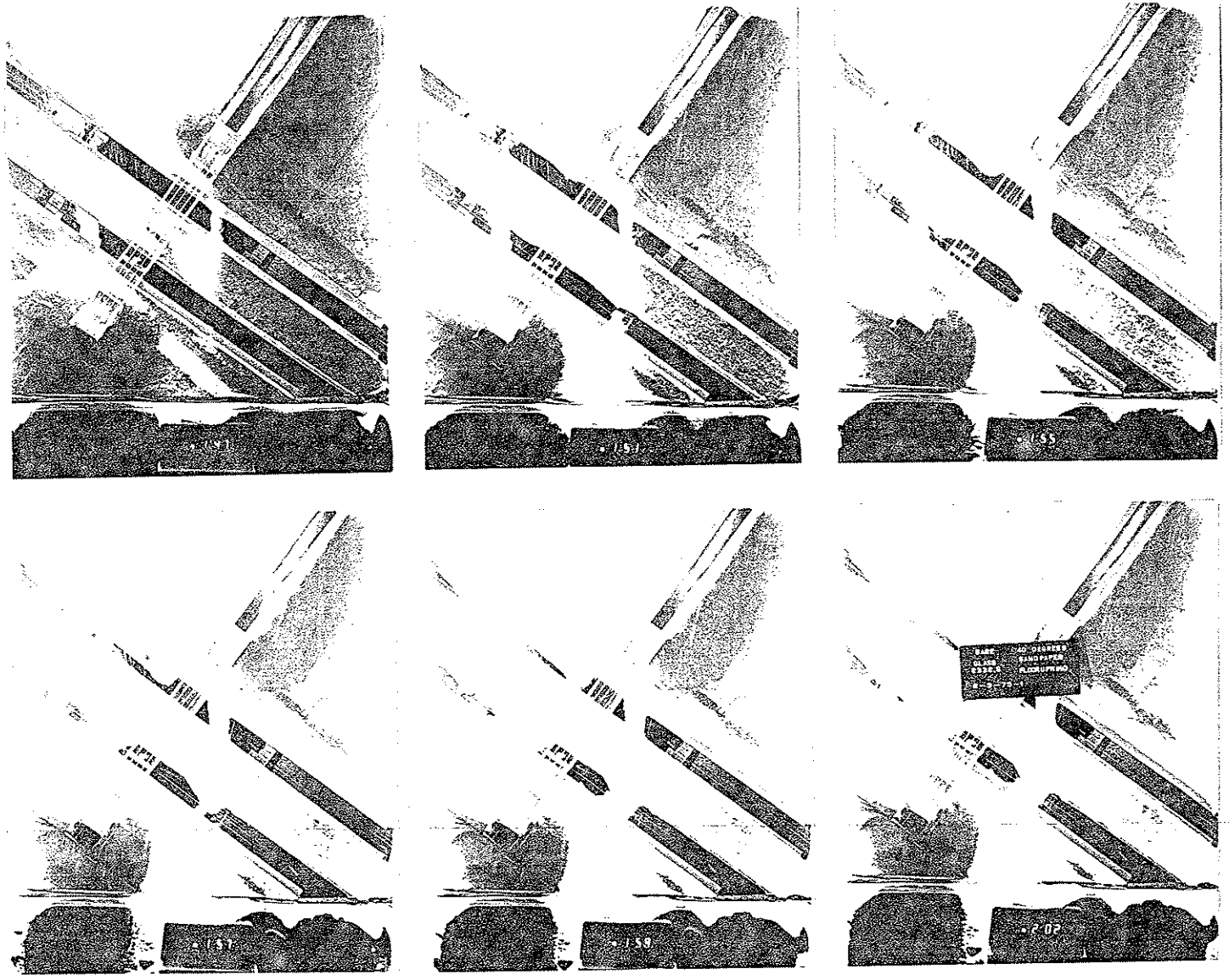
RUN 12-7-1 BARE, ΔT - 1568, 2851, 3278, 3706, 4134, 4419



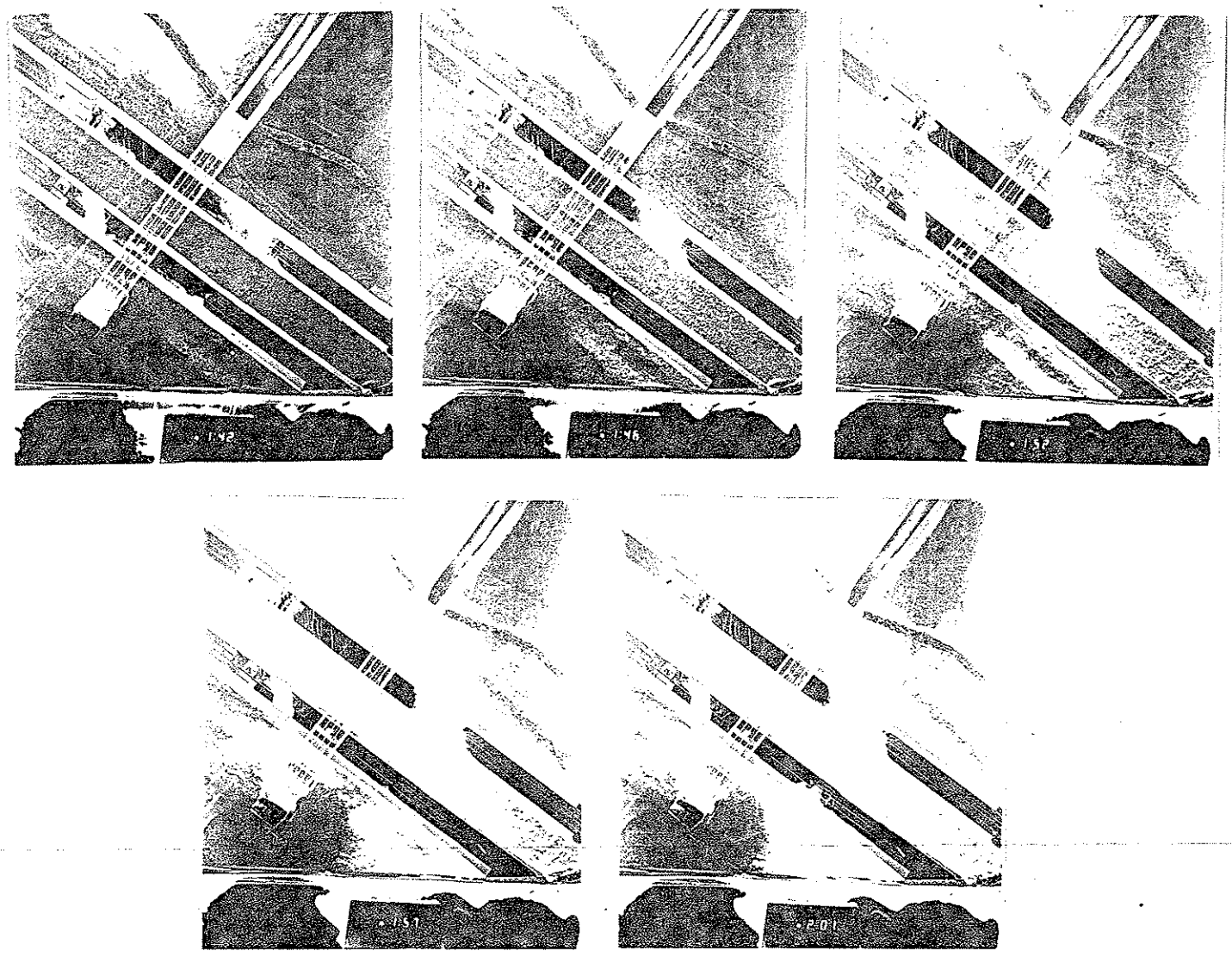
RUN 12-9-1 DOT-1, ΔT = 454, 1363, 2272, 3333, 3938, 4544



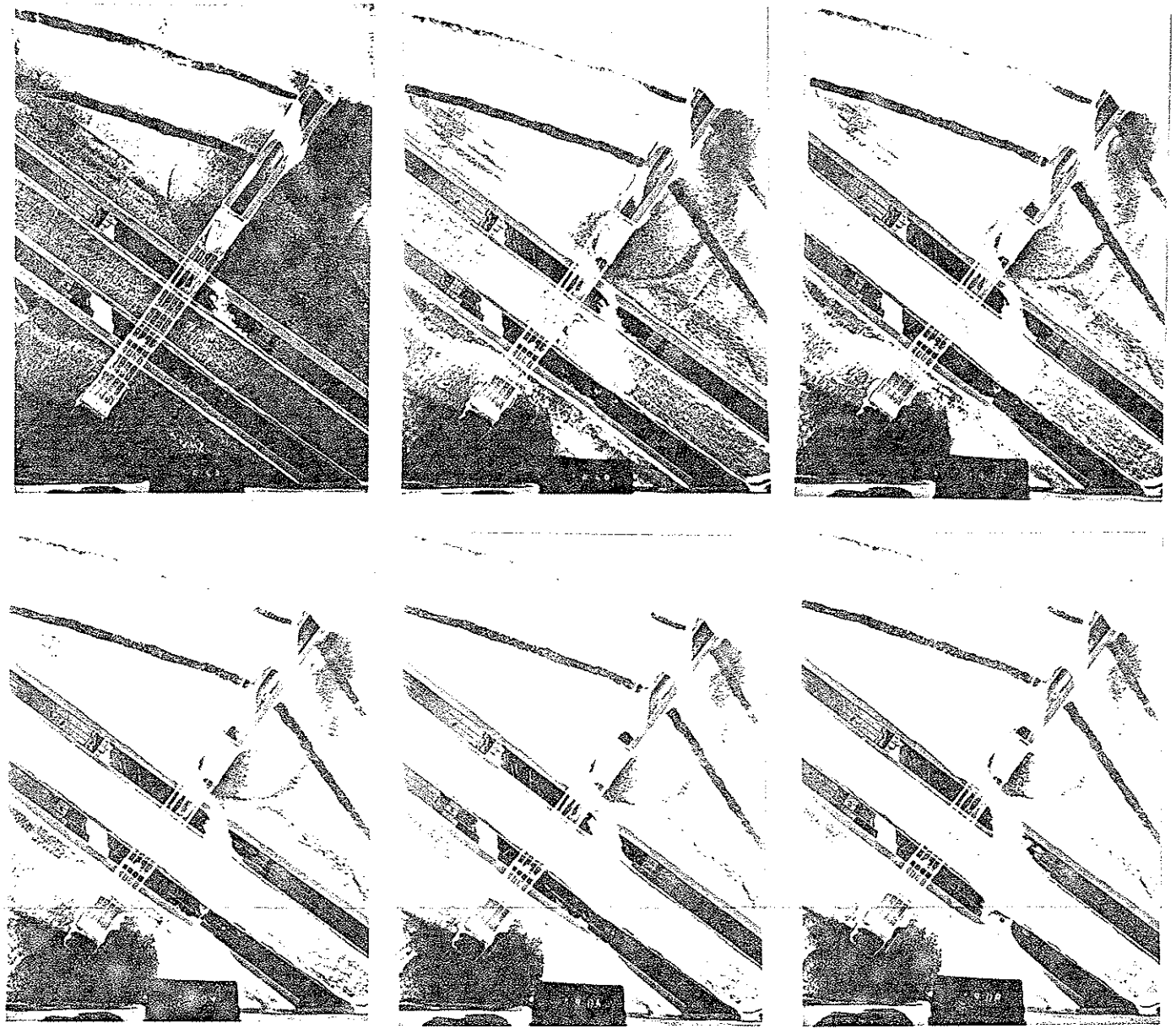
RUN 12-27-1 F-20, ΔT = 782, 1408, 2190, 2816, 3442



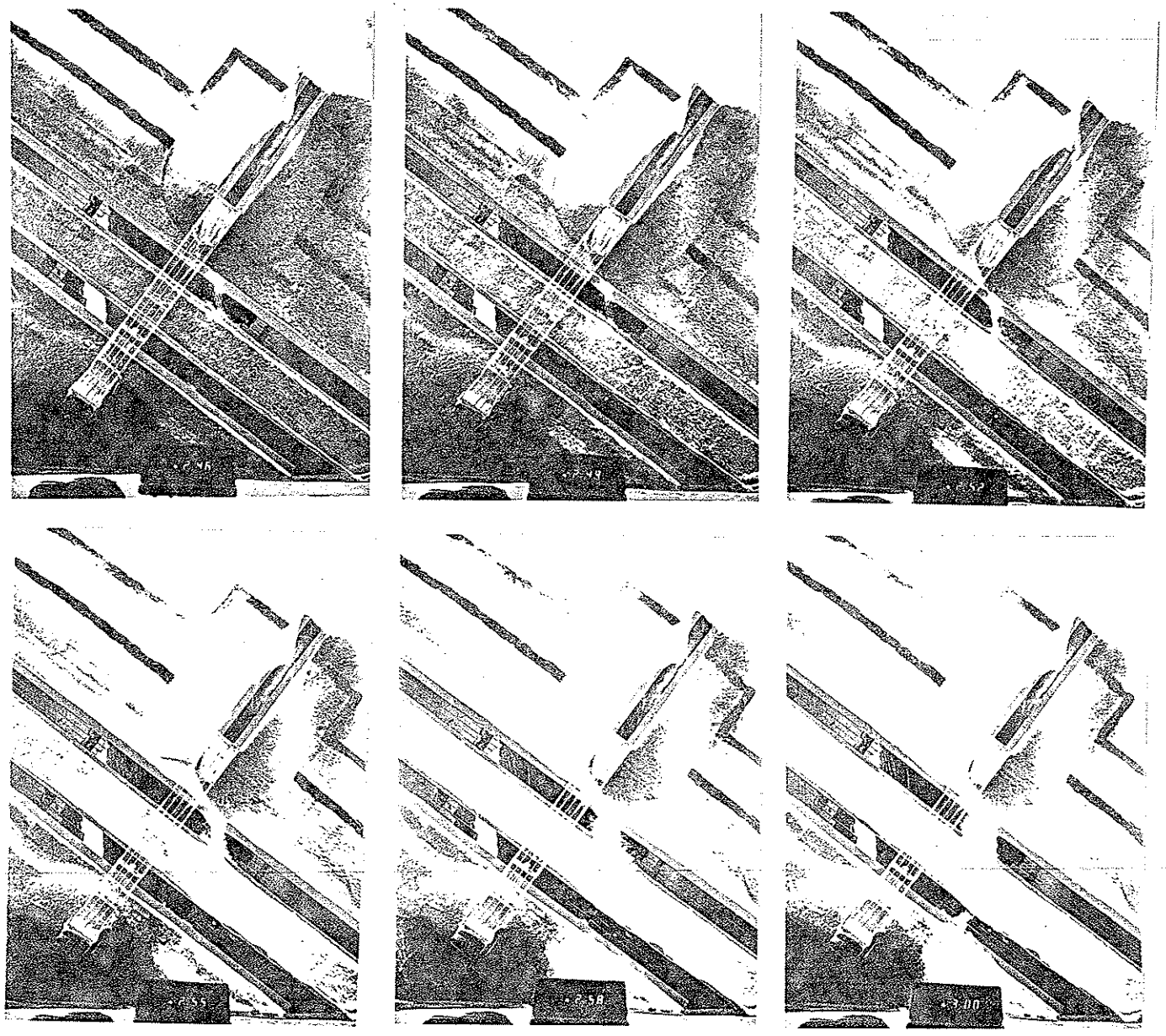
RUN 2-9-1 BARE, ΔT = 2679, 3444, 4210, 4592, 4975, 4975



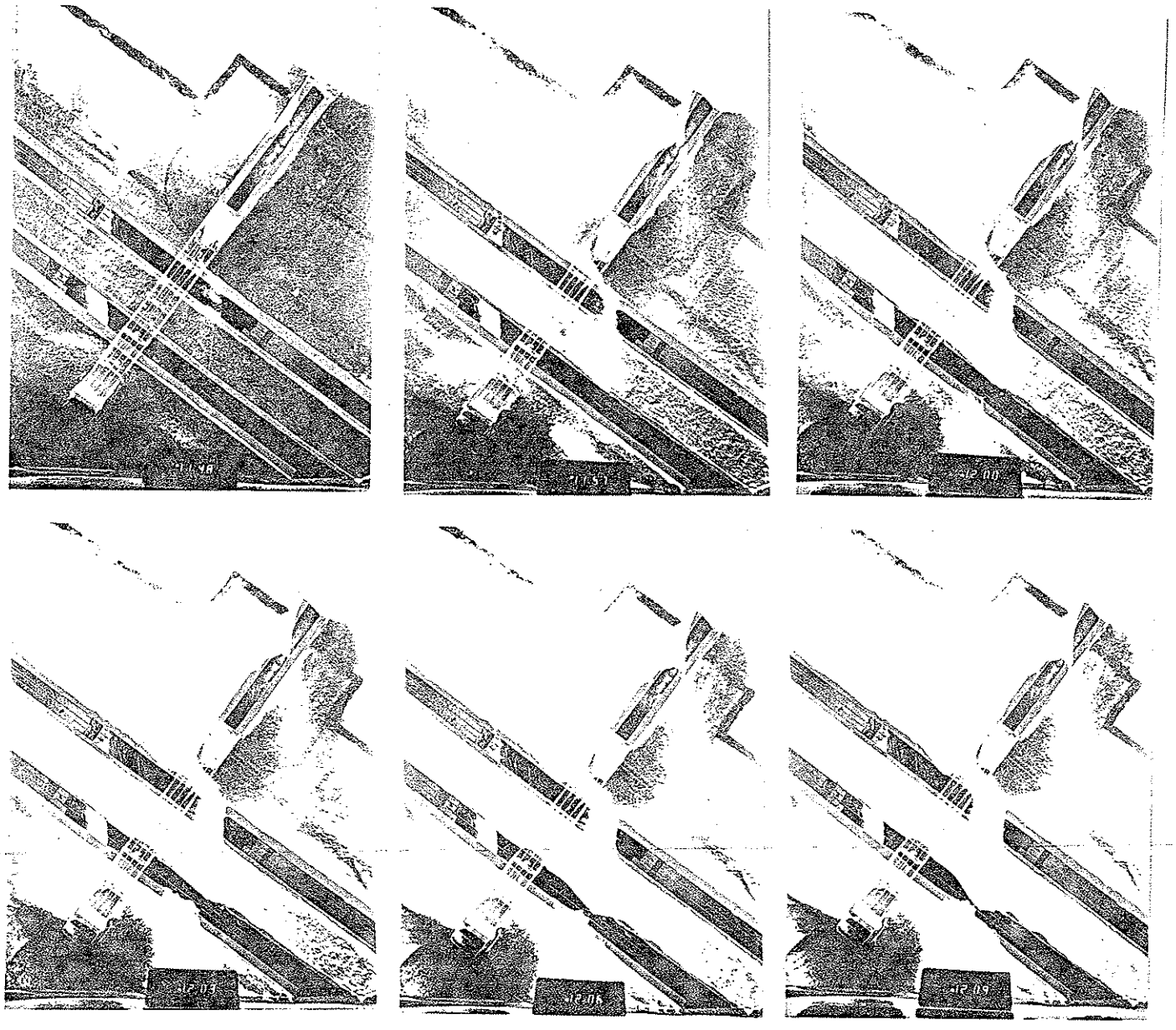
RUN 2-12-1 DOT-1, ΔT = 1745, 2443, 3490, 4363, 5061



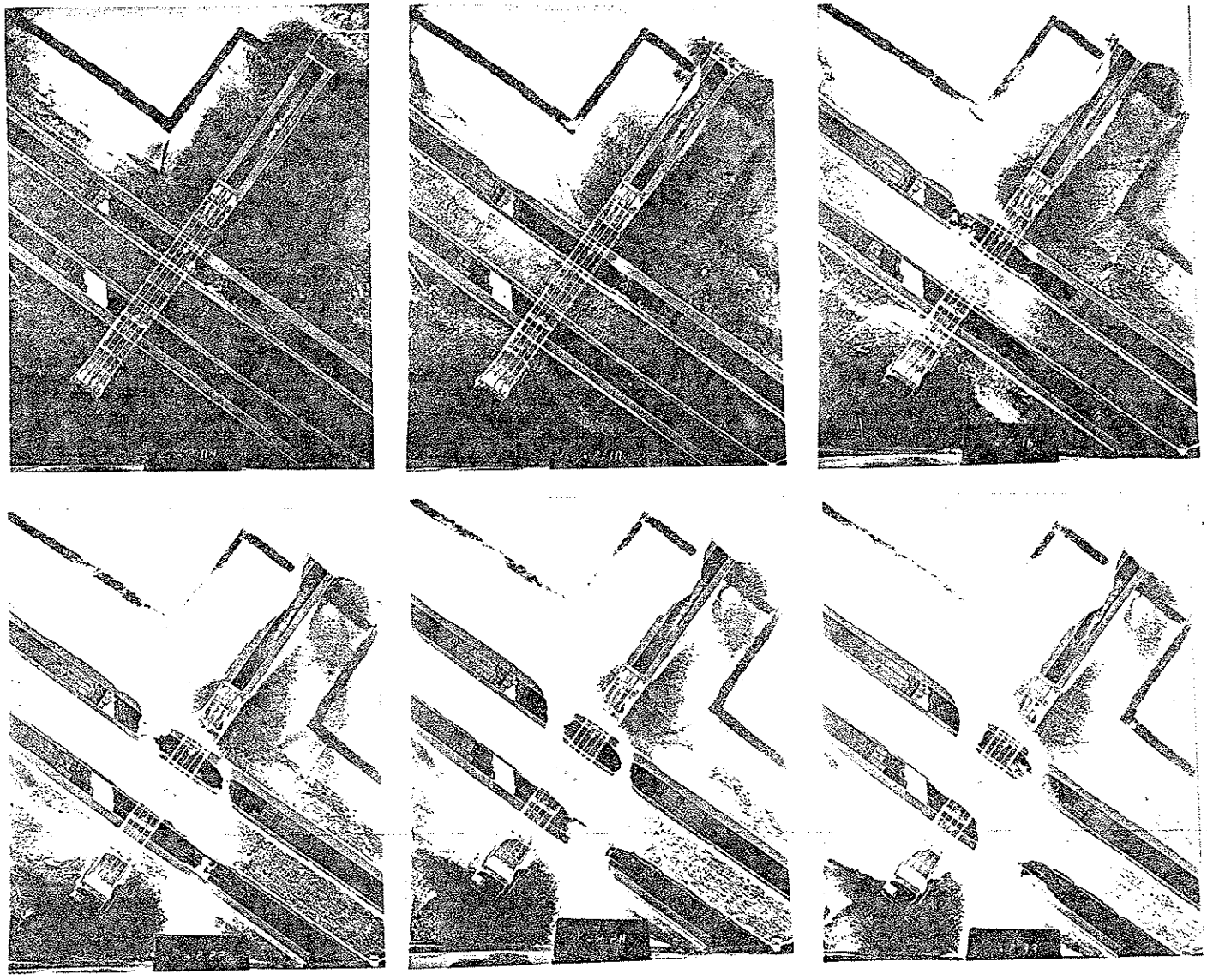
RUN 2-19-1 I-40, ΔT = 2207, 3310, 3862, 4229, 4597, 4965



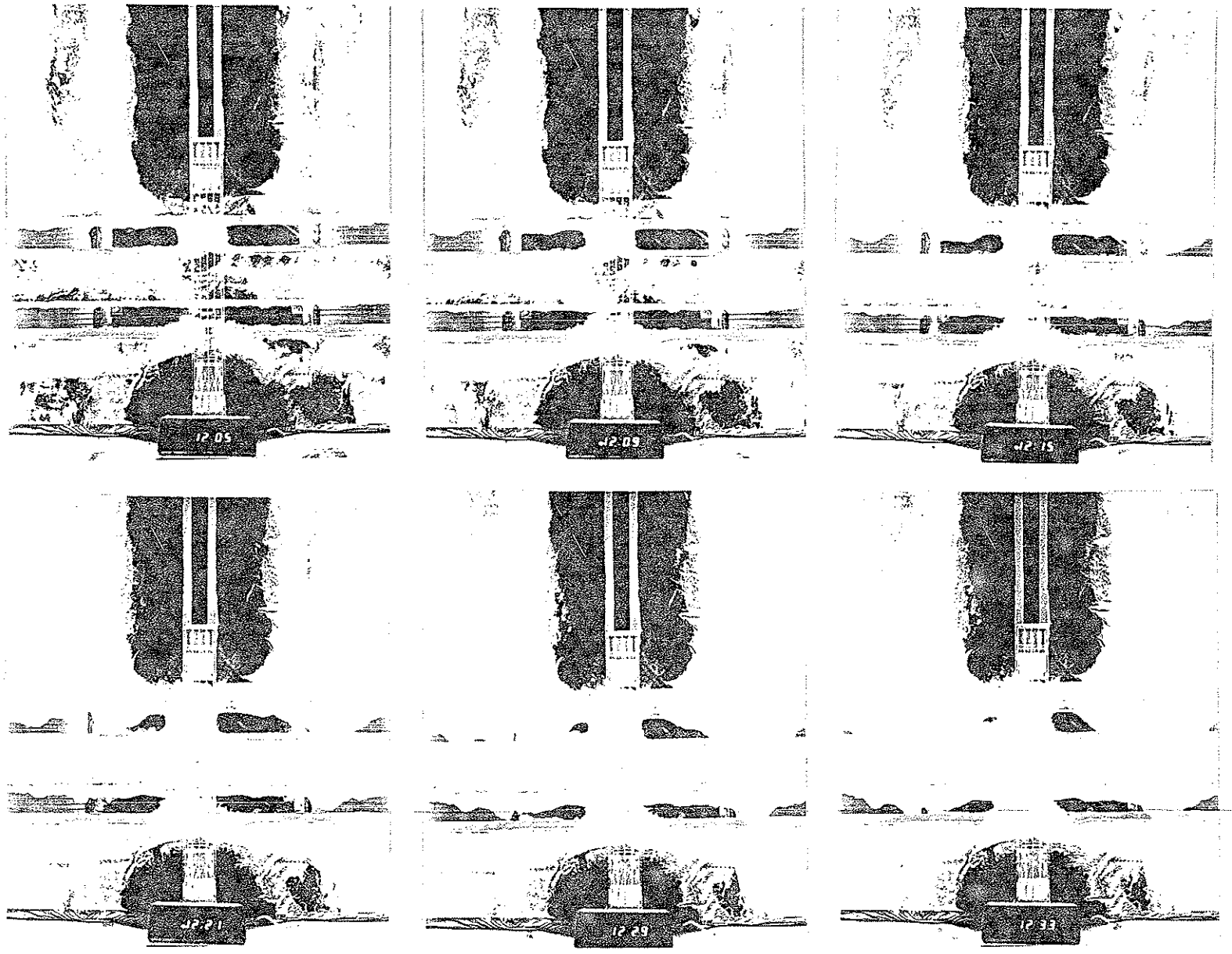
RUN 2-19-2 D-40, ΔT = 2574, 3125, 3677, 4229, 4780, 5148



RUN 2-20-1 G-40, ΔT = 2677, 4183, 4684, 5186, 5688, 6190



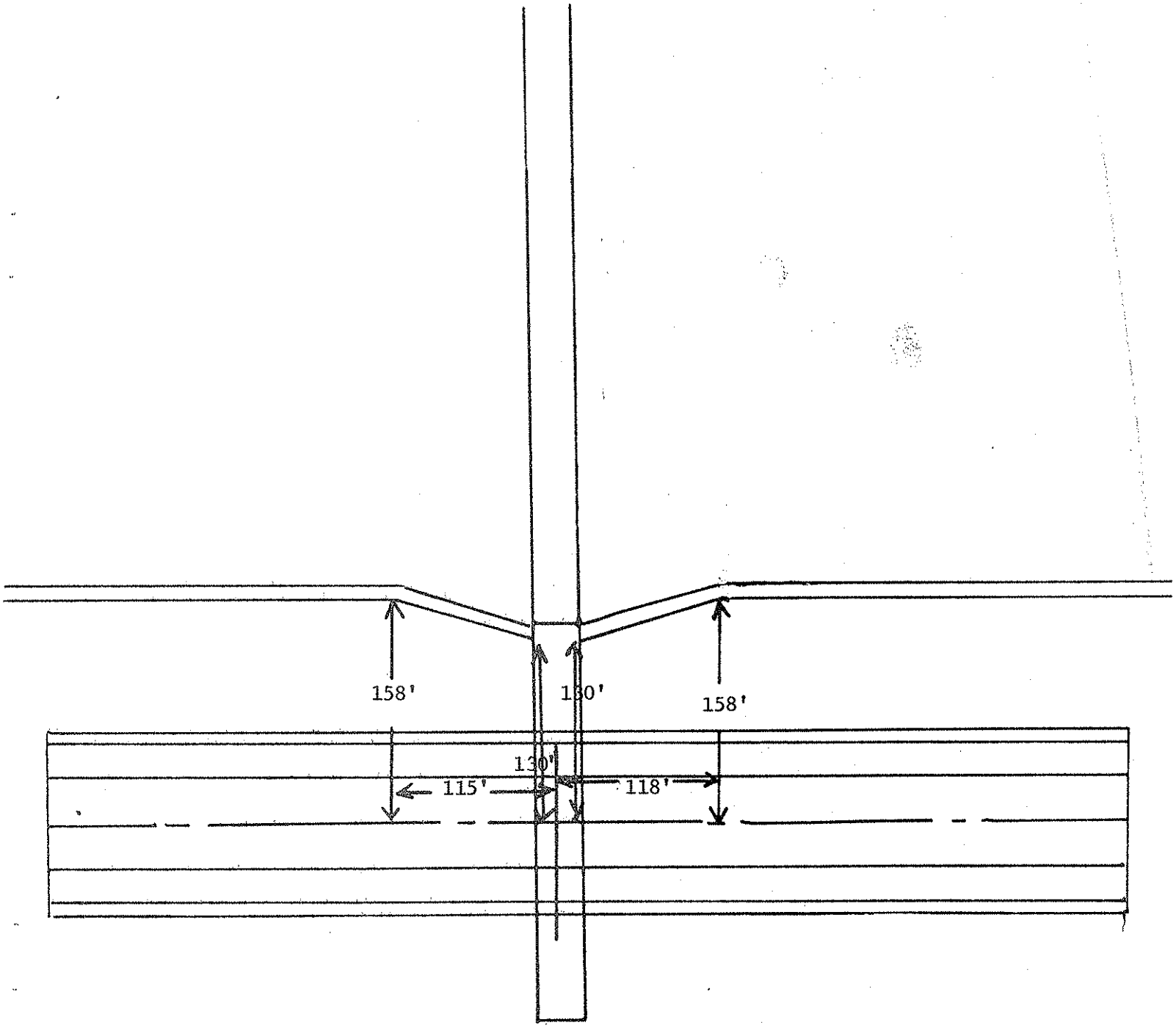
RUN 2-21-1 F-40, ΔT = 1678, 2594, 3509, 4424, 5340, 6102



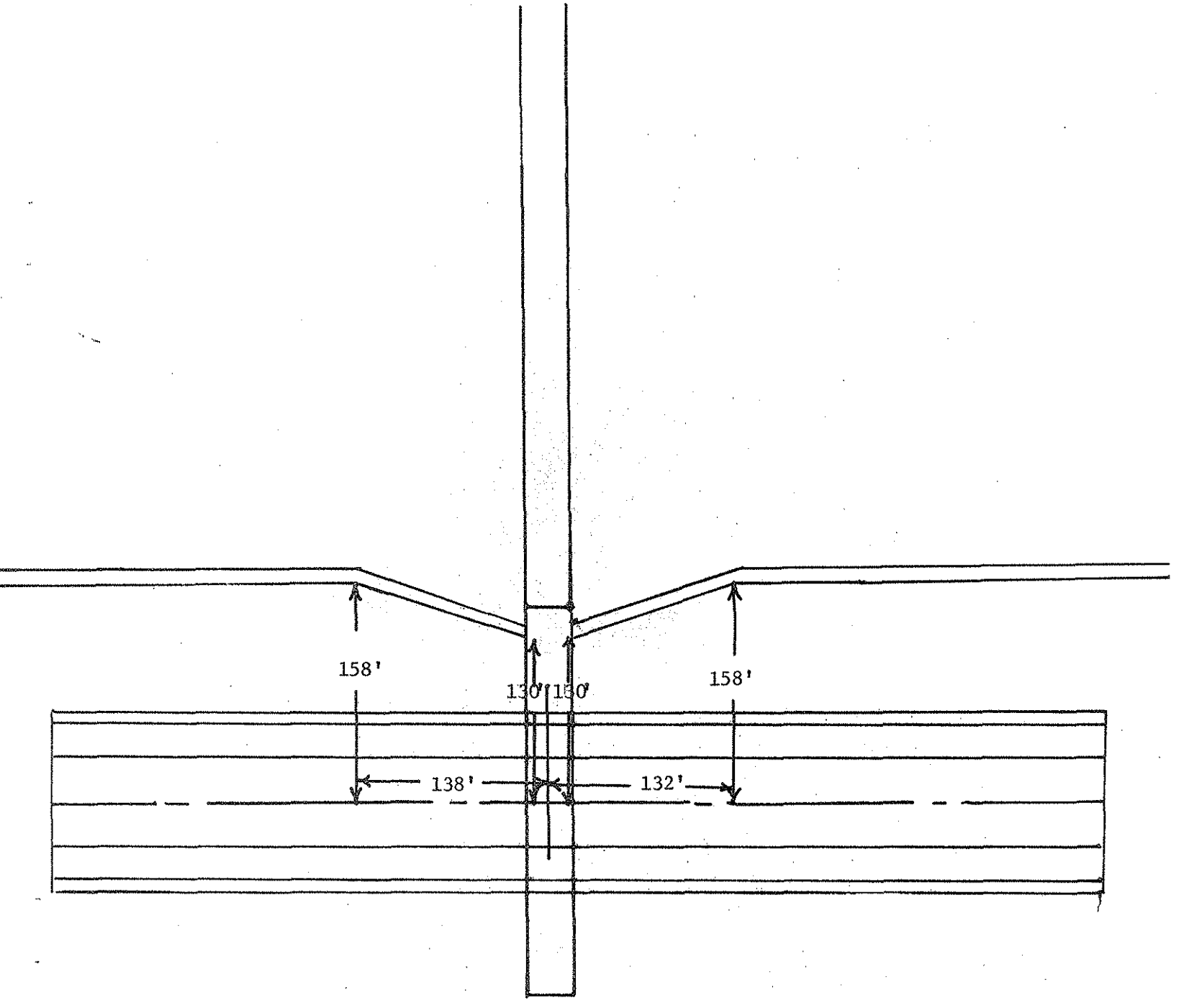
RUN 3-24-1 BARE, ΔT = 2360, 2738, 3304, 3871, 4626, 5004

Part 8. Snowdrift Control Configuration Drawings

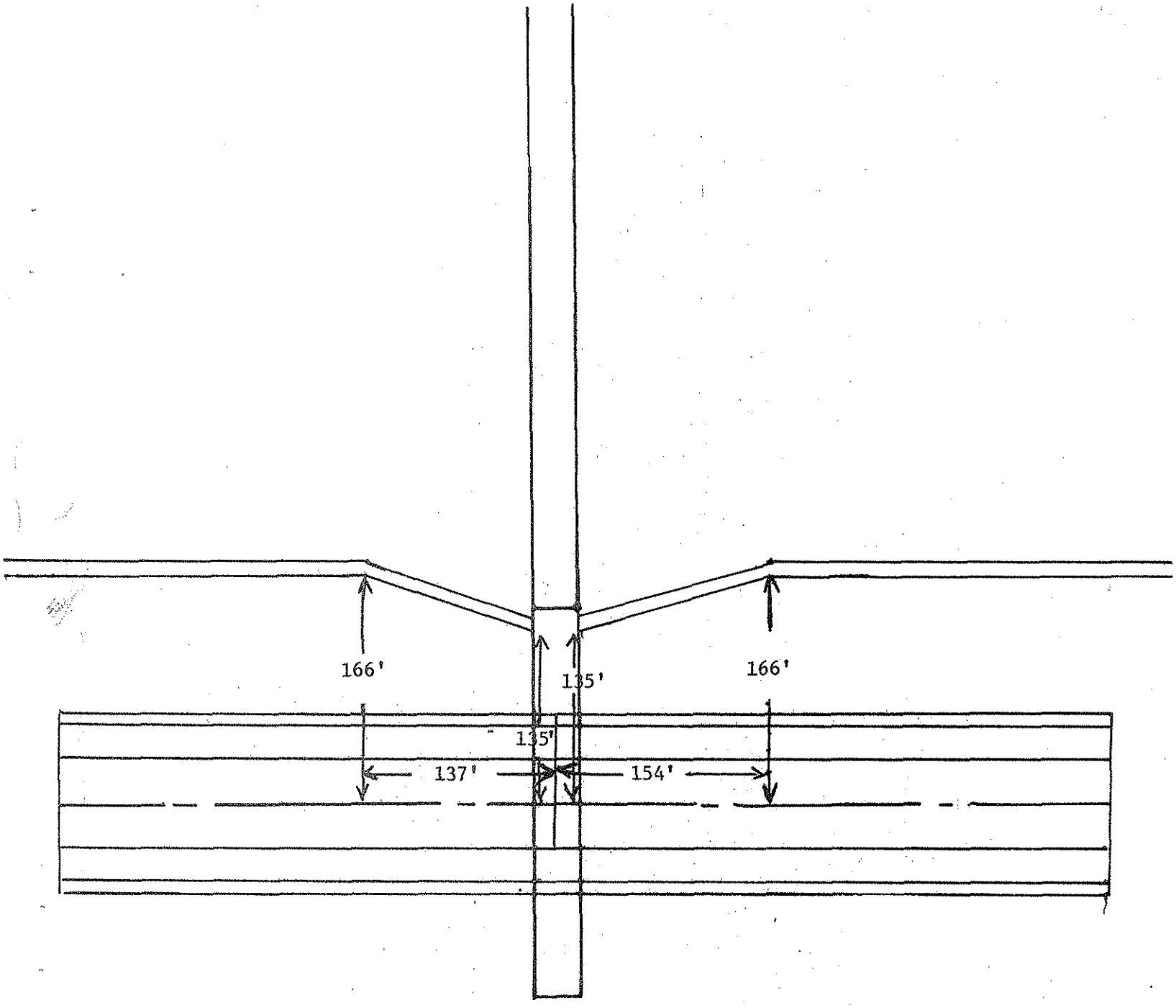
The following pages contain dimensioned drawings of all snowdrift control configurations attempted for model 1.



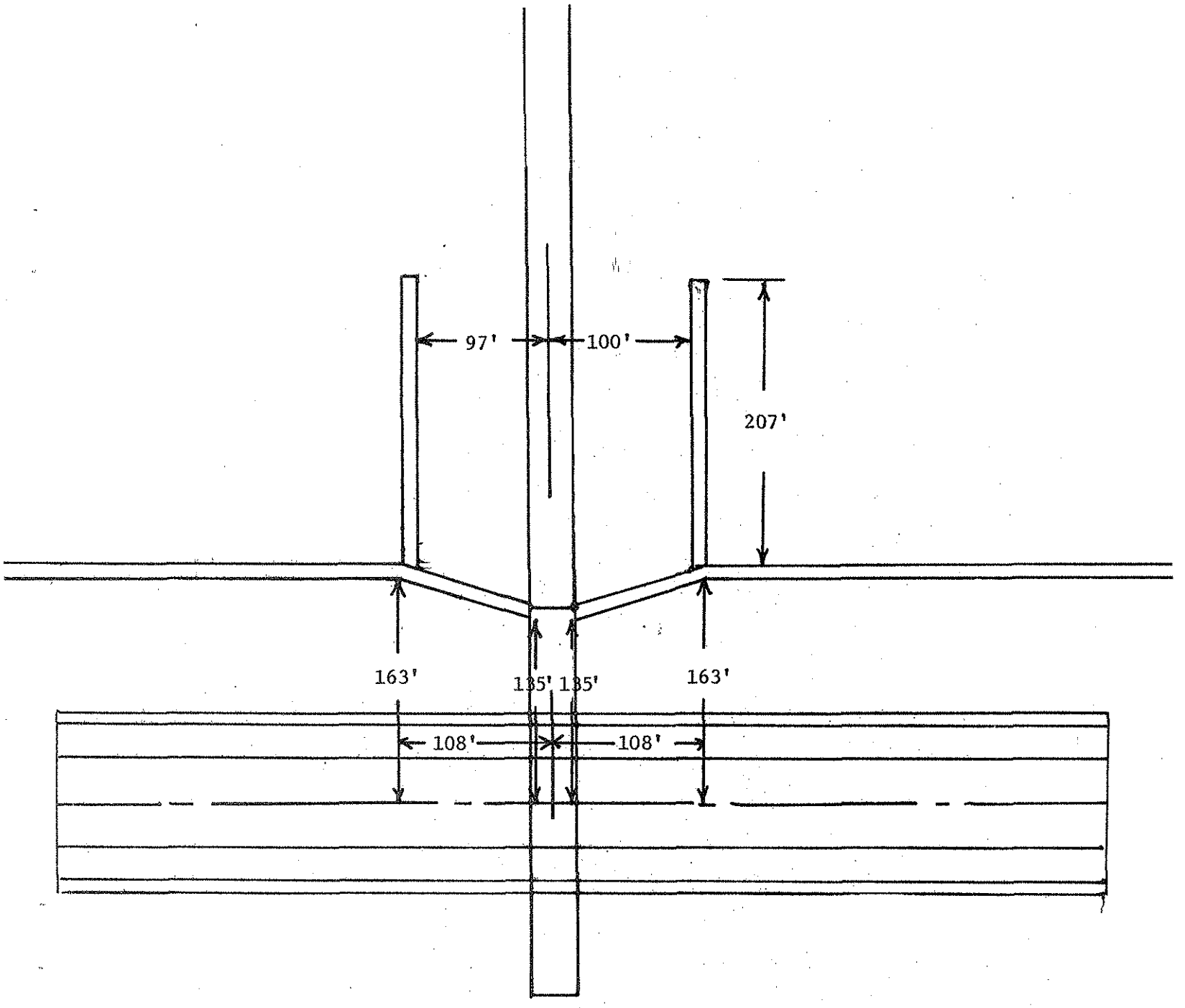
Run 10-31-2, Plan DOT-1



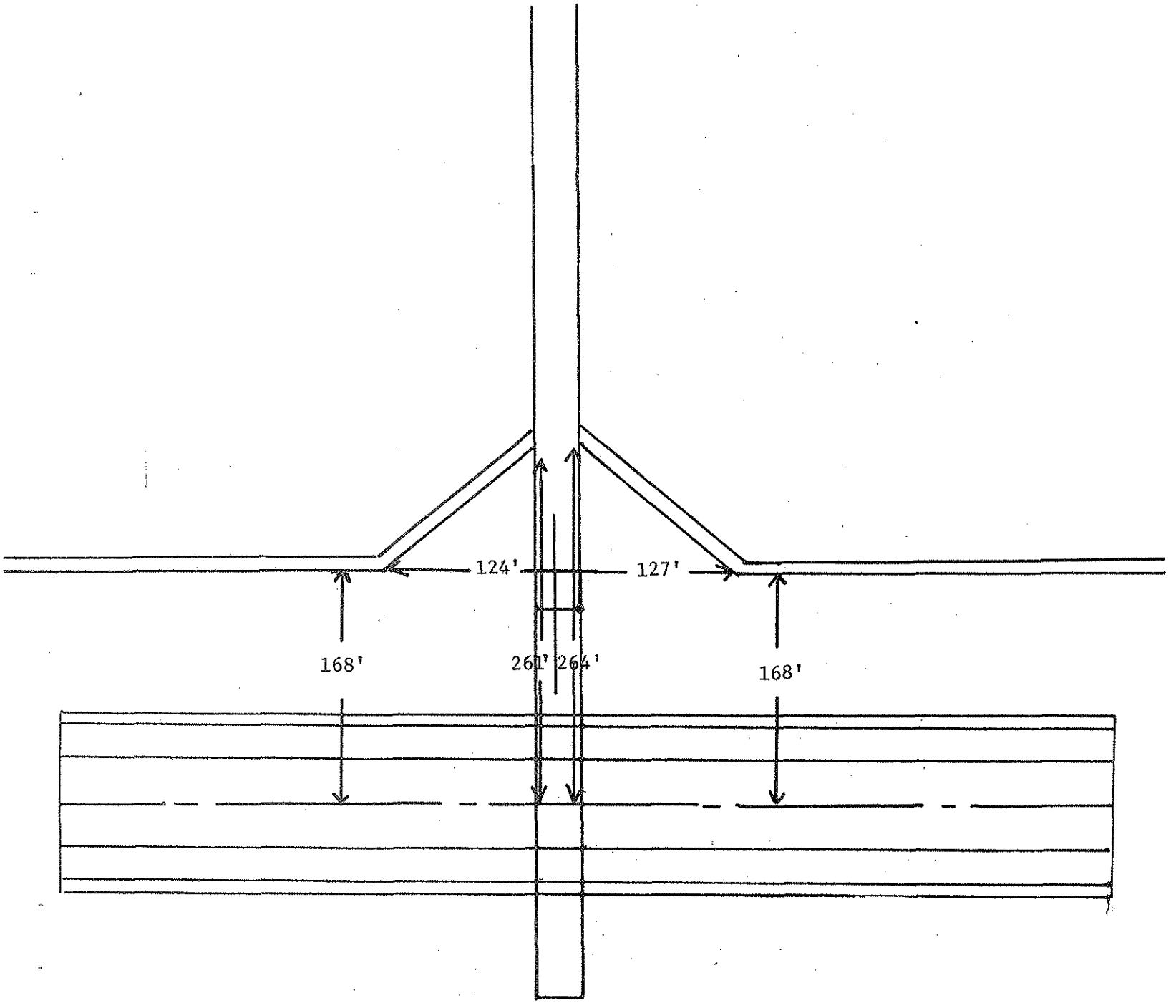
Run 11-1-1, Plan DOT-1



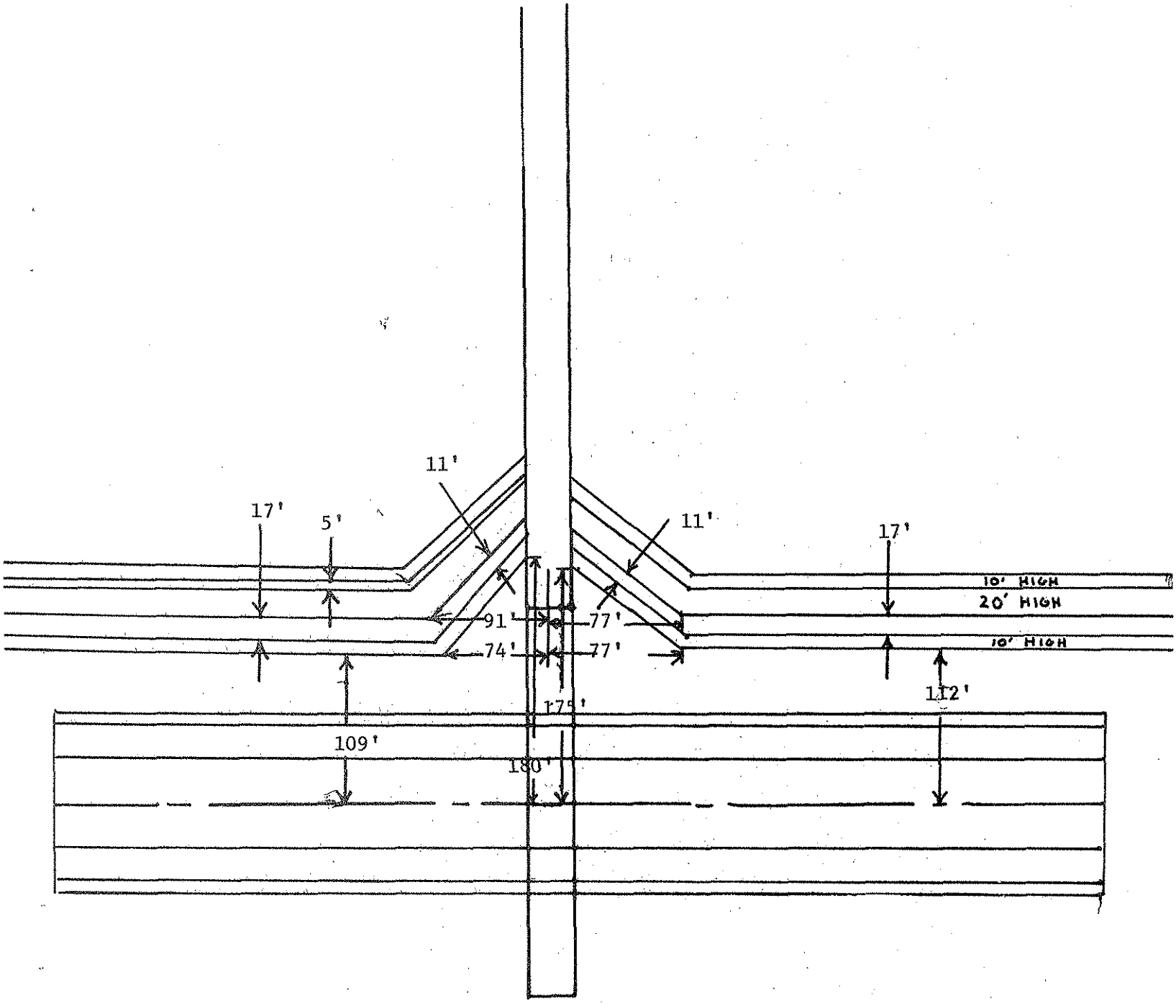
Run 11-6-1, Plan DOT-1 With Guardrail



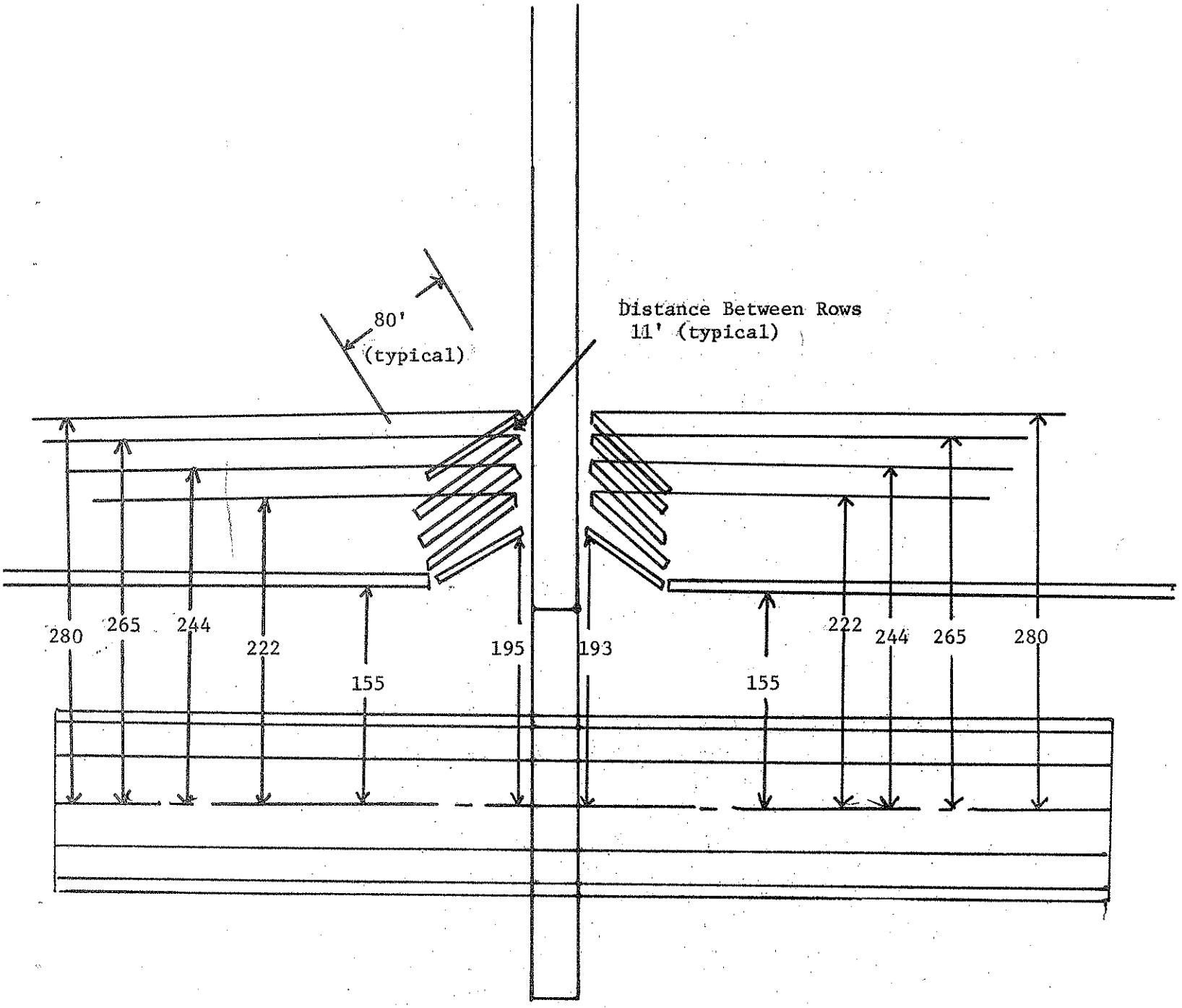
Run 11-7-2, Plan DOT-2



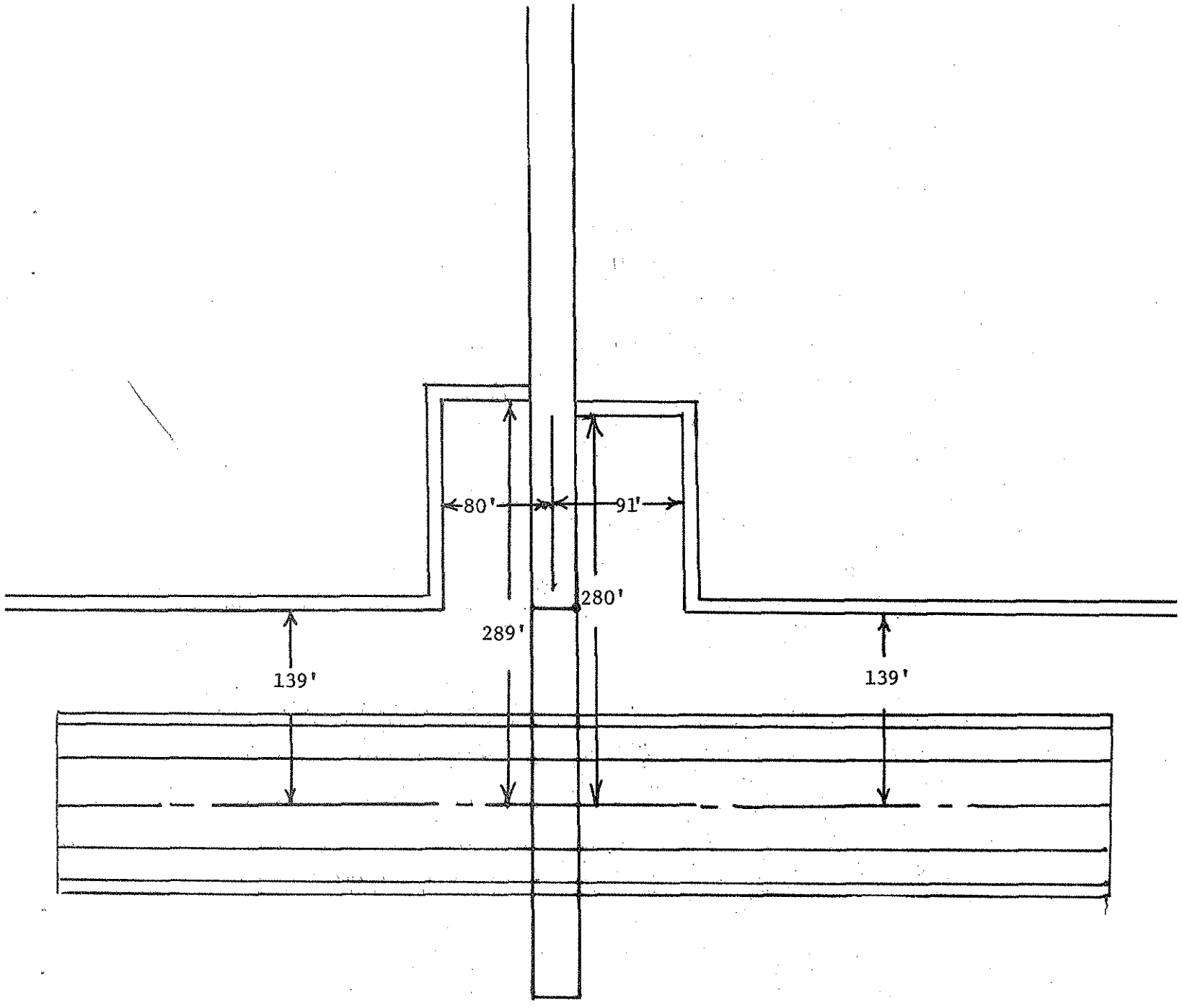
Run 11-7-3, Plan A-0



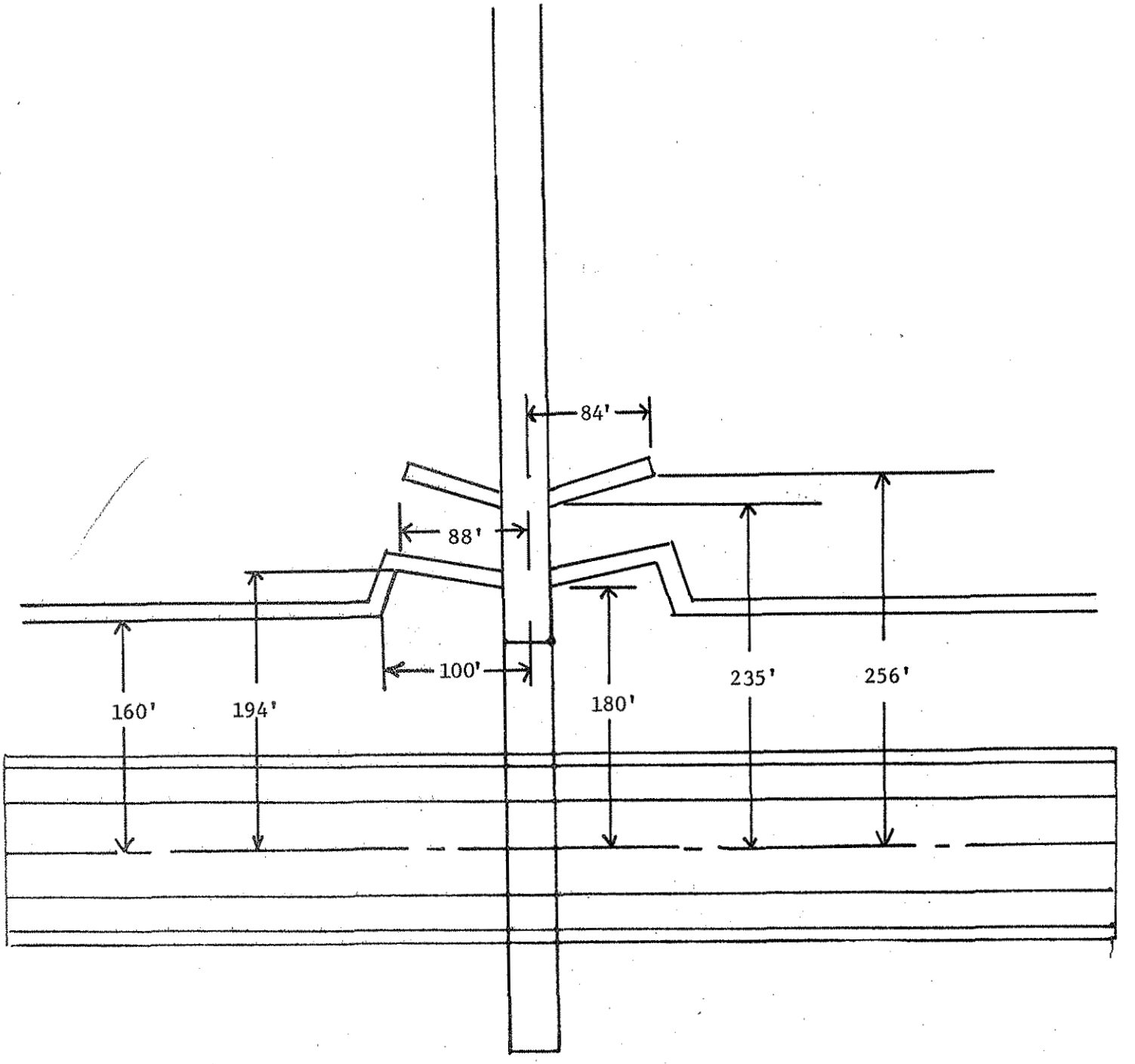
Run 11-9-1 Plan B - 0



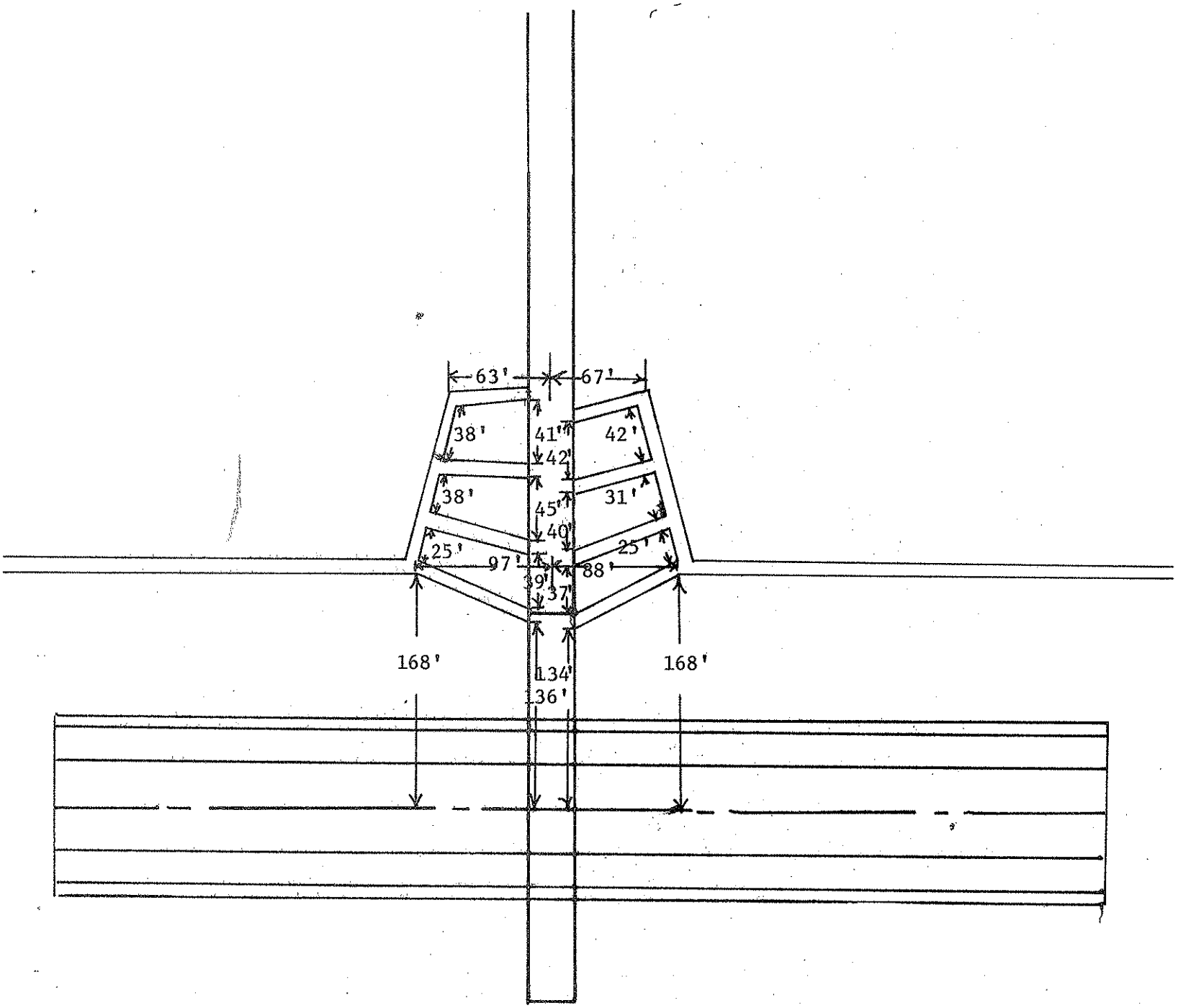
Run 11-10-1, Plan C-0



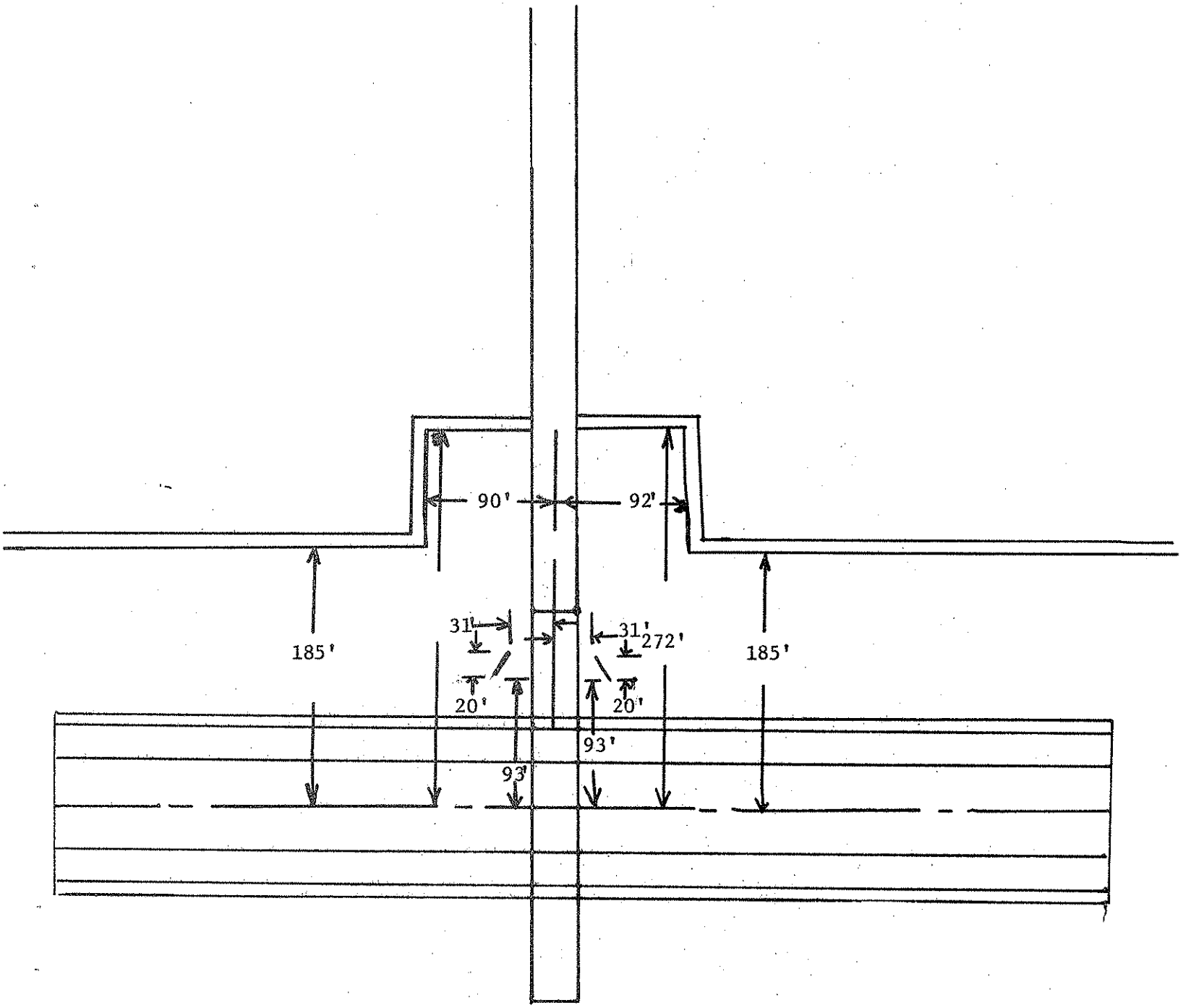
Run 11-10-2, Plan D-O



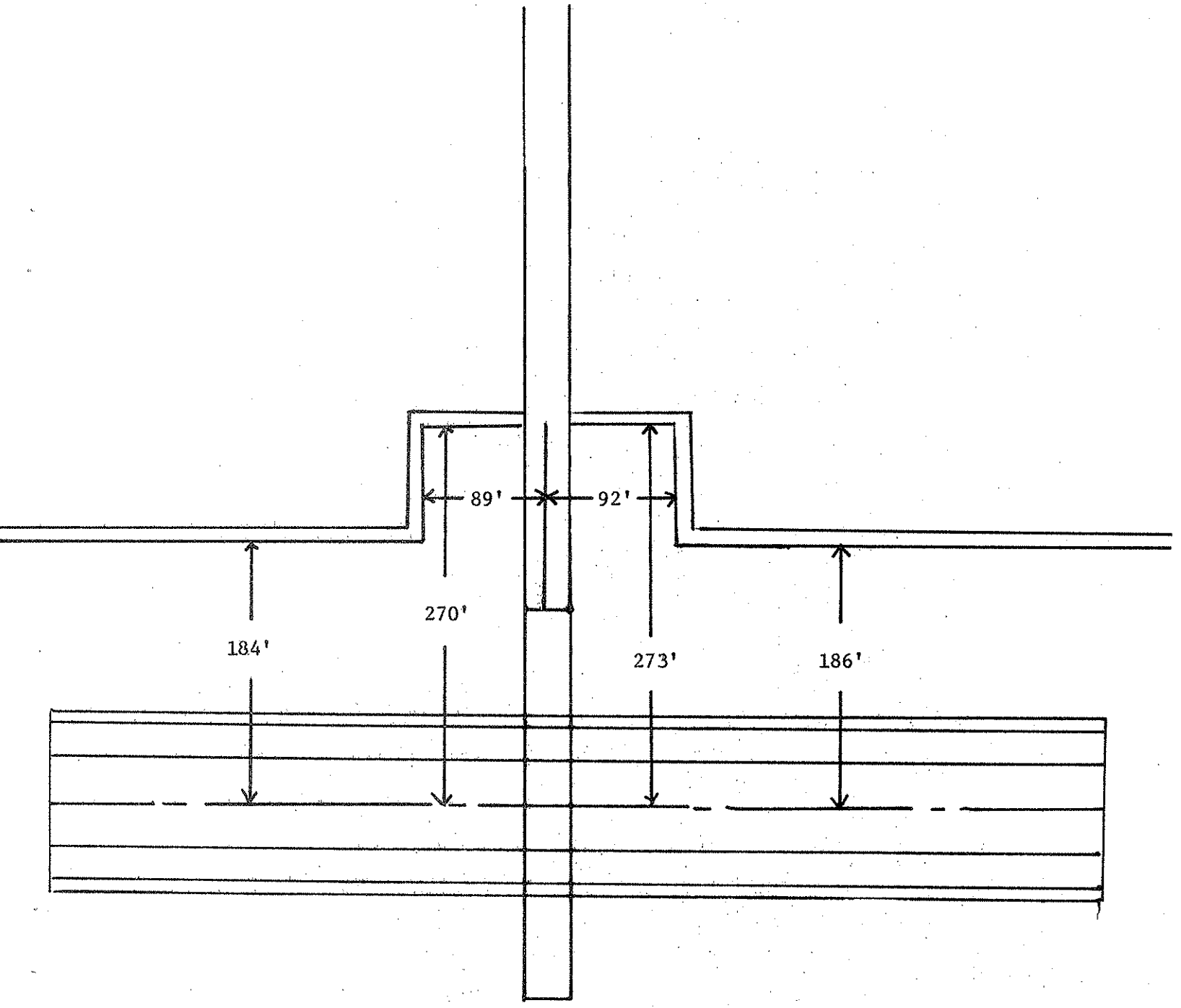
Run 11-10-4, Plan E-0



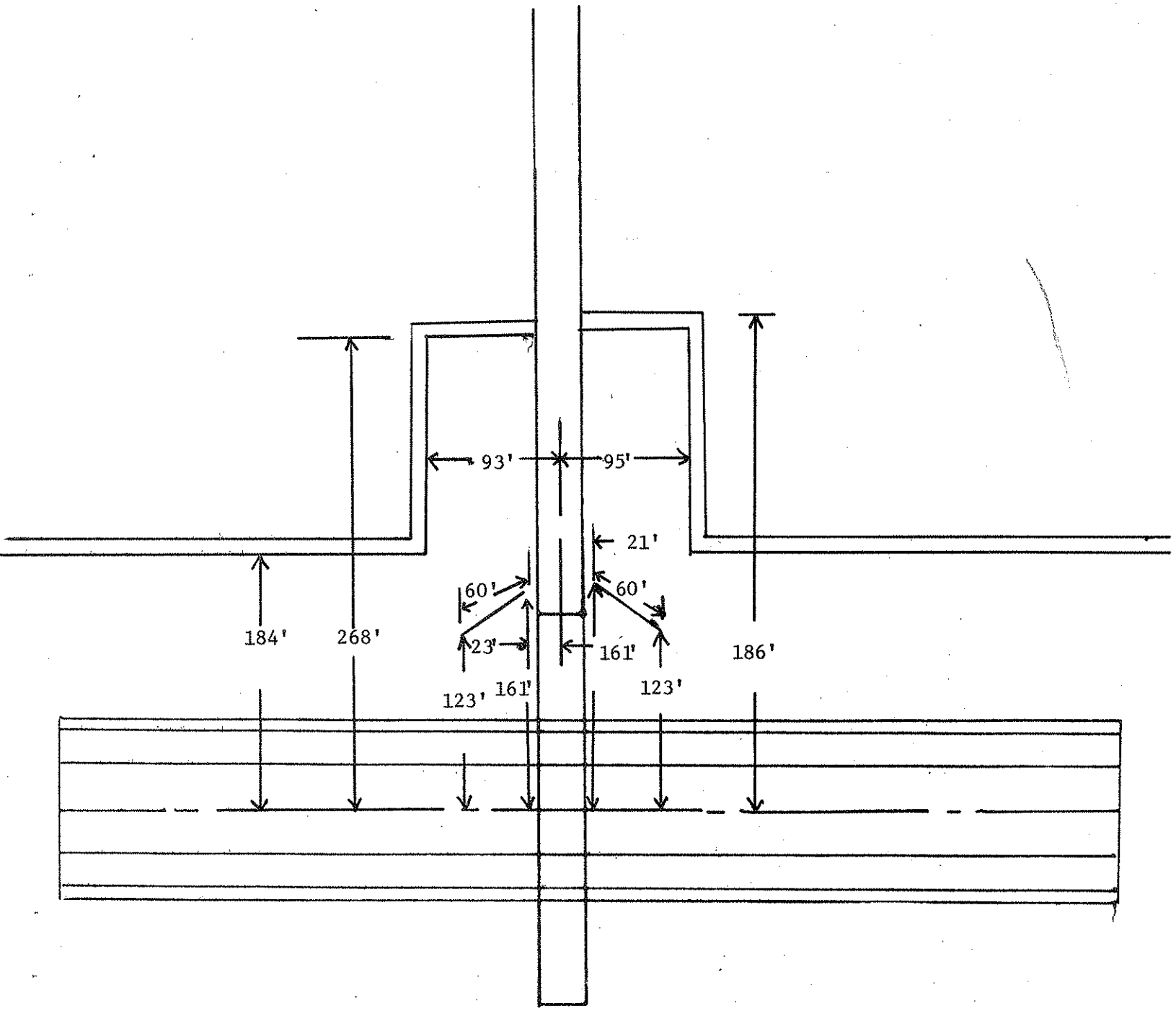
Run 11-10-5 Plan F - 0



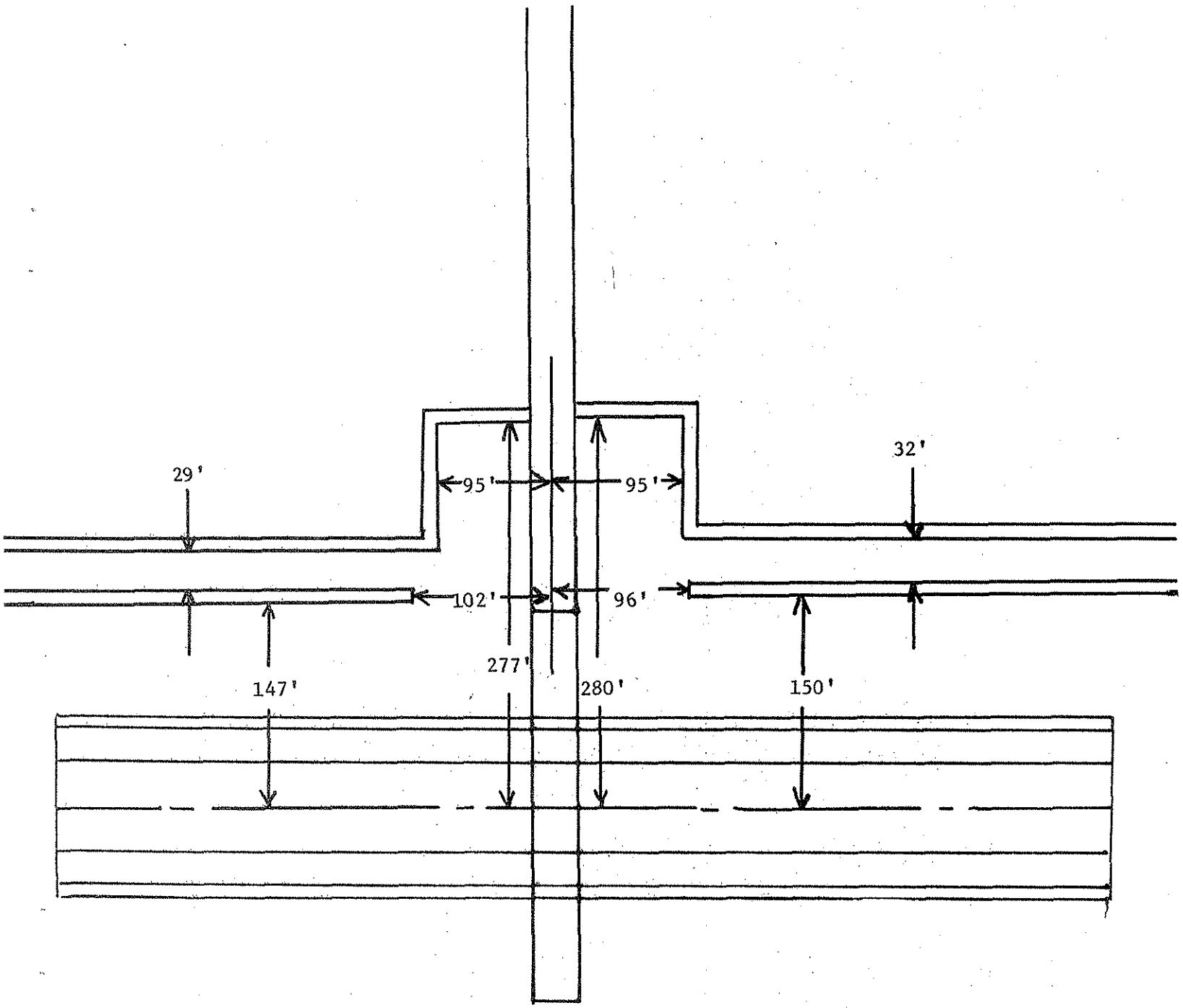
Run 11-14-1, Plan G-0



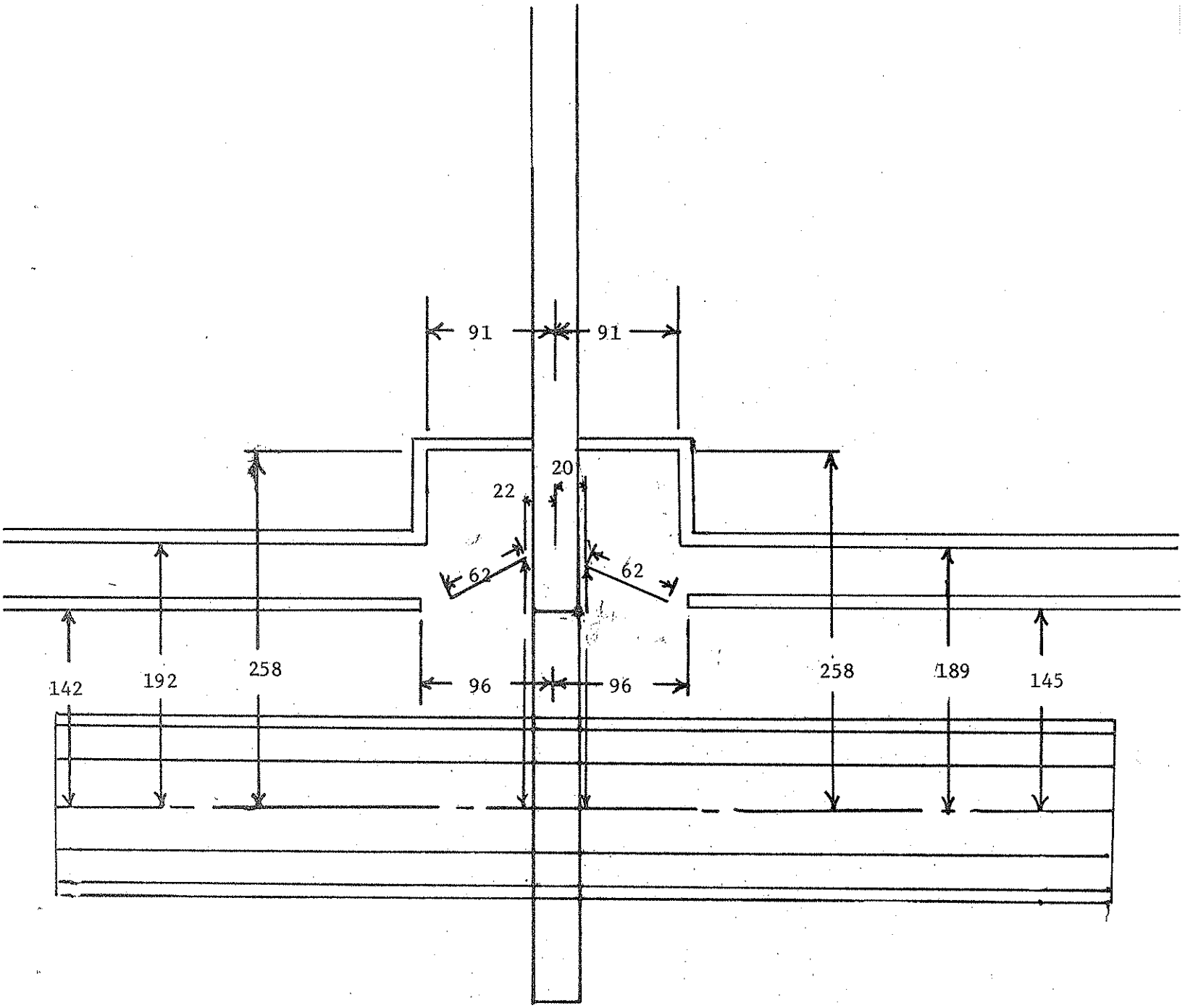
Run 11-15-1, Plan H-0



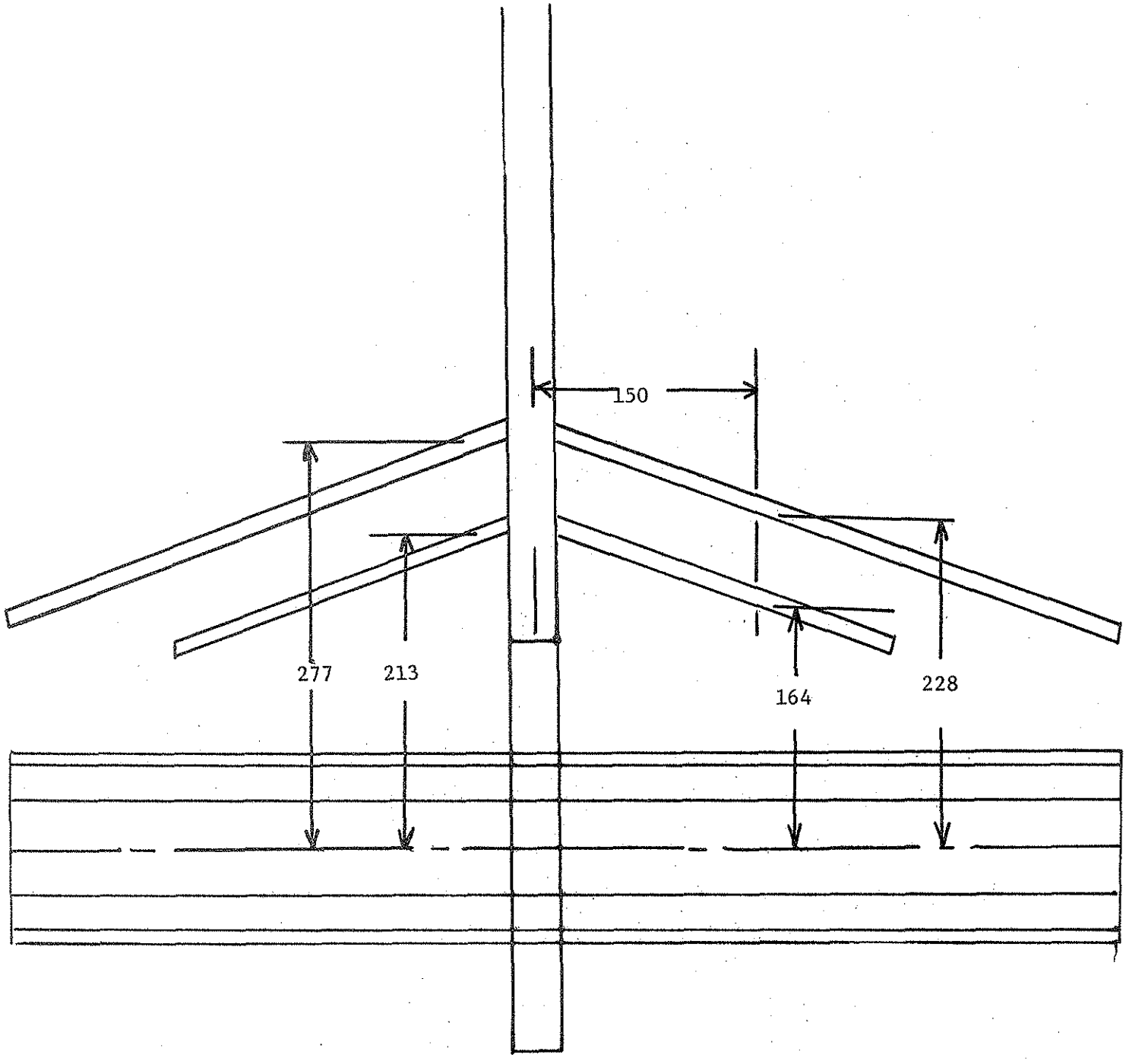
Run 11-15-2, Plan I-0



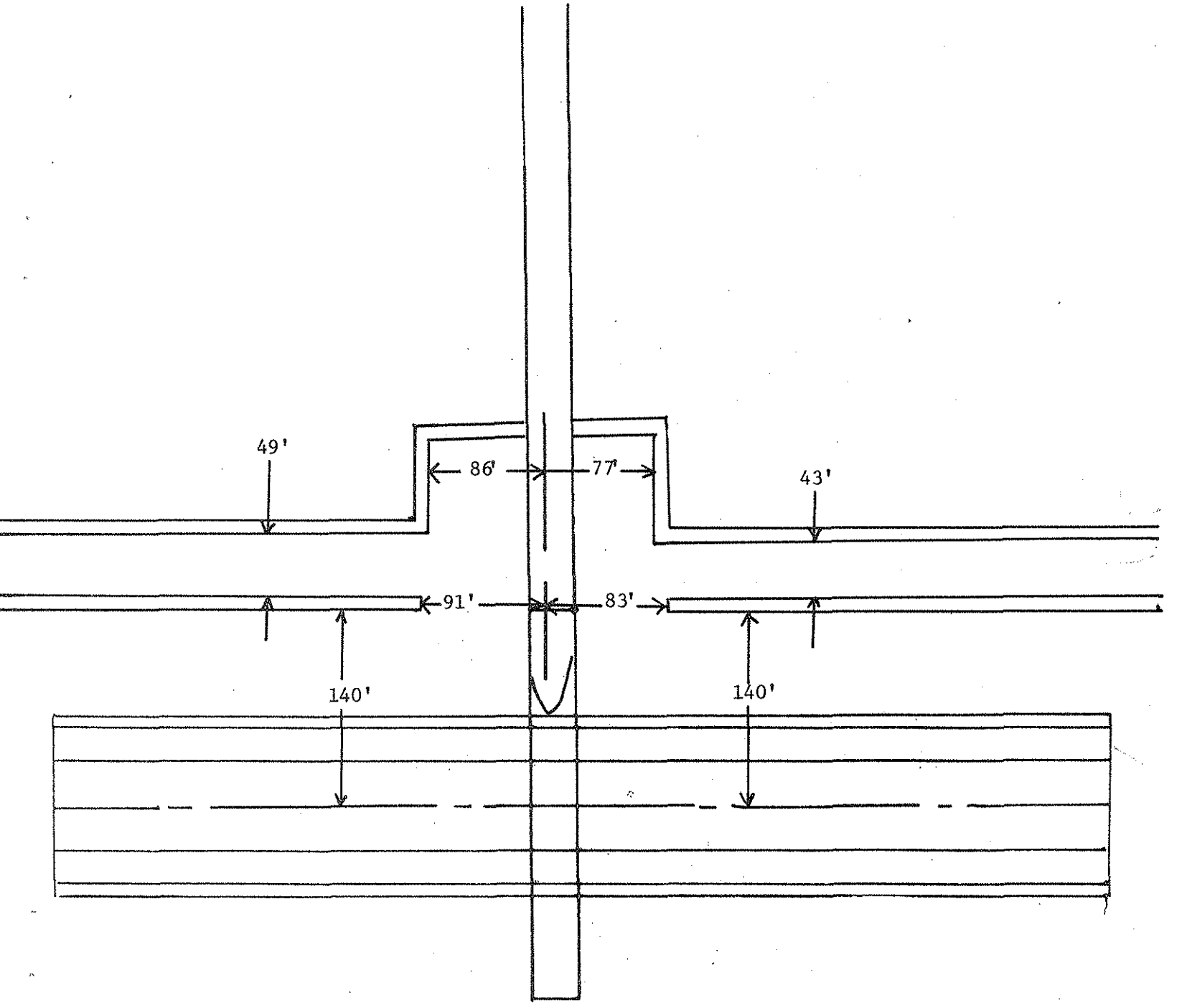
Run 11-15-3 Plan T - 0



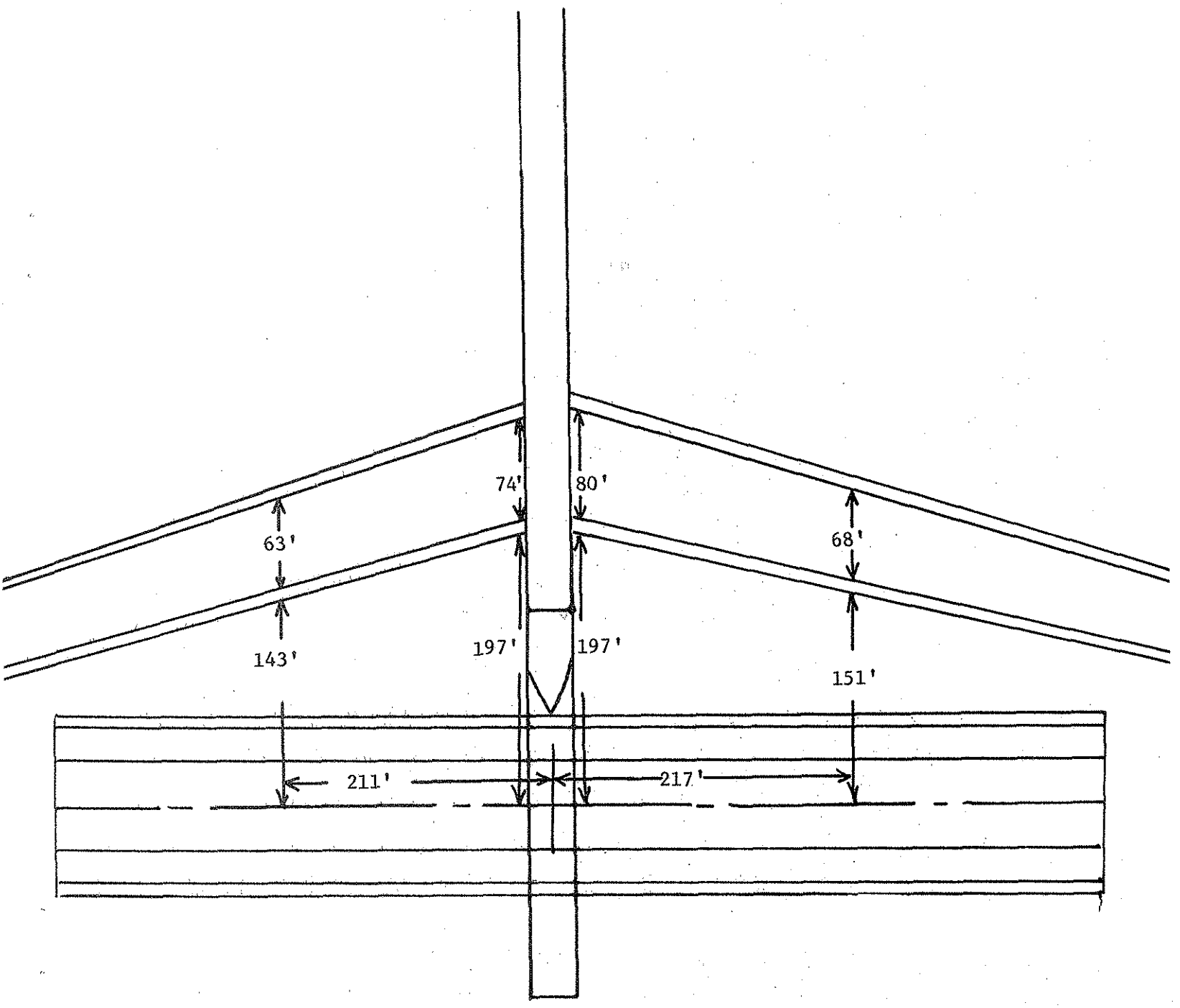
Run 11-16-2 Plan K - 0



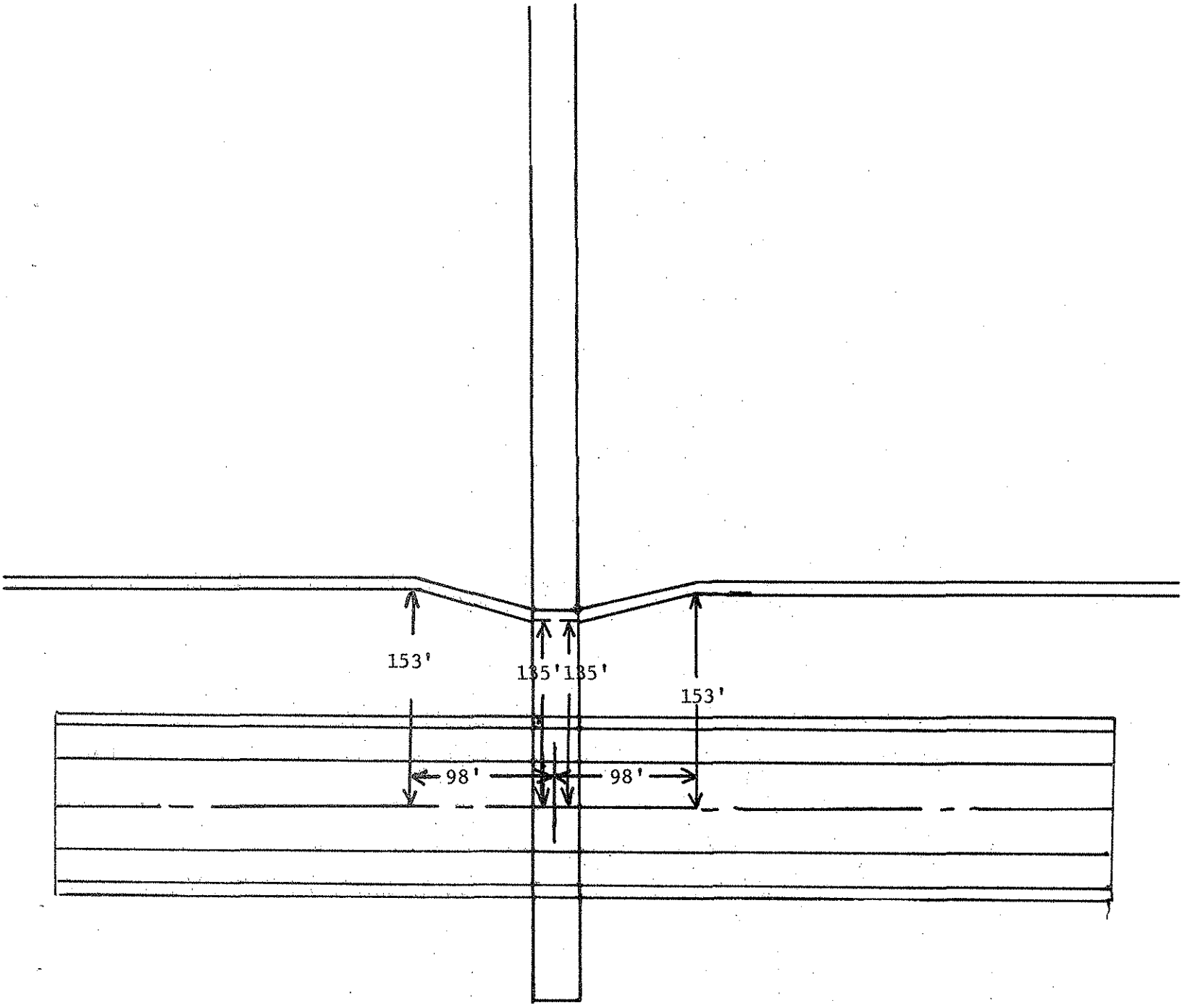
Run 11-20-1 Plan M - 0



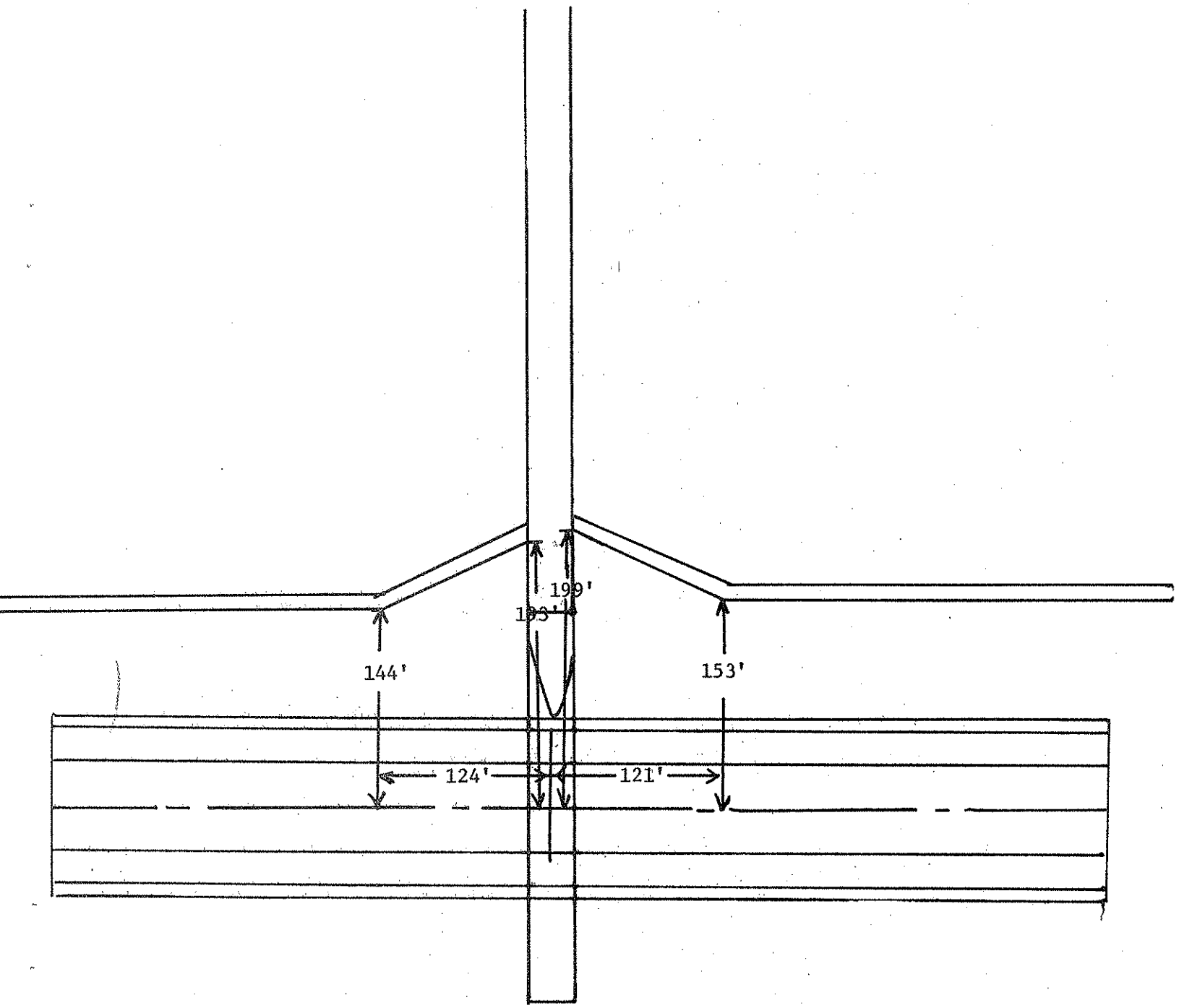
Run 11-22-1, Plan N-0



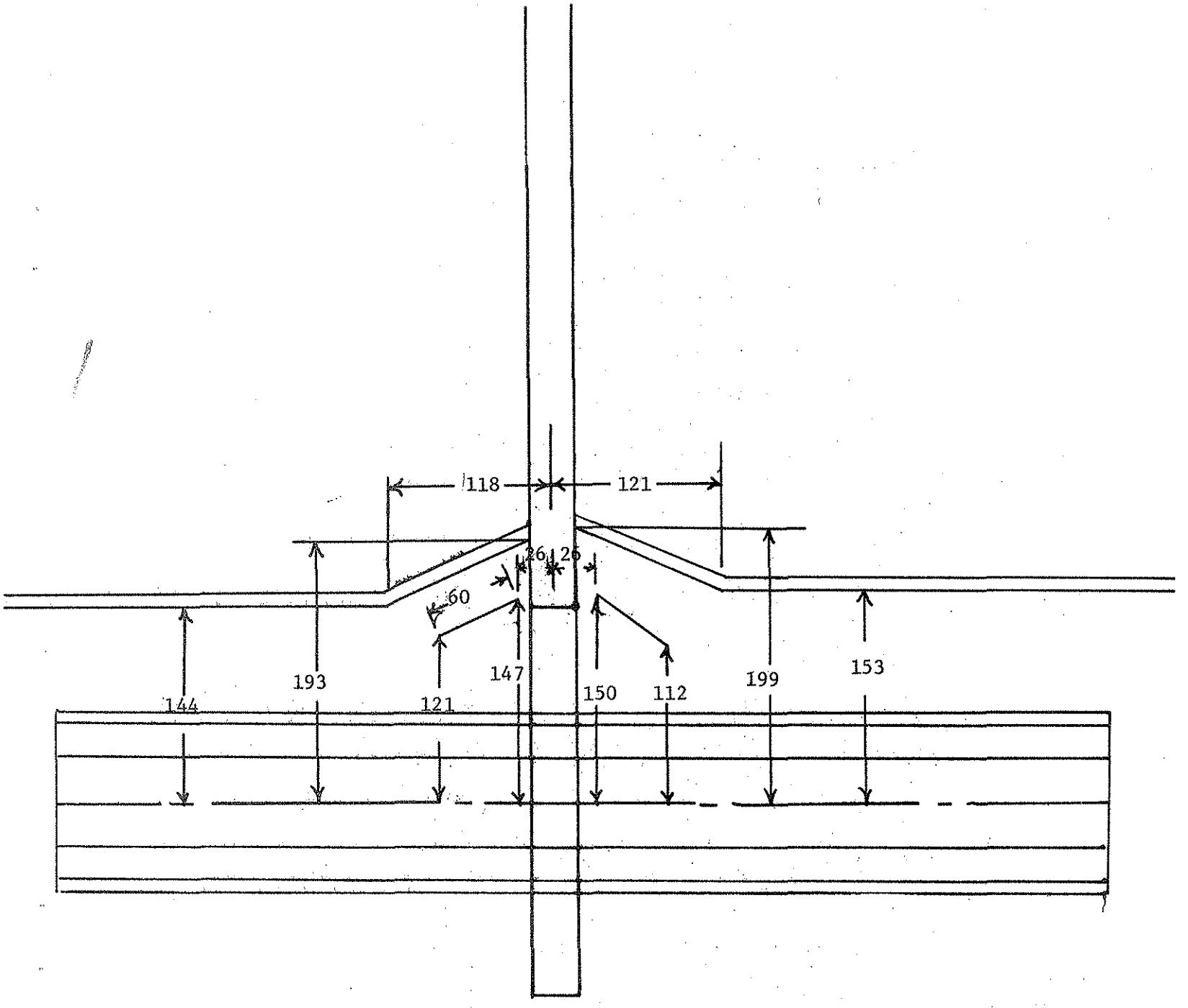
Run 11-23-1 Plan 0 - 0



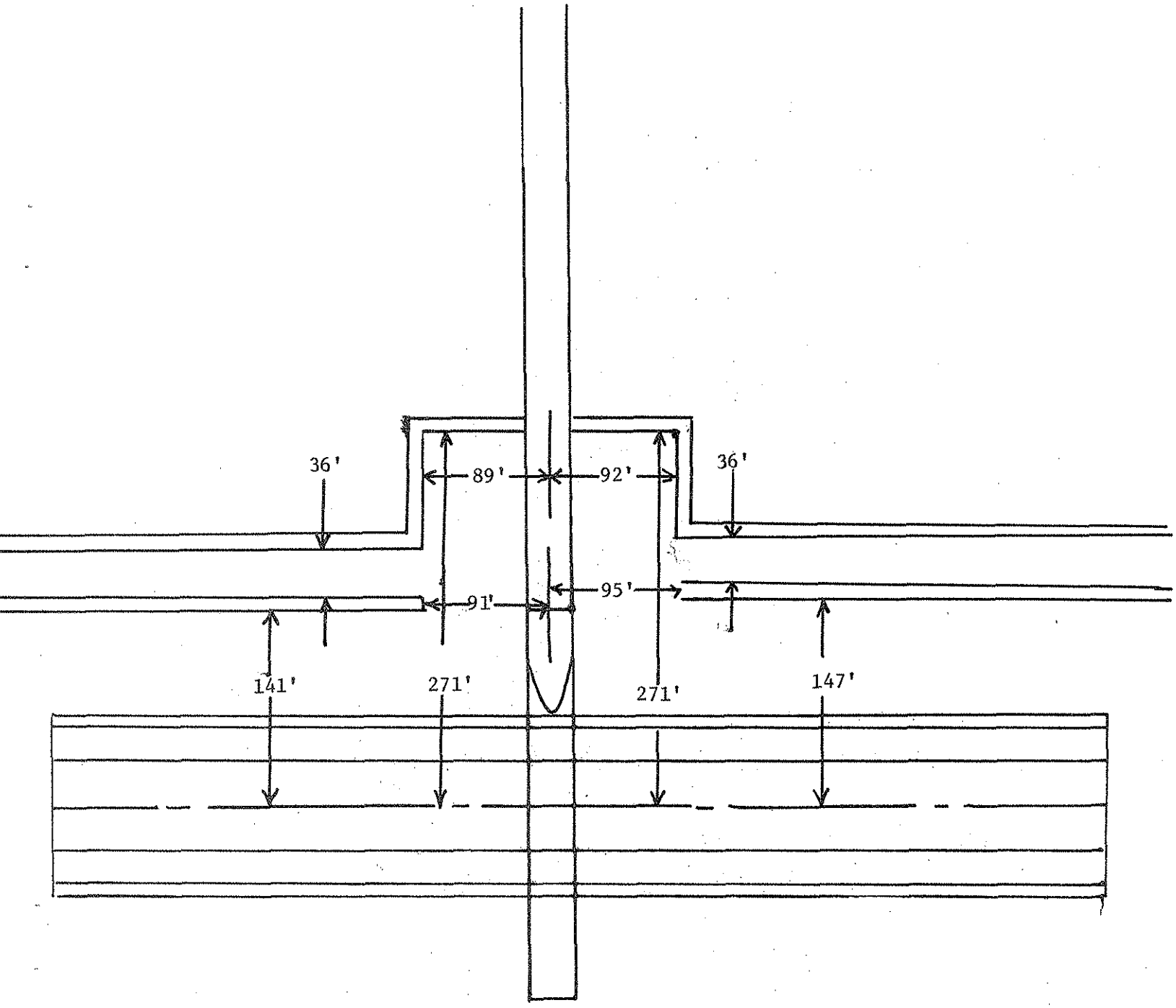
Run 12-9-1 Plan Dot - 1



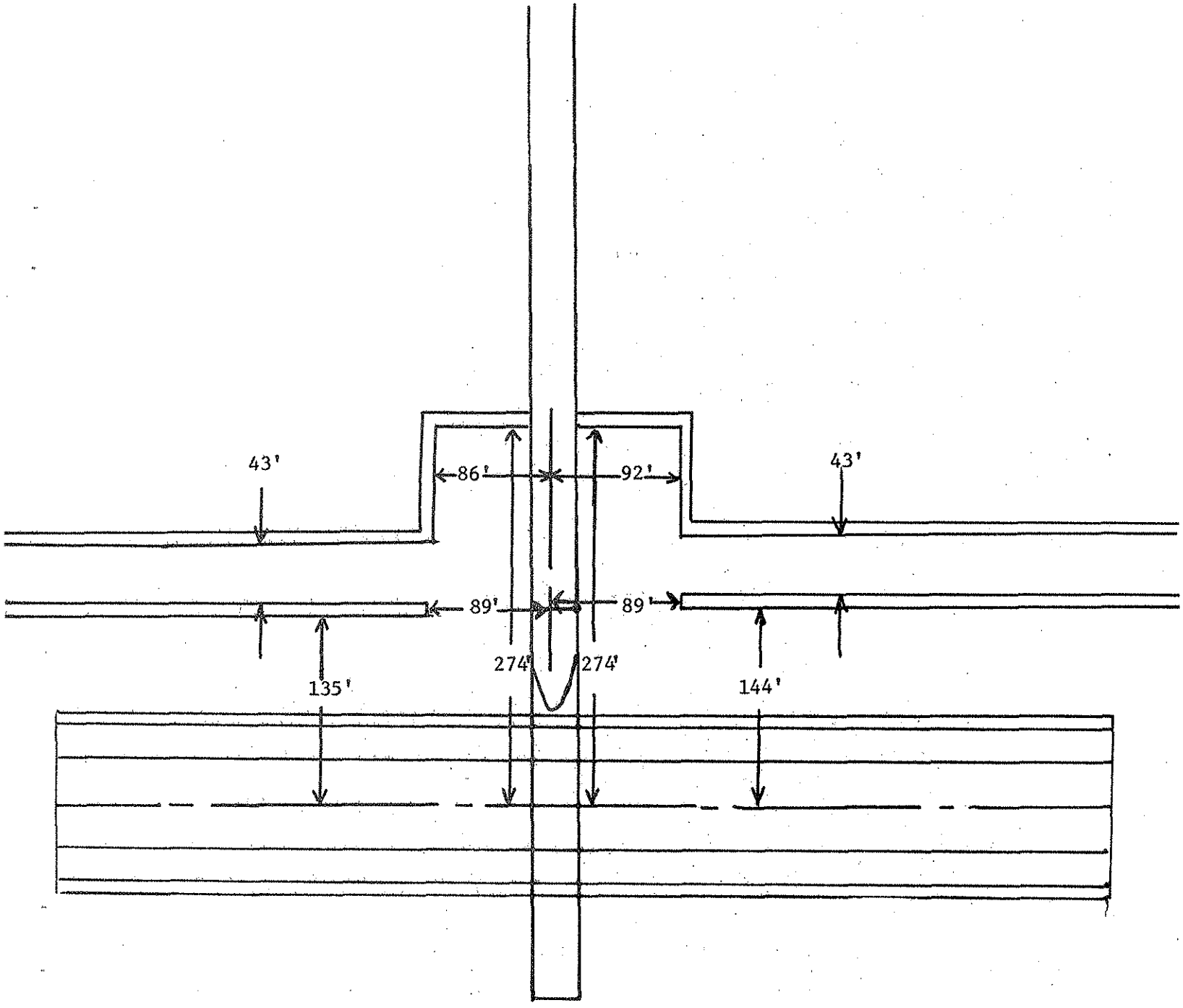
Run 12-19-1, Plan A-20



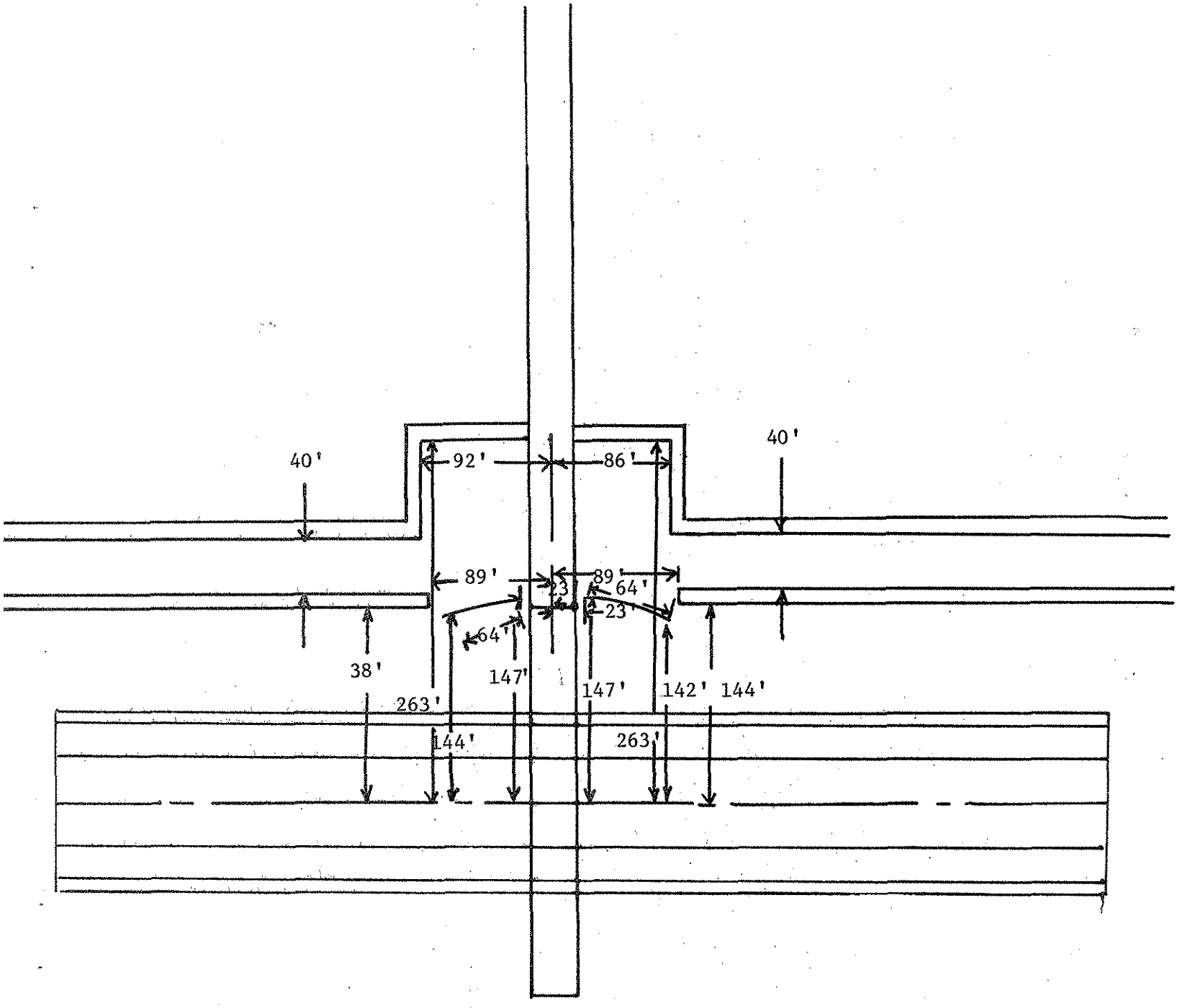
Run 12-19-2 Plan B - 20



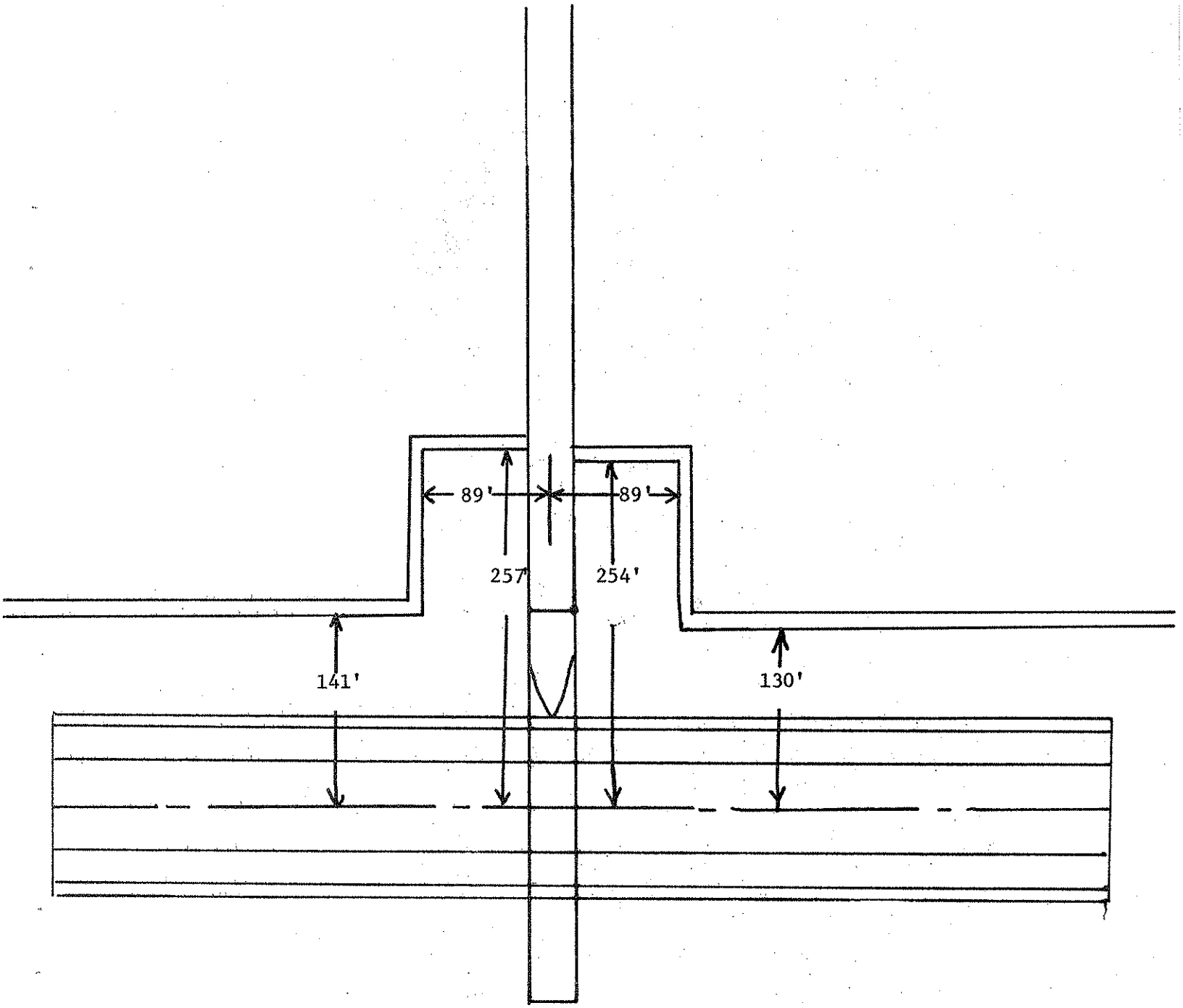
Run 12-19-3, Plan C-20



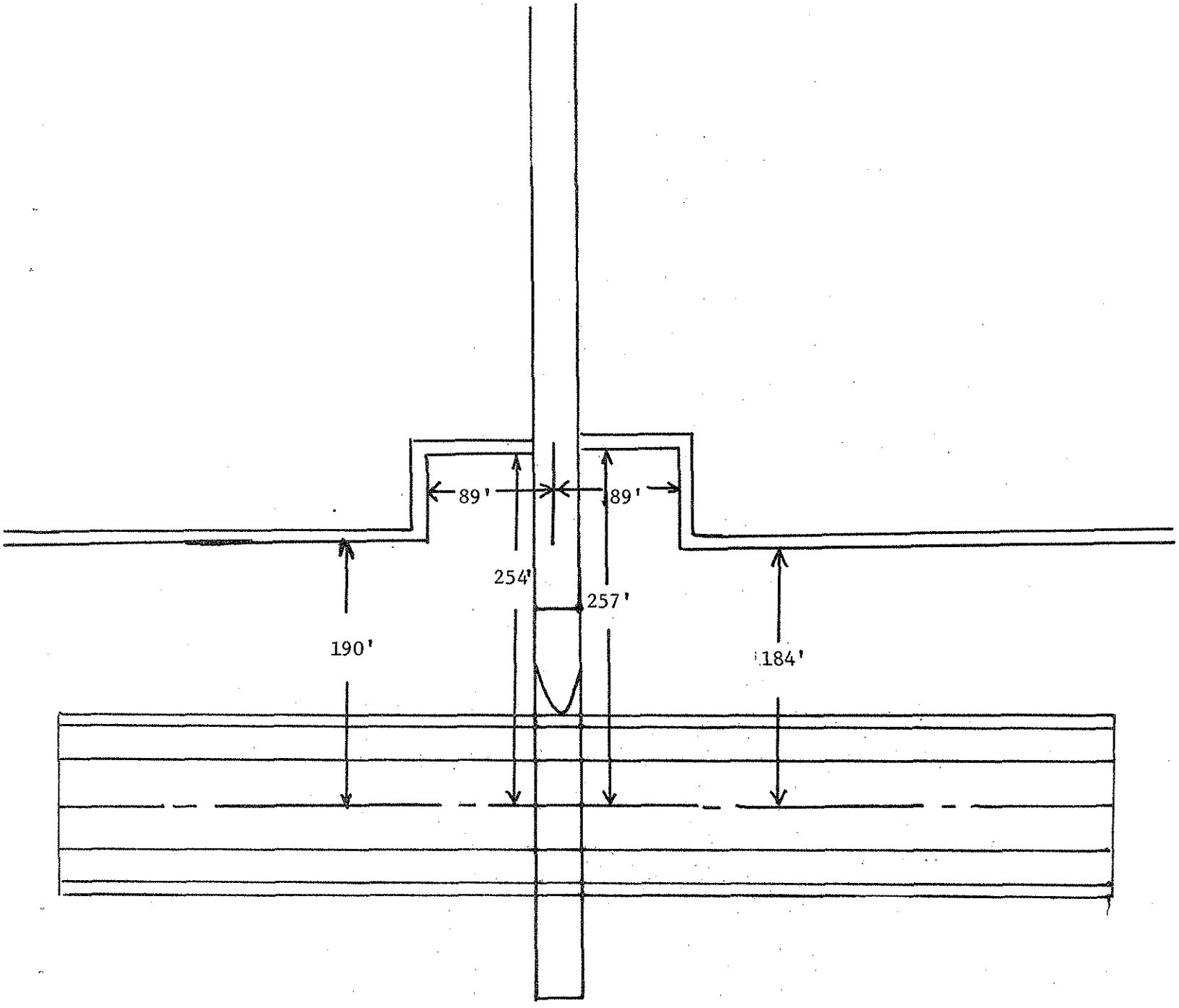
Run 12-20-1, Plan D-20



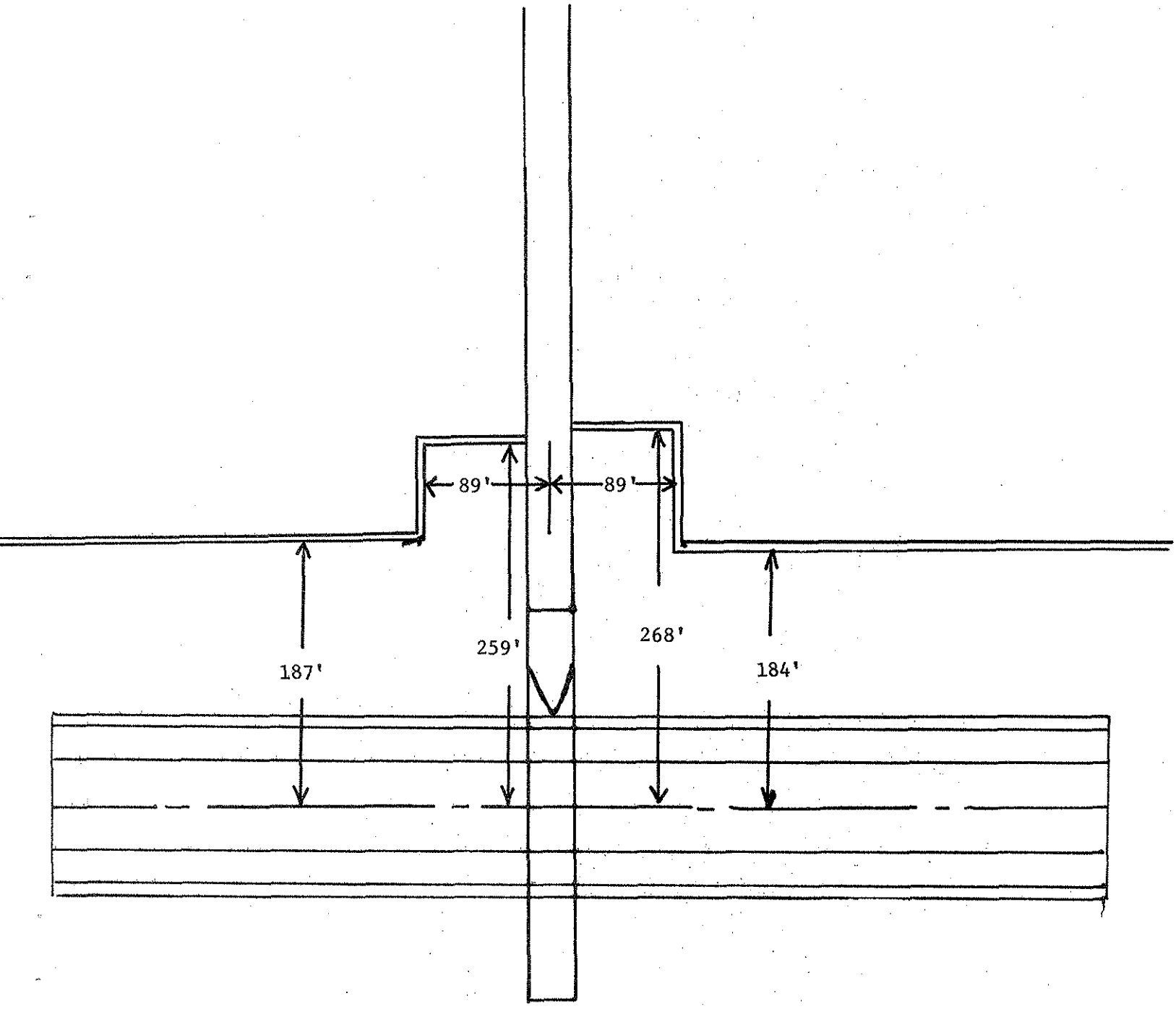
Run 12-22-1 Plan E - 20



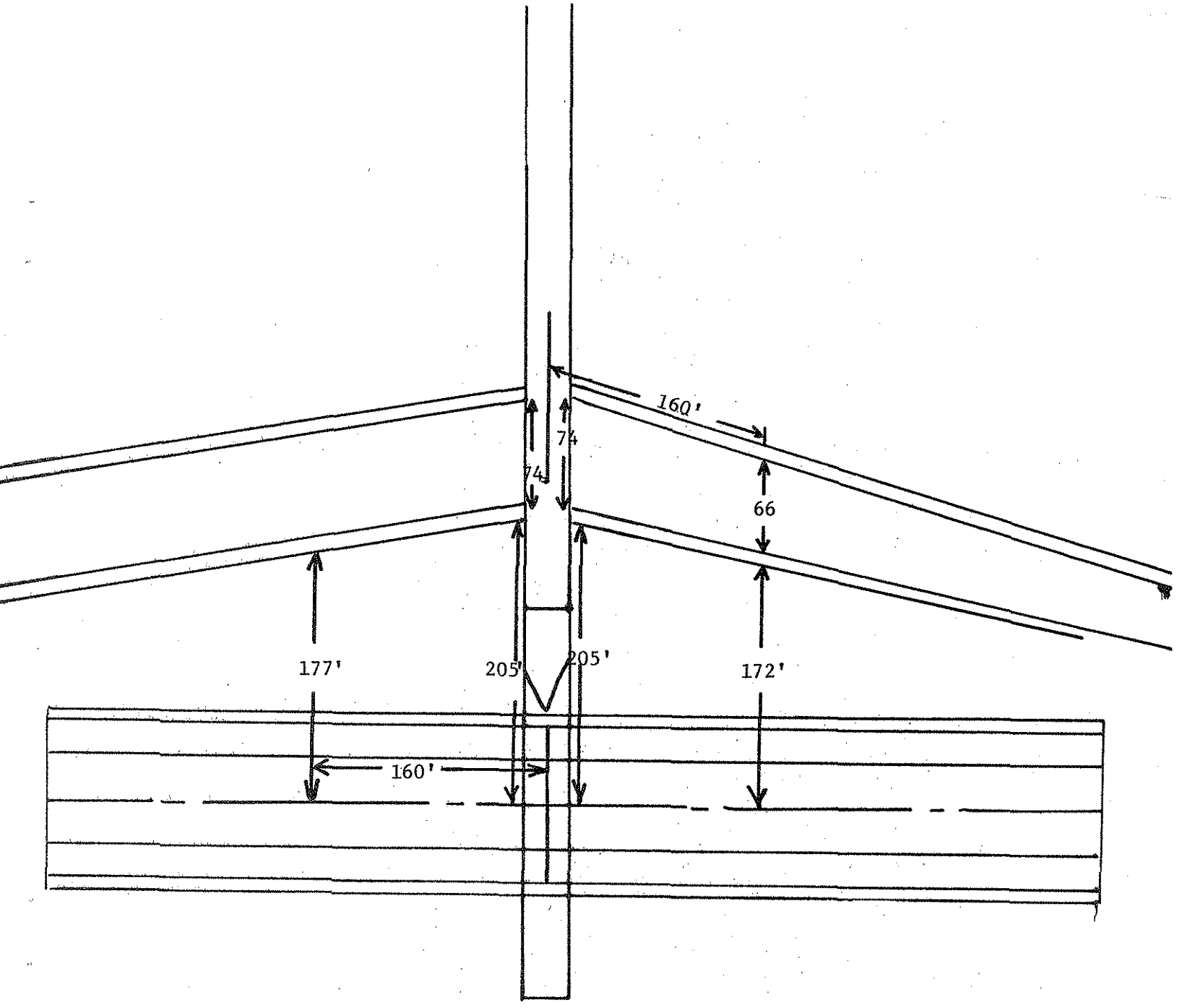
Run 12-27-1, Plan F-20



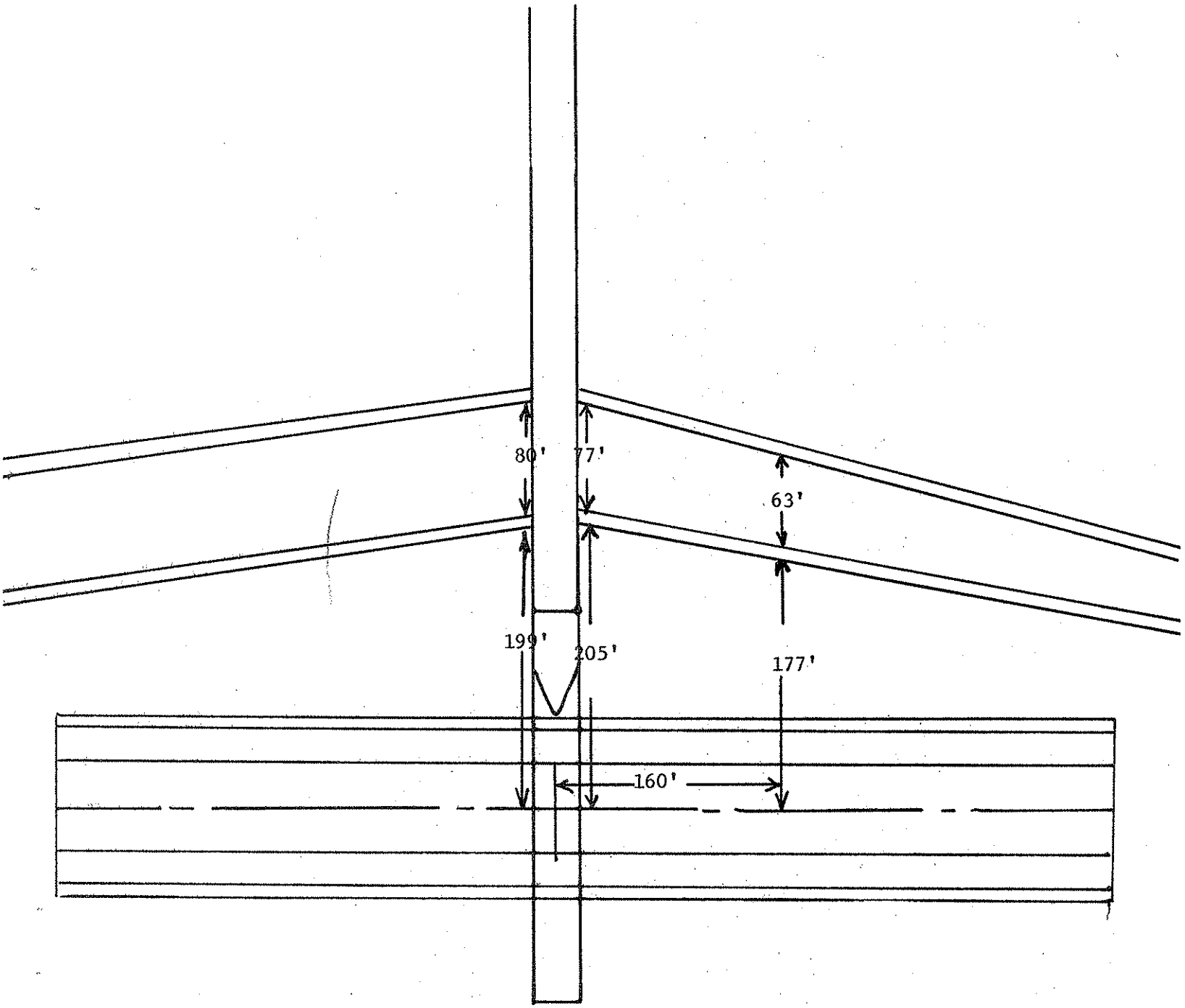
Run 12-27-2, Plan G-20



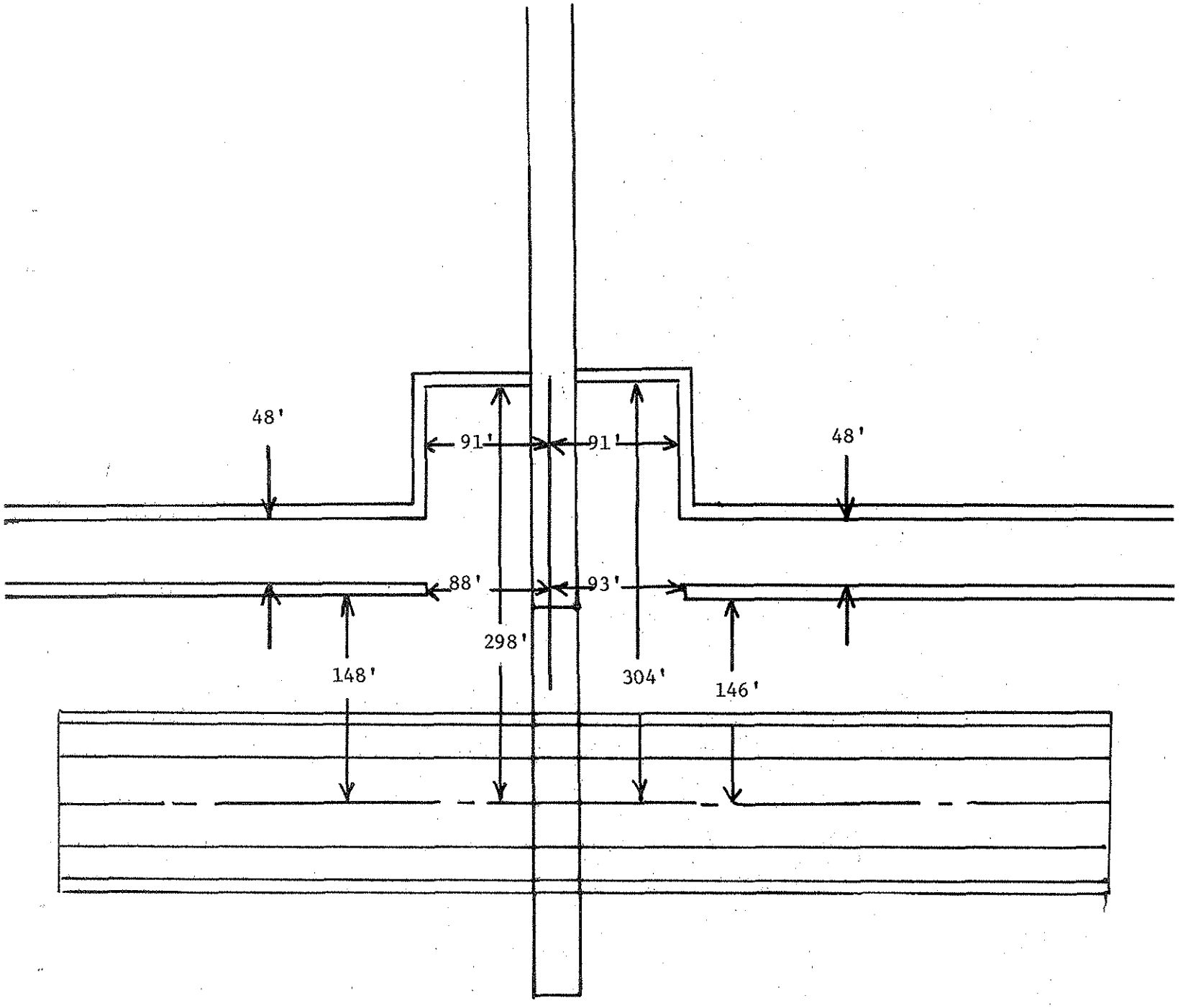
Run 12-27-3, Plan H-20



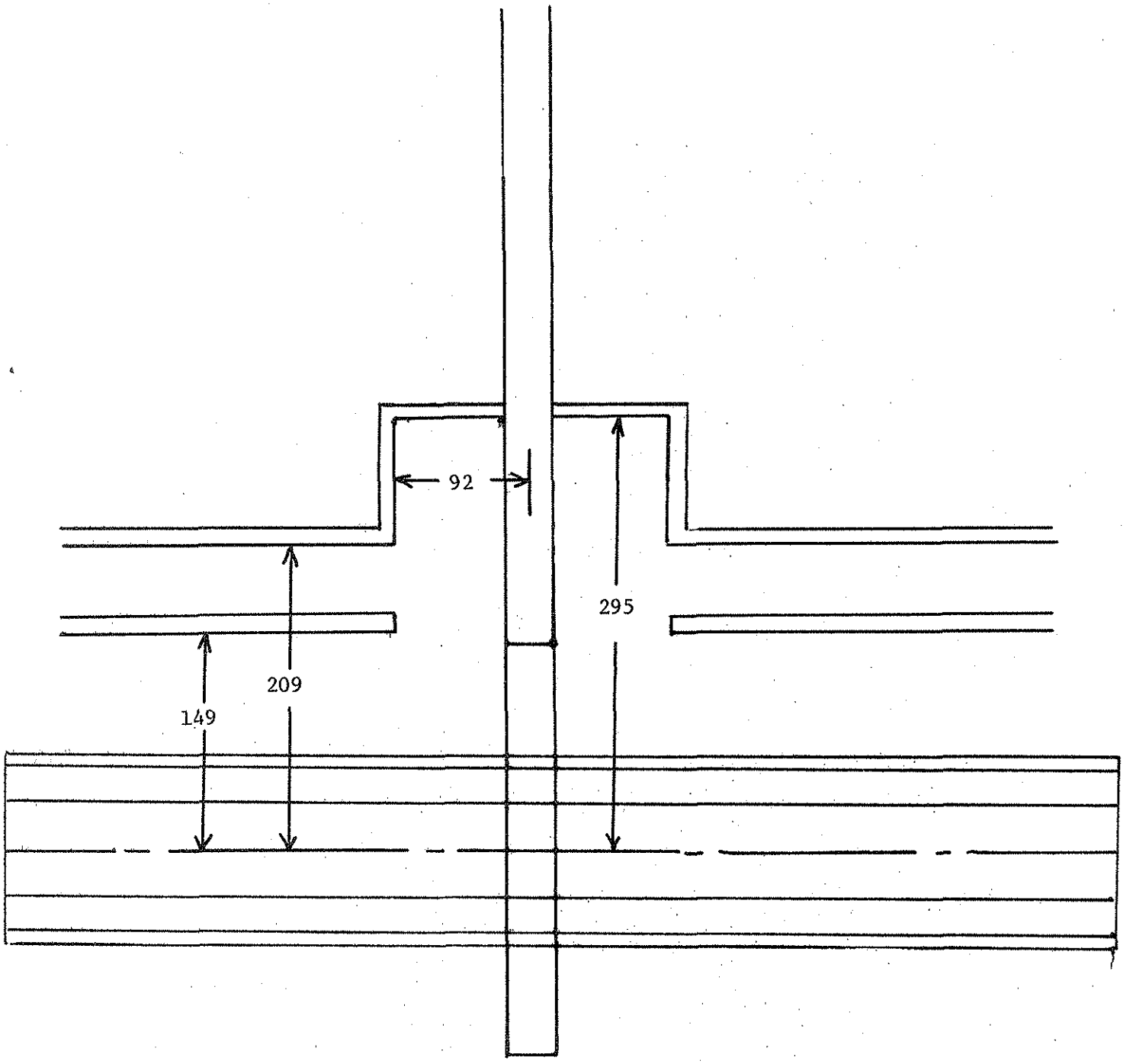
Run 12-28-1, Plan I-20



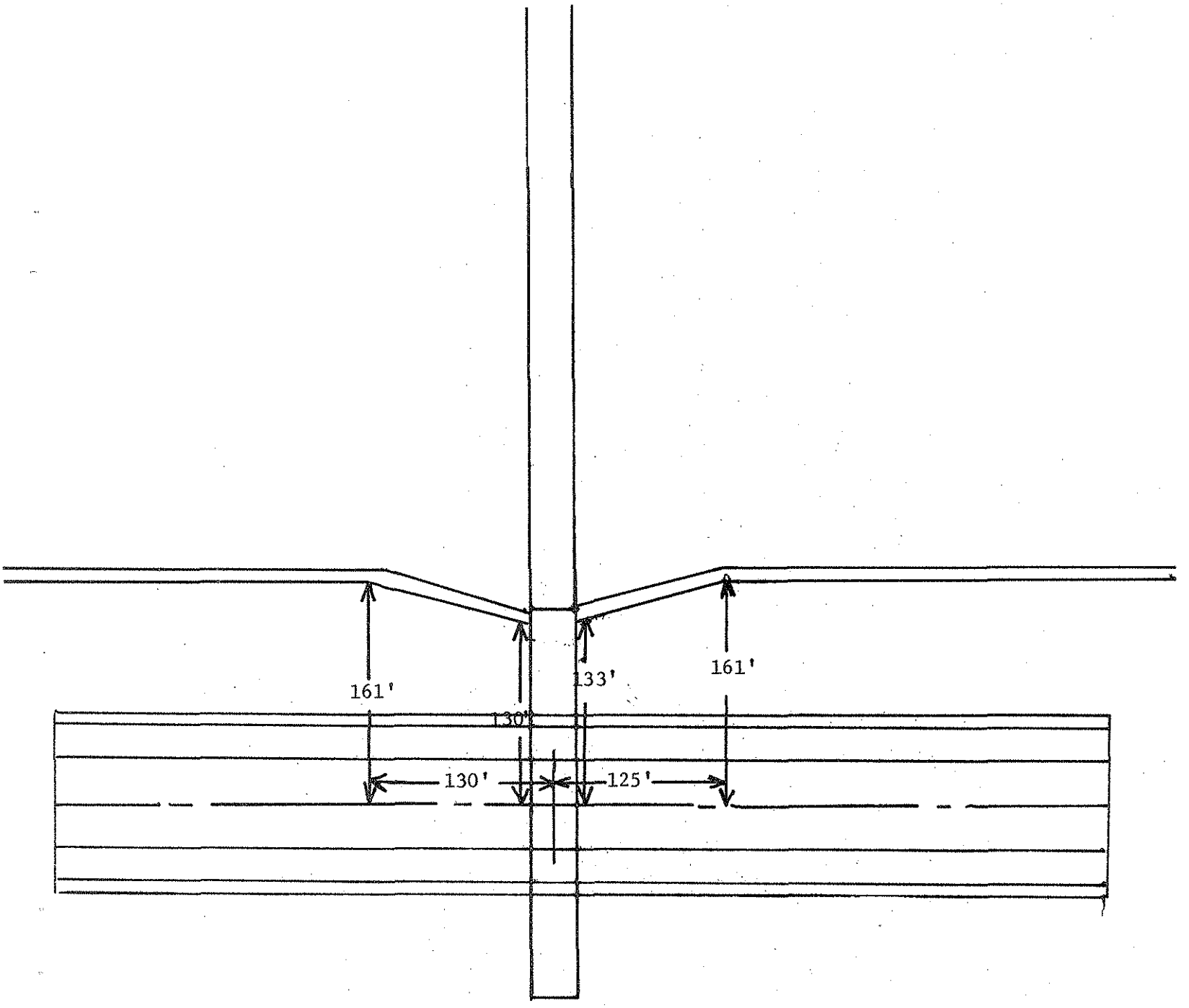
Run 12-28-2, Plan J-20



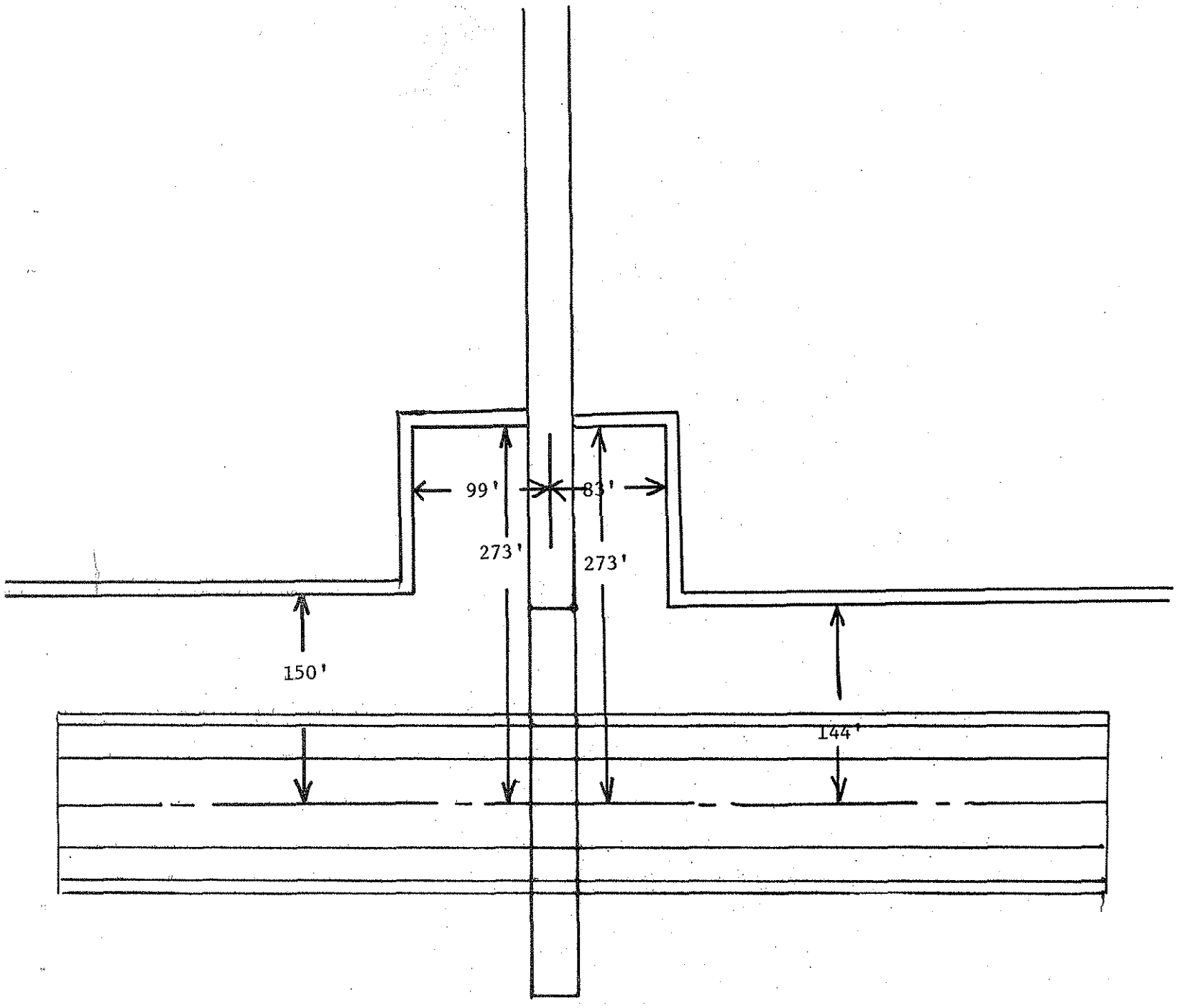
Run 1-5-1 Plan K - 20



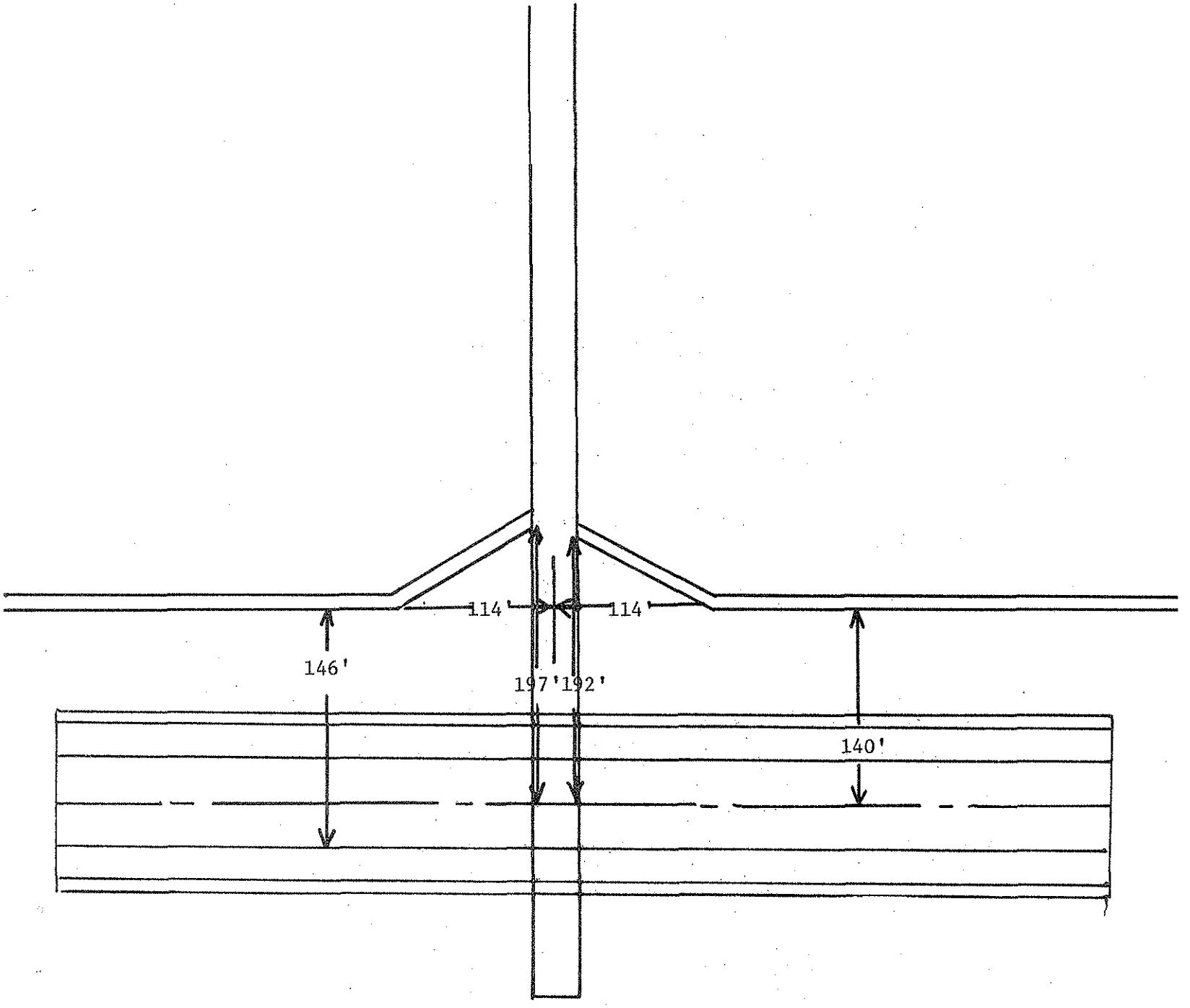
Run 1-16-1 Plan L-20



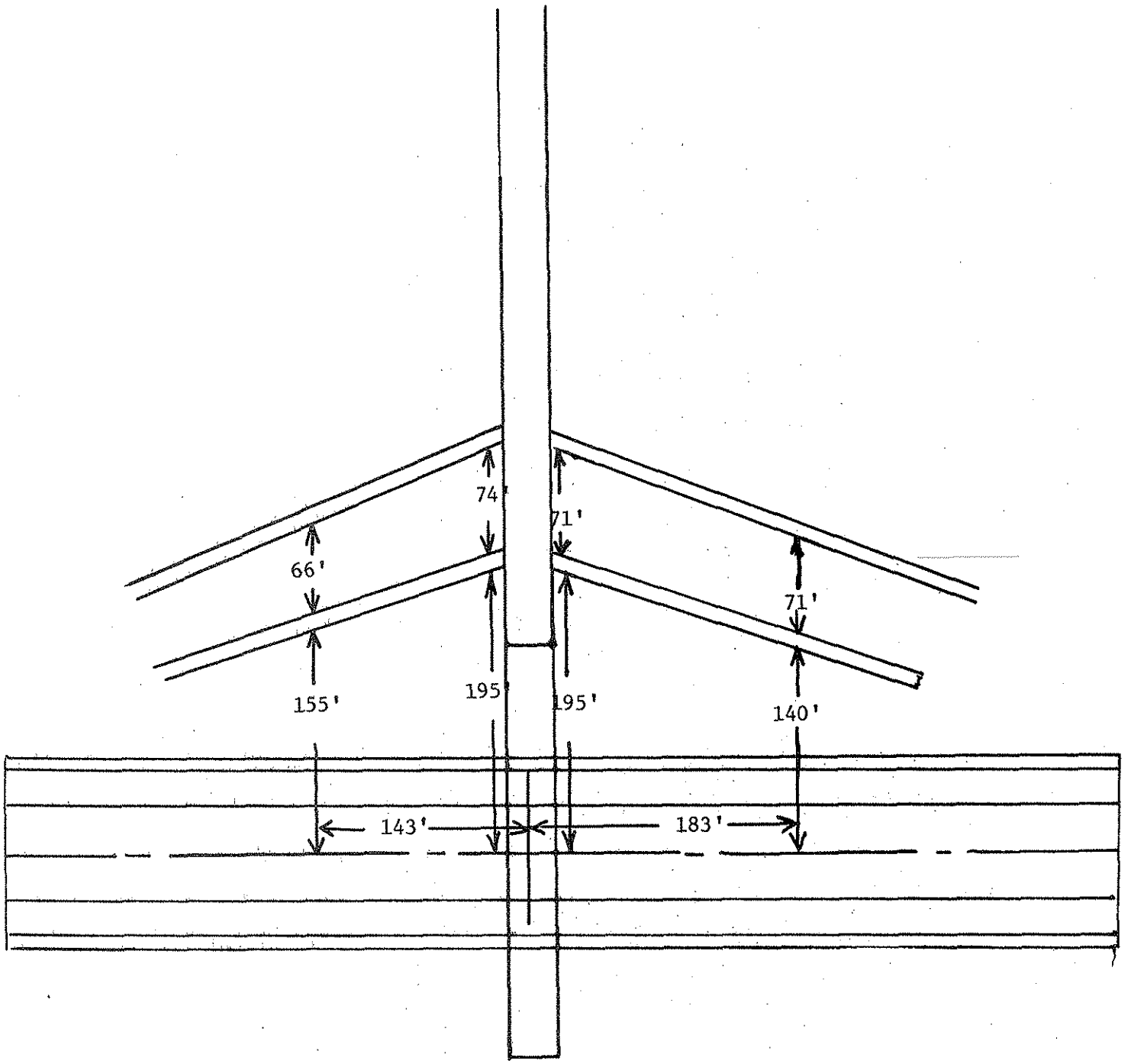
Run 2-12-1 Plan Dot - 1



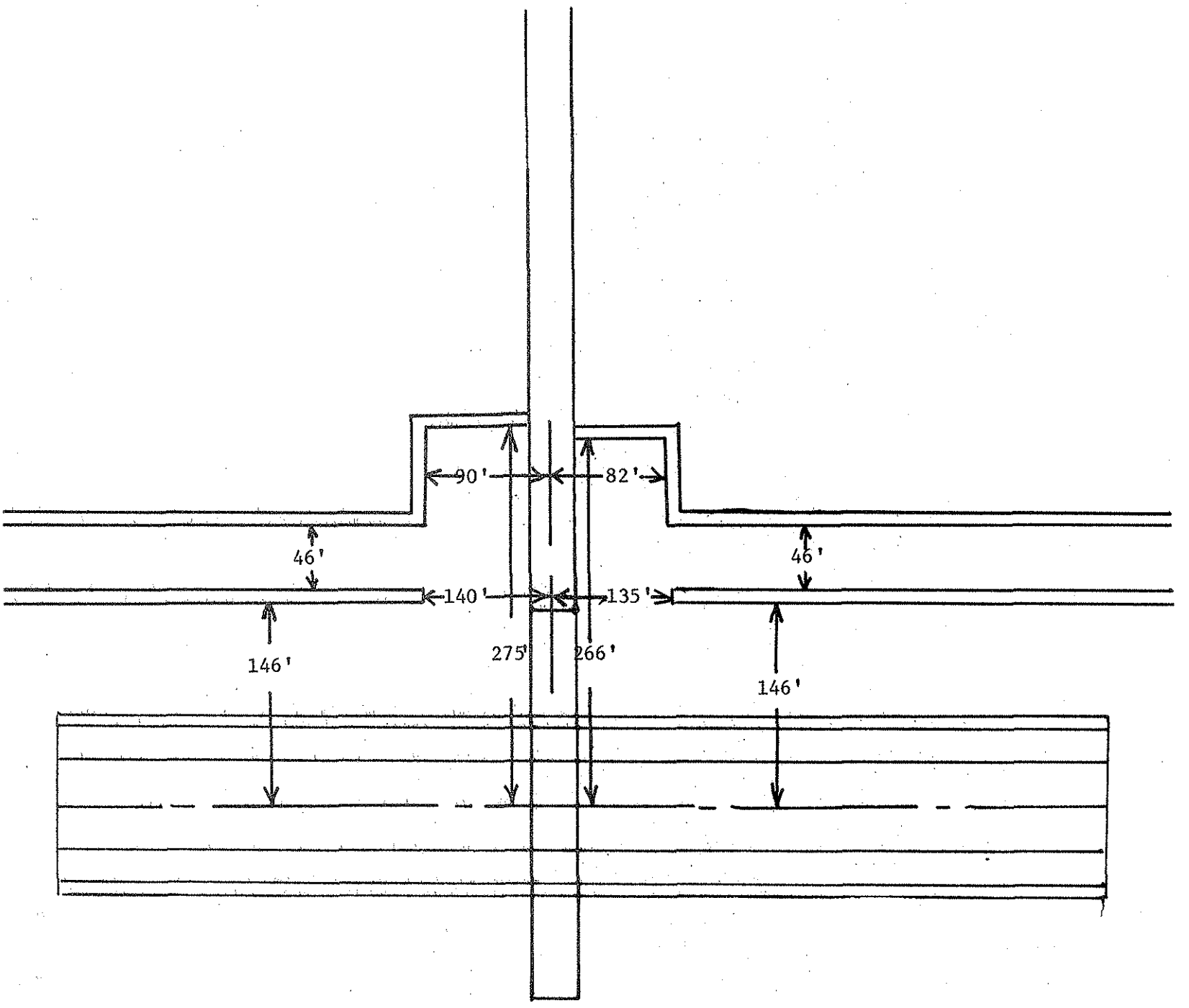
Run 2-13-1 Plan F - 40



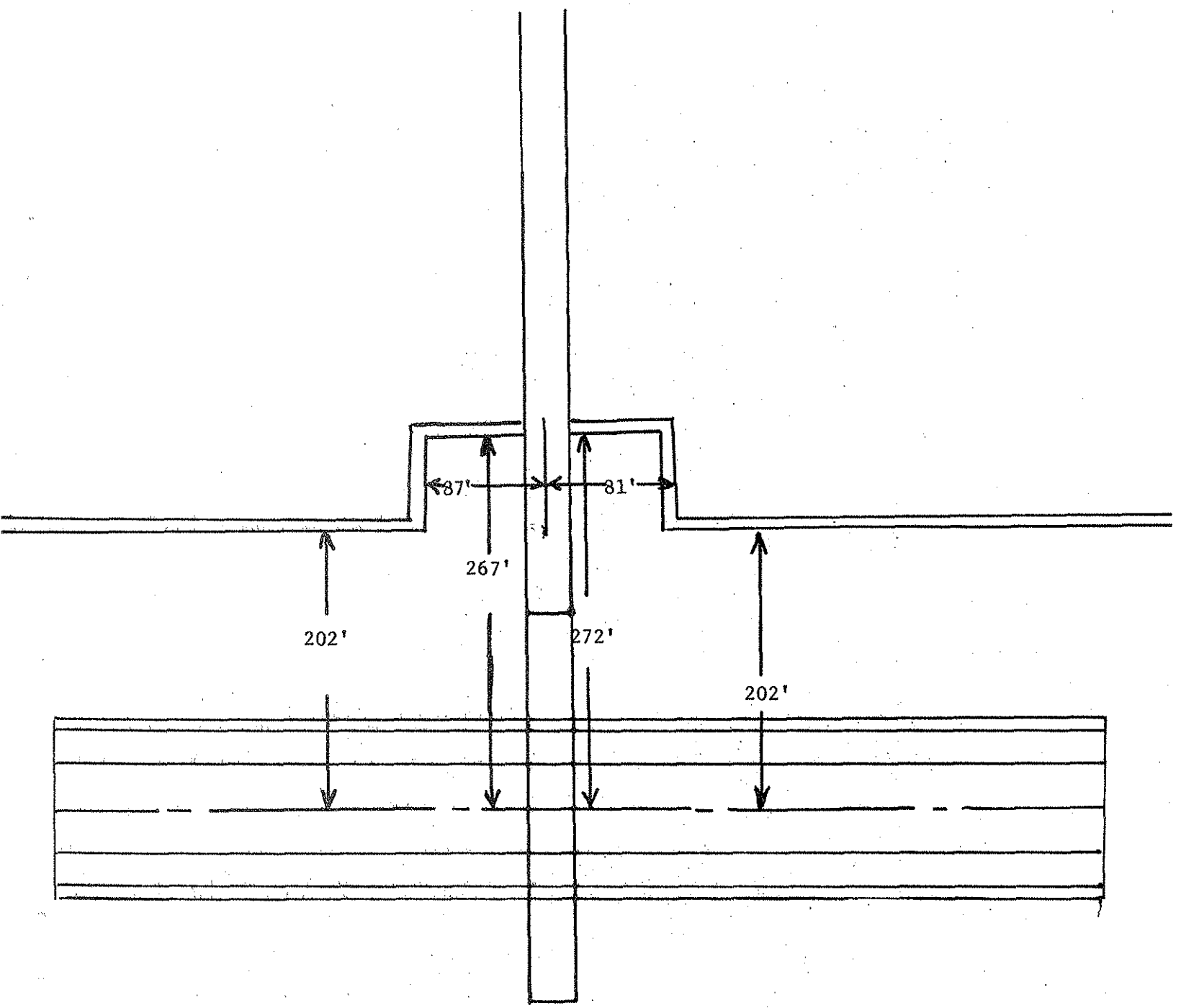
Run 2-16-1 Plan A - 40



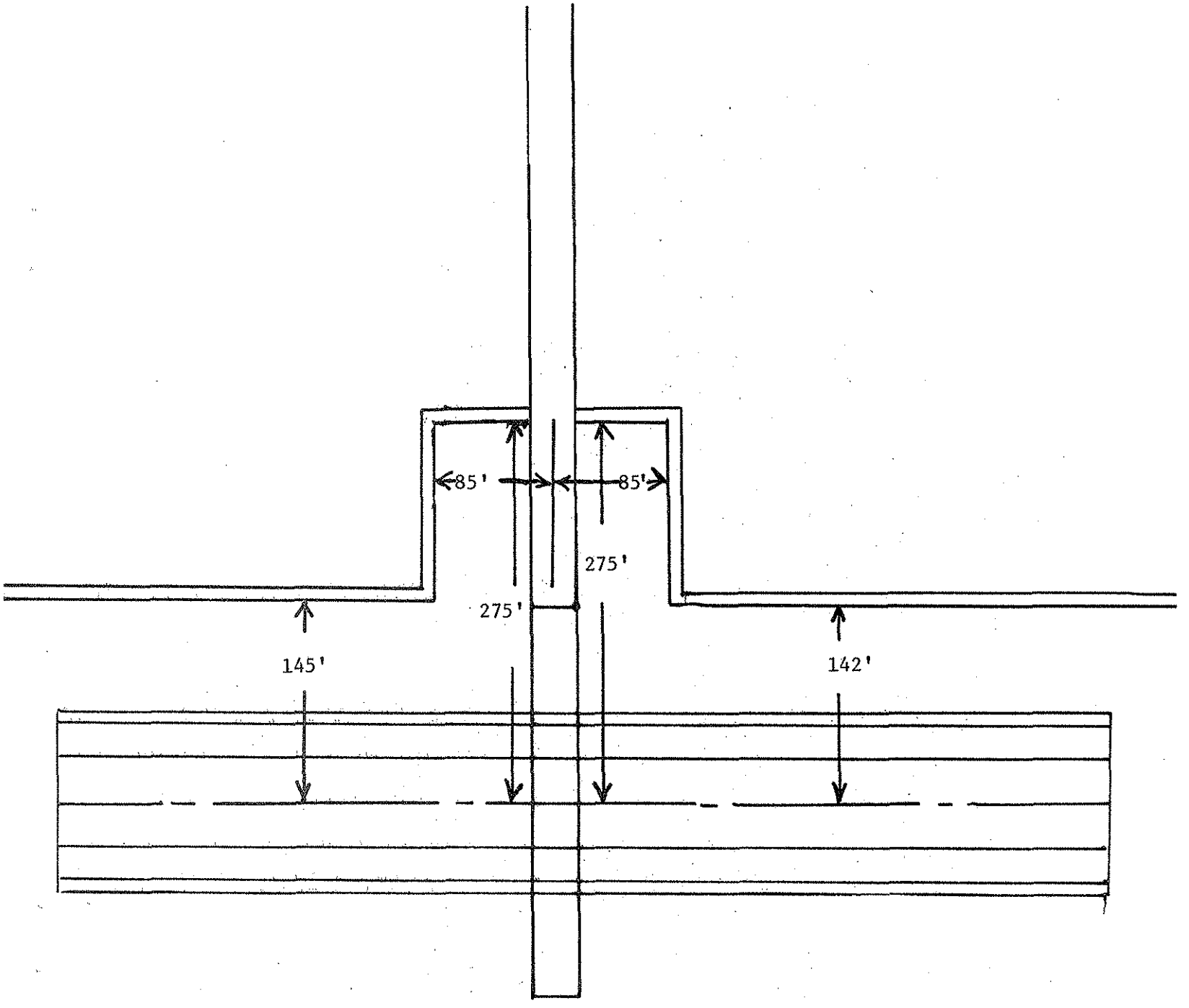
Run 2-19-1 Plan I - 40



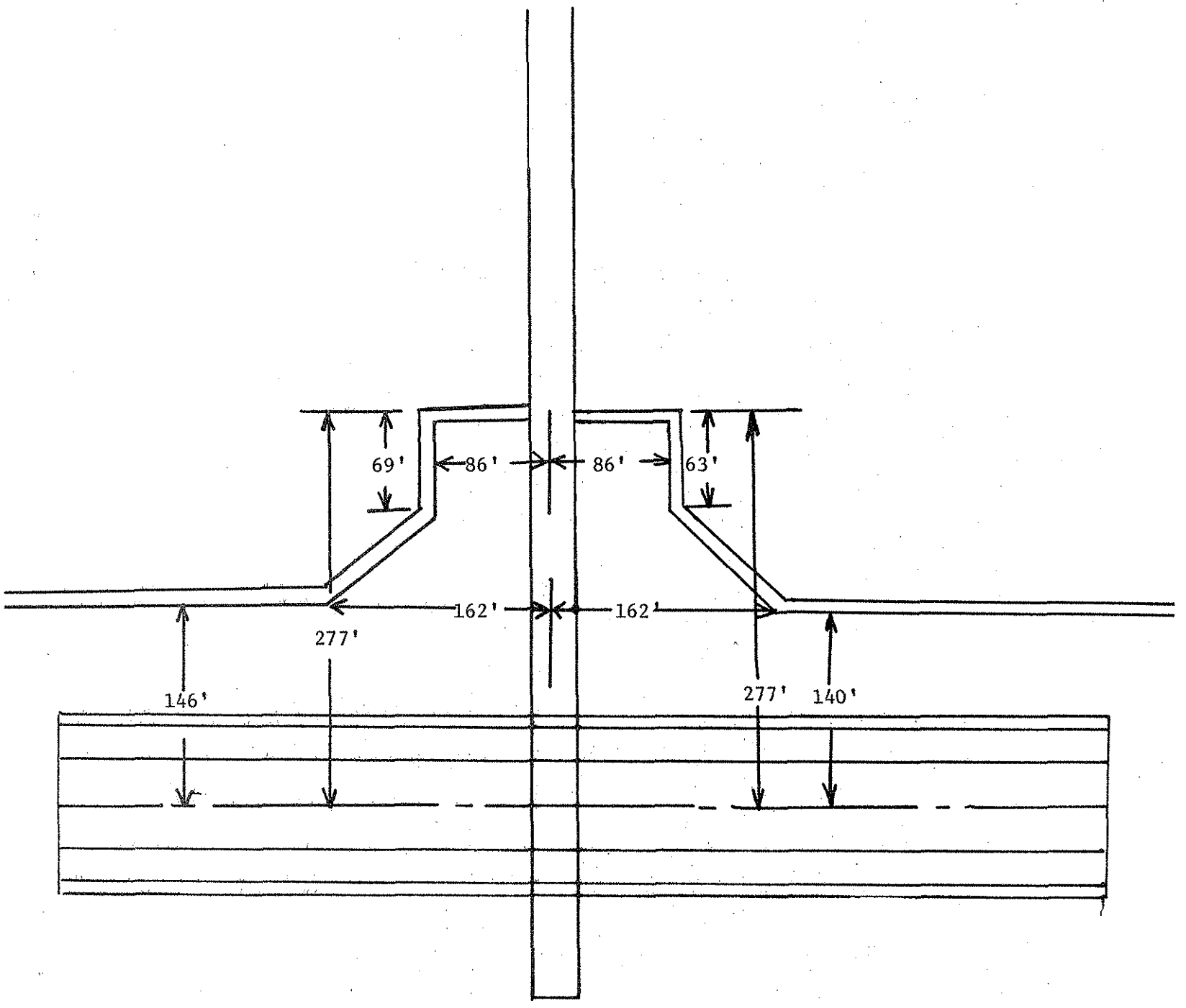
Run 2-19-2 Plan D - 40



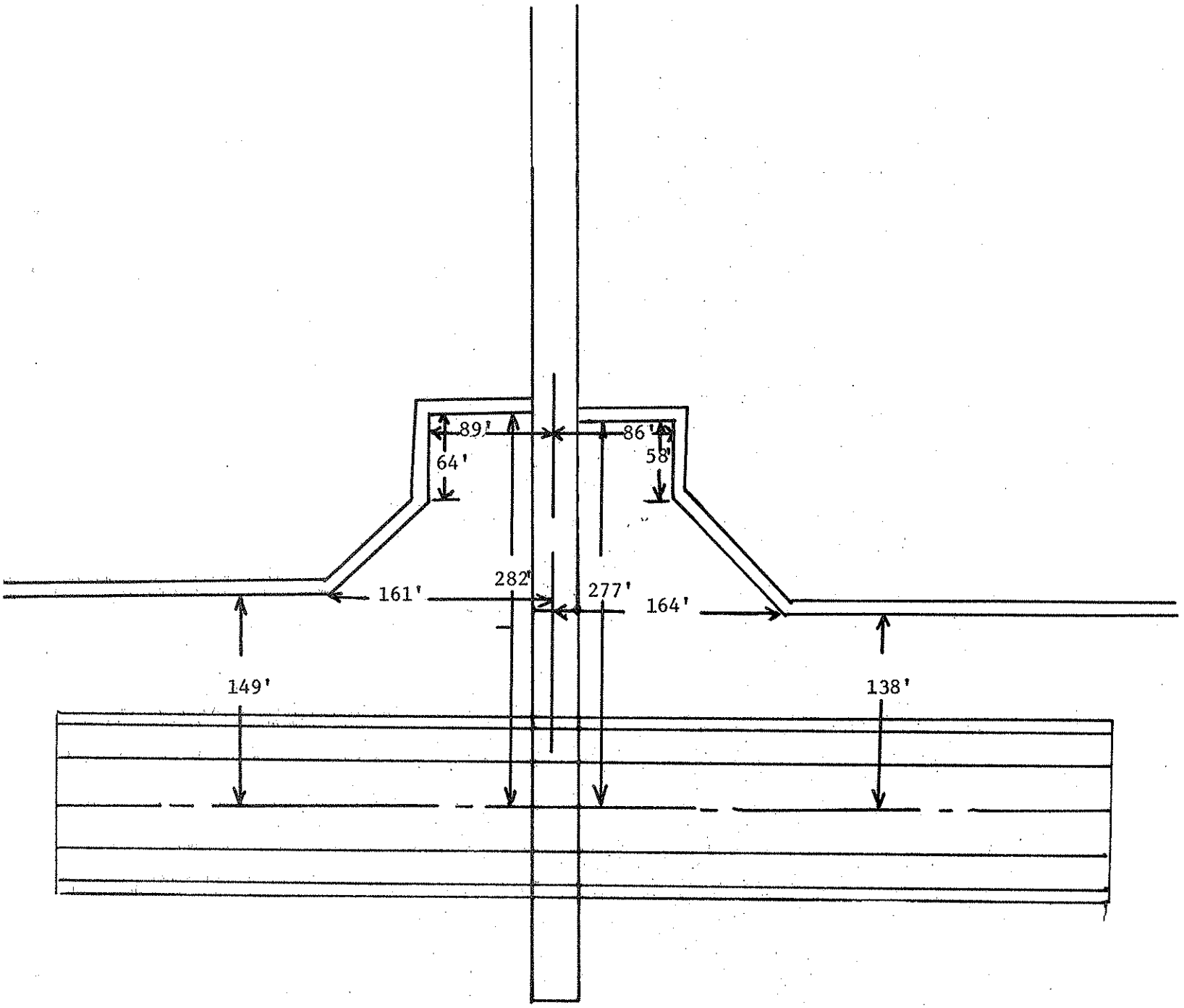
Run 2-20-1, Plan G-40



Run 2-21-1 Plan F - 40



Run 2-22-1 Plan FM - 40



Run 2-23-1, Plan FM-40

Table 9. Bare Model Calibration Data

This table lists data for the 17 calibration experiments which proved to have valid and reasonable results. The various parameters are discussed in the main body of the report. The amount of data scatter is shown by column 12, which is the final rate of area accumulation of simulated snow made dimensionless by the mass-rate-roughness parameter. Without any data scatter, all values in column 12 would be the same.

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Constant Data	(8) $\frac{\rho}{\rho_p}\frac{U_\infty}{gh}(1-\frac{U_o}{U_\infty})$ (9) $A_1^2\frac{D_p}{h}(\frac{U_\infty}{U_o})^2$ (10) $\frac{\rho}{\rho_p}\frac{U_\infty}{gh}(1-\frac{U_o}{U_\infty}) \times [A_1^2\frac{D_p}{h}(\frac{U_\infty}{U_o})^2]^{-3/7}$												Name Date of Test Course No. Section
Column No	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Item	RUN NO.	dA/dt	ρ	U_∞	$\frac{U_\infty^2}{gh}$	$\frac{\rho}{\rho_p}\frac{U_\infty^2}{gh}$	$\frac{dA/L^2}{dU_\infty t/L}$				$\frac{\rho_p D_p}{\rho D}$	$\frac{2(7)}{(10)}$	
Units		in^2/min	$slugs/ft^3$	ft/s			$x(10)^5$		$x(10)^4$			$x(10)^5$	
Ref.													
1. 0°	10/18/3	16.57	0.002325	19.12	85.23	0.0929	4.30	0.0607	7.81	1.303	7.717	6.60	
2.	10/19/1	14.17	0.00237	18.09	76.29	0.0847	3.88	0.0537	7.13	1.199	7.576	6.48	
3.	10/12/1	11.03	0.00230	20.73	100.19	0.0475	2.64	0.0307	3.99	0.879	28.75	6.01	
4.	10/12/2	12.05	0.00233	20.02	93.44	0.0449	2.98	0.0284	3.77	0.833	28.09	7.15	
5.	10/12/3	20.26	0.00233	23.49	128.64	0.0618	4.28	0.0425	5.19	1.087	28.09	7.87	
6.	10/17/1	9.95	0.00239	20.98	102.62	0.0317	2.35	0.0201	2.65	0.686	121.9	6.88	
7.	10/17/2	8.88	0.00235	20.44	97.40	0.0296	2.15	0.0184	2.48	0.646	125.4	6.31	
8.	11/7/1	12.80	0.00235	24.43	139.14	0.0422	2.60	0.0289	3.54	0.871	121.7	5.96	
9.	11/13/1	6.50	0.00231	18.06	76.04	0.0227	1.78	0.0130	1.90	0.511	122.2	6.96	
10.	11/16/1	3.59	0.00242	15.41	55.36	0.0173	1.15	0.00865	1.45	0.382	120.3	6.09	
11. *	3/24/1	5.12	0.00245	17.78	41.06	0.0130	1.35	0.00737	9.48	0.391	113.5	6.93	
12. *	3/26/1	8.51	0.00245	21.13	57.99	0.0184	1.89	0.01169	1.34	0.534	116.7	7.10	
13. *	3/27/1	5.92	0.00249	18.81	45.95	0.0148	1.48	0.00874	1.06	0.441	114.6	6.70	
14.													
15. 20°	12/7/1	8.83	0.00259	18.56	80.31	0.0269	2.36	0.0157	2.07	0.595	109.0	7.93	
16.	12/15/1	8.90	0.00246	19.26	86.48	0.0275	2.29	0.0165	2.22	0.607	114.7	7.55	
17. 40°	2/9/1	9.91	0.00261	20.58	98.74	0.0333	2.39	0.0208	2.54	0.723	108.2	6.61	
18.	2/20/2	10.83	0.00239	20.32	96.26	0.0297	2.64	0.0185	2.48	0.650	118.1	8.13	
19.													
20.													
21.													
22.													
23.													
24.													
25.	* Columns 5,6,7,8,10,12 are with U_∞ = 4 x 0.95/0.90 since U_{bridge}/U_∞ = 0.95 instead of 0.90												

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