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Sags and Tensions of Solid Copper Overehad Conductors under Indian Conditions
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Sags and Tensions of Solid Copper Overhead Conductors under Indian Conditions.

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The tables and curves which accompany the present note will, it is hoped, be found to be of considerable use to those who are engaged on the construction of overhead transmission and distribution lines in India. Although there are a considerable number of such lines in existence, no tables—so far as the authors are aware—have hitherto been published for the guidance of engineers in charge of overhead construction work, and as a result each engineer has had to work out for himself the correct sag or tension to be used in each particular case.

The curves and tables give the correct values of the sags and tensions to be used at different temperatures in erecting overhead lines in *still* air in order that the conditions laid down by the Indian Electricity Rules (1911) may be complied with.

From many points of view, India is an ideal country for overhead lines. It is true that owing to the ubiquity of the white ant, the cheap type of construction represented by a wood-pole line cannot be used. But apart from this disadvantage, all the other conditions affecting the working of an overhead line are of a highly favourable nature. The temperature varies between narrow limits ; there is no snow or ice to form a coating on the wires and load them beyond the limits of safety : and the wind pressure never reaches the excessive values which occur in countries visited by tornadoes.

According to the Indian Electricity Rules (1911), "The factor of safety of an aerial line including the supports thereof and any guard wires or bearer wires in connection therewith, shall be at least four under all conditions, the maximum wind pressure being taken at 25 lbs per square foot. For cylindrical bodies the effective area shall be taken as two-thirds of the projected area exposed to wind pressure".

The above extract from the Indian Electricity Rules sufficiently defines the conditions which must be satisfied by a properly constructed overhead line, with one exception : nothing is said about a lower temperature limit. In order to be on the safe side, we have taken this limit to be 50°F. Accordingly the most severe conditions to which the line is supposed to be subjected correspond to a wind pressure of 25 lbs per square foot and a temperature of 50°F, and under these extreme conditions the line must still possess a factor of safety of at least four.

The tensile strength of different sizes of copper wire we have supposed to be given by Trotter's formula, namely,

$$T = 30 - 20\ D,$$

where T = Tensile strength in tons per square inch
and D = Diameter of wire in inches.

Young's modulus was assumed to be 16×10^6 lbs. per square inch, and the temperature coefficient of expansion of copper to be $.93 \times 10^{-5}$ per °F.

The usual parabolic equation for the curve assumed by the wire was employed, namely,

$$d = \frac{l^2\, w}{8\, t},$$

where d = Sag
l = Distance between supports
w = Resultant total force per unit length,
and t = Tension

The method of arriving at the results given was as follows :—

From the known weight per unit length and the wind pressure of 25 lbs per square foot, the total load per unit length of wire under the assumed most severe conditions was calculated for each size of wire. Next, assuming a factor of safety of four, the working stress intensity was determined for each size, and from it the maximum working tension. Using the values of the maximum load per unit length and maximum working tension, the excess length—*i. e.*, the difference between the actual length of the conductor in the span and the span itself (the horizontal distance between points of support)— was determined for the various sizes of wire and the various spans by means of the formula

$$\text{Excess length} = \frac{1}{24} \cdot \frac{w^2}{t^2}\, l^2$$

Next, from the known value of Young's modulus and the working stress intensity the extension arising from the stress was calculated (in making this calculation it is safe to take the original length of conductor as equal to the span). By subtracting this extension from the excess length under the most severe conditions, the excess length of a conductor in a span was obtained when the conductor is relieved of all stress. This excess length was in some cases found to be negative—*i. e.*, if the conductor were allowed to contract by removing the stress, the length of the unstressed conductor would be found to be less than the length of span. Since the greatest wind pressure has been assumed to occur at the lowest temperature, the excess lengths of the unstressed conductors calculated as above are taken to represent these lengths at the minimum temperature (50°F) assumed. If now the conductor is stressed, its excess length will increase in proportion to the stress intensity, and the relation between stress intensity and excess length will be represented by a straight line (the temperature being assumed to remain constant).

Suppose next that the temperature rises by 10°F. The unstressed conductor will expand and its excess length when unstressed will increase. If now the temperature is maintained constant at the higher value and stress is applied to the conductor, the new line which represents the relation connecting excess length with stress intensity, will be parallel to the similar line for the lower temperature.

Thus if we assume equal temperature intervals of 10°F. the relation connecting excess length with stress intensity at the various temperatures will be represented by a series of parallel equidistant straight lines.

Take then any span length, and for it draw such a series of equidistant parallel lines: call this diagram A. Next draw for the same span the curve connecting stress intensity with excess length when there is no wind. Call this diagram B. This latter curve will be the same for all sizes of wires for the particular span selected. The scales for stress intensity and excess length must be the same in the two diagrams. Make a tracing of the straight line diagram A. Two such diagrams for a span of 100 feet are shown in figures 1 and 2.

We now have all the necessary data for determining, for the given span and the various sizes of wire, the relation between excess length and temperature when there is no wind.

The actual procedure is then as follows :—

From the previously calculated table we find for any given size of wire the excess length of the unstressed wire at 50°F. We then superpose the tracing of diagram A on diagram B in such a way that, the axes of the two diagrams being parallel, the lowest (50°F) line of the A diagram intersects the axis of excess length of the B diagram at a point corresponding to the excess length of the given conductor when unstressed and at a temperature of 50°F. Then the intersections of the other straight lines with the curve of diagram B immediately determine the excess lengths at the various temperatures.

From the excess lengths (or corresponding stress intensities) the sags and tensions at the various temperatures and for the various sizes of conductors are easily calculated.

Each length of span requires its own diagrams A and B, but the same diagrams are used for all the different sizes of wire in a given span.

A few words of explanation may be desirable regarding a peculiarity noticeable in the curves and tables. It will be observed that as the size of the conductor increases the sag at first decreases. This is due to the fact that wind pressure becomes a smaller and smaller percentage of the total load per unit length of conductor as the size of the conductor increases, and if the tensile strength remained constant, the sag would steadily decrease with increasing size of the conductor. The curves, however, show that beyond a certain size the sag, after passing through a minimum value, begins to increase with increasing size of the conductor. This is due to the fact that beyond a certain limit the wind pressure load becomes relatively unimportant, while on the other hand with increasing size the tensile strength continues to decrease steadily. It is this decrease in the tensile strength that necessitates the use of a larger sag for the same factor of safety.

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TABLE I—Sags of wires in inches, in still air, for a span of 100 ft.

Temp, F°	Sizes of wires. S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	5·5	5·2	5·0	4·8	4·8	4·8	4·6	4·6	4·7	4·7	4·7	4·8	4·9	5·[illegible]
60°	6·2	5·8	5·6	5·4	5·3	5·3	5·2	5·2	5·3	5·3	5·3	5·4	5·5	5·7
70°	6·9	6·6	6·3	6·1	6·0	6·0	5·8	5·8	5·9	5·9	6·0	6·1	6·2	6·4
80°	7·9	7·5	7·2	6·9	6·8	6·8	6·6	6·6	6·7	6·7	6·8	6·9	7.0	7·3
90°	9·0	8·5	8·1	7·8	7·7	7·7	7.5	7·5	7·6	7·6	7·7	7·8	8·0	8·3
100°	10·3	9·6	9·3	8·9	8·8	8·8	8·6	8·6	8·7	8·7	8·8	8·9	9·2	9·4
110°	11·6	11·0	10·5	10·2	10·0	10·0	9·7	9·7	9·9	9·9	10·0	10·2	10·4	10·7
120°	12·8	12·3	11·8	11·5	11·3	11·3	11·0	11·0	11·1	11·1	11·4	11·5	11·8	12·0
130°	14·1	13·5	13·2	12·8	12·7	12·7	12·4	12·3	12·5	12·5	12·7	12·8	13·0	13·3

TABLE II.—Sags of wires in inches, in still air, for a span of 120 ft.

Temp. F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	9·1	8·6	8·0	7·6	7·5	7·3	7·3	7·1	7·1	7·1	7·2	7·2	7·3	7·5
60°	103	9·6	8·9	8·5	8·3	8·2	8·1	7·9	7·9	7·9	8·0	8·0	8·2	8·3
70°	11·6	10·9	10·1	9·5	9·3	9·1	9·0	8·8	8·8	8·8	8·9	8·9	9·1	9·3
80°	13·0	12·3	11·4	10·8	10·6	10·4	10·2	10·0	10·0	10·0	10·1	10·1	10·4	10·6
90°	14·4	13·7	12·7	12·1	11·9	11·7	11·5	11·3	11·3	11·3	11·4	11·4	11·7	11·9
100°	15·9	15·1	14·1	13·5	13·2	13·0	12·9	12·6	12·6	12·6	12·8	12·8	13·0	13·2
110°	17·5	16·6	15·6	14·9	14·7	14·4	14·3	14·0	14·0	14·0	14·2	14·2	14·4	14·7
120°	19·0	18·1	17·3	16·5	16·3	16·0	15·9	15·5	15·5	15·5	15·7	15·7	16·0	16·3
130°	20·5	19·6	18·6	18·1	17·8	17·5	17·2	17·0	17·0	17·0	17·3	17·3	17·5	17·8

TABLE III.—Sags of wires in inches, in still air, for a span of 140 ft.

Temp. F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	14·9	13·4	12·2	11·4	11·0	10·8	10·3	10·1	10·1	10·0	10·0	10·1	10.2	10·4
60°	16·5	14·8	13 6	12·6	12 2	12·0	11·4	11 2	11·2	11·1	11·1	11·2	11·3	11·5
70°	18·3	16·5	15·1	14·1	13·7	13·3	12·7	12·5	12·5	12·3	12·3	12·5	12·5	12·8
80°	19.9	18·1	16·6	15·6	15·1	14·8	14·1	13·8	13·8	13·7	13·7	13·8	13·9	14·2
90°	21·6	19·8	18·3	17 2	16 7	16·4	15·6	15·4	15·4	15·2	15·2	15·4	15·4	15·8
100°	23·3	21·4	20·0	18·8	18·3	18·0	17·2	16·9	16·9	16·7	16·7	16·9	17·0	17·3
110°	25·2	23·2	21·8	20·6	20·1	19·7	18·9	18·6	18·6	18·4	18·4	18·6	18·7	19·1
120°	26·6	25·0	23·4	22·2	21·8	21·3	20·6	20·3	20·3	20·0	20·0	20 3	20·4	20·8
130°	28·1	26·6	25·2	24·0	23·5	23·1	22·3	22·0	22·0	21·7	21·7	22·0	22·1	22·5

TABLE IV.—Sags of wires in inches, in still air, for a span of 160 ft.

	Sizes of wires, S. W. G.													
Temp. F°	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	22·3	19·9	17·8	16·3	15·5	15·0	14·3	13·8	13·7	13 6	13·4	13·4	13·7	13·8
60°	24·3	21·5	19 6	17·9	17·1	16 6	15·7	15·3	15·1	15 0	14·8	14 8	15·1	15·3
70°	26·0	23·3	21·3	19·5	18·7	18·2	17·3	16.7	16·5	16·4	16·3	16·3	16·5	16·7
80°	28·1	25·3	23·1	21·3	20·6	19·9	18·9	18·4	18·2	18·1	17·9	17 9	18·2	18·4
90°	29·3	27·0	25·1	23·1	22·2	21·7	20·7	20·1	19·9	19·8	19·6	19·6	19·9	20·1
100°	31·0	28·5	26·9	25·1	24 2	23·5	22 4	21·8	21·7	21·5	21·4	21·4	21·7	21·8
110°	32·4	30·2	28·5	26·7	26·0	25·4	24·4	23·7	23·5	23·4	23·1	23·1	23·5	23·7
120°	34·0	31·8	30·0	28·5	27·4	27·0	26·2	25·6	25·4	25·2	25·1	25·1	25·4	25·6
130°	35·5	33·3	31·7	30·0	29·3	28·6	27·7	27·2	27·0	26·8	26·8	26·8	27·0	27·2

TABLE V.—Sags of wires in inches, in still air, for a span of 180 ft.

Temp. F°	Sizes of wires S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	31·6	28·0	25·3	22:6	21·4	20·6	19·3	18·7	18·5	18·1	17·9	17·9	18·0	18·2
60°	33·2	29·8	27·3	24·7	23·4	22·4	21·1	20·5	20·2	19·7	19·6	19·5	19·6	19 9
70°	35·4	31·8	29·2	26·8	25·4	24·5	22 8	22·4	22·0	21·6	21·4	21·3	21·5	2 17
80°	37·2	33·6	31·0	28·8	27·5	26·4	24·9	24·3	24·0	23·5	23·4	23·4	23·4	23·6
90°	39 0	35·4	32·8	30·6	29·3	28·4	27 0	26·2	26·0	25 4	25·3	25·2	25·4	25·6
100°	40·8	37·4	34·7	32·3	31·0	30·2	28·8	28·3	27·9	27·5	27·3	27·2	27·4	27·6
110°	42·6	39·4	36·6	34·2	32·7	31·8	30·7	30·3	29·9	29·3	29·1	29 1	29·2	29·5
120°	43·6	41 1	38·5	36·1	34·7	34 0	32·3	31·8	31·5	31·1	30·9	30·8	31·0	31·3
130°	45·7	42·7	40·3	38·2	36·6	35·8	34·2	33·5	33·5	32·8	32 5	32·4	32·8	33·0

TABLE VI—Sags of wires in inches, in still air, for a span of 200 ft.

Temp. F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	42·5	37·3	33·2	30·3	28·4	26·8	25 2	24·2	23·6	23·2	22·8	22·5	22·5	22·8
60°	45·0	39·4	35·7	32·4	30·5	29·1	27·3	26·3	25·8	25·2	24·8	24·6	24·6	24·8
70°	47·4	41·8	37·9	34·6	32·6	31·5	29·2	28·5	27·7	27·2	27·0	26·7	26 7	27·0
80°	49·3	44·3	39·8	36·8	34·8	33·7	31·5	30·4	29 9	29·3	28·9	28·7	28·7	29·1
90°	51·2	46·5	42·0	38·9	37·2	35·9	33 5	32·7	32·1	31·4	31·0	30·8	30·8	31·0
100°	52·4	48·5	44·4	41·4	39·1	38·1	35·8	35·1	34·0	33·7	33·1	32·9	32·9	33·5
110°	53·3	50·4	47·2	43·7	41·4	40·2	38·1	37 2	36·5	35·8	35·2	34·9	34·9	35·6
120°	54·8	52·2	48·9	45·8	44·0	42·5	40·3	39·2	38·6	37·9	37·3	37·1	37·1	37·8
130°	56·1	52·9	50·5	48·3	46·2	44·8	42 5	41·3	40·6	40·2	39·7	39·2	39·2	39·9

TABLE VII.—Tensions of wires, in pounds, in still air, for a span of 100 ft.

Temp. F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	137	182	232	292	352	430	529	623	735	863	1000	1150	1280	1450
60°	121	161	208	260	314	383	473	555	659	772	895	1020	1140	1280
70°	107	142	185	231	279	340	419	494	588	688	794	904	1010	1140
80°	94·0	126	163	204	246	300	370	437	517	606	700	800	892	1000
90°	82·8	111	143	180	217	265	327	385	455	534	618	704	784	880
100°	72·1	98·0	125	158	190	231	286	337	398	466	540	616	685	770
110°	64·4	86·0	111	138	167	204	251	295	351	411	475	540	604	679
120°	58·0	76·9	98·6	123	148	180	222	262	311	364	420	480	533	606
130°	52·6	69·5	88·5	110	136	163	199	234	279	326	379	431	484	543

TABLE VIII.—Tensions of wires, in pounds, in still air, for a span of 120 ft.

Temp. F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	117	157	210	266	324	401	485	586	705	882	956	1100	1230	1410
60°	104	141	187	238	290	360	435	526	631	736	858	1000	1110	1260
70°	92·3	125	166	213	259	322	390	471	563	668	768	887	989	1120
80°	82·4	111	147	187	229	284	344	418	502	594	680	785	875	991
90°	74·3	99 2	132	167	202	252	306	369	443	524	600	693	776	880
100°	67·3	90·0	118	150	183	226	274	331	397	470	537	620	695	792
110°	61·4	81·8	107	136	164	204	246	296	356	420	484	559	628	711
120°	56·6	74·9	97·0	123	148	184	222	268	322	381	437	504	565	641
130°	52 4	69·2	90·0	112	136	168	203	244	294	347	396	457	518	589

TABLE IX.—Tensions of wires, in pounds, in still air, for a span of 140 ft.

Temp F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	97·2	139	186	243	299	372	467	553	671	800	988	1070	1210	1380
60°	88·0	126	168	218	269	335	422	504	605	721	892	961	1090	1240
70°	79·8	113	150	195	240	300	378	454	545	647	800	865	979	1130
80°	73·4	103	137	176	217	271	340	408	490	584	721	778	880	1010
90°	67·4	93·9	124	160	197	245	306	367	441	524	647	700	794	905
100°	62·4	83·8	114	147	180	223	279	334	400	477	590	636	720	823
110°	57·9	80·0	105	134	163	203	254	303	364	432	534	579	656	748
120°	54·7	74·5	97·0	124	151	188	232	278	334	395	490	531	604	686
130°	51·8	70·0	90·5	115	140	173	215	257	308	366	454	490	558	635

TABLE X.—Tensions of wires, in pounds, in still air, for a span of 160 ft.

Temp. F°	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
	Sizes of wires, S. W. G.													
50°	85·5	122	167	222	276	348	438	549	647	771	903	1040	1170	1340
60°	78·5	112	152	202	251	316	399	497	589	700	823	950	1070	1220
70°	73·4	104	140	185	229	288	363	445	536	638	749	865	973	1110
80°	67·8	95·5	129	169	208	263	331	414	488	580	681	787	885	1010
90°	65·0	89·5	119	156	193	241	303	379	445	529	623	720	809	926
100°	61·5	84·6	111	144	177	222	279	348	409	487	570	658	743	850
110°	58·8	79·8	105	135	165	206	257	321	377	448	528	609	685	782
120°	56·1	75·7	99·0	127	157	194	239	297	349	415	485	560	634	726
130°	53·7	72·4	94·0	120	146	183	226	280	328	389	455	526	595	684

TABLE XI.—Tensions of wires, in pounds, in still air, for a span of 180 ft.

	Sizes of wires, S. W. G.													
Temp. F°	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	76·4	109	149	202	253	322	410	499	610	735	865	1000	1140	1300
60°	72·7	103	138	185	232	295	376	456	559	672	792	915	1040	1180
70°	68·2	96·2	129	170	214	270	346	417	512	615	725	838	948	1090
80°	64·9	91·1	122	159	198	251	319	385	470	565	664	767	870	998
90°	61·8	86·3	115	149	185	233	294	357	434	522	613	709	805	922
100°	59 2	81·7	109	142	175	219	275	330	404	482	567	655	744	854
110°	56·6	77·6	103	134	166	208	258	309	377	453	531	613	698	800
120°	55·3	74·1	97·8	127	156	194	245	294	358	428	501	578	659	754
130°	52·8	71·6	93·6	120	148	185	232	279	338	405	477	550	624	716

TABLE XII.—Tensions of wires, in pounds, in still air, for a span of 200 ft.

Temp F°	Sizes of wires, S. W. G.													
	10	9	8	7	6	5	4	3	2	1	0	2/0	3/0	4/0
50°	70·1	101	140	186	236	302	389	476	586	707	838	976	1110	1270
60°	66·2	95·8	130	174	220	281	359	439	538	650	769	894	1020	1170
70°	62·8	90·3	123	163	205	260	334	405	501	600	709	822	940	1080
80°	60·5	85·0	117	153	193	243	311	379	464	559	661	765	875	1000
90°	58·2	81·1	111	145	180	228	292	353	432	521	615	714	815	928
100°	56·9	77·8	105	136	171	215	273	329	407	485	576	668	765	869
110°	55·9	74·9	98·6	129	162	203	257	311	380	456	542	630	720	816
120°	54·4	72·3	95·3	123	152	192	243	294	359	431	511	593	678	769
130°	53·0	71·3	92·2	117	145	183	230	280	341	407	480	561	642	729

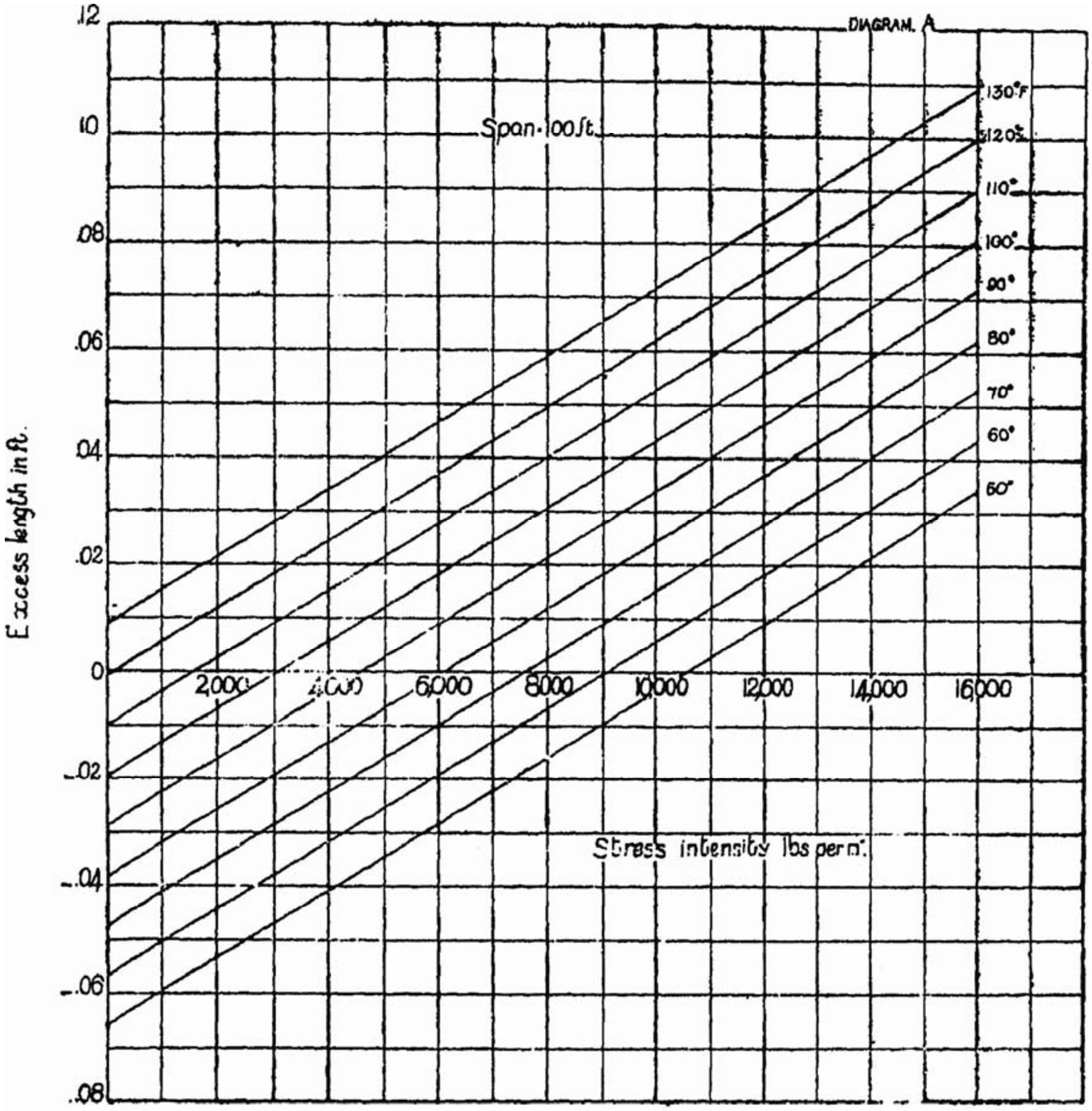


Fig. I.

Relation connecting stress intensity with excess length for various temperatures.

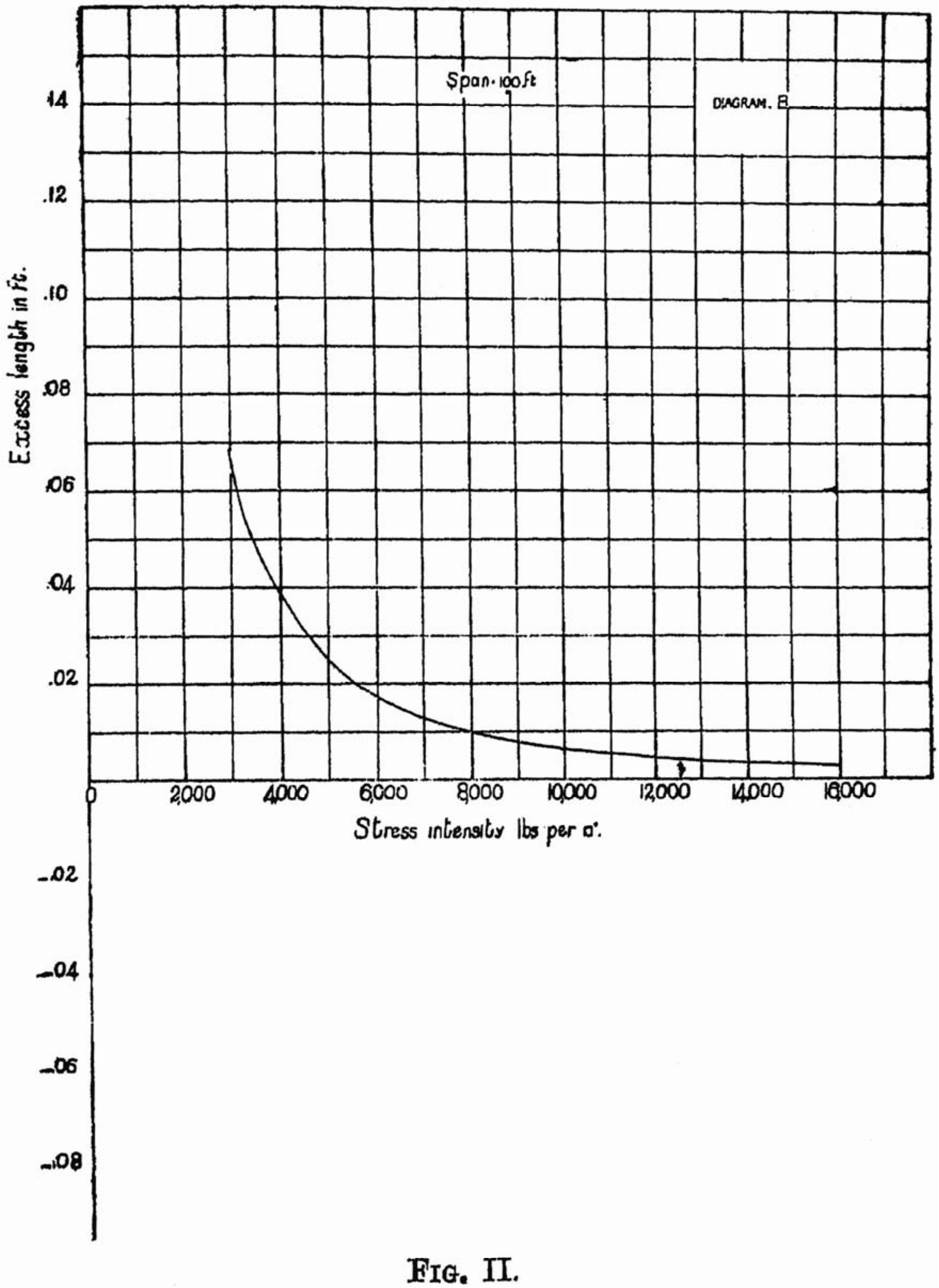
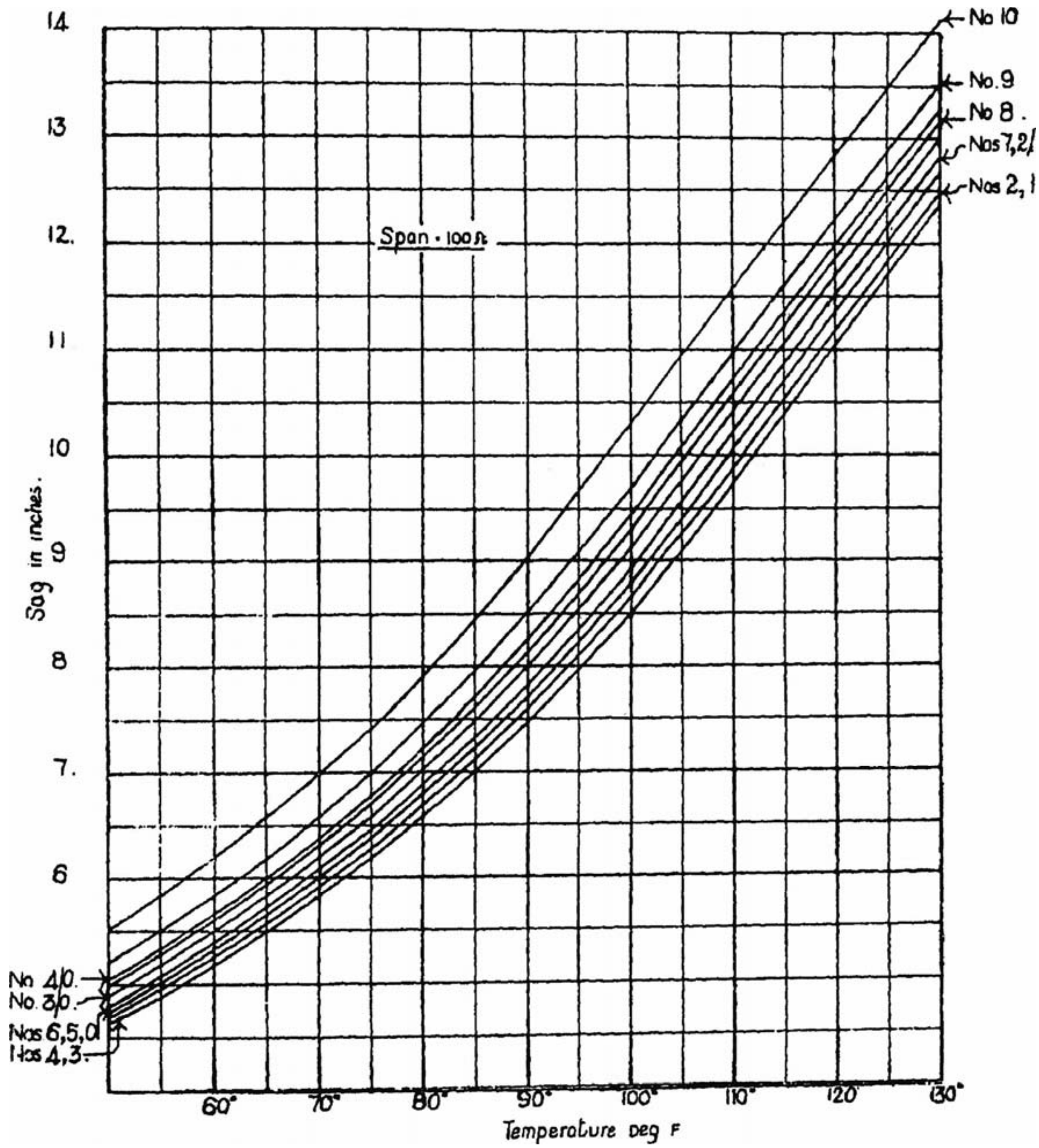
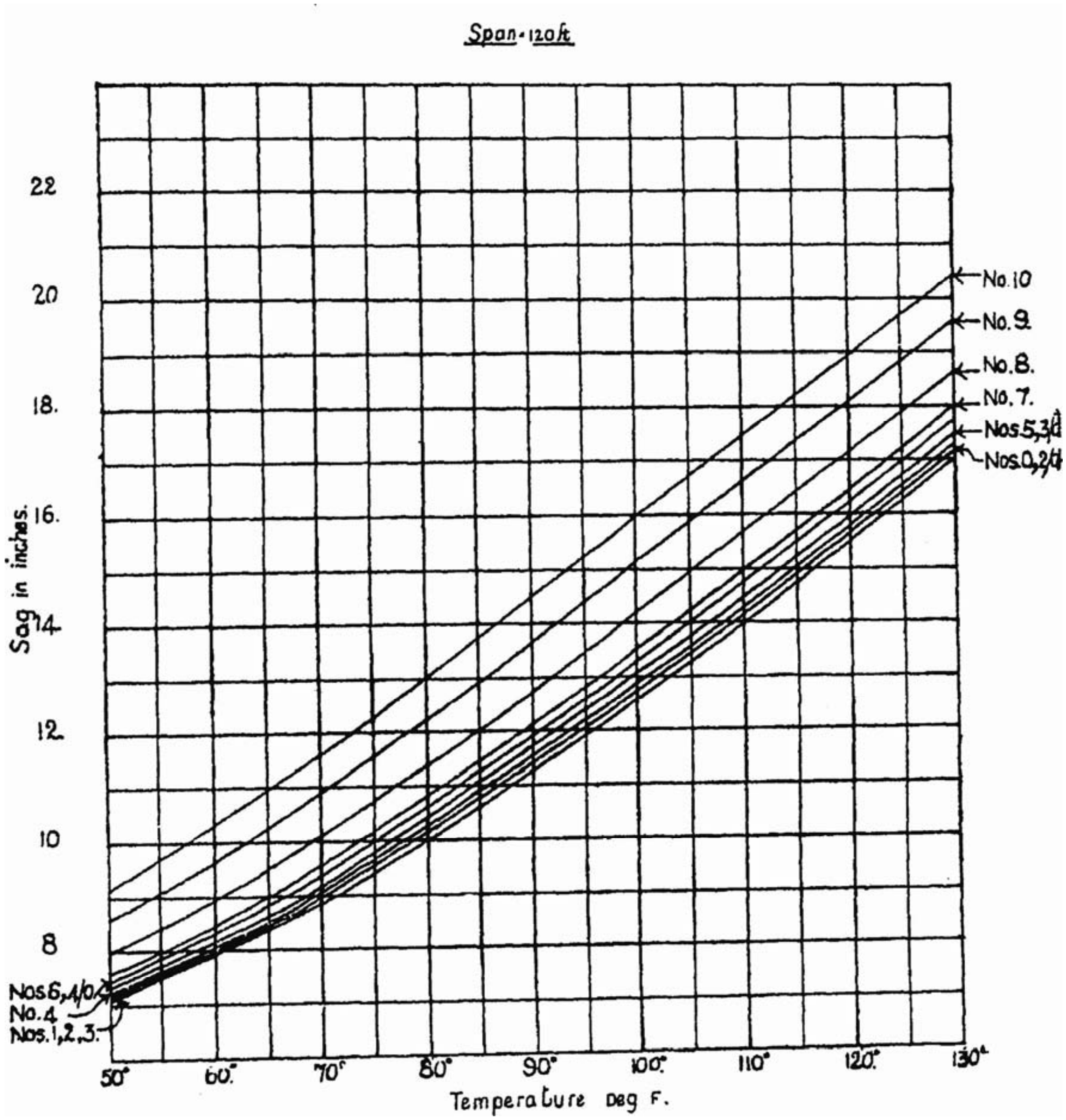


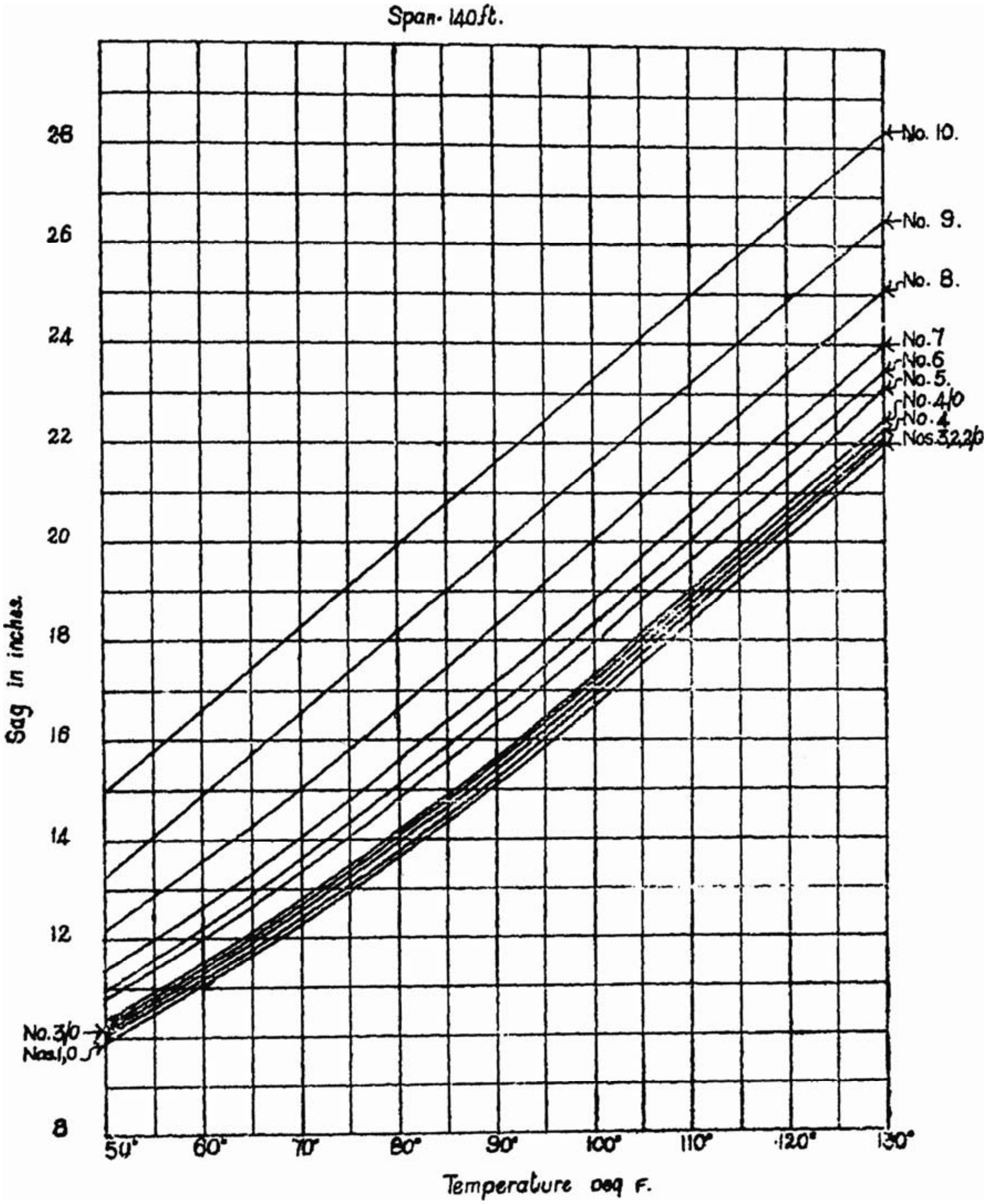
FIG. II.

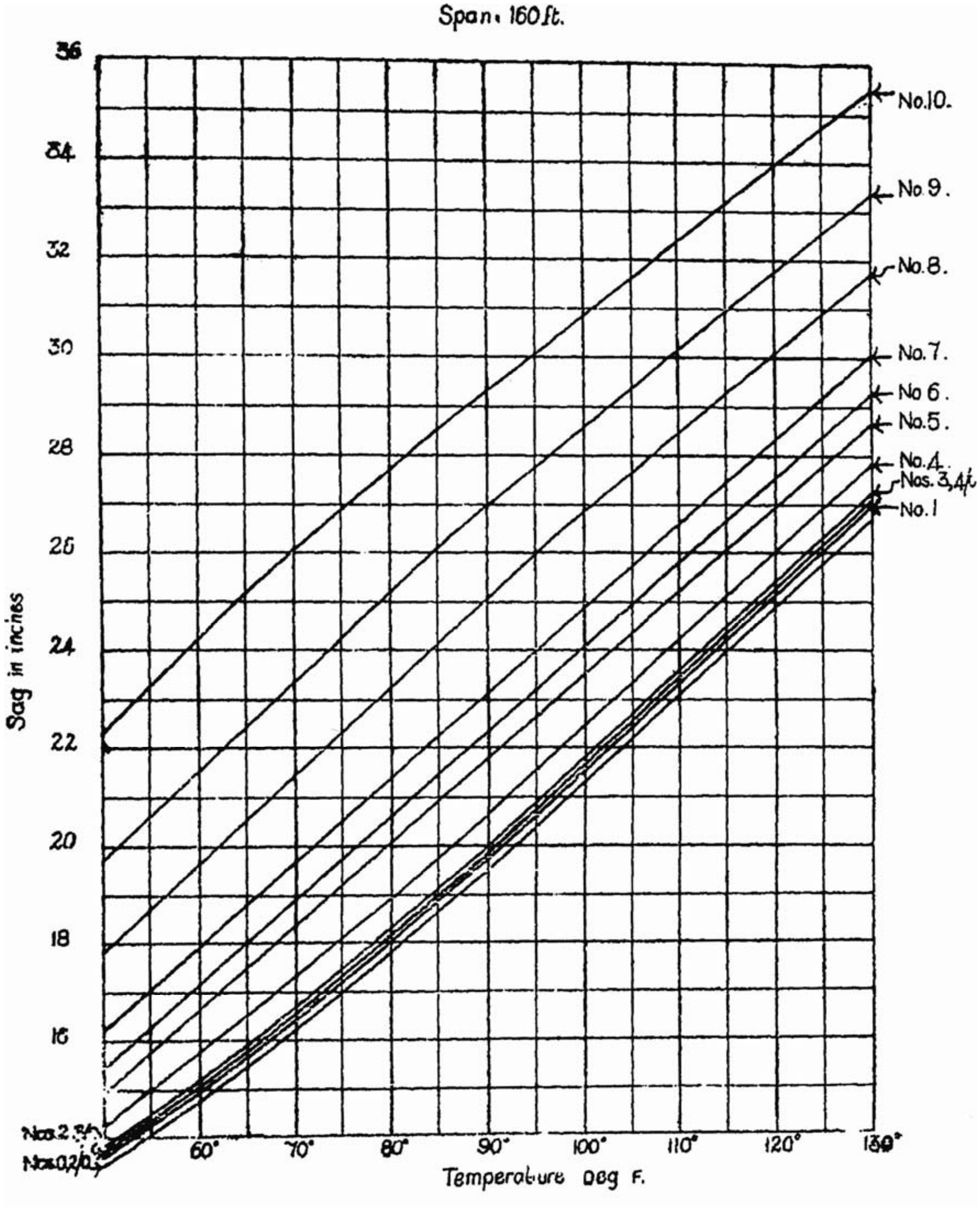
Relation connecting stress intensity with excess length for a span of 100 ft.

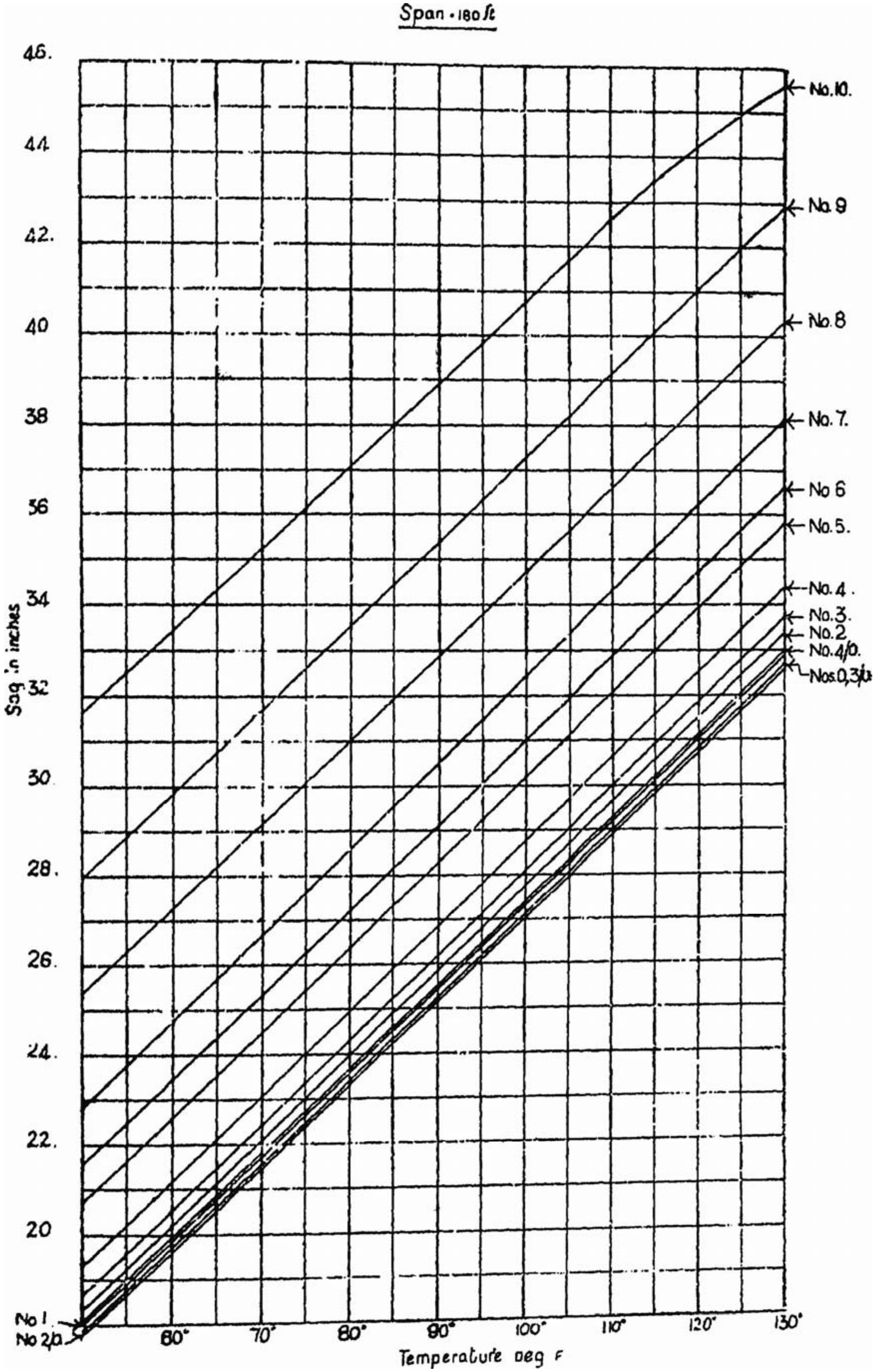


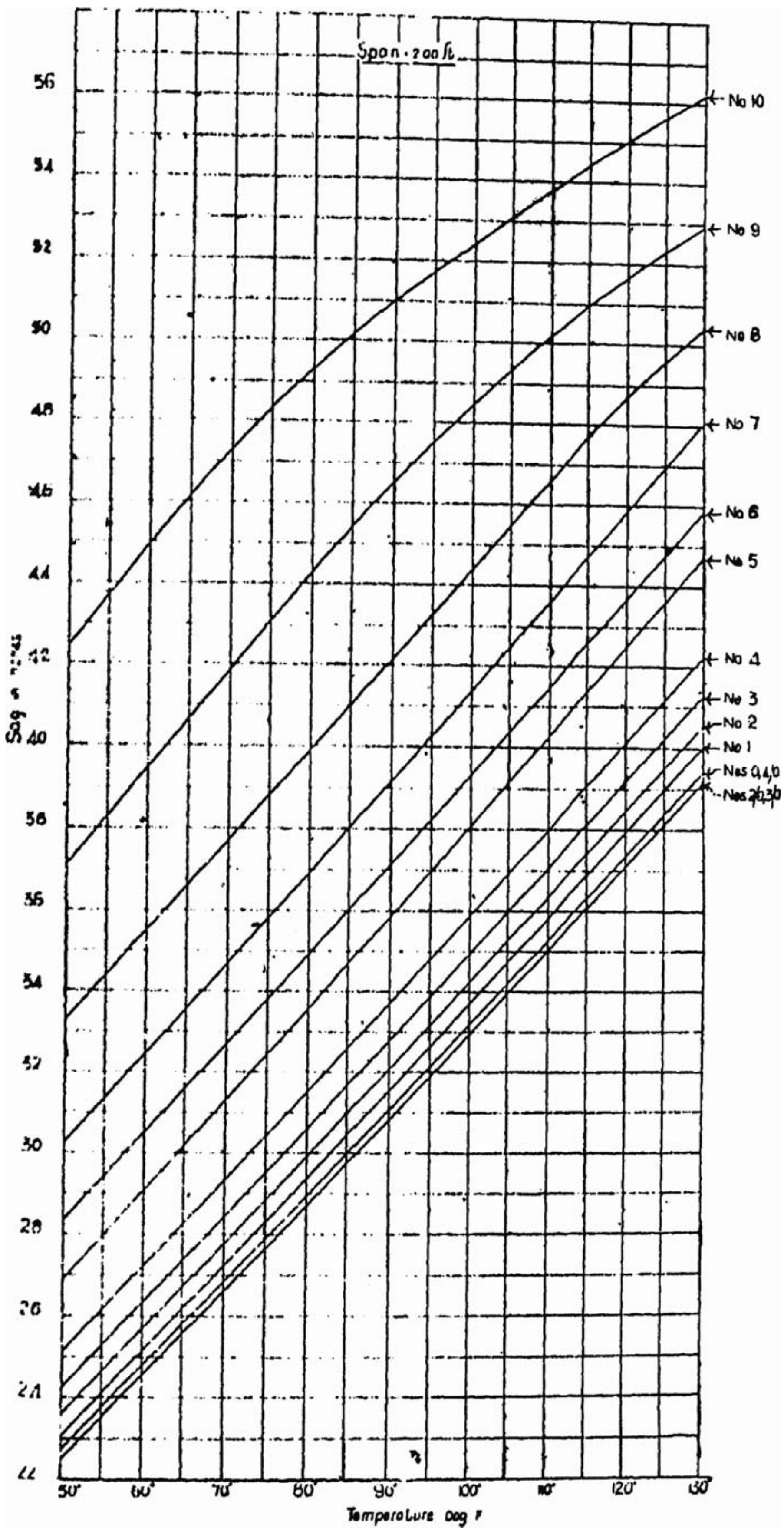
14
13
12.
11
10
9
8
7.
6
Sag in inches.
Span · 100 ft
No 10
No. 9
No 8 .
Nos 7,2/
Nos 2, 1
No 4/0.
No. 3/0.
Nos 6,5,0
Nos 4,3.
60°
70°
80°
90°
100°
110°
120
130°
Temperature deg F


Span-120ft
22
20
18.
16.
14
12
10
8
Sag in inches.
No.10
No.9
No.8.
No.7.
Nos 5,3/0
Nos 0,2/0
Nos 6,4/0
No.4
Nos.1,2,3.
50°
60°
70°
80°
90°
100°
110°
120°
130°
Temperature Deg F.

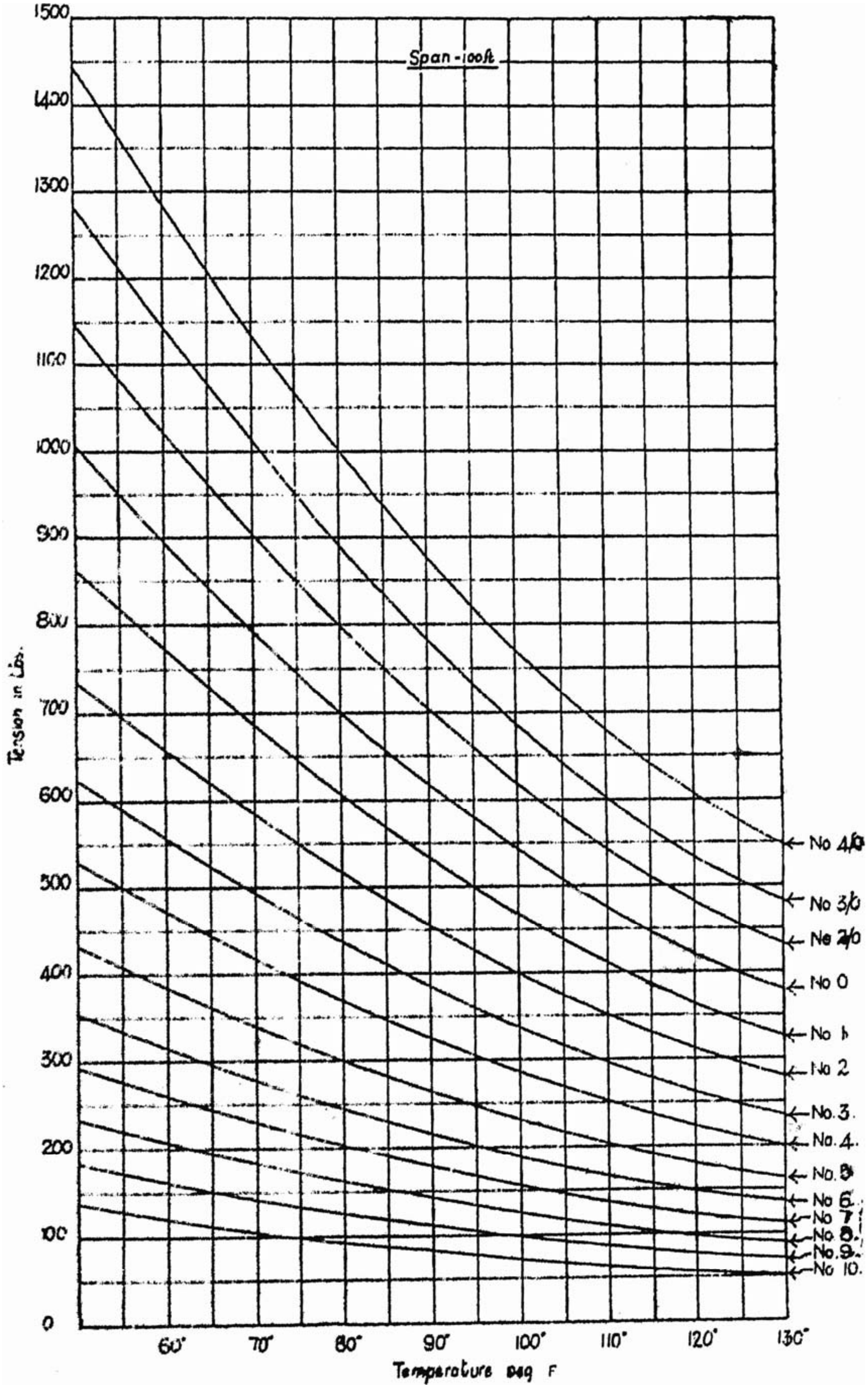

Span- 140ft.
28
26
24
22
20
18
16
14
12
8
Sag in inches
No. 10.
No. 9.
No. 8.
No.7
No.6
No.5.
No.4/0
No.4
Nos.3,2,2/0
No.3/0
Nos.1,0
50°
60°
70°
80°
90°
100°
110°
120°
130°
Temperature deg F.

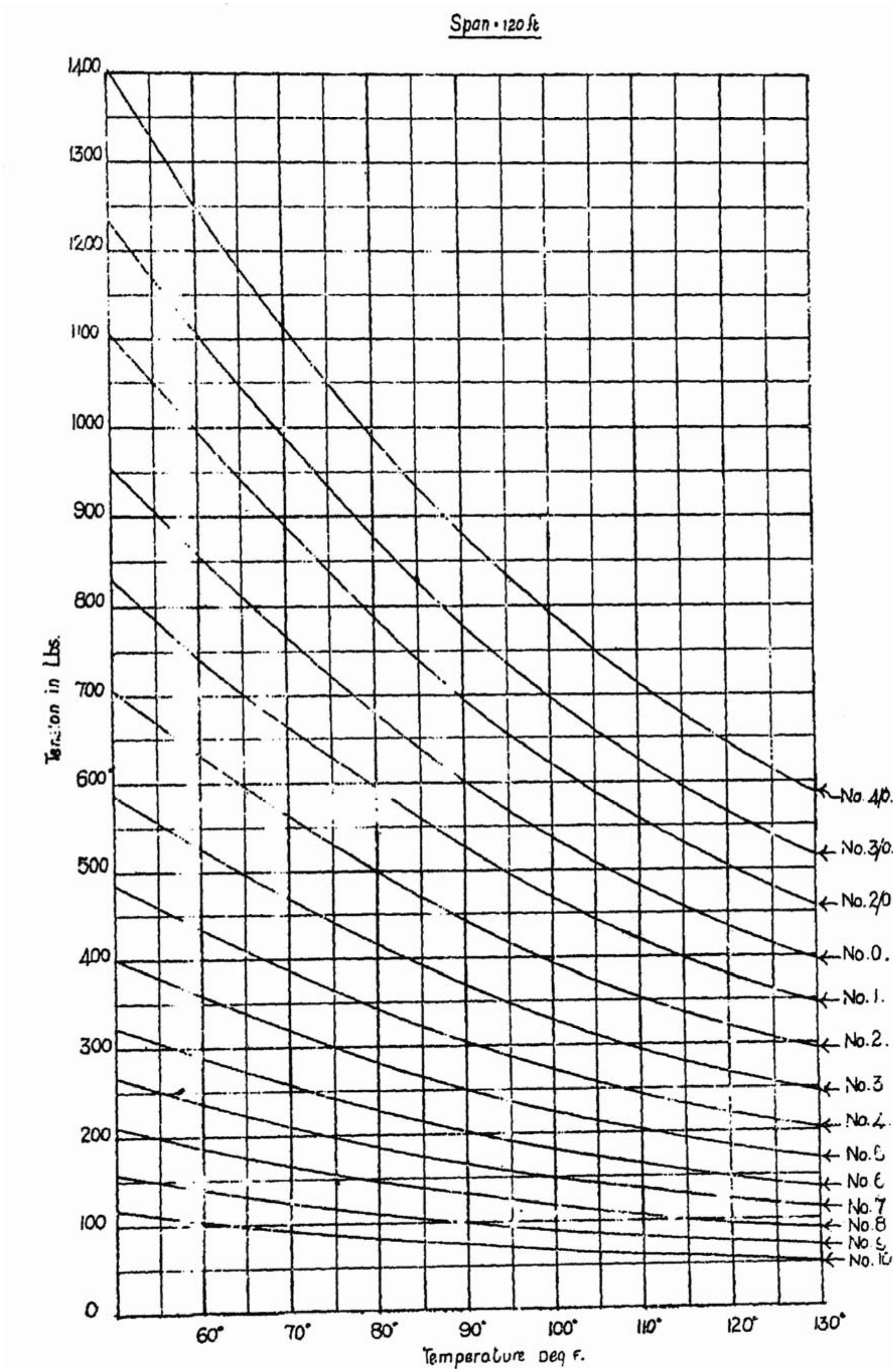

Span. 160 ft.
36
34
32
30
28
26
24
22
20
18
16
Sag in inches
No.10.
No. 9.
No. 8.
No. 7.
No 6.
No. 5.
No. 4.
Nos. 3, 4
No. 1
60°
70°
80°
90°
100°
110°
120°
130°
Temperature Deg F.

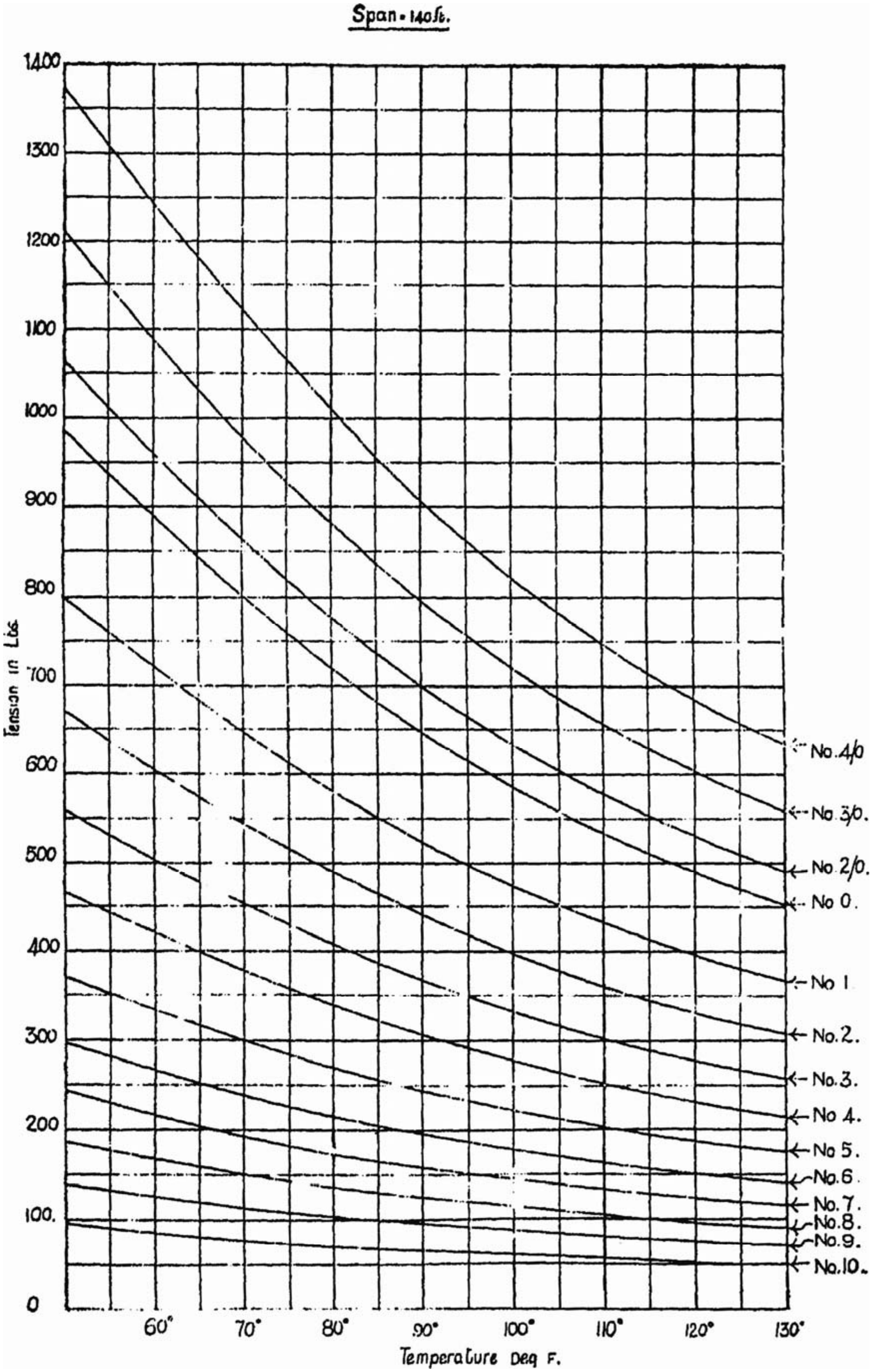

Span . 180 ft
Sag in inches
Temperature deg F
No. 10.
No. 9
No. 8
No. 7.
No 6
No. 5.
No. 4 .
No. 3.
No. 2
No. 4/0.
Nos 0, 3/0
No 1
No 2/0
46.
44
42.
40
38
36
34
32
30
28.
26.
24.
22.
20
60°
70°
80°
90°
100°
110°
120°
130°

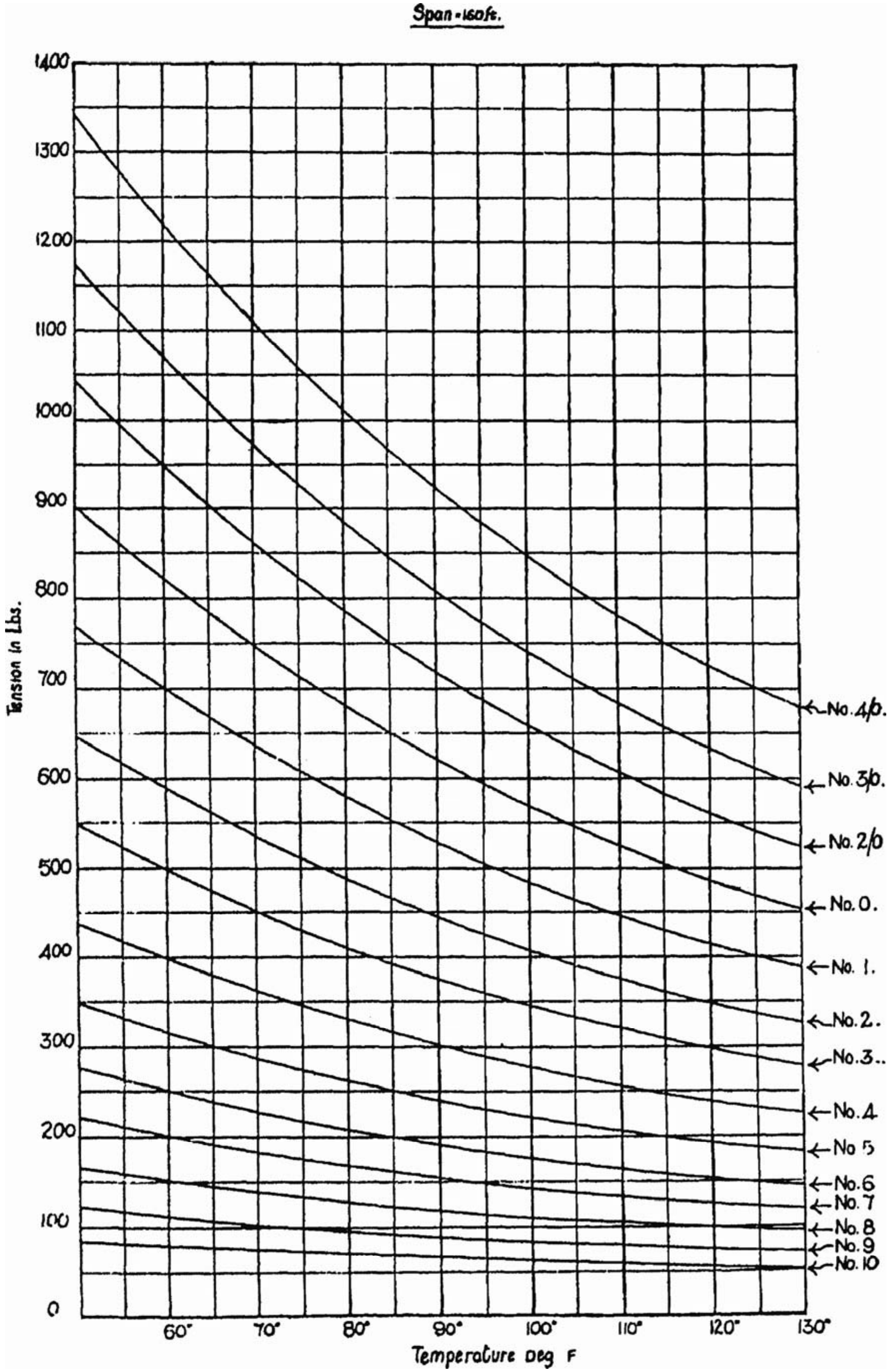


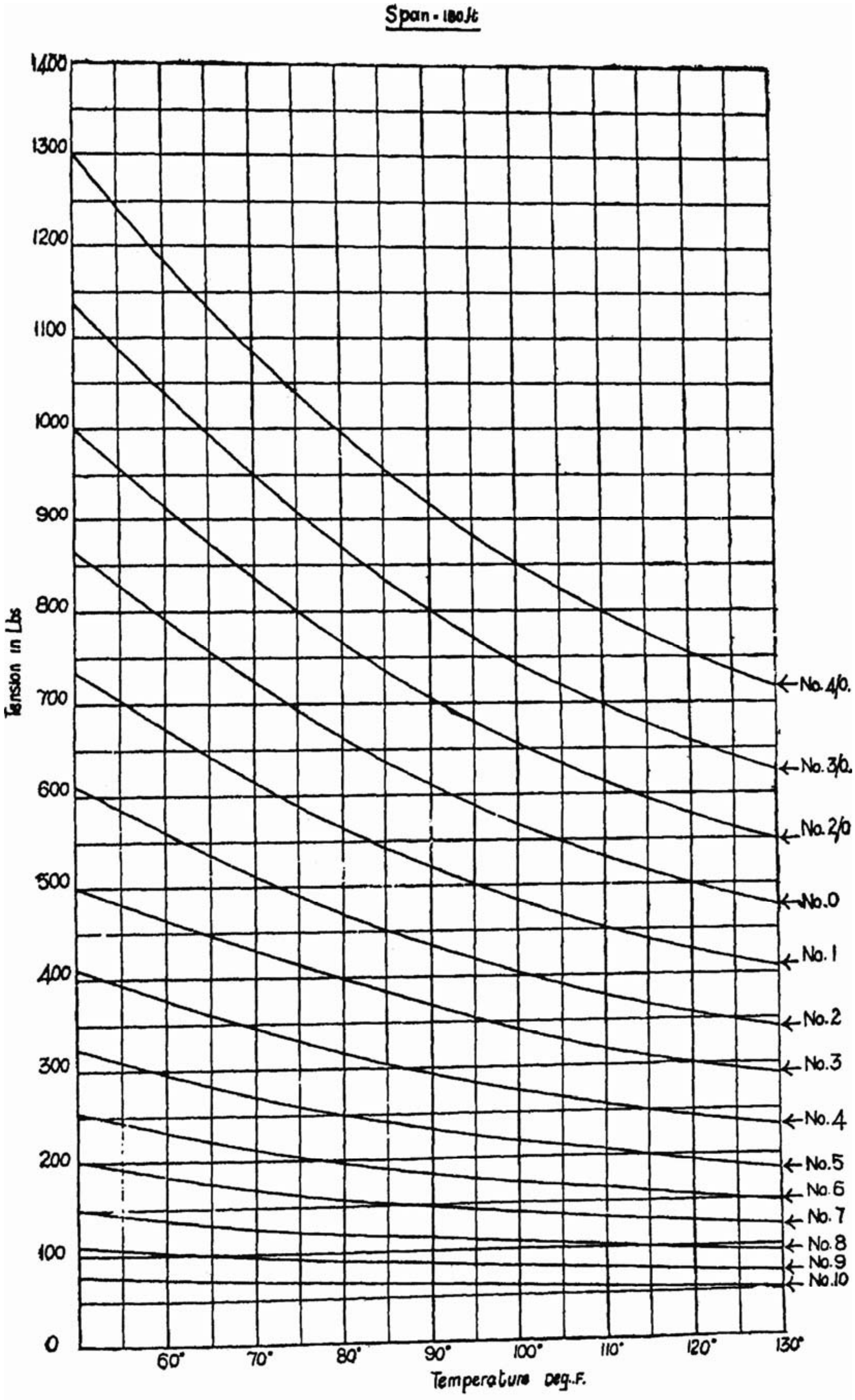
Span - 200 ft
No 10
No 9
No 8
No 7
No 6
No 5
No 4
No 3
No 2
No 1
Sag
Temperature deg F


Span - 100ft
Tension in Lbs.
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60°
70°
80°
90°
100°
110°
120°
130°
Temperature deg F
No 4/0
No 3/0
No 2/0
No 0
No 1
No 2
No. 3.
No. 4.
No. 5
No 6
No 7
No 8.
No. 9.
No 10.

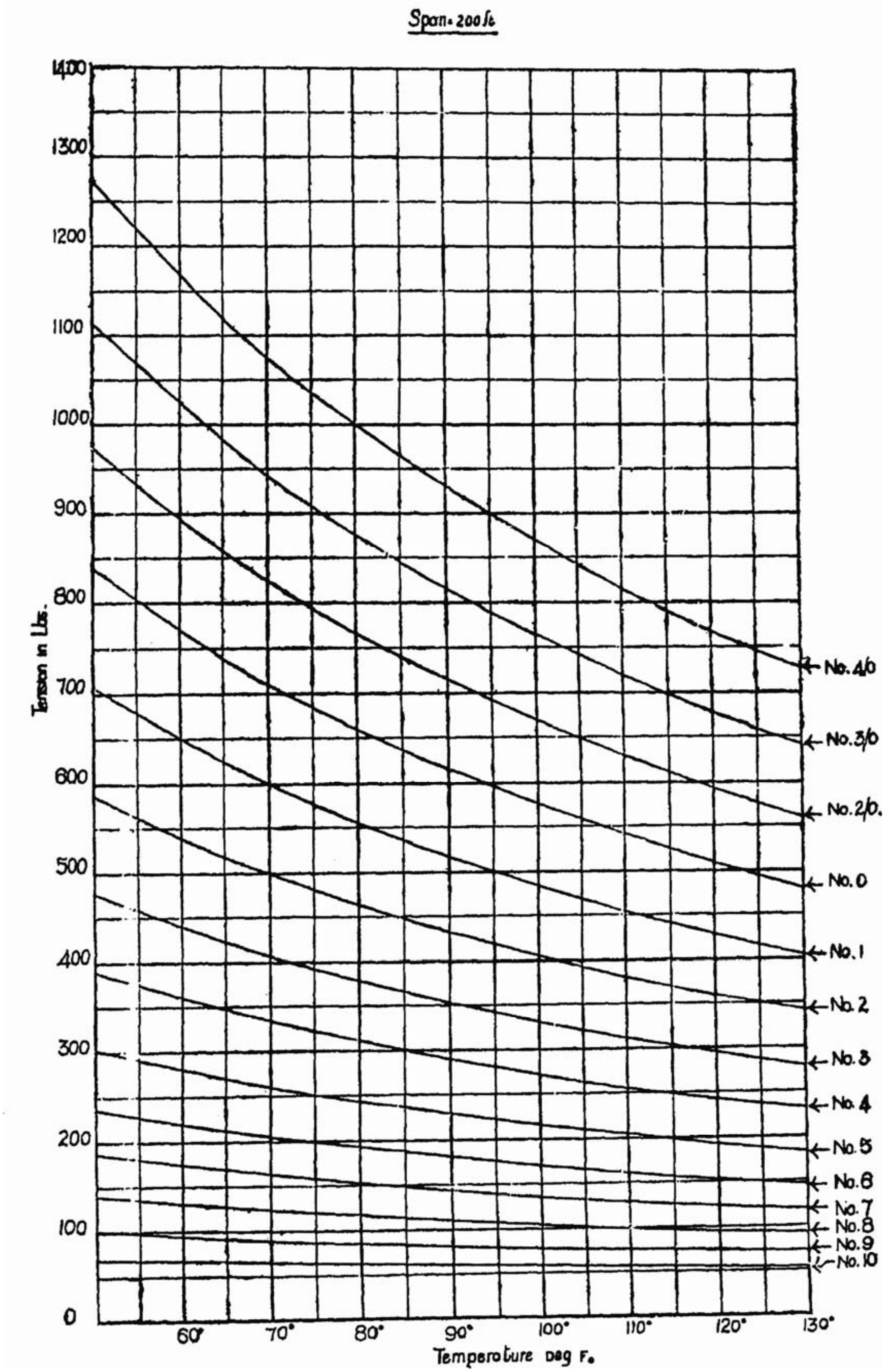

Span • 120 ft
Tension in Lbs.
Temperature Deg F.
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60°
70°
80°
90°
100°
110°
120°
130°
No. 4/0.
No. 3/0.
No. 2/0
No. 0.
No. 1.
No. 2.
No. 3
No. 4.
No. 5
No. 6
No. 7
No. 8
No. 9
No. 10


Span = 140 ft.
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100.
0
Tension in Lbs
60°
70°
80°
90°
100°
110°
120°
130°
Temperature Deg F.
No. 4/0
No. 3/0.
No. 2/0.
No 0.
No 1
No. 2.
No. 3.
No 4.
No 5.
No. 6.
No. 7.
No. 8.
No. 9.
No. 10.


Span = 160 ft.
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Tension in Lbs.
60°
70°
80°
90°
100°
110°
120°
130°
Temperature Deg F
No. 4/0.
No. 3/0.
No. 2/0
No. 0.
No. 1.
No. 2.
No. 3..
No. 4
No 5
No. 6
No. 7
No. 8
No. 9
No. 10



Span - 180 ft
Tension in Lbs
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60°
70°
80°
90°
100°
110°
120°
130°
Temperature deg. F.
No. 4/0.
No. 3/0.
No. 2/0
No. 0
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
No. 8
No. 9
No. 10


Span = 200 ft
Tension in Lbs.
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60°
70°
80°
90°
100°
110°
120°
130°
Temperature deg F.
No. 4/0
No. 3/0
No. 2/0.
No. 0
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
No. 8
No. 9
No. 10