AN EXPERIMENTAL STUDY OF ANALYSIS OF TRANSMISSION TOWERS

THESIS FOR DEGREE OF B. S.

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1926

Towers

Civil engineering Structural engineering

PREFACE

The writer of this thessis in this note wishes to thank the members of the faculty of the Michigan State College for the help he has received during the past years and in due concideration has written this thessis to show his appreciation.

AN EXPERIMENTAL STUDY OF ANALYSIS OF TRANSMISSION TOWERS

Thesis Submitted to the Faculty of

THE MICHIGAN STATE COLLEGE

by

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Candidate for the Degree of Bachelor of Science

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Analysis of

Two general types

Flex Towers,

Flexible frames are heavier than poles and are intended to take care of longer spans. Their chief function is to take care primarily of transverse loads with a small margin of safety so that under unusual conditions of service they could provide a little resistance in the direction of the line and distribute a load coming in this direction over a number of supporting structures and transfer such a load to the still heavier structures placed at regular intervals in the line or they may transfer all loads coming on them in the direction of the line to a point where they will be resisted.

Rigid Towers

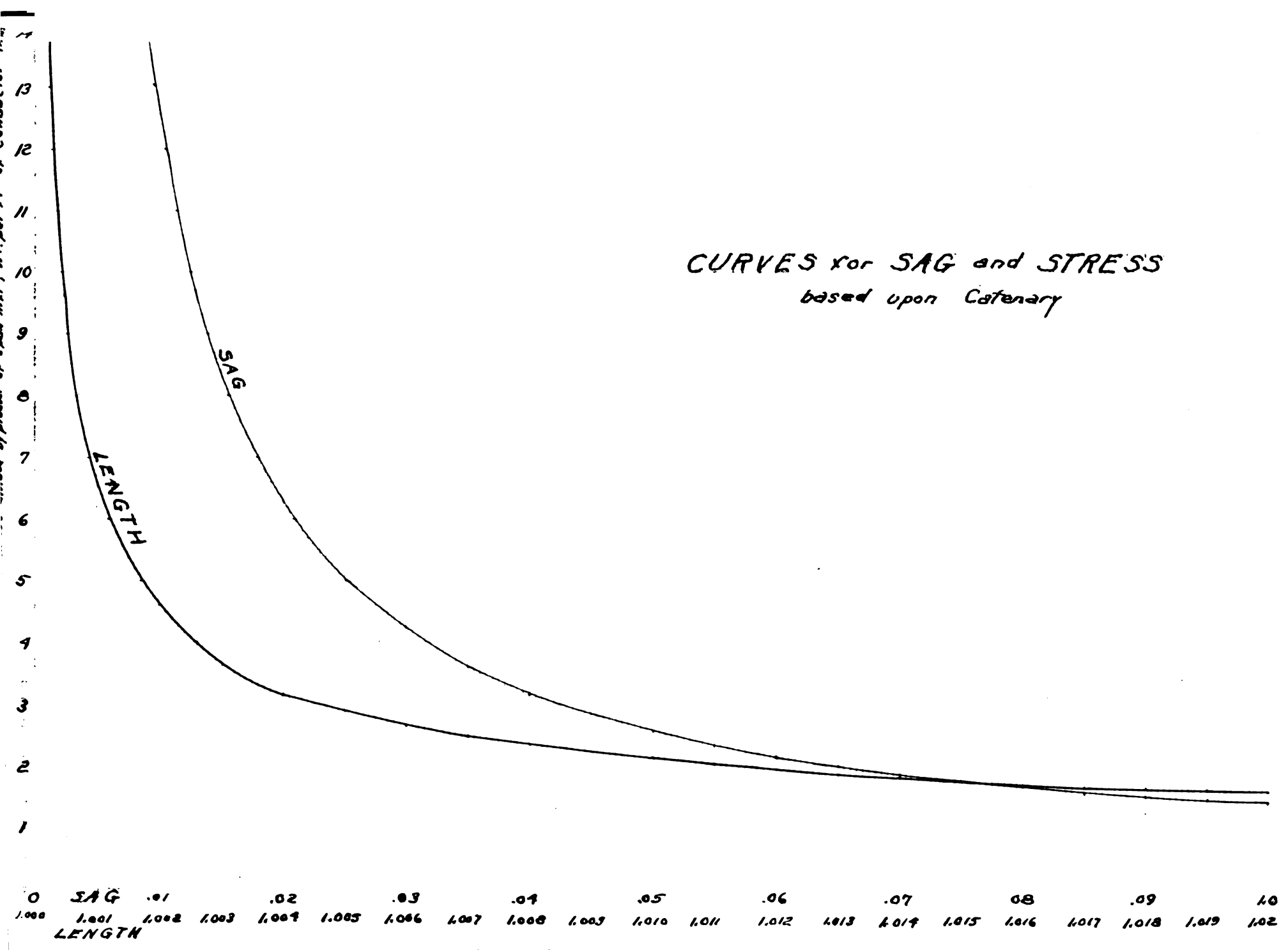
Rigid towers are the largest and heaviest structures made for transmission line supports. They are intended to have strength to carry loads coming upon them either in thedirections of the line or at right angles to this direction. They are usually designed for a combination of both loads. These towers are built in triangular rectangular or square depending upon conditions. The width at ground line varies from one seventh to one third the total height

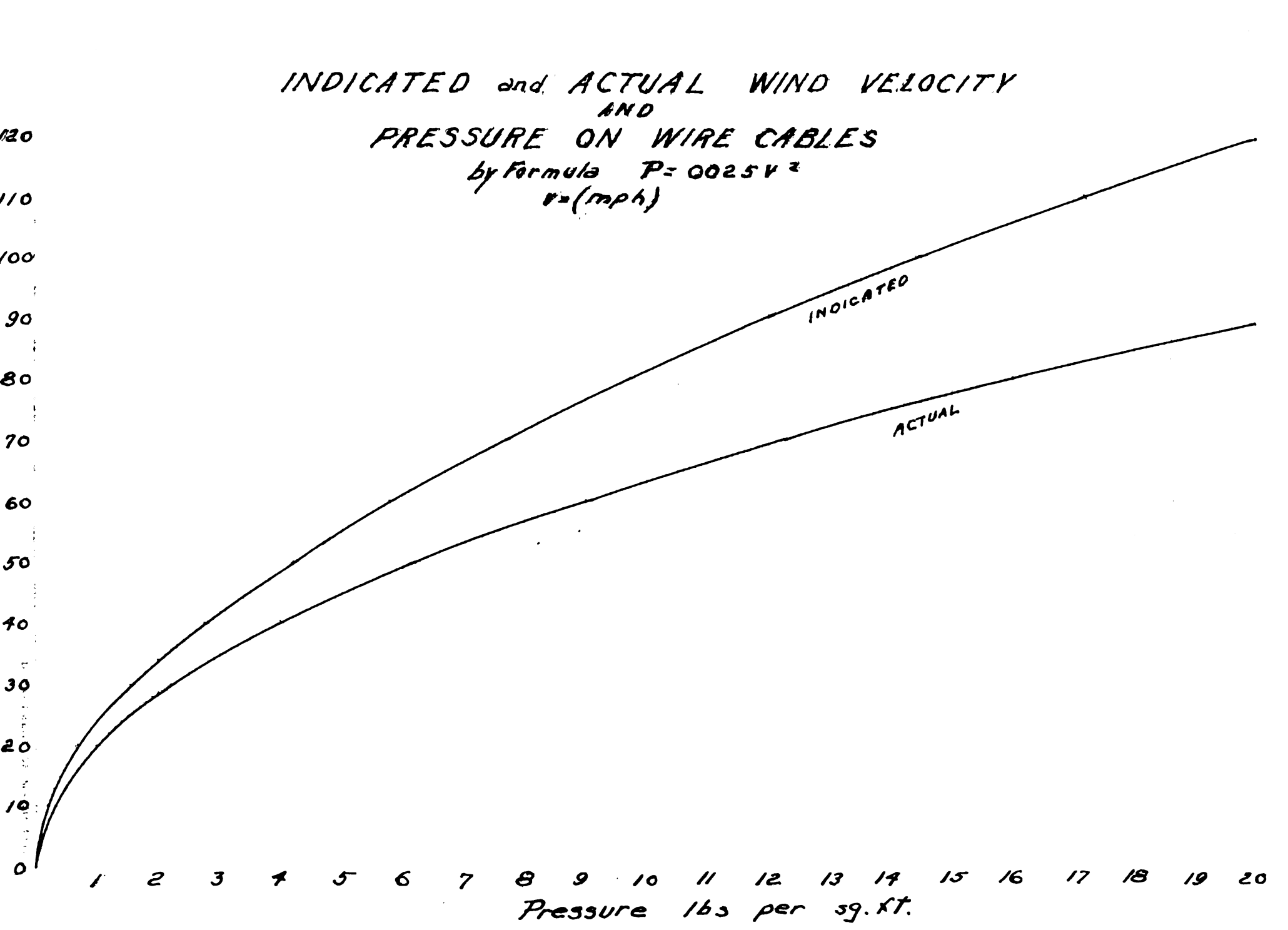
Loadings,

1 Dead load of the wires together with any coating on them also dead weight of structure itself.

2 Wind loads on the wires and the structure transverse to the direction of the line.

3 Pulls in the direction of the line caused by dead load and the wind load on the wires.


CURVES for SAG and STRESS
based upon Catenary
SAG
LENGTH
13
12
11
10
9
8
7
6
5
4
3
2
1
0
SAG .01 .02 .03 .04 .05 .06 .07 .08 .09 .10
1.000 1.001 1.002 1.003 1.004 1.005 1.006 1.007 1.008 1.009 1.010 1.011 1.012 1.013 1.014 1.015 1.016 1.017 1.018 1.019 1.02
LENGTH


INDICATED and ACTUAL WIND VELOCITY
AND
PRESSURE ON WIRE CABLES
by Formula P= 0025 V²
V=(mph)
120
110
100
90
80
70
60
50
40
30
20
10
0
INDICATED
ACTUAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Pressure lbs per sq. ft.

Reference for use of Thomas's Curve

Formula Stress factor = $\frac{\text{Stress in Line}}{\text{Length of Conductor} \times \text{Wt. per ft.}}$

Stress factor is ordinate for both Sag and Stress

Sag = Span x abcissa of sag curve

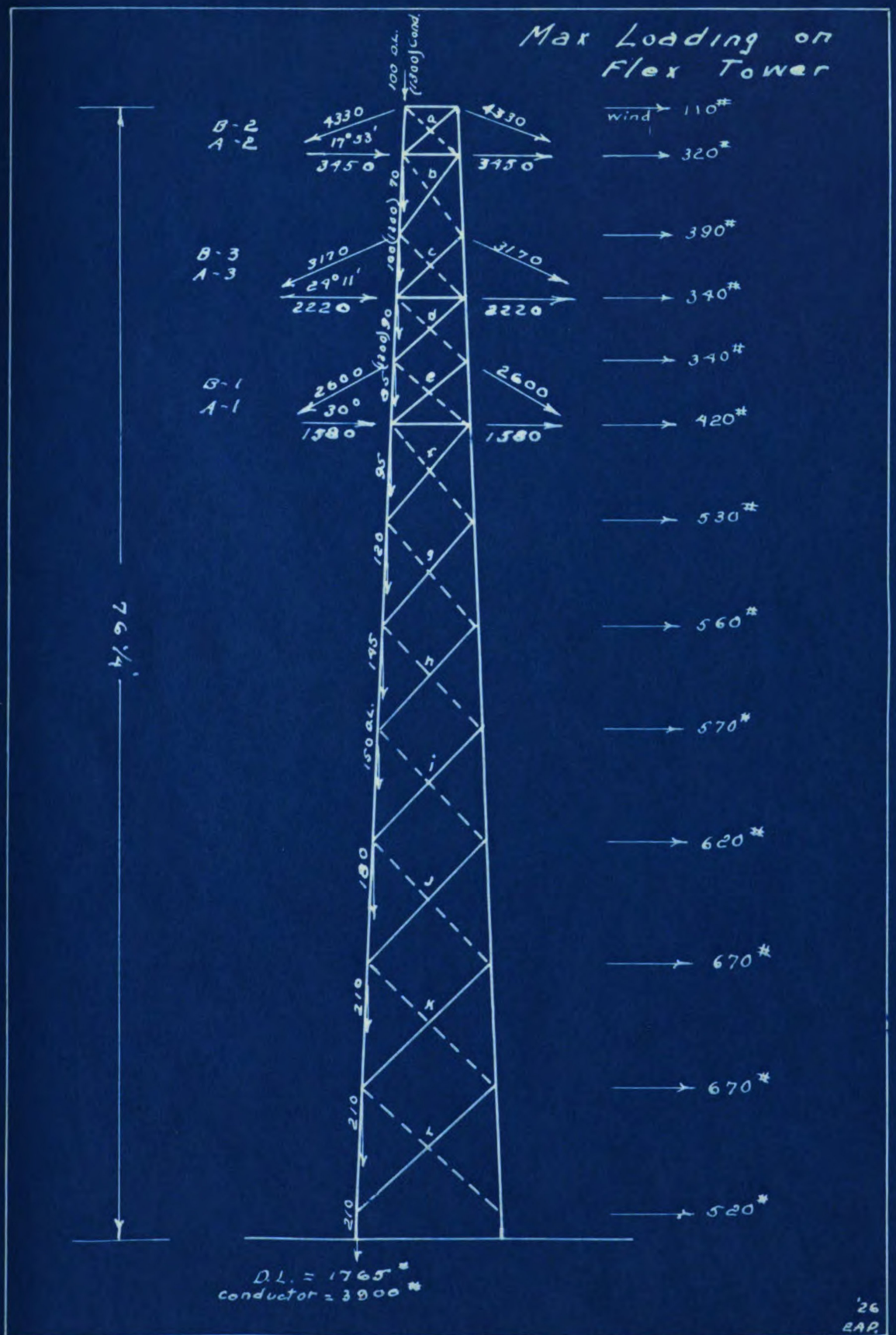
Length = Span x abcissa of length curve

Wind pressure on conductor

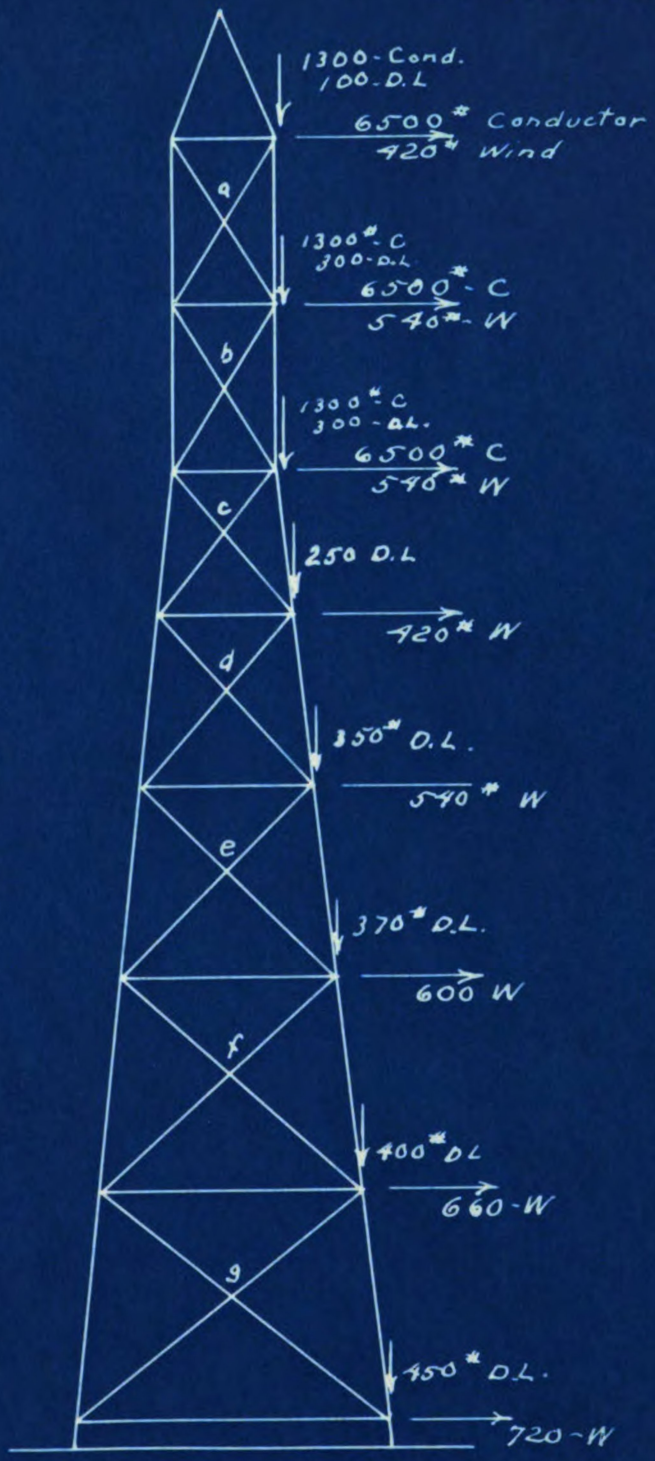
It has been determined by many experiments that the wind pressure on circular objects = $.0025V^2$

In which V = velocity in m.p.h.

The two curves indicated and actual velocities are based upon experiments. The indicated is the velocity used by the U.S.W.B. As a result of considerable investigation the corrected velocity times a logarithmic factor equals the true velocity.


Max Loading on Flex Tower
100 O.L. 7/8" Gal. Cond.
B-2
A-2
4330
17°33'
3450
4330
3450
wind 110#
320#
B-3
A-3
3170
29°11'
2220
3170
2220
390#
340#
340#
B-1
A-1
2600
30°
1380
2600
1580
420#
530#
560#
570#
620#
670#
670#
520#
100 (120) 90
90 (100) 90
95
120
175
150 Gal.
180
210
210
210
764'
D.L. = 1765#
conductor = 3800#
'26
E.A.P.

Max Loading on Anchor Tower



'26
EAP

CONDUCTOR LOADINGS

Class "B"

Gauge B & S	Diameter	Area	Ultimate Tension
500,000	.819	.3924	23,540

Load per Lin. ft. vert. Dead	Lin. ft. vert. 1/2" ice	Lin. ft. horz. 1/2" ice	Max. load Plane resultant
1.525	2.345	1.213	2.64

Length of conductor and sag

Tower span 550 ft.

Stress equals 3,500

From Curves

Stress Factor = $\frac{3,500}{550 \times 1.525} = 4.17$

Sag = 550 x .031 = 17.1 ft.

Length = 550 x 1.0024 = 551.32 ft.

Max. vertical stress 1,300

Max. horizontal stress 670

Tower Loadings

Wind Flex tower 20# per sq. ft.

Anchor tower 30# " " "

Flex towers are designed to stand max. stress perpendicular to line

Anchor towers are designed to stand max stress from all directions

BAR	ORIG		MOMENT			ALLOW. STRESS
(a)	$\frac{4120 \times 42.5 + 110 \times 42.5}{2 \times 43.95}$	=	2,450 x	$\frac{4.3}{3.3}$	3200	13,000
(b)	$\frac{180000 + 3610 \times 42.5}{2 \times 46.2}$		3,595 x	$\frac{6.5}{3.5}$	6400	"
(c)	$\frac{344,500 + 3085 \times 51}{2 \times 53.1}$		4740 x	$\frac{6.0}{4.3}$	7070	"
(d)	$\frac{502,000 + 2390 \times 55.25}{2 \times 57.5}$		5540 x	$\frac{6.3}{3.9}$	7730	"
(e)	$\frac{631,200 + 2405 \times 59.50}{2 \times 61.6}$		6410 x	$\frac{6.3}{4.6}$	8640	"
(f)	$\frac{777,700 + 1792 \times 62.25}{2 \times 66.95}$		6670 x	$\frac{7.2}{5.3}$	9550	"
(g)	$\frac{891200 + 265 \times 70.55}{2 \times 73.88}$		6130 x	$\frac{8.1}{5.5}$	9910	"
(h)	$\frac{893,060 + 280 \times 77.65}{2 \times 81.15}$		5525 x	$\frac{9.3}{6.3}$	8570	"
(i)	$\frac{895,232 + 285 \times 77.65}{2 \times 87.23}$		5160 x	$\frac{10.1}{6.6}$	7900	"
(j)	$\frac{897,647 + 310 \times 92.35}{2 \times 95.05}$		4730 x	$\frac{11.2}{7.3}$	7240	"
(k)	$\frac{900,507 + 325 \times 100.55}{2 \times 104.45}$		4360 x	$\frac{11.55}{8.3}$	6650	"
(l)	$\frac{903,777 + 325 \times 108.89}{2 \times 111.79}$		4070 x	$\frac{12.1}{8.6}$	5720	"

	Stress		
A-1	3,450	Allowable	7,500
B-1	4,330	"	"
A-2	2,600	"	"
B-2	1,582	"	"
A-3	2,220	"	"
B-3	3,170	"	"

[illegible] (CONTINUED)

BAR	MOMENT AREAS INTEGRATED [illegible]	
I-a	110 x 1.45	160
I-b	160 + 110 x 4.25 + 7520 x 2.7	20,108
I-c	20,108 + 7550 x 4.9 + 390 x 2.1	56,878
I-d	56,878 + 7720 x 4.55 + 4780 x 2.1	99,778
I-e	99,778 + 12,500 x 4.25 + 540 x 2.1	153,693
I-f	15[illegible],693 + 1284 x 5.45 + 5[illegible]84 x 3.5	235,513
I-g	235,513 + 16424 x 6.83 + 550 x 3.5	349,463
I-h	349, 463 + 16954 x 7 + 560 x 3.5	460,023
I-i	460,023 + 17514 x 718 + 570 x 3.6	587,873
I-j	587,873 + 16584 x 7.8 + 650 x 3.9	730,793
I-k	730,793 + 18704 x 8.[illegible]3 + 670 x 3.9	889,203
I-l	889, 203 + 19374 x 8.33 + 670 x 3.7	1,052,663

	MOMENT	DIVISOR	STRESS	AREA
I-a	160	3.5 + 1.45/3	40	40,000
I-b	20,108	5.8 + 2.7/3	4,270	"
I-c	56,878	4.4 + 2.1/3	11,150	"
I-d	99,778	4.3 + 2.1/3	18,800	"
I-e	153,693	5.1 + 2.1/3	26,550	"
I-f	235,513	5.5 + 3.3/3	35,600	"
I-g	349,463	6.2 + 3.3/3	47,800	71,000
I-h	460,023	6.8 + 3.5/3	57,800	"
I-i	587,873	7.3 + 3.6/3	66,800	"
I-j	730,793	8.2 + 3.9/3	76,800	96,500
I-k	889,203	8.9 + 3.9/3	87,800	"
I-l	1,052,663	9.7 + 3.9/3	90,500	"

BAR	MOMENT AT OUT [illegible]	
L-a	500 x II.I2 + 6920 x 4.375	35,780
L-b	35,780 + 7420 x 8.75 + 7040 x 4.375	I3I,700
L-c	I3I,700 + I4,460 x 7.625 + 7040 x 4.375	265,000
L-d	265,000 + 22,500 x 8.I + 420 x 3.85	440,620
L-e	440,620 + 22,420 x 9.5 + 540 x 4.5	597,050
L-f	667,050 + 23,460 x I0.5 + 600 x 5.0	780,500
L-g	780,500 + 24,060 x II.5 + 660 x 5.5	I,060,000

BAR	MOMENT	DIVISOR	ACTUAL STRESS	ALLOWABLE STRESS
L-a	35,780	5.I2 + 8.75/7	5,600	30,000
L-b	I3I,700	5.I2 + 8.75/7	I6,500	"
L-c	265,000	6.75 + 7.5/7	29,000	"
L-d	440,620	8.85 + 9.0/7	37,700	52,700
L-e	597,050	II.I2 + I0/7	42,500	"
L-f	780,500	I3.66 + II.I/7	45,000	"
L-g	I,060,000	I7.2I + I2.I/7	5I,700	"

(a)	$\frac{6920}{5.1}$		13,580
(b)	$\frac{6920}{5.1}$		13,580
(c)	$\frac{6920 \times 6.75 + 7040 \times 15.5 + 7040 \times 24.25}{2 \times 27.50}$	$6125 \times \frac{11}{5.5}$	10,380
(d)	$\frac{36,900 + 420 \times 31.75}{2 \times 35.6}$	$4920 \times \frac{14}{8.8}$	7,840
(e)	$\frac{550,250 + 540 \times 40.6}{2 \times 45.1}$	$4130 \times \frac{16.7}{11.5}$	5,760
(f)	$\frac{371,850 + 600 \times 50.6}{2 \times 55.6}$	$5550 \times \frac{19.5}{14.5}$	4,920
(g)	$\frac{401,850 + 660 \times 61.6}{2 \times 67.1}$	$5500 \times \frac{22.5}{17.5}$	4,340

RIVETS

All rivets in towers are in single shear allowable 10,000

Flex tower

Max. stress in cross arms

$\frac{9,910}{10,000}$ 2 rivets

Max. stress in channel

$\frac{96,500}{10,000}$ 10 rivets

Anchor tower

Max stress in cross arms

$\frac{13,000}{10,000}$ 2 rivets

Max. stress angles

$\frac{58,700}{10,000}$ 6 rivets

Pocket
has:
2 Plans