TRANSMISSION CHARACTERISTICS OF

OPEN WIRE CIRCUITS

1. GENERAL

1.01 This addendum makes available Tables Nos. 46 through 59 to cover transmission information pertaining to WR copper-steel(30 per cent conductivity) wire and additional information regarding 080 copper-steel (40 per cent conductivity) wire. These tables should be attached according to page number to those now contained in Section 304-100-100.

1.02 The information contained in Issues 1, 2 and 3 of this addendum is incorporated in this issue without change except that Paragraph 4 has been changed so that Copper-Steel is redesignated Copper-Steel (40 per cent). The tables provided with Issue 3 are reissued and are unchanged except for the inclusion of the words,"(40 per cent conductivity)" in the title of Table No. 45. These tables, numbered 11, 12, 13, 28A, 28B, 42, 43, 44 and 45 should be inserted in the section by page number and the replaced tables destroyed.

2. CHARACTERISTICS OF 080 HARD DRAWN COPPER WIRE CIRCUITS

2.01 Tables 42 and 43 give, for 8-inch and 12-inch spaced conductors respectively, dry and wet weather attenuation, phase change, and impedance of 080 hard drawn copper side and phantom circuits on DP insulators over the frequency range from 100 to 30,000 cycles. The dry weather attenuation on CSA or CS insulators is the same as the dry weather attenuation for DP insulators shown on the table. The wet weather values for CSA or CS insulators may be obtained approximately by adding to the dry weather DP insulator values one-half of the difference between the dry and wet weather DP insulator values. The DC loop resistance per mile of the 080 copper circuits is 17.5 ohms for the side circuit and 8.8 ohms for the phantom.

3. CHARACTERISTICS OF 109 HIGH STRENGTH STEEL AND 134 STEEL WIRE CIRCUITS

3.01 Table 44 gives dry and wet weather attenuation, phase change, and impedance of 109 high strength steel and 134 steel wire side and phantom circuits over the range from 300 to 4000 cycles.

4. CHARACTERISTICS OF COPPER-STEEL CIRCUITS (40 PER CENT)

4.01 Table 45 gives dry and wet weather attenuation, phase change and impedance for the phantoms of 8- and 12-inch spaced 104, 128 and 165 copper-steel (40 per cent) conductors over the range from 200 to 4000 cycles.

4.02 The dry weather phase shift characteristics for the 6-inch spaced copper-steel pairs, which for all practical purposes may be used also for the other spacings, are shown in the table below. Other characteristics of copper-steel wire are given in the section.

Freq.	Phase Shift - Radians/Mi.		
	104 mil	128 mil	165 mil
200	.0134	.0115	.0098
500	.0238	.0215	.0195
1000	.0402	.0379	.0361
1500	.0566	.0552	.0532
2000	.0732	.0714	.0703
2500	.0900	.0884	.0874
3000	.107	.106	.105
4000	.141	.140	.139
5000	.175	.174	.173

Attached:
Tables 11, 12, 13, 28A, 28B,
42, 43, 44 and 45 dated October, 1948
and Tables 46 through 59 dated May, 1951.

TABLE NO. 11

DRY WEATHER ATTENUATION OF COPPER PAIRS

Calculated for hard-drawn copper at 68° F.
with 53 pairs of CS insulators per mile

Frequency Kilocycles Per Second	Attenuation - db per Mile								
	165 Mil Wire With Uniform Spacing of:			128 Mil Wire with Uniform Spacing of:			104 Mil Wire with Uniform Spacing of:		
	6"	8"	12"	6"	8"	12"	6"	8"	12"
.1	.0260	.0249	.023	.0351	.0338	.032	.0442	.0426	.041
.2	.0306	.0290	.027	.0436	.0417	.039	.0569	.0547	.052
.5	.0335	.0315	.029	.0510	.0483	.045	.0707	.0673	.063
1.0	.0347	.0326	.030	.0534	.0504	.047	.0759	.0718	.067
1.5	.0357	.0336	.031	.0543	.0512	.048	.0775	.0733	.068
2.0	.0370	.0348	.032	.0553	.0521	.048	.0786	.0741	.069
2.5	.0384	.0361	.033	.0561	.0530	.049	.0793	.0749	.070
3.0	.0399	.0377	.034	.0573	.0540	.050	.0802	.0758	.070
4.0	.0432	.0410	.038	.0599	.0567	.052	.0821	.0773	.072
5.0	.0473	.0445	.041	.0630	.0594	.055	.0843	.0797	.074
6.0	.0507	.0480	.044	.0666	.0632	.058	.0867	.0822	.076
9.0	.0610	.0575	.053	.0770	.0730	.067	.0956	.0906	.084
10.0	.0644	.0606	.056	.0805	.0760	.070	.0991	.0937	.087
11.0	.0673	.0633	.058	.0847	.0797	.073	.103	.0973	.090
14.0	.0747	.0705	.065	.0943	.0890	.082	.114	.107	.099
20.0	.0880	.0828	.076	.110	.1040	.096	.132	.125	.116
27.0	.101	.0951	.087	.126	.119	.110	.151	.144	.133
30.0	.106	.0999	.092	.132	.125	.116	.159	.151	.140
40.0	.122	.114	.106	.151	.142	.132	.181	.171	.159
50.0	.135	.127	.118	.167	.158	.147	.200	.189	.176
60.0	.148	.139	.129	.182	.172	.160	.218	.206	.192
70.0	.159	.150	.139	.196	.185	.172	.234	.221	.206
80.0	.170	.160	.148	.209	.197	.183	.249	.236	.219
90.0	.180	.170	.157	.221	.209	.194	.263	.249	.232
100.0	.189	.178	.165	.233	.220	.204	.277	.262	.244
110.0	.198	.187	.173	.244	.231	.214	.290	.274	.255
120.0	.207	.195	.181	.254	.241	.224	.302	.286	.266
130.0	.216	.203	.189	.265	.250	.233	.314	.297	.277
140.0	.224	.211	.196	.274	.259	.241	.325	.308	.287
150.0	.231	.218	.203	.283	.268	.249	.335	.317	.296
160.0	.239	.226	.209	.292	.276	.257	.345	.327	.305
170.0	.246	.233	.216	.301	.285	.265	.356	.337	.314
180.0	.253	.239	.222	.309	.293	.272	.366	.347	.323
190.0	.260	.246	.228	.318	.301	.280	.376	.356	.332
200.0	.267	.252	.234	.327	.309	.288	.386	.366	.341
300.0	.328	.310	.288	.400	.379	.353	.472	.447	.418
400.0	.380	.359	.335	.462	.438	.408	.544	.516	.483
500.0	.426	.404	.376	.518	.491	.458	.609	.578	.541
600.0	.469	.444	.414	.569	.540	.505	.668	.634	.594
700.0	.508	.481	.449	.615	.584	.546	.722	.686	.643
800.0	.544	.516	.482	.659	.626	.585	.773	.735	.688
900.0	.579	.549	.513	.701	.666	.623	.821	.781	.732
1000.0	.612	.581	.543	.740	.703	.658	.867	.824	.773

Notes:

1. These values may also be used for either Toll or DP insulators.
2. They may also be used, for practical purposes, for cases in which the number of pairs of insulation per mile is other than 53.

TABLE NO. 12

WET WEATHER ATTENUATION OF COPPER PAIRS

Calculated for hard-drawn copper at 68° F.
with 53 pairs of CS insulators per mile

Frequency Kilocycles Per Second	Attenuation - db per Mile								
	165 Mil Wire with Uniform Spacing of:			128 Mil Wire with Uniform Spacing of:			104 Mil Wire with Uniform Spacing of:		
	6"	8"	12"	6"	8"	12"	6"	8"	12"
.1	.0309	.0300	.0288	.0413	.0402	.0389	.0518	.0505	.0489
.2	.0349	.0345	.0318	.0489	.0472	.0451	.0632	.0612	.0587
.5	.0376	.0359	.0338	.0558	.0533	.0502	.0762	.0705	.0691
1.0	.0390	.0372	.0350	.0582	.0554	.0522	.0813	.0775	.0730
1.5	.0404	.0384	.0367	.0595	.0567	.0534	.0833	.0793	.0746
2.0	.0419	.0400	.0377	.0608	.0580	.0545	.0847	.0805	.0757
2.5	.0440	.0419	.0394	.0621	.0593	.0559	.0859	.0819	.0771
3.0	.0457	.0438	.0413	.0636	.0608	.0576	.0870	.0831	.0782
4.0	.0500	.0479	.0457	.0674	.0641	.0608	.0898	.0857	.0807
5.0	.0549	.0524	.0501	.0710	.0680	.0646	.0930	.0889	.0840
6.0	.0594	.0567	.0541	.0748	.0721	.0683	.0963	.0923	.0873
9.0	.0713	.0686	.0650	.0877	.0844	.0796	.108	.103	.0975
10.0	.0751	.0724	.0682	.0924	.0885	.0833	.112	.106	.101
11.0	.0787	.0757	.0714	.0967	.0929	.0874	.116	.110	.105
14.0	.0883	.0848	.0800	.108	.104	.0978	.129	.122	.116
20.0	.105	.101	.0953	.128	.123	.116	.151	.144	.137
27.0	.122	.117	.111	.148	.142	.135	.175	.167	.159
30.0	.129	.124	.118	.156	.150	.142	.185	.176	.168
40.0	.149	.144	.137	.181	.174	.165	.213	.203	.194
50.0	.168	.162	.154	.202	.195	.185	.237	.227	.217
60.0	.185	.179	.171	.222	.214	.204	.260	.249	.238
70.0	.201	.194	.186	.241	.232	.222	.281	.270	.258
80.0	.216	.209	.201	.258	.250	.238	.301	.289	.277
90.0	.231	.224	.215	.275	.266	.255	.320	.308	.295
100.0	.245	.237	.228	.292	.283	.271	.339	.326	.313
110.0	.258	.250	.241	.307	.297	.285	.356	.343	.329
120.0	.270	.263	.253	.322	.312	.299	.373	.359	.345
130.0	.283	.275	.265	.336	.326	.313	.389	.375	.361
140.0	.295	.287	.277	.350	.340	.327	.405	.390	.376
150.0	.307	.299	.288	.364	.353	.339	.419	.405	.390
160.0	.318	.310	.300	.377	.366	.354	.434	.421	.406
170.0	.330	.321	.311	.390	.378	.366	.449	.435	.420
180.0	.341	.332	.322	.402	.391	.378	.463	.450	.434
190.0	.352	.343	.333	.415	.404	.391	.478	.464	.448
200.0	.361	.352	.342	.426	.415	.402	.491	.477	.460
300.0	.460	.451	.440	.540	.528	.514	.620	.603	.586
400.0	.542	.532	.521	.635	.621	.606	.725	.708	.688
500.0	.618	.608	.597	.722	.708	.692	.823	.805	.784
600.0	.690	.679	.668	.804	.789	.774	.914	.895	.874
700.0	.757	.746	.736	.880	.864	.849	1.000	.980	.958
800.0	.823	.812	.902	.954	.939	.924	1.083	1.063	1.041
900.0	.886	.876	.867	1.027	1.012	.997	1.164	1.143	1.121
1000.0	.946	.937	.928	1.095	1.079	1.065	1.239	1.218	1.197

Notes:

1. When Toll or DP insulators are involved the above losses should be corrected by adding the differential loss given in Table 13.
2. When the number of pairs of CS insulators per mile is other than 53, add to the above losses (algebraically) the quantity $D[\frac{n}{53} - 1]$ where D is the differential loss given in Table 13 and n is the number of pairs of insulators. In the case of Toll or DP insulators add $D(\frac{2n}{53} - 1)$

Revised October, 1948

TABLE NO. 13

WET AND DRY WEATHER ATTENUATION DIFFERENCES

Calculated for open wire pairs of hard-drawn copper with uniform spacing and 53 pairs of CS insulators per mile

Frequency Kilocycles Per Second	Difference Between Wet and Dry Weather Conditions Attenuation - db per Mile								
	165 Mil Wire with Uniform Spacing of:			128 Mil Wire with Uniform Spacing of:			104 Mil Wire with Uniform Spacing of:		
	6"	8"	12"	6"	8"	12"	6"	8"	12"
10	.011	.012	.013	Use values for 165 mil wire on 8" spacing	Use values for 165 mil wire on 12" spacing	.013	Use values for 165 mil wire on 12" spacing	.013	.014
20	.017	.017	.019			.020		.019	.021
30	.023	.024	.025			.027		.026	.028
40	.027	.029	.031			.033		.032	.034
50	.033	.034	.036			.039		.037	.040
60	.038	.039	.042			.044		.043	.046
70	.042	.044	.047			.050		.048	.052
80	.047	.049	.052			.055		.054	.057
90	.051	.054	.057			.060		.059	.063
100	.055	.059	.062			.065		.064	.068
110	.060	.063	.066			.070		.069	.073
120	.064	.068	.071			.075		.074	.079
130	.068	.072	.076			.080		.079	.084
140	.072	.077	.081			.085		.083	.089
150	.076	.081	.085			.090		.088	.094
160	.079	.084	.091			.097		.094	.101
170	.084	.088	.095			.101		.098	.106
180	.088	.093	.100			.106		.103	.111
190	.092	.097	.105			.111		.108	.116
200	.094	.100	.108			.114		.111	.119
300	.132	.141	.152			.161		.156	.168
400	.162	.173	.186			.198		.192	.205
500	.192	.204	.221			.234		.227	.243
600	.221	.235	.254			.269		.261	.280
700	.249	.265	.287			.303		.294	.315
800	.279	.296	.320			.339		.328	.353
900	.307	.327	.354			.374		.362	.389
1000	.334	.356	.385			.407		.394	.424

Notes:

1. The attenuation change from dry to wet weather for either Toll or DP insulators is about twice that for CS insulators.
2. For other than 53 pairs of insulators per mile reduce (or increase) the above differential losses proportionally.

TABLE NO. 28A

B COPPER - STEEL TREE WIRE

TABLE I ATTENUATION AND PHASE CHANGE - 68°F

Freq. kc.	Attenuation - DB Per Mile: Size 080 with Uniform Spacing of: 6"	8"	12"	Size 104 with Uniform Spacing of: 6"	8"	12"	Phase Change - Radians Per Mile: Size 080 with Uniform Spacing of: 6"	8"	12"	Size 104 with Uniform Spacing of: 6"	8"	12"
	Dry Weather						Dry Weather					
1	0.269	0.257	0.243	0.185	0.175	0.164	0.049	0.048	0.047	0.044	0.043	0.042
6	.357	.337	.313	.226	.212	.196	0.232	0.231	0.229	0.228	0.226	0.224
9	.368	.347	.321	.232	.218	.202	0.345	0.343	0.340	0.340	0.337	0.335
11	.372	.351	.326	.235	.222	.205	0.420	0.418	0.415	0.414	0.412	0.408
14	.378	.357	.331	.239	.225	.208	0.533	0.530	0.526	0.526	0.523	0.519
27	.390	.369	.343	.252	.238	.221	1.02	1.02	1.01	1.01	1.00	1.00
80	.454	.435	.412	.323	.311	.296	3.02	3.01	2.99	2.99	2.97	2.95
140	.572	.556	.539	.456	.446	.436	5.29	5.26	5.23	5.23	5.20	5.17
	Wet Weather						Wet Weather					
1	0.277	0.265	0.251	0.190	0.181	0.170	0.050	0.049	0.047	0.044	0.043	0.042
6	.371	.352	.328	.237	.225	.210	0.234	0.233	0.231	0.230	0.228	0.226
9	.385	.365	.340	.247	.234	.219	0.348	0.346	0.344	0.343	0.341	0.338
11	.392	.372	.347	.253	.240	.225	0.424	0.422	0.419	0.418	0.415	0.412
14	.401	.381	.356	.259	.247	.232	0.538	0.535	0.531	0.530	0.527	0.524
27	.427	.408	.385	.286	.274	.260	1.03	1.03	1.02	1.02	1.01	1.00
80	.539	.524	.508	.404	.396	.388	3.05	3.03	3.01	3.01	3.00	2.98
140	.708	.700	.694	.585	.582	.580	5.33	5.31	5.28	5.28	5.25	5.22

TABLE NO. 28B

B COPPER - STEEL TREE WIRE

TABLE II. CHARACTERISTIC IMPEDANCE

Characteristic Impedance - Ohms

Freq. kc	Size 080 with Uniform Spacing of: 6"	8"	12"	Size 104 with Uniform Spacing of: 6"	8"	12"
	Dry Weather			Dry Weather		
1	710-j443	743-j452	789-j464	608-j293	641-j298	686-j304
6	558-j97	592-j98	639-j98	528-j59	562-j59	610-j59
9	552-j66	586-j67	634-j69	526-j40	560-j40	607-j40
11	550-j55	584-j55	632-j55	524-j33	558-j33	606-j33
14	548-j43	582-j43	630-j43	523-j26	557-j26	605-j26
27	546-j22	580-j22	628-j22	522-j13	556-j13	604-j13
80	544-j7	578-j7	626-j7	521-j4	555-j4	603-j4
140	544-j3	578-j3	626-j3	521-j2	555-j2	603-j1
	Wet Weather			Wet Weather		
1	705-j431	737-j439	781-j449	603-j284	635-j288	679-j293
6	553-j93	586-j94	633-j94	524-j56	557-j56	604-j56
9	547-j63	581-j63	628-j63	521-j37	554-j37	601-j37
11	545-j52	579-j52	626-j51	520-j30	553-j30	600-j30
14	543-j41	577-j41	624-j40	519-j23	552-j23	599-j23
27	541-j20	575-j20	622-j19	518-j11	551-j11	598-j11
80	539-j5	573-j5	620-j4	517-j3	550-j2	597-j2
140	539-j2	573-j1	620-j1	517-j1	550-j0	597-j0

TABLE 42

Characteristics of 080 Hard Drawn Copper

8" Spacing - DP Insulators - 68°F

Side Circuit

Freq. kc	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
.1	.056	.075	.0073	.0062	1350-j1186 = 1797/41.30°	1456-j780 = 1652/28.18°
.2	.075	.090	.0111	.0103	1017-j788 = 1287/37.77°	1062-j629 = 1234/30.63°
.5	.099	.111	.0209	.0207	766-j418 = 873/28.62°	770-j367 = 853/25.48°
1.0	.111	.123	.0372	.0375	683-j234 = 722/18.92°	678-j210 = 710/17.21°
1.5	.115	.127	.0541	.0547	662-j162 = 682/13.75°	657-j143 = 672/12.28°
2.0	.117	.130	.0712	.0719	653-j123 = 664/10.67°	647-j109 = 656/ 9.57°
2.5	.118	.132	.0884	.089	649-j99 = 657/ 8.67°	643-j87 = 649/ 7.70°
3.0	.119	.134	.106	.107	647-j83 = 652/ 7.32°	640-j72 = 644/ 6.42°
4.0	.120	.138	.140	.142	645-j63 = 648/ 5.58°	638-j54 = 640/ 4.83°
5.0	.122	.141	.175	.177	644-j51 = 646/ 4.53°	636-j43 = 637/ 3.87°
9.0	.129	.156	.314	.318	642-j29 = 643/ 2.58°	634-j23 = 634/ 2.08°
10.0	.131	.160	.349	.353	642-j27 = 643/ 2.41°	634-j21 = 634/ 1.90°
14.0	.142	.177	.489	.493	641-j21 = 641/ 1.87°	634-j15 = 634/ 1.35°
20.0	.161	.204	.697	.704	640-j17 = 640/ 1.52°	633-j12 = 633/ 1.08°
30.0	.190	.248	1.04	1.05	638-j13 = 638/ 1.17°	631-j9 = 631/ 0.82°

Phantom (Of Nonpole Pairs)

Freq. kc	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
.1	.046	.069	.0063	.0050	823-j689 = 1073/39.93°	878-j359 = 949/22.23°
.2	.060	.078	.0098	.0089	632-j446 = 774/35.22°	666-j314 = 736/25.25°
.5	.076	.091	.0193	.0191	503-j226 = 551/24.20°	504-j181 = 536/19.75°
1.0	.082	.097	.0358	.0362	465-j122 = 481/14.70°	459-j99 = 470/12.17°
1.5	.083	.100	.0527	.0536	457-j83 = 464/10.30°	449-j67 = 454/ 8.48°
2.0	.084	.103	.0698	.0711	453-j63 = 457/ 7.92°	445-j49 = 448/ 6.28°
2.5	.085	.105	.0869	.0886	452-j50 = 455/ 6.32°	443-j39 = 445/ 5.03°
3.0	.085	.107	.104	.106	451-j42 = 453/ 5.32°	442-j32 = 443/ 4.14°
4.0	.086	.111	.139	.141	450-j32 = 451/ 4.07°	441-j23 = 442/ 2.98°

TABLE 43

Characteristics of 080 Hard Drawn Copper

12" Spacing - DP Insulators - 68°F

Side Circuit

Freq. kc	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
.1	.054	.074	.0071	.0060	1406-j1224 = 1864/$\overline{41.04}$°	1510-j774 = 1697/$\overline{27.14}$°
.2	.072	.087	.0108	.0100	1064-j809 = 1337/$\overline{37.25}$°	1109-j632 = 1276/$\overline{29.68}$°
.5	.094	.107	.0205	.0204	812-j426 = 917/$\overline{27.68}$°	813-j368 = 892/$\overline{24.35}$°
1.0	.104	.117	.0369	.0373	729-j236 = 766/$\overline{17.93}$°	722-j208 = 751/$\overline{16.07}$°
1.5	.107	.120	.0538	.0544	708-j162 = 726/$\overline{12.88}$°	700-j143 = 714/$\overline{11.55}$°
2.0	.109	.123	.0710	.0718	700-j123 = 711/$\overline{9.97}$°	692-j107 = 700/$\overline{8.78}$°
2.5	.110	.125	.0882	.0892	696-j100 = 703/$\overline{8.18}$°	688-j86 = 693/$\overline{7.12}$°
3.0	.110	.127	.106	.107	694-j84 = 699/$\overline{6.90}$°	686-j71 = 690/$\overline{5.91}$°
4.0	.112	.131	.140	.142	692-j63 = 695/$\overline{5.20}$°	684-j53 = 686/$\overline{4.43}$°
5.0	.114	.134	.175	.177	691-j51 = 693/$\overline{4.22}$°	683-j42 = 684/$\overline{3.52}$°
10.0	.123	.153	.349	.354	689-j27 = 690/$\overline{2.25}$°	681-j20 = 681/$\overline{1.68}$°
20.0	.150	.197	.697	.705	687-j16 = 687/$\overline{1.33}$°	679-j11 = 679/$\overline{0.93}$°
30.0	.177	.240	1.04	1.05	685-j13 = 685/$\overline{1.08}$°	678-j8 = 678/$\overline{0.68}$°

Phantom (Of Nonpole Pairs)

Freq. kc	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
.1	.048	.059	.0065	.0058	792-j700 = 1057/$\overline{41.47}$°	849-j510 = 990/$\overline{31.00}$°
.2	.062	.071	.0100	.0096	607-j437 = 748/$\overline{35.75}$°	625-j374 = 728/$\overline{30.90}$°
.5	.080	.088	.0196	.0196	476-j223 = 526/$\overline{25.10}$°	474-j201 = 515/$\overline{22.98}$°
1.0	.087	.095	.0360	.0365	438-j121 = 454/$\overline{15.45}$°	432-j110 = 446/$\overline{14.28}$°
1.5	.089	.097	.0530	.0539	429-j81 = 437/$\overline{10.70}$°	422-j75 = 429/$\overline{10.08}$°
2.0	.090	.099	.0700	.0712	425-j62 = 429/$\overline{8.30}$°	418-j56 = 422/$\overline{7.63}$°
2.5	.090	.100	.0875	.0890	424-j50 = 427/$\overline{6.73}$°	416-j45 = 418/$\overline{6.17}$°
3.0	.091	.102	.105	.107	423-j42 = 425/$\overline{5.67}$°	415-j38 = 417/$\overline{5.23}$°
4.0	.092	.104	.139	.141	422-j32 = 423/$\overline{4.33}$°	414-j28 = 415/$\overline{3.87}$°

TABLE 44

Characteristics of 109 High Strength Steel and 134 Steel Wire

0.8 Oz. Zinc Coating - 12" Spacing - 68°F

DP Insulators

Freq. kc	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
109 Side Circuits						
.3	.181	.207	.028	.026	1754-j1314 = 2192/36.83°	1818-j1122 = 2136/31.68°
1.0	.289	.313	.067	.068	1279-j629 = 1425/26.18°	1274-j578 = 1399/24.40°
2.0	.407	.436	.121	.095	1142-j443 = 1225/21.20°	1130-j413 = 1203/20.08°
3.0	.528	.560	.167	.169	1054-j383 = 1121/19.97°	1042-j360 = 1102/19.07°
4.0	.623	.660	.212	.215	1004-j339 = 1060/18.65°	991-j320 = 1041/17.90°
109 Phantoms (Of Nonpole Pairs)						
.3	.166	.195	.026	.025	969-j713 = 1203/36.35°	1006-j588 = 1165/30.30°
1.0	.259	.286	.064	.065	721-j334 = 795/24.85°	717-j300 = 777/22.70°
2.0	.366	.396	.115	.116	642-j237 = 684/20.27°	635-j215 = 670/18.70°
3.0	.466	.502	.160	.162	598-j200 = 631/18.50°	589-j185 = 617/17.43°
4.0	.548	.588	.204	.207	572-j176 = 598/17.10°	563-j164 = 586/16.23°
134 Side Circuits						
.3	.136	.159	.026	.025	1563-j945 = 1826/31.17°	1599-j788 = 1783/26.23°
1.0	.250	.273	.069	.070	1252-j520 = 1356/22.55°	1245-j473 = 1332/20.80°
2.0	.389	.416	.120	.121	1084-j404 = 1157/20.43°	1073-j377 = 1137/19.36°
3.0	.502	.533	.167	.168	1004-j348 = 1063/19.12°	992-j328 = 1045/18.30°
4.0	.599	.632	.209	.212	945-j311 = 995/18.22°	933-j294 = 978/17.48°
134 Phantom Circuits (Of Nonpole Pairs)						
.3	.123	.149	.024	.023	883-j524 = 1027/30.68°	902-j415 = 993/24.70°
1.0	.220	.246	.064	.064	711-j281 = 765/21.57°	706-j249 = 749/19.43°
2.0	.341	.371	.112	.114	625-j219 = 662/19.32°	617-j199 = 648/17.88°
3.0	.436	.470	.156	.158	579-j185 = 608/17.72°	570-j172 = 595/16.79°
4.0	.516	.554	.197	.200	548-j165 = 572/16.75°	539-j153 = 560/15.85°

TABLE 45

Characteristics of Nonpole Pair Phantoms of Copper-Steel Wire (40 Per Cent Conductivity)

8" and 12" Spacings - DP Insulators - 68°F

Freq.	Attenuation db/mi. Dry	Attenuation db/mi. Wet	Phase Shift Radians/mi. Dry	Phase Shift Radians/mi. Wet	Characteristic Impedance Dry	Characteristic Impedance Wet
			104-Mil Wire - 8" Spacing			
200	.077	.097	.011	.010	706-j555 = 898/38.17°	750-j408 = 854/28.55°
500	.104	.120	.021	.021	528-j299 = 607/29.52°	534-j252 = 590/25.27°
1000	.120	.136	.037	.037	467-j172 = 498/20.22°	463-j149 = 486/17.83°
1500	.126	.143	.054	.055	450-j121 = 466/15.05°	444-j105 = 456/13.30°
2000	.129	.148	.071	.072	443-j93 = 453/11.85°	436-j80 = 443/10.40°
2500	.131	.152	.087	.089	439-j75 = 445/ 9.70°	431-j64 = 436/ 8.45°
3000	.133	.155	.104	.106	437-j63 = 442/ 8.20°	429-j53 = 432/ 7.05°
4000	.135	.159	.138	.141	434-j48 = 437/ 6.31°	426-j40 = 428/ 5.37°
			104-Mil Wire - 12" Spacing			
200	.080	.100	.012	.010	676-j540 = 865/38.62°	720-j408 = 828/29.53°
500	.109	.125	.021	.021	501-j294 = 581/30.40°	508-j252 = 567/26.38°
1000	.127	.143	.038	.038	440-j171 = 472/21.23°	437-j150 = 462/18.95°
1500	.134	.150	.054	.055	422-j120 = 439/15.97°	417-j106 = 430/14.27°
2000	.138	.156	.071	.072	414-j92 = 424/12.53°	408-j81 = 416/11.23°
2500	.141	.160	.088	.089	410-j75 = 417/10.37°	404-j65 = 409/ 9.13°
3000	.142	.163	.105	.106	408-j63 = 413/ 8.78°	401-j54 = 405/ 7.67°
4000	.144	.167	.139	.141	405-j48 = 408/ 6.76°	398-j41 = 400/ 5.88°
			128-Mil Wire - 8" Spacing			
200	.060	.077	.010	.009	598-j423 = 733/35.27°	628-j304 = 698/25.83°
500	.077	.091	.019	.019	474-j216 = 521/24.50°	476-j177 = 508/20.40°
1000	.086	.101	.036	.036	438-j120 = 454/15.32°	433-j100 = 444/13.00°
1500	.090	.105	.053	.054	428-j83 = 436/10.98°	421-j69 = 427/ 9.30°
2000	.091	.108	.070	.071	424-j63 = 429/ 8.45°	417-j52 = 420/ 7.10°
2500	.092	.111	.087	.088	422-j51 = 425/ 6.89°	415-j41 = 417/ 5.65°
3000	.093	.113	.104	.106	421-j43 = 423/ 5.93°	413-j34 = 414/ 4.70°
4000	.094	.117	.138	.140	420-j33 = 421/ 4.50°	412-j25 = 413/ 3.47°
			128-Mil Wire - 12" Spacing			
200	.063	.079	.010	.009	570-j412 = 703/35.96°	600-j307 = 674/27.10°
500	.082	.095	.020	.019	447-j213 = 495/25.48°	449-j178 = 483/21.63°
1000	.092	.106	.036	.036	410-j119 = 427/16.18°	406-j102 = 419/14.10°
1500	.096	.111	.053	.054	400-j83 = 409/11.72°	394-j70 = 400/10.07°
2000	.098	.114	.070	.071	396-j63 = 401/ 9.04°	389-j53 = 393/ 7.76°
2500	.099	.117	.087	.088	394-j51 = 397/ 7.38°	387-j43 = 389/ 6.34°
3000	.100	.119	.104	.106	392-j43 = 394/ 6.26°	386-j35 = 388/ 5.18°
4000	.101	.123	.138	.140	391-j33 = 392/ 4.82°	384-j26 = 385/ 3.87°
			165-Mil Wire - 8" Spacing			
200	.043	.057	.009	.008	501-j290 = 579/30.07°	516-j198 = 553/21.00°
500	.051	.063	.018	.018	429-j137 = 450/17.72°	427-j104 = 439/13.68°
1000	.055	.068	.035	.035	411-j73 = 417/10.07°	405-j56 = 409/ 7.87°
1500	.056	.071	.052	.053	407-j50 = 410/ 7.00°	400-j38 = 402/ 5.43°
2000	.057	.073	.069	.070	406-j38 = 408/ 5.35°	398-j28 = 399/ 4.02°
2500	.058	.075	.086	.088	405-j31 = 406/ 4.38°	397-j22 = 398/ 3.17°
3000	.059	.077	.103	.105	404-j26 = 405/ 3.68°	396-j18 = 396/ 2.60°
4000	.060	.081	.137	.140	403-j20 = 403/ 2.84°	396-j13 = 396/ 1.88°
			165-Mil Wire - 12" Spacing			
200	.045	.058	.009	.008	474-j285 = 553/31.02°	490-j203 = 530/22.50°
500	.054	.066	.018	.018	401-j136 = 423/18.73°	400-j107 = 414/14.98°
1000	.059	.071	.035	.036	383-j73 = 390/10.79°	378-j58 = 382/ 8.72°
1500	.060	.074	.052	.053	379-j50 = 382/ 7.52°	373-j39 = 375/ 5.97°
2000	.061	.076	.069	.070	377-j38 = 379/ 5.75°	371-j29 = 372/ 4.47°
2500	.062	.078	.086	.088	376-j31 = 377/ 4.72°	369-j23 = 370/ 3.57°
3000	.063	.080	.103	.105	375-j26 = 376/ 3.97°	369-j19 = 369/ 2.95°
4000	.064	.084	.137	.140	374-j20 = 375/ 3.07°	368-j14 = 368/ 2.18°

TABLE NO. 46

Primary Constants of 80 Mil 40% Copper Steel Wires at 68°F
53 Pairs of CS Insulation Per Mile

Freq. kc	Resistance Ohms per Mile Loop	Inductance Millihenries per Mile Loop 6"	8"	12"	Dry Weather Leakance Micromhos per Mile Loop
0	43.7	3.37	3.71	3.97	-
.1	43.7	3.37	3.71	3.97	.007
.2	43.7	3.37	3.71	3.97	.012
.5	43.7	3.37	3.70	3.96	.028
1	43.8	3.37	3.69	3.92	.058
1.5	43.9	3.37	3.67	3.88	.076
2	44.0	3.37	3.62	3.85	.098
2.5	44.2	3.36	3.59	3.82	.119
3	44.4	3.36	3.57	3.80	.140
4	44.8	3.34	3.54	3.78	.180
5	45.2	3.33	3.52	3.76	.220
10	46.3	3.31	3.48	3.73	.408
15	46.7	3.29	3.47	3.72	.578
20	47.2	3.28	3.46	3.72	.748
30	47.5	3.28	3.45	3.71	1.075
40	47.8	3.27	3.45	3.71	1.390
50	48.2	3.27	3.45	3.70	1.695
60	48.7	3.26	3.45	3.70	1.985
70	49.3	3.26	3.45	3.70	2.280
80	49.9	3.26	3.45	3.70	2.570
90	50.6	3.26	3.45	3.70	2.860
100	51.4	3.26	3.45	3.70	3.120
110	52.2	3.26	3.45	3.70	3.390
120	53.0	3.26	3.44	3.70	3.650
130	53.8	3.26	3.44	3.70	3.970
140	54.7	3.26	3.44	3.70	4.230
150	55.6	3.26	3.44	3.70	4.500
160	56.5	3.26	3.44	3.70	4.800
170	57.5	3.26	3.44	3.70	5.100
180	58.4	3.26	3.44	3.70	5.400
190	59.4	3.26	3.44	3.70	5.700
200	60.4	3.26	3.44	3.70	6.000
Dry Weather Capacitance Microfarad per Mile Loop		.00917	.00878	.00808	

TABLE NO. 47

Primary Constants of 104 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq. kc	Resistance Ohms per Mile Loop	Inductance Millihenries per Mile Loop 6"	8"	12"	Dry Weather Leakance Micromhos per Mile Loop
0	34.4	3.36	3.54	3.80	-
.1	34.4	3.36	3.54	3.80	.007
.2	34.5	3.36	3.57	3.80	.012
.5	34.7	3.35	3.53	3.79	.028
1	35.0	3.34	3.52	3.78	.058
1.5	35.3	3.32	3.50	3.76	.076
2	35.6	3.27	3.46	3.71	.098
2.5	36.0	3.24	3.42	3.68	.119
3	36.5	3.22	3.40	3.66	.140
4	37.3	3.19	3.37	3.63	.180
5	38.0	3.17	3.35	3.61	.220
10	39.4	3.13	3.31	3.57	.408
15	39.7	3.12	3.30	3.56	.578
20	40.1	3.11	3.29	3.55	.748
30	40.8	3.10	3.28	3.54	1.075
40	41.0	3.10	3.28	3.54	1.390
50	41.3	3.10	3.28	3.54	1.695
60	41.6	3.10	3.28	3.54	1.985
70	42.0	3.10	3.28	3.54	2.280
80	42.4	3.10	3.28	3.54	2.570
90	42.7	3.10	3.28	3.54	2.860
100	43.1	3.10	3.28	3.54	3.120
110	43.5	3.10	3.28	3.54	3.390
120	43.9	3.10	3.28	3.54	3.650
130	44.4	3.10	3.28	3.54	3.970
140	44.8	3.10	3.28	3.54	4.230
150	45.3	3.10	3.28	3.54	4.500
160	45.9	3.10	3.28	3.54	4.800
170	46.4	3.10	3.28	3.54	5.100
180	47.0	3.10	3.28	3.54	5.400
190	47.5	3.10	3.28	3.54	5.700
200	48.1	3.10	3.28	3.54	6.000
Dry Weather Capacitance Microfarad per Mile Loop		.00967	.00912	.00846	

TABLE NO. 48

Primary Constants of 128 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq. kc	Resistance Ohms per Mile Loop	Inductance Millihenries per Mile Loop 6"	8"	12"	Dry Weather Leakance Micromhos per Mile Loop
0	22.7	3.22	3.40	3.66	-
.1	22.7	3.22	3.40	3.66	.007
.2	23.2	3.22	3.40	3.66	.012
.5	23.7	3.21	3.39	3.65	.028
1	24.6	3.17	3.35	3.61	.058
1.5	24.9	3.13	3.31	3.57	.076
2	25.2	3.10	3.28	3.54	.098
2.5	25.4	3.07	3.25	3.51	.119
3	25.5	3.05	3.23	3.49	.140
4	25.8	3.03	3.21	3.47	.180
5	26.0	3.01	3.19	3.45	.220
10	26.7	2.98	3.16	3.42	.408
15	27.0	2.97	3.15	3.41	.578
20	27.3	2.97	3.15	3.41	.748
30	27.9	2.96	3.14	3.40	1.075
40	28.1	2.96	3.14	3.40	1.390
50	28.4	2.96	3.14	3.40	1.695
60	28.7	2.96	3.14	3.40	1.985
70	29.0	2.96	3.14	3.40	2.280
80	29.3	2.96	3.14	3.40	2.570
90	29.7	2.96	3.14	3.40	2.860
100	30.1	2.96	3.14	3.40	3.120
110	30.6	2.96	3.14	3.40	3.390
120	31.1	2.96	3.14	3.40	3.650
130	31.6	2.96	3.14	3.40	3.970
140	32.2	2.96	3.14	3.40	4.230
150	32.8	2.96	3.14	3.40	4.500
160	33.4	2.96	3.14	3.40	4.800
170	34.1	2.96	3.14	3.40	5.100
180	34.7	2.96	3.14	3.40	5.400
190	35.4	2.96	3.14	3.40	5.700
200	36.1	2.96	3.14	3.40	6.000
Dry Weather Capacitance Microfarad per Mile Loop		.01011	.00951	.00878	

TABLE NO. 49

Attenuation of 80 Mil 40% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq.-kc	Dry Weather Attenuation - db per Mile 6"	8"	12"	Increase due to Wet Weather - db per Mile 6"	8"	12"
.1	.095	.093	.089	.010	.010	.010
.2	.131	.128	.122	.008	.008	.008
.5	.193	.187	.179	.006	.006	.006
1	.245	.235	.222	.006	.006	.006
1.5	.271	.258	.243	.007	.007	.007
2	.286	.272	.256	.007	.007	.007
2.5	.296	.282	.264	.007	.007	.007
3	.303	.289	.270	.008	.008	.008
4	.313	.298	.278	.009	.009	.009
5	.320	.304	.283	.010	.010	.010
10	.334	.319	.296	.014	.015	.015
15	.340	.324	.301	.017	.018	.019
20	.344	.328	.303	.021	.022	.023
30	.347	.332	.307	.028	.029	.030
40	.351	.335	.310	.033	.035	.036
50	.355	.338	.314	.038	.040	.042
60	.360	.343	.318	.042	.045	.052
70	.365	.348	.323	.047	.050	.058
80	.370	.353	.328	.051	.055	.064
90	.376	.358	.333	.056	.060	.070
100	.382	.365	.339	.060	.065	.076
110	.389	.371	.345	.065	.070	.079
120	.395	.378	.351	.070	.075	.084
130	.402	.384	.357	.075	.080	.090
140	.409	.391	.363	.080	.085	.096
150	.417	.398	.370	.085	.090	.101
160	.424	.405	.377	.090	.095	.107
170	.432	.413	.384	.095	.100	.113
180	.439	.420	.391	.100	.105	.118
190	.447	.428	.398	.105	.111	.123
200	.455	.435	.405	.110	.117	.128

1) The attenuation change from dry to wet weather for either Toll or DP insulators is about twice that for CS insulators.

2) For other than 53 pairs of insulators per mile reduce (or increase) the above differential losses proportionally.

TABLE NO. 50

Attenuation of 104 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq.-kc	Dry Weather Attenuation - db per Mile 6"	8"	12"	Increase due to Wet Weather - db per Mile 6"	8"	12"
.1	.086	.084	.080	.008	.008	.008
.2	.118	.115	.110	.007	.007	.007
.5	.172	.166	.158	.006	.006	.006
1	.213	.204	.193	.006	.006	.006
1.5	.234	.223	.210	.007	.007	.007
2	.247	.235	.220	.007	.007	.007
2.5	.256	.244	.227	.007	.007	.007
3	.264	.251	.234	.008	.008	.008
4	.276	.261	.243	.009	.009	.009
5	.284	.269	.250	.010	.010	.010
10	.300	.284	.263	.013	.013	.014
15	.305	.288	.268	.016	.016	.017
20	.308	.291	.272	.019	.019	.021
30	.315	.298	.277	.025	.026	.028
40	.318	.300	.279	.031	.032	.034
50	.321	.303	.282	.036	.037	.040
60	.324	.306	.285	.042	.043	.046
70	.328	.310	.288	.047	.048	.052
80	.332	.314	.292	.052	.054	.057
90	.335	.317	.295	.057	.059	.063
100	.338	.320	.298	.062	.064	.068
110	.342	.324	.302	.066	.069	.073
120	.346	.327	.305	.071	.074	.079
130	.350	.332	.309	.076	.079	.084
140	.354	.335	.313	.081	.083	.089
150	.358	.340	.317	.085	.088	.094
160	.364	.345	.322	.089	.094	.101
170	.368	.349	.326	.093	.098	.106
180	.374	.355	.331	.097	.103	.111
190	.378	.359	.335	.101	.108	.116
200	.384	.364	.340	.105	.111	.119

1) The attenuation change from dry to wet weather for either Toll or DP insulators is about twice that for CS insulators.

2) For other than 53 pairs of insulators per mile reduce (or increase) the above differential losses proportionally.

TABLE NO. 51

Attenuation of 128 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq.-kc	Dry Weather Attenuation - db per Mile			Increase due to Wet Weather - db per Mile		
	6"	8"	12"	6"	8"	12"
.1	.071	.068	.065	.006	.006	.007
.2	.097	.093	.089	.005	.006	.006
.5	.137	.132	.124	.005	.005	.005
1	.168	.160	.149	.005	.005	.005
1.5	.181	.172	.160	.005	.005	.005
2	.189	.179	.166	.006	.006	.006
2.5	.194	.184	.170	.006	.006	.007
3	.197	.186	.171	.006	.007	.008
4	.202	.191	.177	.007	.008	.009
5	.205	.194	.179	.008	.009	.010
10	.214	.202	.187	.012	.013	.013
15	.218	.206	.190	.015	.016	.017
20	.221	.208	.192	.017	.019	.020
30	.226	.213	.198	.024	.025	.027
40	.229	.216	.200	.029	.031	.033
50	.232	.219	.203	.034	.036	.039
60	.235	.222	.206	.039	.042	.044
70	.238	.225	.209	.044	.047	.050
80	.241	.228	.211	.049	.052	.055
90	.245	.232	.215	.054	.057	.060
100	.249	.235	.218	.059	.062	.065
110	.254	.240	.223	.063	.066	.070
120	.259	.244	.227	.068	.071	.075
130	.264	.249	.231	.072	.076	.080
140	.269	.254	.236	.077	.081	.085
150	.274	.259	.241	.081	.085	.090
160	.280	.264	.246	.084	.090	.096
170	.286	.270	.252	.088	.094	.101
180	.292	.276	.257	.093	.098	.106
190	.298	.282	.262	.097	.102	.111
200	.305	.288	.268	.100	.106	.115

1) The attenuation change from dry to wet weather for either Toll or DP insulators is about twice that for CS insulators.

2) For other than 53 pairs of insulators per mile reduce (or increase) the above differential losses proportionally.

TABLE NO. 52

Impedance of 80 Mil 40% Copper Steel Wires at 68°F
53 Pairs of CS Insulators Per Mile

Freq.-kc	Dry Weather Impedance - Ohms		
	6"	8"	12"
.1	1996-j1890	2045-j1937	2136-j2015
.2	1446-j1311	1485-j1334	1554-j1385
.5	982-j772	1016-j780	1068-j806
1	780-j486	812-j488	859-j502
1.5	705-j360	740-j358	785-j367
2	670-j285	702-j284	749-j289
2.5	650-j236	681-j235	728-j239
3	638-j201	669-j200	715-j204
4	623-j156	653-j155	702-j157
5	616-j127	646-j127	694-j128
10	604-j66	633-j66	683-j67
15	601-j45	630-j45	680-j45
20	599-j34	629-j34	679-j34
30	599-j23	628-j23	678-j23
40	597-j17	627-j17	678-j17
50	597-j14	627-j14	677-j14
60	596-j12	627-j12	677-j12
70	596-j10	627-j10	677-j10
80	596-j9	627-j9	677-j9
90	596-j8	627-j8	677-j8
100	596-j7	627-j7	677-j7
110	596-j7	627-j7	677-j7
120	596-j6	626-j6	677-j6
130	596-j6	626-j6	677-j6
140	596-j6	626-j5	677-j6
150	596-j5	626-j5	677-j5
160	596-j5	626-j5	677-j5
170	596-j5	626-j5	677-j5
180	596-j5	626-j5	677-j5
190	596-j4	626-j4	677-j4
200	596-j4	626-j4	677-j4

1) Wet weather impedance is about 5% less at .1 kc, 1.6% less at 1 kc and about 1.1% less at 10 kc and above.

TABLE NO. 53

Impedance of 104 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq.-kc	Dry Weather Impedance - Ohms		
	6"	8"	12"
.1	1736-j1631	1791-j1676	1863-j1737
.2	1267-j1120	1309-j1150	1365-j1188
.5	878-j651	911-j665	956-j682
1	713-j404	744-j410	788-j417
1.5	656-j295	688-j298	732-j302
2	627-j234	658-j235	703-j238
2.5	611-j194	643-j195	688-j197
3	601-j166	633-j167	679-j168
4	589-j130	622-j131	668-j131
5	582-j107	616-j107	663-j108
10	572-j57	605-j57	652-j57
15	569-j38	603-j38	650-j38
20	568-j29	601-j29	648-j29
30	567-j20	600-j20	647-j20
40	566-j15	600-j15	647-j15
50	566-j12	600-j12	647-j12
60	566-j10	600-j10	647-j10
70	566-j9	600-j9	647-j9
80	566-j8	600-j8	647-j8
90	566-j7	600-j7	647-j7
100	566-j6	600-j6	647-j6
110	566-j6	600-j6	647-j6
120	566-j5	600-j5	647-j5
130	566-j5	600-j5	647-j5
140	566-j4	600-j5	647-j5
150	566-j4	600-j4	647-j4
160	566-j4	600-j4	647-j4
170	566-j4	600-j4	647-j4
180	566-j4	600-j4	647-j4
190	566-j3	600-j3	647-j4
200	566-j3	600-j3	647-j3

1) Wet weather impedance is about 5% less at .1 kc, 1.6% less at 1 kc and about 1.1% less at 10 kc and above.

TABLE NO. 54

Impedance of 128 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq.-kc	Dry Weather Impedance - Ohms		
	6"	8"	12"
.1	1398-j1278	1445-j1314	1509-j1363
.2	1042-j876	1080-j898	1132-j929
.5	751-j497	783-j506	828-j519
1	637-j304	669-j308	714-j312
1.5	598-j218	630-j220	676-j223
2	580-j171	612-j172	658-j173
2.5	569-j140	601-j141	648-j142
3	562-j119	595-j119	642-j120
4	555-j91	588-j91	635-j92
5	551-j74	584-j74	631-j74
10	544-j39	578-j39	625-j39
15	542-j26	576-j26	624-j26
20	542-j20	576-j20	624-j20
30	541-j13	575-j13	622-j13
40	541-j10	575-j10	622-j10
50	541-j8	575-j8	622-j8
60	541-j7	575-j7	622-j7
70	541-j6	575-j6	622-j6
80	541-j5	575-j5	622-j5
90	541-j5	575-j5	622-j5
100	541-j4	575-j4	622-j4
110	541-j4	575-j4	622-j4
120	541-j4	575-j4	622-j4
130	541-j3	575-j3	622-j3
140	541-j3	575-j3	622-j3
150	541-j3	575-j3	622-j3
160	541-j3	575-j3	622-j3
170	541-j3	575-j3	622-j3
180	541-j3	575-j3	622-j3
190	541-j3	575-j3	622-j3
200	541-j3	575-j3	622-j3

1) Wet weather impedance is about 5% less at .1 kc, 1.6% less at 1 kc and about 1.1% less at 10 kc and above.

TABLE NO. 55

Propagation Constant of 80 Mil 40% Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq.-kc	Dry Weather Propagation Constant - Per Mile 6"	8"	12"
.1	.0110+j.0115	.0107+j.0113	.0102+j.0108
.2	.0151+j.0166	.0147+j.0164	.0141+j.0158
.5	.0223+j.0283	.0215+j.0280	.0205+j.0271
1	.0282+j.0448	.0270+j.0448	.0255+j.0436
1.5	.0312+j.0609	.0297+j.0596	.0280+j.0594
2	.0329+j.0772	.0314+j.0775	.0294+j.0760
2.5	.0341+j.0936	.0326+j.0944	.0304+j.0924
3	.0349+j.110	.0333+j.110	.0311+j.109
4	.0360+j.144	.0343+j.143	.0320+j.142
5	.0368+j.177	.0351+j.177	.0326+j.176
10	.0385+j.348	.0367+j.348	.0341+j.347
15	.0392+j.519	.0374+j.519	.0347+j.518
20	.0396+j.690	.0377+j.690	.0349+j.690
30	.0400+j1.04	.0382+j1.03	.0354+j1.03
40	.0404+j1.38	.0385+j1.38	.0357+j1.38
50	.0409+j1.72	.0390+j1.72	.0362+j1.72
60	.0414+j2.06	.0395+j2.06	.0366+j2.06
70	.0420+j2.41	.0400+j2.41	.0372+j2.41
80	.0426+j2.75	.0406+j2.75	.0377+j2.75
90	.0433+j3.09	.0413+j3.09	.0384+j3.09
100	.0440+j3.44	.0420+j3.44	.0390+j3.44
110	.0448+j3.78	.0427+j3.78	.0397+j3.78
120	.0455+j4.12	.0435+j4.12	.0404+j4.12
130	.0463+j4.47	.0442+j4.47	.0411+j4.47
140	.0471+j4.81	.0450+j4.81	.0418+j4.81
150	.0480+j5.15	.0458+j5.15	.0426+j5.15
160	.0488+j5.50	.0466+j5.50	.0434+j5.50
170	.0497+j5.84	.0475+j5.84	.0442+j5.84
180	.0506+j6.18	.0483+j6.18	.0450+j6.18
190	.0515+j6.53	.0492+j6.53	.0458+j6.53
200	.0524+j6.87	.0501+j6.87	.0467+j6.87

1) The real component of the propagation constant is given in nepers per mile and the imaginary component in radians per mile.

2) Real component of wet weather propagation constant can be obtained from wet weather attenuation values (Table IV) by dividing by 8.686. The imaginary component is about 1% greater than for dry weather at 1 kc and above.

TABLE NO. 56

Propagation Constant of 104 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq.-kc	Dry Weather Propagation Constant - Per Mile		
	6"	8"	12"
.1	.0099+j.0105	.0096+j.0103	.0092+j.0099
.2	.0136+j.0154	.0132+j.0150	.0126+j.0145
.5	.0198+j.0267	.0191+j.0261	.0182+j.0254
1	.0246+j.0433	.0235+j.0427	.0222+j.0419
1.5	.0269+j.0598	.0257+j.0591	.0241+j.0584
2	.0284+j.0762	.0271+j.0755	.0253+j.0748
2.5	.0295+j.0927	.0280+j.0921	.0262+j.0915
3	.0304+j.110	.0289+j.109	.0269+j.108
4	.0317+j.143	.0300+j.143	.0280+j.142
5	.0327+j.177	.0309+j.176	.0288+j.176
10	.0346+j.347	.0327+j.347	.0303+j.346
15	.0352+j.519	.0331+j.518	.0309+j.518
20	.0355+j.690	.0335+j.689	.0313+j.689
30	.0363+j1.03	.0343+j1.03	.0319+j1.03
40	.0366+j1.38	.0346+j1.38	.0321+j1.38
50	.0369+j1.72	.0349+j1.72	.0325+j1.72
60	.0373+j2.06	.0353+j2.06	.0328+j2.06
70	.0377+j2.41	.0357+j2.41	.0332+j2.41
80	.0382+j2.75	.0361+j2.75	.0336+j2.75
90	.0385+j3.09	.0365+j3.09	.0339+j3.09
100	.0389+j3.44	.0369+j3.44	.0343+j3.44
110	.0394+j3.78	.0373+j3.78	.0347+j3.78
120	.0398+j4.12	.0377+j4.12	.0351+j4.12
130	.0403+j4.47	.0382+j4.47	.0356+j4.47
140	.0408+j4.81	.0386+j4.81	.0360+j4.81
150	.0413+j5.15	.0391+j5.15	.0365+j5.15
160	.0419+j5.50	.0397+j5.50	.0370+j5.50
170	.0424+j5.84	.0402+j5.84	.0375+j5.84
180	.0431+j6.18	.0408+j6.18	.0381+j6.18
190	.0436+j6.53	.0413+j6.53	.0386+j6.53
200	.0442+j6.87	.0419+j6.87	.0391+j6.87

1) The real component of the propagation constant is given in nepers per mile and the imaginary component in radians per mile.

2) Real component of wet weather propagation constant can be obtained from wet weather attenuation values (Table V) by dividing by 8.686. The imaginary component is about 1% greater than for dry weather at 1 kc and above.

TABLE NO. 57

Propagation Constant of 128 Mil 30% Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq.-kc	Dry Weather Propagation Constant - Per Mile		
	6"	8"	12"
.1	.0081+j.0089	.0079+j.0086	.0075+j.0083
.2	.0111+j.0132	.0108+j.0129	.0103+j.0125
.5	.0158+j.0239	.0152+j.0234	.0143+j.0228
1	.0193+j.0405	.0184+j.0399	.0173+j.0394
1.5	.0208+j.0570	.0198+j.0564	.0185+j.0559
2	.0218+j.0736	.0206+j.0731	.0189+j.0715
2.5	.0224+j.0903	.0212+j.0898	.0196+j.0894
3	.0227+j.107	.0215+j.107	.0197+j.106
4	.0233+j.141	.0220+j.141	.0204+j.140
5	.0237+j.175	.0224+j.175	.0207+j.174
10	.0246+j.346	.0232+j.345	.0215+j.345
15	.0251+j.518	.0238+j.517	.0219+j.517
20	.0254+j.689	.0237+j.688	.0221+j.688
30	.0261+j1.03	.0246+j1.03	.0227+j1.03
40	.0264+j1.38	.0248+j1.38	.0230+j1.38
50	.0267+j1.72	.0252+j1.72	.0233+j1.72
60	.0271+j2.06	.0255+j2.06	.0237+j2.06
70	.0274+j2.41	.0259+j2.41	.0240+j2.41
80	.0278+j2.75	.0262+j2.75	.0243+j2.75
90	.0283+j3.09	.0267+j3.09	.0248+j3.09
100	.0287+j3.44	.0271+j3.44	.0252+j3.44
110	.0292+j3.78	.0276+j3.78	.0256+j3.78
120	.0298+j4.12	.0281+j4.12	.0261+j4.12
130	.0303+j4.47	.0286+j4.47	.0266+j4.47
140	.0310+j4.81	.0292+j4.81	.0272+j4.81
150	.0316+j5.15	.0298+j5.15	.0276+j5.15
160	.0322+j5.50	.0304+j5.50	.0283+j5.50
170	.0330+j5.84	.0311+j5.84	.0290+j5.84
180	.0336+j6.18	.0318+j6.18	.0296+j6.18
190	.0343+j6.53	.0324+j6.53	.0302+j6.53
200	.0351+j6.87	.0331+j6.87	.0309+j6.87

1) The real component of the propagation constant is given in nepers per mile and the imaginary component in radians per mile.

2) Real component of wet weather propagation constant can be obtained from wet weather attenuation values (Table VI) by dividing by 8.686. The imaginary component is about 1% greater than for dry weather at 1 kc and above.

TABLE NO. 58

Phase Delay of Copper Steel Wires at 68°F
53 Pairs of CS Insulators per Mile

Freq. kc	Phase Delay - Microseconds per Mile								
	80 Mil 40%			104 Mil 30%			128 Mil 30%		
	6"	8"	12"	6"	8"	12"	6"	8"	12"
.1	18.29	17.94	17.24	16.78	16.31	15.74	14.11	13.74	13.24
.2	13.24	13.02	12.54	12.24	11.93	11.54	10.54	10.27	9.93
.5	9.00	8.87	8.62	8.48	8.30	8.09	7.59	7.44	7.27
1	7.14	7.08	6.94	6.89	6.79	6.67	6.44	6.36	6.26
1.5	6.46	6.41	6.33	6.34	6.27	6.19	6.04	5.99	5.93
2	6.14	6.10	6.05	6.06	6.01	5.95	5.86	5.82	5.78
2.5	5.96	5.92	5.88	5.90	5.86	5.82	5.75	5.72	5.69
3	5.85	5.82	5.78	5.81	5.77	5.74	5.68	5.66	5.63
4	5.72	5.71	5.67	5.69	5.67	5.65	5.61	5.59	5.58
5	5.65	5.66	5.61	5.63	5.62	5.61	5.57	5.55	5.54
10	5.54	5.53	5.52	5.53	5.52	5.52	5.50	5.49	5.49
15	5.51	5.50	5.49	5.50	5.49	5.49	5.49	5.48	5.48
20	5.49	5.49	5.49	5.49	5.48	5.48	5.48	5.48	5.47
30	5.49	5.48	5.48	5.48	5.47	5.47	5.47	5.47	5.47
40	5.48	5.48	5.48	5.47	5.47	5.47	5.47	5.47	5.47
50	5.48	5.48	5.47	5.47	5.47	5.47	5.47	5.47	5.47
60	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
70	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
80	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
90	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
100	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
110	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
120	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
130	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
140	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
150	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
160	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
170	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
180	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
190	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47
200	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47	5.47

1) Wet weather values are about 1% higher at 1 kc and above.

TABLE NO. 59

Velocity of Propagation of Copper Steel Pairs at 68°F
53 Pairs of CS Insulators per Mile

Freq. kc	Velocity - Miles per Second								
	80 Mil 40%			104 Mil 30%			128 Mil 30%		
	6"	8"	12"	6"	8"	12"	6"	8"	12"
.1	54700	55800	58000	59600	61300	63500	70800	72800	75500
.2	75500	76800	79700	81700	83800	86700	94900	97400	101000
.5	111000	113000	116000	118000	120000	124000	132000	134000	138000
1	140000	142000	144000	145000	147000	150000	155000	157000	160000
1.5	155000	156000	158000	158000	159000	161000	165000	167000	169000
2	163000	164000	165000	165000	166000	167000	171000	172000	173000
2.5	168000	169000	170000	169000	171000	172000	174000	175000	178000
3	171000	172000	173000	172000	173000	174000	176000	177000	179000
4	175000	175000	176000	176000	176000	177000	178000	179000	180000
5	177000	177000	178000	178000	178000	179000	180000	180000	182000
10	180000	180000	181000	181000	181000	181000	182000	182000	183000
15	182000	182000	182000	182000	182000	182000	182000	183000	183000
20	182000	182000	182000	182000	182000	182000	182000	183000	183000
30	182000	182000	183000	183000	183000	183000	183000	183000	183000
40	183000	183000	183000	183000	183000	183000	183000	183000	183000
50	183000	183000	183000	183000	183000	183000	183000	183000	183000
60	183000	183000	183000	183000	183000	183000	183000	183000	183000
70	183000	183000	183000	183000	183000	183000	183000	183000	183000
80	183000	183000	183000	183000	183000	183000	183000	183000	183000
90	183000	183000	183000	183000	183000	183000	183000	183000	183000
100	183000	183000	183000	183000	183000	183000	183000	183000	183000
110	183000	183000	183000	183000	183000	183000	183000	183000	183000
120	183000	183000	183000	183000	183000	183000	183000	183000	183000
130	183000	183000	183000	183000	183000	183000	183000	183000	183000
140	183000	183000	183000	183000	183000	183000	183000	183000	183000
150	183000	183000	183000	183000	183000	183000	183000	183000	183000
160	183000	183000	183000	183000	183000	183000	183000	183000	183000
170	183000	183000	183000	183000	183000	183000	183000	183000	183000
180	183000	183000	183000	183000	183000	183000	183000	183000	183000
190	183000	183000	183000	183000	183000	183000	183000	183000	183000
200	183000	183000	183000	183000	183000	183000	183000	183000	183000

1) Wet weather velocities are about 1% less at 1 kc and above.