

STEEL DESIGN FOR EXTENSION
OF THE BOOM OF
STEAMER CARL D. BRADLEY

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE
Frederick Neil Jackson
1943

STEEL DESIGN
FOR EXTENSION OF THE BOOM
OF
STEAMER CARL D. BRADLEY

A Thesis Submitted to
The Faculty of
Michigan State College
of
Agriculture and Applied Science
by

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Candidate for the Degree of
Bachelor of Science

March 1943

THESIS

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PREFACE

To Mr. Hugh Lewis, Operations Manager, and to Mr. George E. Breech, Chief Design Engineer of the Bradley Transportation Company and the Michigan Limestone and Chemical Company I wish to express my appreciation and indebtedness for their direct assistance with this thesis, and for the use of the original plans for the design of the present boom.

Although this thesis is merely an assumed problem, there are plans in the process for an actual extension of forty feet to be placed in the boom of the steamer Carl D. Bradley. Mr. Breech's explanation of these plans has proved an education in itself. To him I am deeply grateful.

PURPOSE

The steamer Carl. D. Bradley of the Bradley transportation company was constructed having a boom of 160 feet in length from center to center of the end pulleys. This length has proved inadequate, and it is the purpose of this thesis to design the steel for a 20 foot extension to be placed in the boom and to determine the reinforcement required for the present members due to the extension.

NOTES ON SPECIFICATIONS

- (1) The Slenderness Ratio, l/r , is equal to or less than 120 for all main members.
- (2) The allowable compressive stresses per square inch are found from the formula $s = 17000 - 0.485 l^2/r^2$
- (3) The wind load is included only when greater than 25% of the total dead load, live load and impact.
- (4) Material in main members should be no less than 5/16" to allow for corrosion. However, due to the war-time restrictions, the sixteenth inch sizes are difficult to obtain so the limiting thickness is 3/8".
- (5) In the new section, 20 foot chords are used to economize in joint construction. The entire 20 foot chord is designed for the maximum stress in either 10 foot section.
- (6) The handbook used was "Steel Construction -- American Institute of Steel Construction."

1	1530	1190	1210	1230	950	920	1010	1130	1330	860	1000	1000	680	720	700	840	480	920
2	350	500	480	480	480	480	480	480	480	480	480	480	480	480	480	480	340	120
3	0	110	110	110	110	160	110	110	350	400	0	0	120	0	0	0	0	0
4	560	620	410	430	660	490	550	590	770	580	540	540	490	480	440	380	400	320
5									4600								1060-2540	

1. Truss
2. Walk, Skirtboard, Corn Slinger, Deck
3. Reinforcing
4. Crossframes, etc
5. Sheaves, pulley



Carl D. Bradley Boom - 20' Extension

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19
Steel Pulleys etc.	7400	2470	2230	2110	2200	2070	2130	2250	2110	2530	2180	2020	1860	1730	1730	1690	1450	2390	3380
Belt & Idlers	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	720	660	360
Total DL	3250	3270	3080	2960	3050	2870	2980	3100	3560	3380	3030	2870	2710	2580	2580	2540	2190	3050	3740
Live Load (Stone)	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	980	890	490
Total DL+LL	4400	4420	4230	4110	4200	4020	4130	4250	4710	4530	4180	4020	3860	3730	3730	3690	3150	3940	4230
Impact	220	220	210	210	210	200	210	210	470	450	420	400	390	370	370	370	310	390	420
Total DL+LL+I	4620	4640	4440	4320	4410	4220	4340	4460	5180	4980	4600	4420	4250	4100	4100	4060	3460	4330	4650

215,055

Rope Pull - 225,342 #

$\alpha = 17^{\circ} 22' 42''$

Carl D. Bradley Boom - 20' Extension

LL+DL+Impact - Boom Horizontal.

46'0"

215,055

W

20,875

4620

4640

4440

4320

4410

4220

4340

4460

5180

4980

4600

4420

4250

4100

4100

4060

3460

4330

4650

9@10'-0"=90'-0"

8@10'-0"=80'-0"

7'-0"

8'-6"

4600

U

V

T

P

Q

R

S

T

U

V

W

X

Y

Z

AA

BB

CC

DD

EE

FF

GG

1

2

3

4

5

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Carl D. Bradley Boom - 20' Extension

4620 x 10 =	46,200
4640 x 20 =	92,800
4440 x 30 =	133,200
4320 x 40 =	172,800
4410 x 50 =	220,500
4220 x 60 =	253,200
4340 x 70 =	303,800
4460 x 80 =	356,800
5180 x 90 =	466,200
4600 x 90 =	414,000
4980 x 100 =	498,000
4600 x 110 =	506,000
4420 x 120 =	530,400
4250 x 130 =	552,500
4100 x 140 =	574,000
4100 x 150 =	615,000
4060 x 160 =	649,600
3460 x 170 =	588,200
4330 x 177 =	766,410
4650 x 185.5 =	862,575
88,180	8,602,185

DL+LL+1 - Boom Horizontal

$$\frac{8602185}{40} = 215,055 = \text{Horiz. Reaction}$$

$$\log 215,055 = 5.33255$$

$$\log \cos \alpha = 9.97971$$

$$5.35284 = 225,342^{\#} = \text{Rope Pull}$$

$$\log 215,055 = 5.33255$$

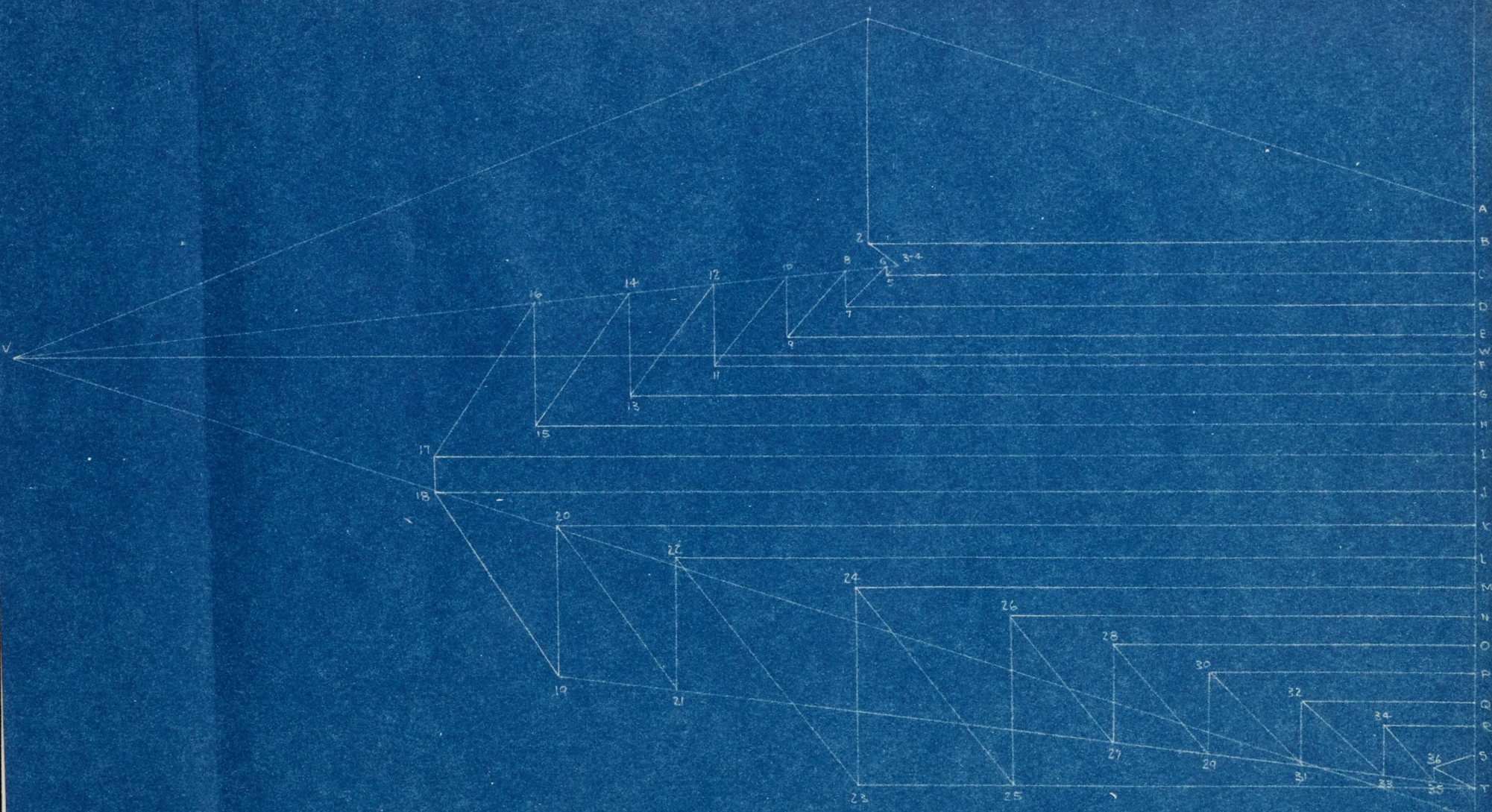
$$\log \tan \alpha = 9.49550$$

$$4.82805 = 67,305^{\#} = \text{Vert Comp of Rope Pull}$$

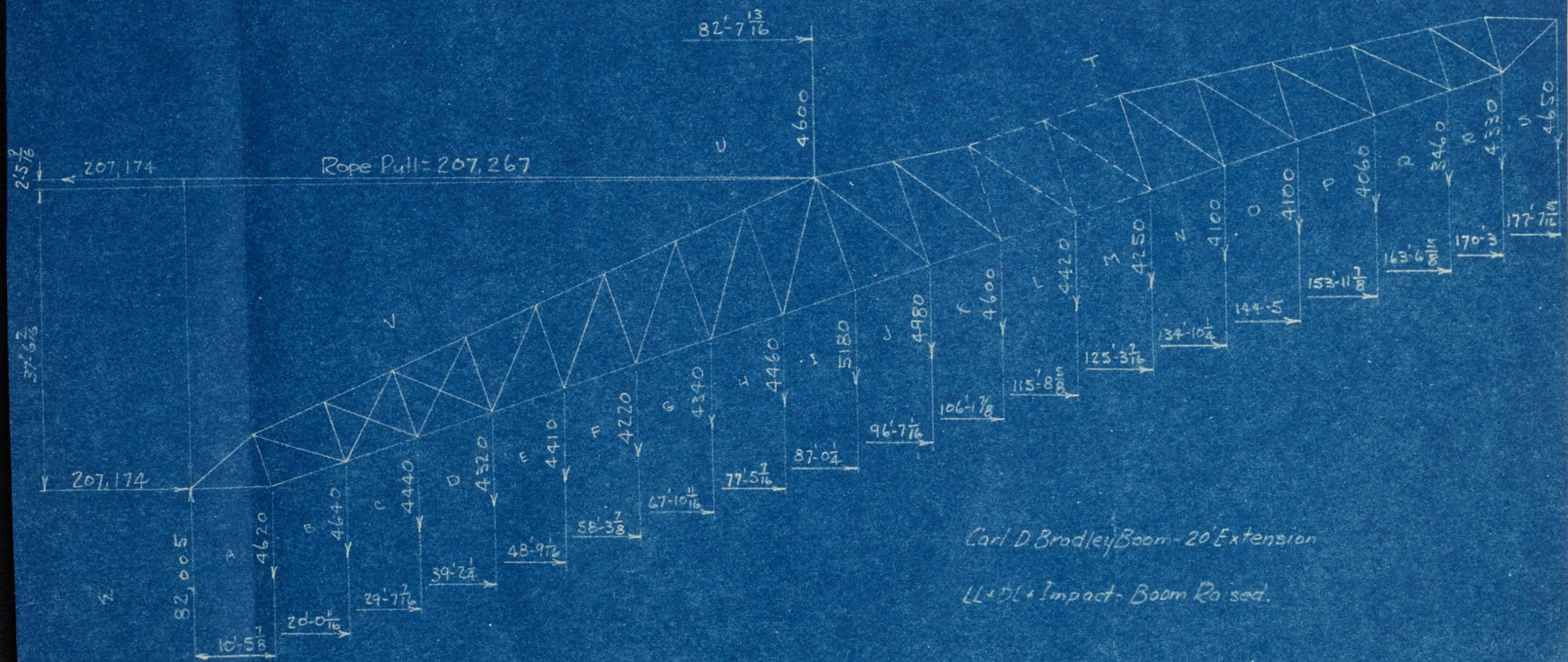
$$88,180$$

$$67,305$$

$$20,875 = \text{Vert Reaction}$$



Boom Horizontal - LL+DL+Impact - 20' Extension - Scale 1"=20,000'



Carl D Bradley Boom - 20' Extension

LL + DL + Impact - Boom Raised.

Carl D. Bradley Boom - 20' Extension
LL+DL+Impact - Boom Raised.

4620	x	10.4896	=	48,461.952
4640	x	20.0573	=	93,065.872
4440	x	29.6198	=	131,511.912
4320	x	39.1875	=	169,290.000
4410	x	48.7552	=	215,010.432
4220	x	58.3229	=	246,122.638
4340	x	67.8906	=	294,645.204
4460	x	77.4581	=	345,440.826
4600	x	82.6510	=	380,194.600
5180	x	87.0208	=	450,767.744
4980	x	96.5885	=	481,010.730
4600	x	106.1563	=	488,318.980
4420	x	115.7188	=	511,477.096
4250	x	125.2865	=	532,467.625
4100	x	134.8542	=	552,902.220
4100	x	144.4167	=	592,108.470
4060	x	153.7896	=	625,197.776
3460	x	163.5521	=	565,890.266
4330	x	170.2500	=	737,182.500
4650	x	177.6094	=	825,883.710
88,180			=	8,286,950.553

$$8,286,950 - 207,174 = \text{Horiz. Reaction}$$

40

$$\log 207,174 = 5.31634$$

$$\log \tan \alpha = 8.47431$$

$$3.79065 = 6.175 = \text{Vert. Component of rope pull.}$$

$$\log \sin \alpha = 8.47412$$

$$5.31653 = 207,267 = \text{Rope Pull}$$

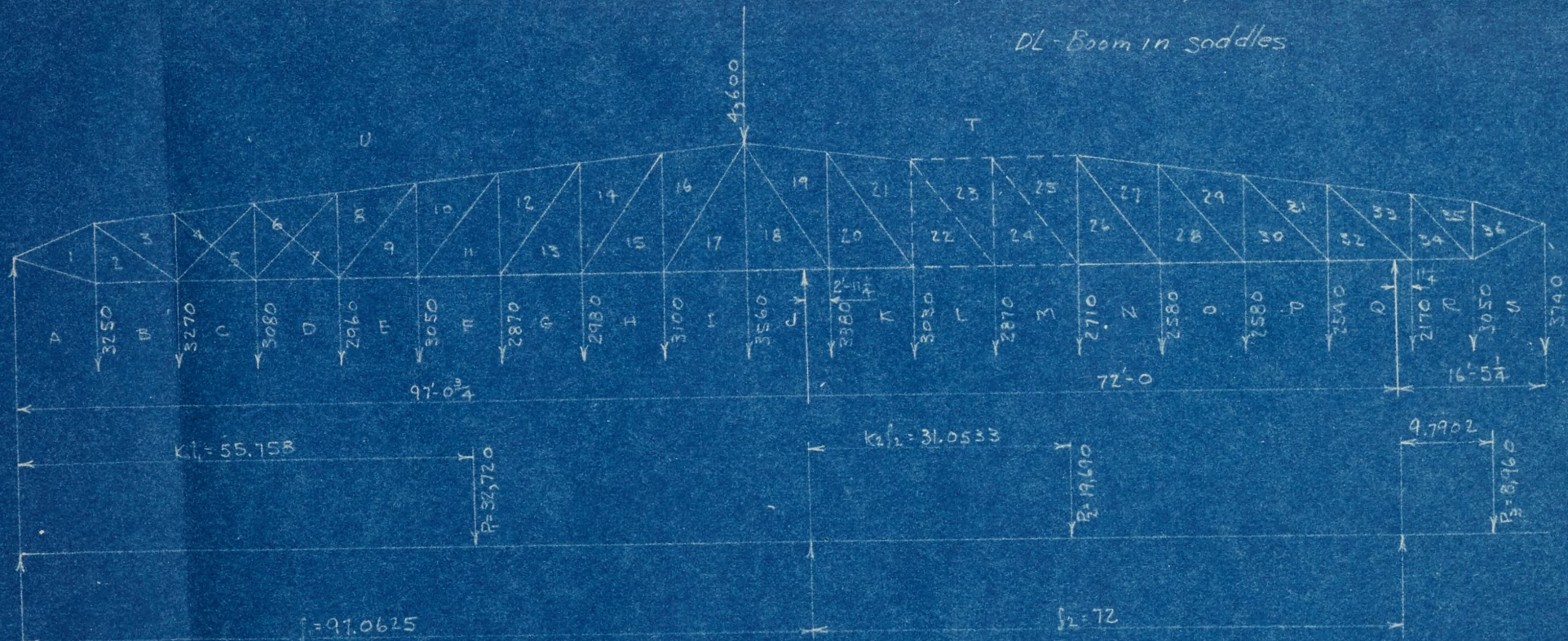
$$88,180$$

$$6.175$$

$$82,005 = \text{Vertical reaction.}$$

Carl D Bradley Boom - 20' Extension

DL - Boom in Saddles



$$M_1 = 0 \quad M_2 = 8,960 \times 9.7902 = 87,720 \quad K_1 = \frac{55.758}{97.0625} = .57445 \quad K_1^2 = .32999 \quad K_1^3 = .18956 \quad K_2 = \frac{31.0533}{72} = .43130 \quad K_2^2 = .18602 \quad K_2^3 = .08023$$

$$2 \times M_1 \times 169.0625 - 87,720 \times 72 = -32,720 \times 9,421.1289 \times .38489 - 19,690 \times 5184 \times .39077$$

$$338.125 M_2 = 6,315,840 - 118,645,936 - 39,887,050$$

$$M_2 = -450,180$$

$$V_1 = 9,286 \quad R_1 = 9,286$$

$$V_1' = -23,434 \quad R_2 = 39,666$$

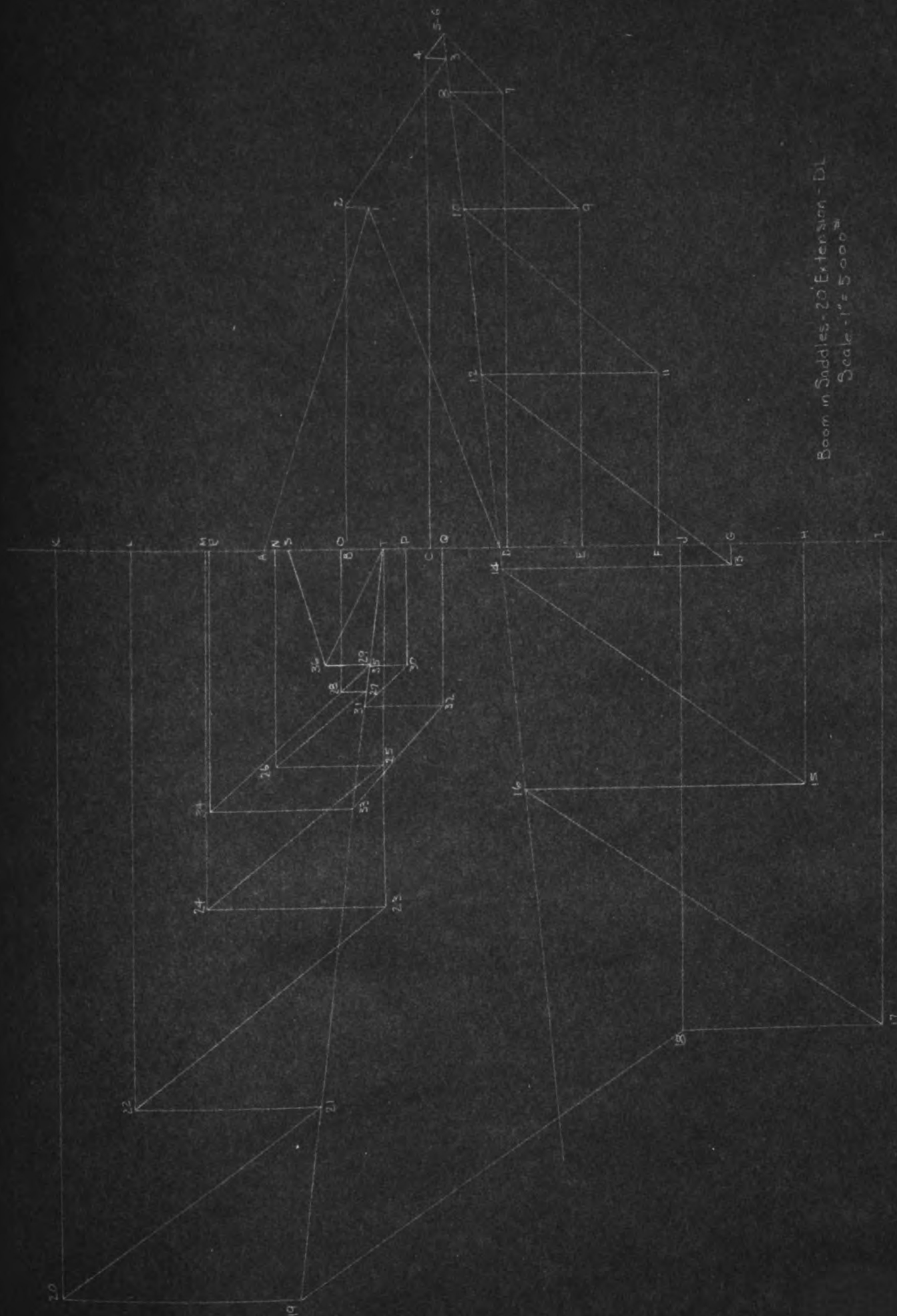
$$V_2 = 16,232 \quad R_3 = 12,418$$

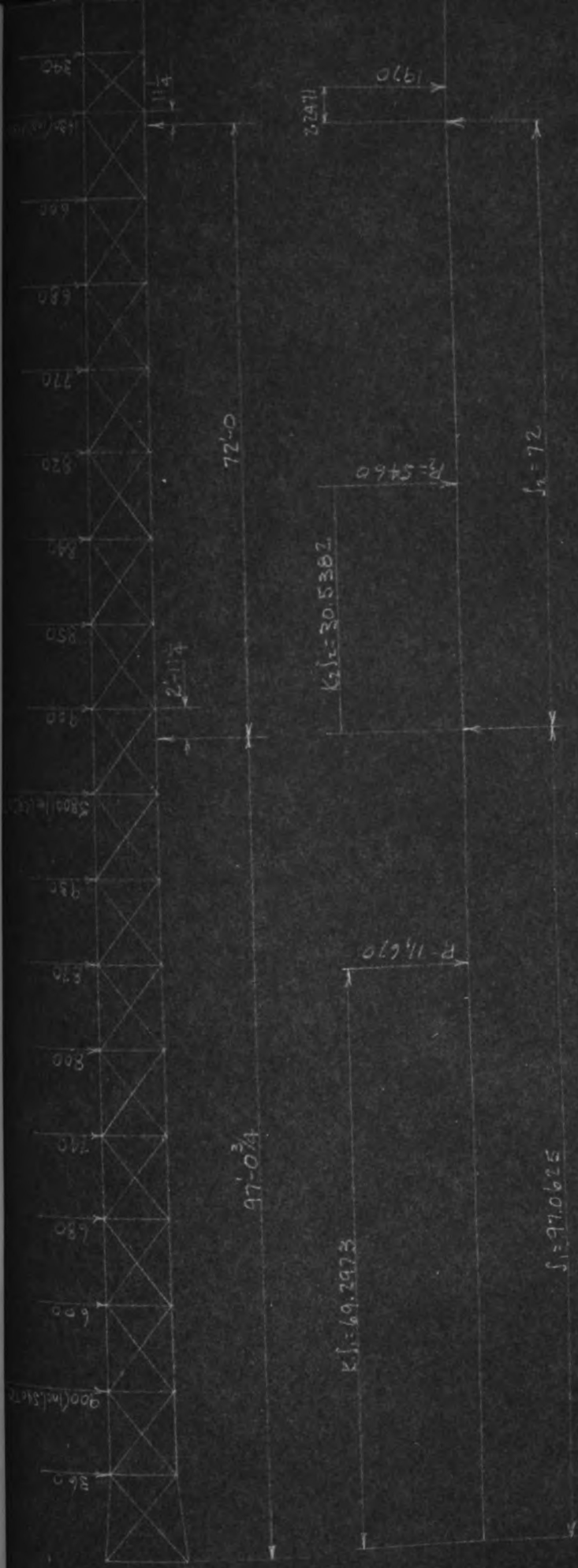
$$V_2' = -3,458 \quad 61,370$$

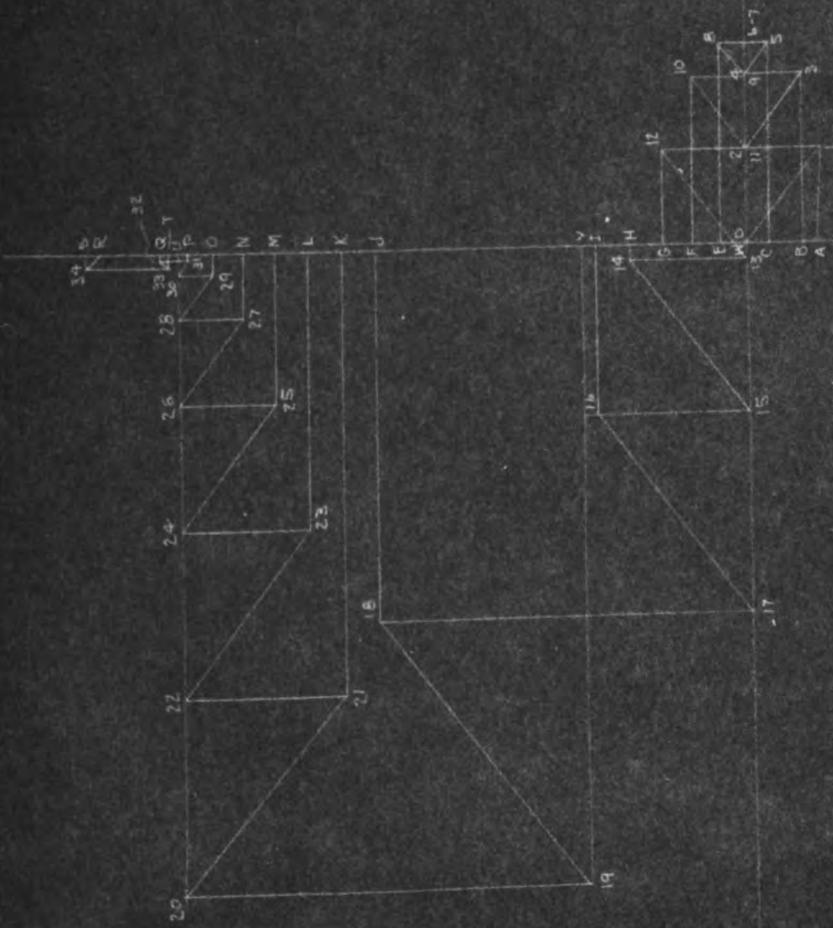
$$V_3 = 8,960$$

V = Shear to right of supports

Boom in Saddles - 20' Extension - DL
 Scale - 1" = 5000'

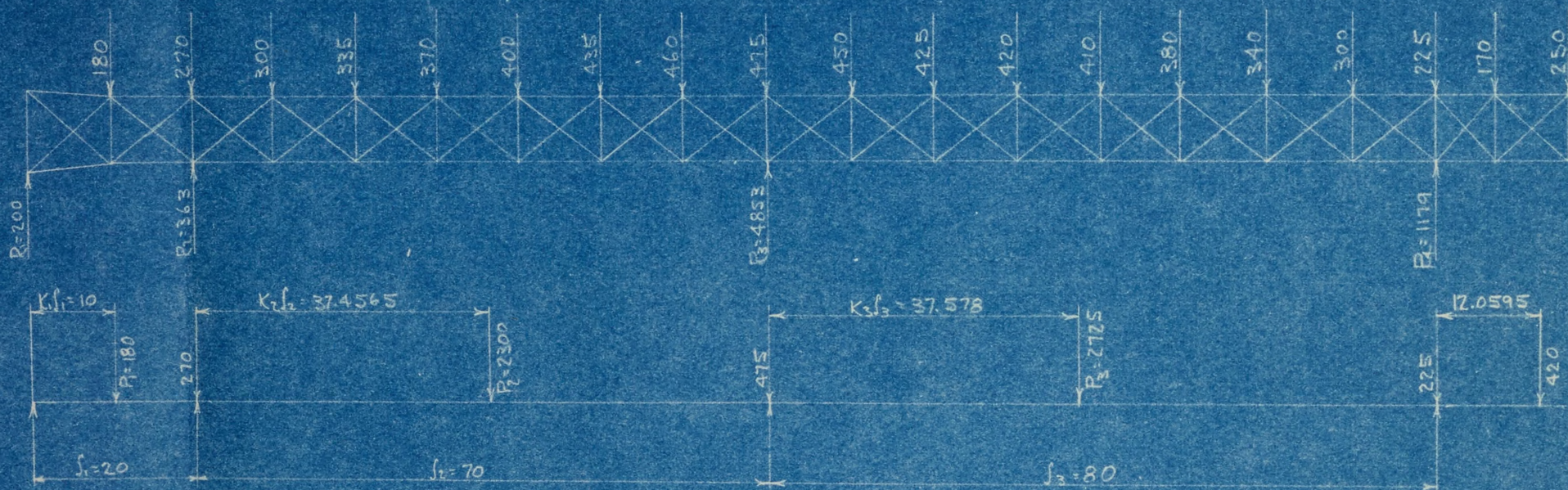






Wind Bot. Chord 20' Ext. Boom in Saddles - Scale 1" = 5000'

Wind-Top Chord.



$$M_1 = 0 \quad M_4 = -5065$$

$$M_1 f_1 + 2M_2(f_1 + f_2) + M_3 f_2 = -P_1 f_1^2 (1 - K_1^3) - P_2 f_2^2 (2K_1 - 3K_1^2 + K_1^3)$$

$$M_2 f_2 + 2M_3(f_2 + f_3) + M_4 f_3 = -P_2 f_2^2 (1 - K_2^3) - P_3 f_3^2 (2K_2 - 3K_2^2 + K_2^3)$$

$$180 M_2 + 70 M_3 = -4,134,915$$

$$70 M_2 + 300 M_3 = -19,266,941$$

$$1260 M_2 + 490 M_3 = -28,944,405$$

$$\frac{-1260 M_2 - 3400 M_3 = 346,804,938}{-4910 M_3 = 317,860,533}$$

$$M_3 = -64,737$$

$$M_3 = -64,737$$

$$180 M_2 - 4,531,590 = -4,134,915$$

$$M_2 = 2,204$$

$$K_1 = .5$$

$$K_1^2 = .25$$

$$K_1^3 = .125$$

$$K_2 = .5351$$

$$K_2^2 = .2863$$

$$K_2^3 = .1532$$

$$K_3 = .4697$$

$$K_3^2 = .2206$$

$$K_3^3 = .1036$$

$$V_1 = \frac{M_1 - M_2}{f_1} + P_1(1 - K_1) = 200$$

$$V_1' = \frac{M_2 - M_1}{f_1} - P_1 K_1 = 20$$

$$V_2' = \frac{M_2 - M_3}{f_2} + P_2(1 - K_2) = 113$$

$$V_2'' = \frac{M_3 - M_2}{f_2} - P_2 K_2 = -2187$$

$$V_3' = \frac{M_3 - M_4}{f_3} + P_3(1 - K_3) = 2191$$

$$V_3'' = \frac{M_4 - M_3}{f_3} - P_3 K_3 = -534$$

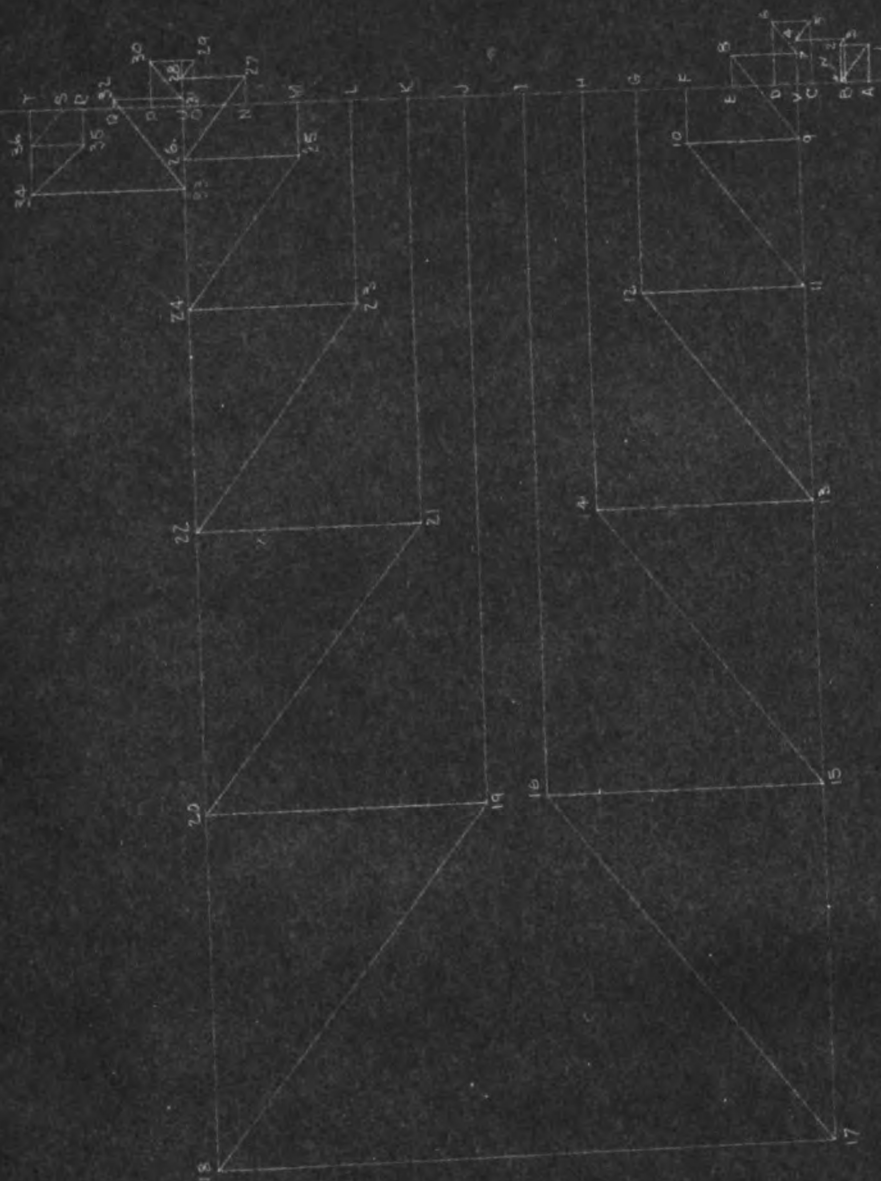
$$V_4' = 420$$

$$R_1 = V_1' = 200$$

$$R_2 = V_2' - V_1' = 93 + 270 = 363$$

$$R_3 = V_3' - V_2' = 4378 + 475 = 4853$$

$$R_4 = V_4' - V_3' = 954 + 225 = 1179$$



Wind: Top Chord - 20' Ext - Slope 1" = 15.00'



Belt Pull - Scale 1" = 3000^{lb} - 20' Extension

ROOM USE ONLY

ROOM USE ONLY.

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