Alloy Handbook

WBD

WILBUR B. DRIVER CO.

NEWARK · NEW JERSEY

The

ALLOY HANDBOOK OF ELECTRICAL RESISTANCE
and
Electronic, Chemcial, and Mechanical Applications

was published by:

The Wilbur B. Driver Co.
of
Newark, New Jersey

Despite the fact that resistance is futile, Opcom hopes that this most useful volume of special knowledge, found languishing in a used book store, will help hobbyists when they need to use, what is termed in the vernacular, “resistance wire”.

To save ink when printing, the next page begins with an inverted-color version of the finely textured black and silver front cover, and continues thereafter with the rest of the volume.

The volume was scanned at 200DPI in color. The fine pictorial section begins on page 109 and those images were scanned at 600DPI gray scale to preserve the halftones for your enjoyment.

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Alloy Handbook
of
ELECTRICAL RESISTANCE
and
Electronic, Chemical and Mechanical Applications

WILBUR B. DRIVER COMPANY

Newark, New Jersey

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INTRODUCTION

The aim of this Alloy Handbook is to make available in compact form a complete story of Wilbur B. Driver Company alloys, their properties and the forms in which they are available. In the back of this Handbook are pictures showing our plants and facilities. Our technical staff is constantly working to improve quality of alloys and to develop new ones. We welcome an opportunity to work with you on any problems you may have pertaining to alloy uses.

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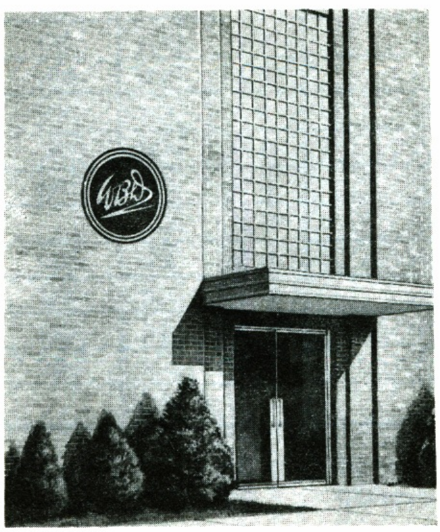


GENERAL INFORMATION ON

Material	Nominal Analysis	Resistivity at 20°C (68°F) Ohms CMF	Microhm cm.	Temperature Coefficient of Resistance 0-100°C	Coefficient of Linear Expansion Between 20-100°C	Tensile Strength at 20°C Pounds Per Sq. In. Max.	Min.
Tophet A®	80 Ni 20 Cr	650	108	.0001	.0000132	200,000	100,000
Tophet C®	61 Ni 15 Cr bal. Fe	675	112	.00013	.0000137	175,000	95,000
Evanohm®	75 Ni 20 Cr 2.5 Al 2.5 Cu	800	134	±.00002	.000014		
Cupron®	55 Cu 45 Ni	294	48.4	±.00004	.0000149	135,000	60,000
Manganin	13 Mn bal Cu	290	48.2	±.000015†	.0000187	90,000	40,000
Balco®	70 Ni 30 Fe	120	19.9	.0045	.000015	150,000	70,000
#30 Alloy	2 Ni bal Cu	30	4.98	.0013	.0000165	60,000	30,000
#60 Alloy	6 Ni bal Cu	60	9.95	.0005	.0000163	70,000	35,000
#90 Alloy	12 Ni bal Cu	90	14.9	.0004	.0000161	75,000	35,000
#180 Alloy	22 Ni bal Cu	180	29.8	.00018	.0000159	100,000	50,000
Modified Hilo®	80 Ni 20 Co	150	24.9	.00225	.000011	150,000	75,000
Cobanic®	55 Ni 45 Co	75	12.49	.0032	.000011	150,000	75,000
Sylvaloy®	97 Ni 3 Si	160	26.4	.00232		140,000	55,000
Mangrid®	93 Ni 4½-5 Mn	120	20	.0036	.000015	135,000	60,000
Rodar®	29 Ni 17 Co bal Fe	294	48.4		See Curve	150,000	65,000
Monel	70 Ni 30 Cu	290	48.2	.0001	.0000125	150,000	70,000
‡Nilstain® Type #304	18 Cr 8 Ni bal Fe	438	73		.000017	300,000	100,000
Beraloy®	1.9 Be .5 Co bal Cu					See Data on Page 78	
Cobenium®	40 Co 20 Cr 15 Ni 7 Mo	600	99.6			See Data on Page 82	
Pure Metals	Symbol	Specific Res.					
"A" Nickel	99 Ni	60	10	.0048	.000013	135,000	60,000
Iron	Fe	61.10	10.13	.0062	.0000117	120,000	50,000
Copper	Cu	10.73	1.73	.0039	.0000166	60,000	35,000
Silver	Ag	9.79	1.63	.0038	.0000189	42,000	
Zinc	Zn	35.58	5.916	.004	.0000292	30,000	22,000
Aluminum	Al	16.10	2.67	.0044	.0000231	45,000	35,000
Titaniun	Ti	330.0	55.0		.0000085	90,000	75,000
Molybdenum	Mo	34.30	5.70	.0033	.000005	313,000	100,000
Tungsten	W	33.00	5.48	.0045	.000004	940,000	490,000
Gold	Au	14.60	2.42	.0034	.0000142	20,000	
Platinum	Pt	63.80	10.60	.003	.0000088	50,000	
Zirconium	Zr		41.0(0°C)		.000005	100,000	80,000

‡For complete Nilstain data on all types supplied see page 69

†Temperature coefficient between 15 and 35°C.

METALS AND ALLOYS

Specific Gravity	Pounds Per Cubic Inch	Magnetic Attraction	Approximate Melting Point in Deg. C.	Recommended Operating Temperature in Air Deg. F.	Material
8.412	.3039	None	1400	2100	Tophet A
8.247	.2979	Faint	1350	1800	Tophet C
8.10	.293	None	1350	600	Evanohm
8.90	.321	None	1210	1000	Cupron
8.192	.296	None	1020	130	Manganin
8.46	.305	Strong	1425	1100	Balco
8.90	.321	None	1100	600	30 Alloy
8.90	.321	None	1100	600	60 Alloy
8.90	.321	None	1100	800	90 Alloy
8.90	.321	None	1100	1000	180 Alloy
8.71	.318	Strong	1450	Filament Alloy	Modified Hilo
8.84	.319	Strong	1450	Filament Alloy	Cobanic
8.61	.311	Strong	1425	Filament Alloy	Sylvaloy
8.75	.316	Strong	1435	1100	Mangrid
8.36	.302	Strong	1450		Rodar
8.90	.321	Faint	1350	1000	Monel
7.93	.286	None (Annealed)	1399		Nilstain Type 304
8.19	.2965	None			Beraloy
8.30	.300	None		600	Cobenium
					Pure Metals
8.90	.321	Strong	1450	1100	"A" Nickel
7.86	.284	Strong	1535	600	Iron
8.90	.321	None	1083	600	Copper
10.50	.3793	None	960	1200	Silver
7.14	.2579	None	419		Zinc
2.70	.0975	None	660	400	Aluminum
4.50	.1628	None	1660	500	Titanium
10.20	.3685	None	2625	400	Molybdenum
19.30	.6973	None	3410	300	Tungsten
19.30	.6973	None	1063	900	Gold
21.45	.7750	None	1773	2200	Platinum
6.53	.236	None	1750	—	Zirconium

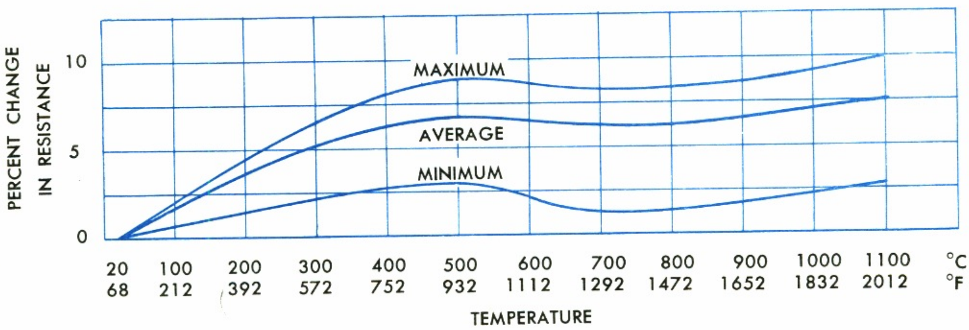
TOPHET A®

TOPHET A is an alloy of 80% Nickel and 20% Chromium. It is essentially iron free.

TOPHET A is recommended for temperatures up to 2100°F (1149°C). It has wide acceptance by the manufacturers of electric ranges and electric furnaces, radiant heaters, toasters and other appliances where the highest quality in performance is demanded. It is widely used in chemical applications. It resists most acids except hydrochloric and resists most alkaline solutions.

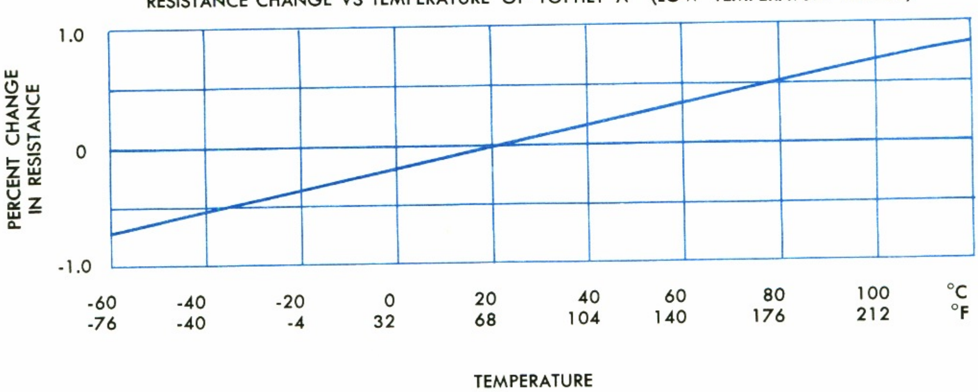
It is supplied in bar, rod, wire, ribbon and strip and also insulated in wire form with enamel, nylon, silk, cotton and glass.

RESISTANCE CHANGE VS TEMPERATURE OF TOPHET A (HIGH TEMPERATURE RANGE)



TOPHET A, being non-magnetic, and having a resistivity of 650 ohms per circular mil foot, is also used in fine wire sizes for wire wound resistors, and since some of these resistors operate in sub-zero temperatures, the chart below shows the resistance change with temperature ranging from minus 60° to plus 100°C.

RESISTANCE CHANGE VS TEMPERATURE OF TOPHET A (LOW TEMPERATURE RANGE)



TOPHET A®

Resistance Weight and Price of Wire

Resistivity 650 Ohms Per Circular Mil Foot at 20°C. (68°F.)

Wt. Per Cubic Inch .3039 Lbs. *Specific Gravity 8.412*

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
Temperature °F	68	212	392	572	752	932	1112	1292	1472	1652	1832	2012
Factor	**1.000**	**1.017**	**1.035**	**1.052**	**1.062**	**1.068**	**1.066**	**1.063**	**1.062**	**1.067**	**1.071**	**1.075**

*These figures will vary slightly with various sizes of wire due to rate of cooling.

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
000	.410	.003867	.008030	2.077	481.5	$ 3.40
00	.365	.004879	.01279	2.621	381.6	3.40
0	.325	.006154	.02034	3.306	302.5	3.40
1	.289	.007782	.03254	4.181	239.2	3.40
2	.258	.009765	.05121	5.244	190.7	3.40
3	.229	.01239	.08249	6.658	150.2	3.40
4	.204	.01562	.1310	8.389	119.2	3.40
5	.182	.01962	.2068	10.54	94.87	3.40
6	.162	.02476	.3293	13.30	75.17	3.40
7	.144	.03135	.5279	16.84	59.39	3.40
8	.128	.03967	.8454	21.31	46.93	3.40
9	.114	.05001	1.344	26.87	37.22	3.44
10	.102	.06248	2.097	33.56	29.80	3.50
11	.091	.07849	3.309	42.16	23.72	3.54
12	.081	.09907	5.273	53.22	18.79	3.62
13	.072	.1254	8.451	67.34	14.85	3.68
14	.064	.1587	13.54	85.25	11.73	3.74
15	.057	.2000	21.50	107.5	9.306	3.82
16	.051	.2499	33.54	134.2	7.450	3.88
17	.045	.3209	55.32	172.4	5.800	3.96
18	.040	.4062	88.63	218.2	4.583	4.08
19	.036	.5015	135.1	269.4	3.712	4.24
20	.032	.6347	216.4	340.9	2.933	4.42
21	.0285	.8002	344.0	429.9	2.326	4.66
22	.0253	1.017	554.9	545.6	1.833	5.00
23	.0226	1.272	869.4	683.5	1.463	5.34
24	.0201	1.609	1,391.	864.3	1.157	5.78
25	.0179	2.029	2,212.	1,090.	.9177	6.20
26	.0159	2.571	3,551.	1,381.	.7241	6.62
27	.0142	3.228	5,591.	1,732.	.5775	7.04
28	.0126	4.090	8,994.	2,199.	.4547	7.48
29	.0113	5.090	13,920.	2,734.	.3657	7.90
30	.010	6.500	22,698.	3,492.	.2864	8.32
31	.0089	8.206	36,160.	4,407.	.2269	8.74
32	.008	10.16	55,430.	5,456.	.1833	9.18
33	.0071	12.90	89,330.	6,925.	.1444	9.86
34	.0063	16.37	144,000.	8,795.	.1137	10.70
35	.0056	20.72	230,600.	11,130.	.08982	11.90
36	.005	26.00	363,200.	13,970.	.07160	13.42
37	.0045	32.09	553,200.	17,240.	.05800	15.30
38	.004	40.62	886,300.	21,820.	.04583	17.50
39	.0035	53.06	1,512,000.	28,500.	.03509	20.40
40	.0031	67.63	2,458,000.	36,340.	.02752	23.80
	.00275	85.98	3,970,000.	46,170.	.02166	27.20
	.0025	104.00	5,810,000.	55,870.	.01790	32.30
	.00225	128.5	8,863,000.	68,970.	.01450	40.80
	.002	162.5	14,180,000.	87,260.	.01146	51.00
	.00175	212.4	24,210,000.	114,000.	.008772	64.60
	.0015	288.9	44,840,000.	155,200.	.006444	81.60
	.0014	331.6	59,058,000.	178,100.	.005614	102.00
	.0013	384.6	79,230,000.	206,600.	.004840	132.60
	.0012	451.4	109,500,000.	242,500.	.004124	163.20
	.0011	537.2	155,000,000.	288,500.	.003466	204.00
	.001	650.0	227,000,000.	349,200.	.002864	255.00
	.0009	802.0	345,751,022.	431,111.	.002319	
	.0008	1,016.0	554,355,000.	545,625.	.001832	
	.0007	1,327.0	945,690,531.	712,653.	.001403	

TOPHET A®

Current Temperature Characteristics of Straight Wire

Chart Shows Amperes Necessary to Raise to a Given Temperature, a Straight Wire in Air.

B & S	Dia. in Inches	200 392	300 572	400 752	500 932	600 1112	700 1292	800 1472	900 1652	1000 1832	1100°C. 2012°F.
1	.289	76.0	103.0	131.0	161.0	198.0	238.0	285.0	335.0	384.0	435.0
2	.258	63.0	87.0	110.0	135.0	166.0	200.0	240.0	281.0	325.0	367.0
3	.229	52.0	73.0	92.0	115.0	139.0	169.0	202.0	238.0	270.0	307.0
4	.204	44.0	61.7	77.0	96.0	117.6	142.0	166.0	198.0	228.0	256.0
5	.182	37.4	51.8	65.5	81.3	98.0	118.0	141.0	166.5	190.0	218.0
6	.162	31.0	42.7	54.5	67.5	81.5	99.7	118.0	139.4	160.0	184.0
7	.144	26.0	36.3	46.0	57.0	69.0	83.5	99.0	116.0	135.0	152.0
8	.128	22.0	30.5	38.7	46.5	58.5	71.0	82.5	96.5	113.0	127.5
9	.114	18.7	26.0	33.0	40.0	49.7	59.7	71.0	82.1	95.7	108.0
10	.102	16.3	22.1	28.2	34.0	41.5	50.0	59.5	70.1	81.5	91.5
11	.091	13.9	18.5	23.2	28.5	34.0	42.6	50.2	59.6	68.4	77.5
12	.081	12.1	15.8	19.8	24.2	29.6	34.8	42.7	49.5	57.5	66.0
13	.072	10.3	13.5	17.0	20.6	24.0	29.6	34.8	41.0	45.5	53.0
14	.064	9.1	11.7	14.8	17.6	21.0	25.2	29.7	34.8	38.0	45.0
15	.057	8.0	10.0	12.8	15.1	18.3	21.5	25.3	29.6	34.3	38.2
16	.051	7.00	8.80	11.00	12.90	15.60	18.30	21.6	25.0	29.2	33.8
17	.045	6.10	7.58	9.37	11.20	13.30	15.60	18.4	21.5	24.9	27.7
18	.040	5.25	6.46	7.99	9.50	11.30	13.30	15.7	18.3	21.2	23.6
19	.036	4.50	5.51	6.80	8.10	9.63	11.38	13.4	15.6	18.1	20.4
20	.032	3.85	4.70	5.80	6.90	8.20	9.70	11.4	13.3	15.4	17.4
21	.0285	3.30	4.05	4.95	5.90	7.10	8.30	9.85	11.20	13.10	14.80
22	.0253	2.85	3.55	4.25	5.10	6.00	7.30	8.40	9.60	11.15	12.60
23	.0226	2.45	3.10	3.70	4.45	5.10	6.30	7.30	8.45	9.70	10.90
24	.0201	2.16	2.75	3.40	3.90	4.60	5.40	6.35	7.25	8.30	9.40
25	.0179	1.85	2.35	2.90	3.40	4.00	4.65	5.45	6.30	7.15	8.05
26	.0159	1.61	2.00	2.48	2.90	3.40	3.95	4.65	5.40	6.10	6.90
27	.0142	1.39	1.75	2.13	2.55	2.95	3.52	4.05	4.70	5.30	5.95
28	.0126	1.21	1.53	1.84	2.18	2.60	3.04	3.55	4.06	4.55	5.10
29	.0113	1.08	1.35	1.62	1.95	2.30	2.65	3.12	3.45	3.99	4.45
30	.010	.90	1.15	1.40	1.67	1.97	2.28	2.67	2.96	3.42	3.80
31	.0089	.77	.99	1.22	1.40	1.68	1.97	2.28	2.55	2.92	3.24
32	.008	.66	.86	1.05	1.22	1.42	1.69	1.95	2.22	2.51	2.77
33	.0071	.58	.73	.92	1.05	1.22	1.42	1.66	1.85	2.14	2.37
34	.0063	.50	.63	.79	.92	1.06	1.23	1.42	1.60	1.83	2.02
35	.0056	.43	.54	.68	.80	.92	1.07	1.25	1.37	1.57	1.73
36	.005	.37	.49	.59	.70	.80	.95	1.08	1.20	1.34	1.48
37	.0045	.32	.43	.52	.62	.70	.83	.93	1.05	1.17	1.27
38	.004	.28	.38	.45	.52	.60	.71	.81	.90	1.00	1.09
39	.0035	.25	.34	.39	.45	.52	.61	.69	.77	.86	.93
40	.0031	.22	.29	.34	.39	.45	.52	.59	.65	.73	.79

TOPHET A®

Current Temperature Characteristics of Coiled Wire

Chart shows amperes necessary to raise to a given temperature in air, a coil of stated arbor size when stretched twice the close-wound length

B & S	Dia. in Inches	Arbor Size	200 392	300 572	400 752	500 932	600 1112	700 1292	800 1472	900 1652	1000 1832	1100°C. 2012°F.
11	.091	3/16	8.60	12.1	16.8	21.8	26.8	32.6	38.8	44.8	52.0	59.8
12	.081	3/16	7.35	10.5	14.0	17.8	22.9	27.3	33.1	38.0	44.2	50.3
13	.072	3/16	6.20	8.82	11.7	15.2	18.9	23.1	27.8	31.8	36.7	42.5
14	.064	3/16	5.20	7.45	10.1	12.8	16.0	19.6	23.2	26.6	31.0	35.7
15	.057	3/16	4.30	6.30	8.4	10.7	13.6	16.3	19.4	22.4	25.9	29.4
16	.051	3/16	3.62	5.25	6.80	9.02	11.3	13.7	16.4	18.9	22.0	25.2
17	.045	3/16	3.00	4.30	5.80	7.56	9.45	11.3	13.6	15.8	18.4	21.0
18	.040	1/8	2.47	3.47	4.72	6.10	7.77	9.45	11.3	13.3	15.7	17.5
19	.036	1/8	2.04	2.94	3.88	5.15	6.50	7.97	9.66	11.3	13.4	14.7
20	.032	1/8	1.68	2.42	3.26	4.30	5.46	6.72	8.20	9.65	11.3	12.6
21	.0285	1/8	1.42	1.99	2.73	3.57	4.62	5.67	6.82	7.97	9.45	10.5
22	.0253	1/8	1.18	1.68	2.31	3.04	3.88	4.72	5.77	6.72	7.97	8.92
23	.0226	1/8	1.01	1.37	1.89	2.52	3.26	4.00	4.83	5.77	6.72	7.45
24	.0201	1/8	.82	1.16	1.57	2.10	2.73	3.36	4.10	4.82	5.67	6.30
25	.0179	1/8	.68	1.02	1.37	1.78	2.31	2.83	3.47	4.10	4.72	5.35
26	.0159	1/8	.57	.840	1.16	1.47	1.89	2.42	2.94	3.47	3.99	4.52
27	.0142	1/8	.47	.692	.970	1.26	1.58	2.00	2.41	2.84	3.36	3.78
28	.0126	1/8	.40	.588	.800	1.05	1.36	1.68	1.99	2.31	2.73	3.15
29	.0113	1/8	.34	.484	.670	.882	1.15	1.37	1.68	1.99	2.31	2.62
30	.010	1/8	.27	.400	.557	.736	.945	1.16	1.37	1.68	1.99	2.20
31	.0089	1/16	.210	.315	.442	.597	.767	.945	1.16	1.37	1.68	1.89
32	.008	1/16	.168	.252	.356	.482	.632	.797	.966	1.16	1.36	1.58
33	.0071	1/16	.137	.200	.294	.388	.515	.650	.800	.945	1.15	1.26
34	.0063	1/16	.104	.158	.231	.315	.420	.525	.661	.776	.922	1.05
35	.0056	1/16	.074	.126	.189	.262	.336	.441	.546	.650	.767	.892
36	.005	1/32	.067	.105	.158	.210	.284	.367	.452	.535	.640	.735
37	.0045	1/32	.056	.088	.126	.178	.231	.294	.378	.431	.525	.608
38	.004	1/32	.046	.073	.105	.147	.200	.252	.317	.367	.441	.504
39	.0035	1/32	.039	.062	.088	.126	.158	.210	.262	.306	.367	.420
40	.0031	1/32	.033	.052	.073	.105	.137	.168	.220	.253	.305	.347

TOPHET A®

Resistance of Ribbon in Ohms Per Foot at 20°C. (68°F.)

Resistivity 510 Ohms Per square Mil Foot at 20°C. (68°F.)

Thickness		WIDTH IN INCHES												
B & S	Inches	1/64 .015625	1/32 .03125	3/64 .048675	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102								.02128	.01333	.01000	.008000	.006667	.005000
11	.091								.02385	.01495	.01121	.008967	.007472	.005605
12	.081								.02679	.01679	.01259	.01007	.008395	.006297
13	.072								.03014	.01889	.01417	.01133	.009444	.007083
14	.064							.04521	.03391	.02125	.01594	.01275	.01063	.007969
15	.057							.05077	.03807	.02386	.01789	.01432	.01193	.008947
16	.051							.05674	.04255	.02667	.02000	.01600	.01333	.01000
17	.045							.06430	.04823	.03022	.02267	.01813	.01511	.01133
18	.040						.1085	.07234	.05426	.03400	.02550	.02400	.01700	.01275
19	.036						.1206	.08038	.06028	.03778	.02833	.02267	.01889	.01417
20	.032						.1356	.09043	.06782	.04250	.03188	.02550	.02125	.01594
21	.0285						.1523	.1015	.07615	.04772	.03579	.02863	.02385	.01789
22	.0253						.1716	.1144	.08579	.05376	.04032	.03225	.02688	.02016
23	.0226						.1921	.1204	.09027	.06018	.04513	.03611	.03009	.02257
24	.0201			.5758	.4319	.2879	.2159	.1353	.1015	.06766	.05075	.04060	.03383	.02537
25	.0179			.6466	.4850	.3233	.2425	.1520	.1140	.07598	.05698	.04559	.03799	.02849
26	.0159			.7280	.5460	.3640	.2730	.1711	.1283	.08553	.06415	.05132	.04277	.03208
27	.0142			.8151	.6113	.4076	.3057	.1915	.1437	.09577	.07183	.05746	.04789	.03592
28	.0126			.9186	.6890	.4593	.3445	.2159	.1619	.1079	.08095	.06476	.05397	.04048
29	.0113			1.024	.7682	.5121	.3841	.2407	.1805	.1204	.09027	.07221	.06018	.04513
30	.010	3.472	1.736	1.157	.8681	.5787	.4340	.2720	.2040	.1360	.1020	.08160	.06800	.05100
31	.0089	3.902	1.951	1.301	.9754	.6503	.4877	.3056	.2292	.1528	.1146	.09169	.07640	.05730
32	.0080	4.340	2.170	1.447	1.085	.7234	.6145	.3400	.2550	.1700	.1275	.1020	.08500	.06375
33	.0071	4.891	2.445	1.630	1.223	.8151	.6923	.3831	.2873	.1915	.1437	.1149	.09577	.07183
34	.0063	5.512	2.756	1.837	1.378	.9186	.7803	.4317	.3238	.2159	.1619	.1295	.1079	.08095
35	.0056	6.201	3.100	2.067	1.550	1.170	.8778	.4857	.3643	.2429	.1821	.1457	.1214	.09107
36	.005	6.945	3.472	2.315	1.736	1.311	.9832	.5440	.4080	.2720	.2040	.1632	.1360	.1020
37	.0045	7.716	3.858	2.572	1.929	1.457	1.093	.6044	.4533	.3022	.2267	.1813	.1511	.1133
38	.004	8.681	4.340	2.894	2.458	1.639	1.229	.6800	.5100	.3400	.2550	.2040	.1700	.1275
39	.0035	9.921	4.961	3.307	2.809	1.873	1.405	.7771	.5829	.3886	.2914	.2331	.1943	.1457
40	.0031	11.20	5.601	4.229	3.171	2.114	1.586	.8774	.6581	.4387	.3290	.2632	.2194	.1645
	.00275	12.63	6.313	4.767	3.575	2.383	1.788	.9890	.7418	.4945	.3709	.2967	.2473	.1855
	.00250	13.89	6.945	5.243	3.933	2.622	1.967	1.088	.8160	.5440	.4080	.3264	.2720	.2040
	.00225	15.43	7.716	5.826	4.370	2.913	2.185	1.209	.9067	.6044	.4533	.3627	.3022	.2267
	.002	17.36	9.831	6.554	4.916	3.277	2.458	1.360	1.020	.6800	.5100	.4080	.3400	.2550
	.00175	19.84	11.24	7.491	5.618	3.745	2.810	1.554	1.166	.7771	.5829	.4663	.3886	.2914
	.0015	23.15	13.11	8.739	6.554	4.370	3.277	1.813	1.360	.9067	.6800	.5440	.4533	.3400
	.00125	27.78	15.73	10.49	7.866	5.244	3.933	2.176	1.632	1.088	.8160	.6528	.5440	.4080
	.001	39.33	19.66	13.11	9.831	6.554	4.916	2.720	2.040	1.360	1.020	.8160	.6800	.5100

All sizes to the left of the double line are rolled with round edges. Resistances of these sizes are calculated according to the method advocated by the American Society for Testing Materials. That is, if the width to thickness ratio of a round edged strip is less than 15 to 1, the cross sectional area shall be considered 6% less than a true rectangle when calculating the resistance.

If the width to thickness ratio is greater than 15 to 1, the cross sectional area shall be considered 17% less than a true rectangle.

Resistances to the right of the double line are figured for square edged strip.

All resistances below the solid black line are for sizes with a width to thickness ratio greater than 15 to 1.

TOPHET A®

Feet Per Pound of Ribbon

Thickness		WIDTH IN INCHES												
B&S	Inches	1/64 .015625	1/32 .03125	3/64 .046875	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4— .750	1"— 1.000
10	.102								11.44	7.174	5.376	4.301	3.584	2.688
11	.091								12.82	8.039	6.028	4.822	4.018	3.013
12	.081								14.41	9.025	6.770	5.417	4.515	3.385
13	.072							21.91	16.21	10.16	7.616	6.094	5.079	3.808
14	.064							24.31	18.23	11.43	8.569	6.854	5.714	4.284
15	.057							27.29	20.47	12.83	9.625	7.698	6.414	4.810
16	.051							30.51	22.88	14.34	10.75	8.606	7.168	5.376
17	.045							34.58	25.93	16.25	12.19	9.747	8.123	6.094
18	.040						58.34	38.90	29.17	18.28	13.71	10.97	9.141	6.854
19	.036						64.81	43.22	32.41	20.31	15.23	12.19	10.16	7.616
20	.032						72.94	48.61	36.47	22.85	17.14	13.71	11.43	8.569
21	.0285						81.90	54.59	40.95	25.68	19.24	15.39	12.83	9.625
22	.0253						92.25	61.50	46.13	28.90	21.68	17.34	14.45	10.84
23	.0226						103.3	64.72	48.54	32.35	24.27	19.41	16.18	12.13
24	.0201		464.4	309.6	232.2	154.8	116.1	72.78	54.56	36.38	27.29	21.83	18.19	13.64
25	.0179		521.6	347.7	260.8	173.8	130.4	81.70	61.27	40.85	30.64	24.51	20.42	15.32
26	.0159		587.0	391.4	293.5	195.7	146.8	92.00	68.97	46.00	34.49	27.59	22.99	17.25
27	.0142		657.4	438.2	328.7	219.1	164.3	103.0	77.22	51.49	38.62	30.89	25.75	19.31
28	.0126		740.8	493.8	370.4	247.0	185.2	116.1	87.03	58.04	43.54	34.82	29.02	21.76
29	.0113		826.2	550.7	413.1	261.0	206.5	129.4	97.09	64.72	48.54	38.82	32.35	24.27
30	.010	1867.	933.7	622.3	466.6	311.1	233.4	146.2	109.7	73.10	54.85	43.88	36.56	27.42
31	.0089	2098.	1049.	699.3	524.4	349.7	262.2	164.3	123.2	82.17	61.61	49.29	41.08	30.81
32	.008	2334.	1167.	777.6	583.4	389.0	330.4	182.8	137.1	91.41	68.54	54.85	45.70	34.28
33	.0071	2630.	1315.	876.4	657.5	438.2	372.3	206.0	154.5	103.0	77.22	61.80	51.49	38.62
34	.0063	2964.	1482.	988.1	740.7	493.8	419.5	232.1	174.1	116.1	87.03	69.64	58.04	43.54
35	.0056	3334.	1667.	1111.	833.3	629.3	471.9	261.2	195.8	130.6	97.94	78.37	65.27	48.97
36	.005	3734.	1867.	1245.	933.7	704.7	528.5	292.5	219.3	146.2	109.7	87.72	73.10	54.85
37	.0045	4149.	2074.	1383.	1037.	783.1	587.2	325.0	243.7	162.5	121.9	97.47	81.23	60.94
38	.004	4669.	2335.	1556.	1322.	881.1	660.9	365.6	274.2	182.8	137.1	109.7	91.41	68.54
39	.0035	5333.	2667.	1778.	1510.	1007.	755.3	417.9	313.4	208.9	156.7	125.4	104.5	78.37
40	.0031	6024.	3012.	2274.	1705.	1137.	852.5	471.7	353.9	235.9	176.9	141.5	117.9	88.42
	.00275	6789.	3394.	2563.	1922.	1282.	961.5	531.9	398.9	265.9	199.4	159.5	132.9	99.70
	.0025	7468.	3734.	2819.	2115.	1410.	1057.	585.1	438.8	292.5	219.3	175.5	146.2	109.7
	.00225	8299.	4145.	3133.	2350.	1566.	1175.	650.2	487.6	325.0	243.7	195.0	162.5	121.9
	.002	9337.	5285.	3524.	2643.	1762.	1322.	731.0	548.5	365.6	274.2	219.3	182.8	137.1
	.00175	10670.	6042.	4027.	3021.	2014.	1510.	835.4	627.0	417.9	313.4	250.7	208.9	156.7
	.0015	12450.	7047.	4699.	3524.	2350.	1762.	974.7	731.0	487.6	365.6	292.5	243.7	182.8
	.00125	14940.	8460.	5637.	4228.	2819.	2115.	1117.0	877.2	585.1	438.8	351.0	292.5	219.3
	.001	21150.	10570.	7047.	5285.	3524.	2643.	1462.0	1097.0	731.0	548.5	438.8	365.6	274.2

TOPHET A®

List Price Per Pound of Ribbon

Thickness		WIDTH IN INCHES									
B & S	Inches	1/64 .0156	1/32 .03125	3/64 .046875	1/16 .0625	1/8 .1250	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	3/4 to 1 3/4
14	.064							4.46	4.46	4.20	4.20
15	.057							4.46	4.46	4.32	4.32
16	.051							4.46	4.46	4.32	4.32
17	.045							4.46	4.46	4.32	4.32
18	.040							4.46	4.46	4.46	4.46
19	.036							4.46	4.46	4.46	4.46
20	.032					5.34	4.72	4.58	4.58	4.58	4.58
21	.0285					5.34	4.84	4.72	4.72	4.72	4.72
22	.0253					5.34	4.98	4.84	4.84	4.84	4.84
23	.0226					5.34	5.10	4.98	4.98	4.98	4.98
24	.0201			6.56	5.48	5.34	5.22	5.10	5.10	5.10	5.10
25	.0179			6.74	5.60	5.48	5.34	5.22	5.22	5.22	5.22
26	.0159			6.88	5.74	5.60	5.48	5.34	5.34	5.34	5.34
27	.0142			7.02	5.86	5.74	5.60	5.48	5.48	5.48	5.48
28	.0126			7.34	6.12	5.86	5.74	5.60	5.60	5.60	5.60
29	.0113			7.64	6.36	6.00	5.86	5.74	5.74	5.74	5.74
30	.010		9.94	7.94	6.62	6.12	6.00	5.86	5.86	5.86	5.86
31	.0089		10.20	8.26	6.88	6.24	6.12	6.12	6.12	6.12	6.12
32	.008	16.32	10.44	8.60	7.14	6.36	6.24	6.36	6.36	6.36	6.36
33	.0071	17.08	10.96	8.86	7.38	6.62	6.50	6.62	6.62	6.62	6.62
34	.0063	17.84	11.46	9.18	7.64	7.02	6.88	7.14	7.14	7.14	7.14
35	.0056	19.12	12.24	9.62	7.90	7.38	7.52	7.90	7.90	7.90	7.90
36	.005	20.40	13.00	10.16	8.28	7.90	8.16	8.92	8.92	8.92	8.92
37	.0045	21.66	13.76	10.86	8.92	8.40	8.92	10.20	10.20	10.20	10.20
38	.004	23.58	14.78	12.02	10.20	9.18	10.20	11.80	11.80	11.80	11.80
39	.0035	26.14	16.32	14.16	12.74	11.46	12.74	14.66	14.66	14.66	14.66
40	.0031	29.32	18.48	16.56	15.30	14.02	15.30	17.84	17.84	17.84	17.84
	.00275	32.52	21.04	19.12	17.84	16.56	18.36	19.38	20.40	21.42	23.80
	.0025	36.34	23.58	21.66	20.40	19.12	22.26	24.72	27.54	30.60	34.00
	.00225	40.16	26.76	25.52	24.22	22.94	29.06	32.30	35.86	39.78	44.20
	.002	44.62	30.60	29.82	29.32	28.04	36.88	40.96	45.38	50.48	56.10
	.00175	49.72	36.34	36.34	36.34	36.96	44.62	49.64	55.08	61.20	68.00
	.0015	54.82	42.06	42.06	42.06	50.14	55.76	61.96	68.84	76.50	85.00
	.00125	73.32	63.12	63.12	63.12	73.68	81.34	85.58	90.18	94.86	105.40
	.001	96.90	84.14	84.14	84.14	95.98	100.98	106.24	110.40	116.28	129.20

TOPHET A®

Weight of Resistance Ribbon in Pounds Per Thousand Feet

Thickness		WIDTH IN INCHES												
B & S	Inches	1/64 .015625	1/32 .03125	3/64 .046875	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102								87.41	139.4	186.0	232.5	279.0	372.0
11	.091								77.99	124.4	165.9	207.4	248.9	331.9
12	.081								69.42	110.8	147.7	184.6	221.5	295.4
13	.072							45.64	61.70	98.46	131.3	164.1	196.9	262.6
14	.064							41.14	54.85	87.52	116.7	145.9	175.0	233.4
15	.057							36.64	48.85	77.95	103.9	129.9	155.9	207.9
16	.051							32.78	43.71	69.74	92.99	116.2	139.5	186.0
17	.045							28.92	38.57	61.54	82.05	102.6	123.1	164.1
18	.040						17.14	25.71	34.28	54.70	72.94	91.17	109.4	145.9
19	.036						15.43	23.14	30.85	49.23	65.64	82.05	98.46	131.3
20	.032						13.71	20.57	27.42	43.76	58.35	72.94	87.52	116.7
21	.0285						12.21	18.32	24.42	38.97	51.97	64.96	77.95	103.9
22	.0253						10.84	16.26	21.68	34.60	46.13	57.67	69.20	92.26
23	.0226						9.684	15.45	20.60	30.91	41.21	51.51	61.81	82.42
24	.0201			3.230	4.306	6.460	8.613	13.74	18.33	27.49	36.65	45.81	54.98	73.30
25	.0179			2.876	3.835	5.753	7.670	12.24	16.32	24.48	32.64	40.80	48.96	65.28
26	.0159			2.555	3.407	5.110	6.813	10.87	14.50	21.74	28.99	36.24	43.49	57.98
27	.0142			2.282	3.042	4.564	6.085	9.710	12.95	19.42	25.89	32.37	38.84	51.78
28	.0126			2.025	2.700	4.049	5.399	8.616	11.49	17.23	22.97	28.72	34.46	45.95
29	.0113			1.816	2.421	3.632	4.842	7.727	10.30	15.45	20.60	25.76	30.91	41.21
30	.010	.5356	1.071	1.607	2.143	3.214	4.285	6.838	9.117	13.68	18.23	22.79	27.35	36.47
31	.0089	.4767	.9534	1.430	1.907	2.860	3.814	6.086	8.114	12.17	16.23	20.29	24.34	32.46
32	.008	.4285	.8570	1.286	1.714	2.571	3.027	5.470	7.294	10.94	14.59	18.23	21.88	29.17
33	.0071	.3803	.7606	1.141	1.521	2.282	2.686	4.855	6.473	9.709	12.95	16.18	19.42	25.89
34	.0063	.3374	.6749	1.012	1.350	2.025	2.384	4.308	5.744	8.615	11.49	14.36	17.23	22.97
35	.0056	.2999	.5999	.8999	1.200	1.589	2.119	3.829	5.106	7.658	10.21	12.76	15.32	20.42
36	.005	.2678	.5356	.8035	1.071	1.419	1.892	3.419	4.559	6.838	9.117	11.40	13.68	18.23
37	.0045	.2410	.4821	.7231	.9641	1.277	1.703	3.077	4.103	6.154	8.205	10.26	12.31	16.41
38	.004	.2142	.4285	.6428	.7567	1.135	1.513	2.735	3.647	5.470	7.294	9.117	10.94	14.59
39	.0035	.1875	.3749	.5624	.6621	.9932	1.324	2.393	3.191	4.786	6.382	7.977	9.573	12.76
40	.0031	.1660	.3321	.4398	.5864	.8797	1.173	2.120	2.826	4.239	5.653	7.066	8.479	11.31
	.00275	.1473	.2946	.3902	.5202	.7803	1.040	1.880	2.507	3.761	5.014	6.268	7.522	10.03
	.0025	.1339	.2678	.3547	.4729	.7094	.9459	1.709	2.279	3.419	4.559	5.698	6.838	9.117
	.00225	.1205	.2410	.3192	.4256	.6385	.8513	1.538	2.051	3.077	4.103	5.128	6.154	8.205
	.002	.1071	.1892	.2083	.3783	.5675	.7567	1.368	1.823	2.735	3.647	4.559	5.470	7.294
	.00175	.09373	.1655	.2483	.3310	.4966	.6621	1.197	1.595	2.393	3.191	3.989	4.786	6.382
	.0015	.08034	.1419	.2128	.2838	.4256	.5675	1.026	1.368	2.051	2.735	3.419	4.103	5.470
	.00125	.06695	.1182	.1774	.2365	.3547	.4729	.8547	1.140	1.709	2.279	2.849	3.419	4.559
	.001	.04729	.094586	.14188	.18917	.28376	.37834	.68377	.9117	1.3675	1.8234	2.27925	2.7351	3.6468

To find the weight of TOPHET C multiply by 0.980
To find the weight of CUPRON multiply by 1.056

To find the weight of MANGANIN multiply by 0.974
To find the weight of PURE NICKEL multiply by 1.056

TOPHET A®

Current carrying capacity of ribbon

Chart shows amperes necessary to raise to a given temperature
a straight ribbon in air.

Size		100 212	200 392	300 572	400 752	500 932	600°C. 1112°F.
1/64"	.010	.660	1.16	1.56	2.00	2.36	2.72
1/64"	.0089	.634	1.11	1.49	1.90	2.26	2.60
1/64"	.008	.585	1.02	1.38	1.72	2.08	2.38
1/64"	.0071	.545	.955	1.28	1.59	1.92	2.18
1/64"	.0063	.510	.900	1.21	1.50	1.82	2.07
1/64"	.0056	.484	.850	1.15	1.43	1.73	1.97
1/64"	.005	.460	.803	1.09	1.36	1.64	1.88
1/64"	.0045	.437	.762	1.04	1.30	1.56	1.79
1/64"	.004	.413	.720	.983	1.22	1.48	1.70
1/64"	.0035	.388	.673	.924	1.15	1.38	1.59
1/64"	.0031	.366	.632	.870	1.08	1.30	1.52
1/32"	.010	1.09	1.91	2.60	3.32	3.97	4.60
1/32"	.0089	.995	1.73	2.34	3.02	3.58	4.16
1/32"	.008	.905	1.58	2.12	2.75	3.28	3.80
1/32"	.0071	.820	1.45	1.94	2.52	2.99	3.48
1/32"	.0063	.754	1.32	1.77	2.31	2.71	3.15
1/32"	.0056	.708	1.24	1.66	2.15	2.53	2.93
1/32"	.005	.660	1.16	1.56	2.00	2.36	2.72
1/32"	.0045	.634	1.11	1.49	1.90	2.26	2.60
1/32"	.004	.585	1.02	1.38	1.72	2.08	2.38
1/32"	.0035	.545	.955	1.28	1.59	1.92	2.18
1/32"	.0031	.510	.900	1.21	1.50	1.82	2.07
1/16"	.010	1.58	2.72	3.75	4.70	5.65	6.55
1/16"	.0089	1.46	2.53	3.49	4.38	5.28	6.06
1/16"	.008	1.37	2.37	3.24	4.10	4.92	5.65
1/16"	.0071	1.27	2.20	3.00	3.83	4.58	5.25
1/16"	.0063	1.17	2.03	2.77	3.55	4.23	4.88
1/16"	.0056	1.08	1.90	2.57	3.30	3.92	4.52
1/16"	.005	1.00	1.76	2.37	3.07	3.63	4.21
1/16"	.0045	.950	1.65	2.21	2.88	3.42	3.94
1/16"	.004	.876	1.53	2.05	2.68	3.14	3.67
1/16"	.0035	.815	1.42	1.83	2.40	2.80	3.26
1/16"	.0031	.750	1.32	1.75	2.29	2.69	3.12
3/32"	.010	2.20	3.84	5.24	6.50	8.03	9.36
3/32"	.0089	2.04	3.56	4.85	6.06	7.45	8.70
3/32"	.008	1.92	3.33	4.56	5.70	6.95	8.12
3/32"	.0071	1.78	3.10	4.20	5.28	6.45	7.54
3/32"	.0063	1.65	2.88	3.92	4.92	6.00	7.00
3/32"	.0056	1.53	2.68	3.64	4.58	5.58	6.50
3/32"	.005	1.43	2.49	3.38	4.28	5.18	6.06
3/32"	.0045	1.34	2.34	3.17	4.02	4.85	5.68
3/32"	.004	1.24	2.16	2.95	3.74	4.50	5.28
3/32"	.0035	1.14	2.00	2.72	3.46	4.12	4.80
3/32"	.0031	1.02	1.80	2.43	3.12	3.72	4.32
1/8"	.010	2.89	5.00	6.90	8.55	10.30	12.00
1/8"	.0089	2.67	4.67	6.40	7.95	9.60	11.10
1/8"	.008	2.50	4.35	5.95	7.42	9.00	10.30
1/8"	.0071	2.33	4.02	5.54	6.90	8.37	9.68
1/8"	.0063	2.16	3.74	5.14	6.40	7.72	8.98
1/8"	.0056	2.00	3.46	4.76	5.95	7.20	8.35
1/8"	.005	1.86	3.23	4.44	5.53	6.68	7.74
1/8"	.0045	1.74	3.01	4.14	5.19	6.25	7.25
1/8"	.004	1.62	2.80	3.85	4.80	5.80	6.75
1/8"	.0035	1.49	2.57	3.52	4.40	5.32	6.13
1/8"	.0031	1.33	2.30	3.16	3.98	4.80	5.60
3/16"	.010	4.22	7.22	10.00	12.60	15.10	17.40
3/16"	.0089	3.90	6.72	9.22	11.70	14.00	16.10
3/16"	.008	3.66	6.30	8.60	10.80	13.10	15.00
3/16"	.0071	3.39	5.80	8.00	10.00	12.20	14.00
3/16"	.0063	3.15	5.40	7.40	9.35	11.30	12.90
3/16"	.0056	2.92	5.00	6.87	8.65	10.40	12.10
3/16"	.005	2.71	4.65	6.38	8.02	9.70	11.30
3/16"	.0045	2.53	4.34	6.00	7.50	9.05	10.50
3/16"	.004	2.34	4.02	5.55	6.95	8.40	9.80
3/16"	.0035	2.14	3.67	5.07	6.34	7.68	9.00
3/16"	.0031	1.98	3.40	4.70	5.85	7.10	8.35

TOPHET A®

COLD ROLLED FURNACE STRIP

Resistance in Ohms Per Foot at 20°C. (68°F.)

Thickness Inches	WIDTH IN INCHES									
	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
.130	.00785	.00628	.00523	.00448	.00392	.00349	.00314	.00262	.00224	.00196
.125	.00816	.00653	.00544	.00466	.00408	.00363	.00326	.00272	.00233	.00204
.120	.00850	.00680	.00567	.00486	.00425	.00378	.00340	.00283	.00243	.00212
.115	.00888	.00710	.00591	.00507	.00444	.00394	.00355	.00296	.00253	.00222
.110	.00928	.00742	.00618	.00530	.00464	.00412	.00371	.00309	.00265	.00232
.105	.00972	.00777	.00648	.00555	.00486	.00432	.00389	.00324	.00278	.00243
.100	.01020	.00816	.00680	.00583	.00510	.00453	.00408	.00340	.00291	.00255
.095	.01074	.00859	.00716	.00616	.00537	.00477	.00430	.00358	.00307	.00268
.090	.01133	.00907	.00756	.00648	.00567	.00504	.00453	.00378	.00324	.00283
.085	.01200	.00960	.00800	.00686	.00600	.00533	.00480	.00400	.00343	.00300
.080	.01276	.01020	.00850	.00729	.00638	.00567	.00510	.00425	.00364	.00319
.075	.01360	.01088	.00907	.00777	.00680	.00604	.00544	.00453	.00389	.00340
.0725	.01408	.01126	.00938	.00804	.00704	.00625	.00563	.00469	.00402	.00352
.070	.01458	.01166	.00971	.00833	.00729	.00648	.00583	.00486	.00416	.00364
.0675	.01512	.01209	.01007	.00864	.00756	.00672	.00604	.00504	.00432	.00378
.065	.01570	.01255	.01046	.00897	.00785	.00697	.00628	.00523	.00448	.00392
.0625	.01632	.01306	.01088	.00933	.00816	.00726	.00652	.00544	.00467	.00408
.060	.01700	.01360	.01133	.00971	.00850	.00756	.00680	.00567	.00486	.00425
.055	.01854	.01484	.01236	.01060	.00927	.00824	.00742	.00618	.00530	.00464
.050	.02040	.01632	.01360	.01166	.01020	.00907	.00816	.00680	.00583	.00510
.045	.02266	.01813	.01511	.01295	.01133	.01007	.00907	.00756	.00648	.00567
.040	.02550	.0204	.01700	.01457	.01275	.01133	.01020	.00850	.00729	.00638
.035	.02910	.0233	.01943	.01665	.01457	.01295	.01166	.00971	.00833	.00729
.030	.03400	.0272	.0227	.01943	.01700	.01511	.01360	.01133	.00971	.00850
.025	.04080	.0326	.0272	.0233	.0204	.01813	.01632	.01360	.01166	.01020
.020	.0510	.0408	.0340	.0291	.0255	.0227	.0204	.01700	.01457	.01275

TOPHET A®

Feet Per Pound of Cold Rolled Furnace Strip.

Thickness Inches	WIDTH IN INCHES									
	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
.130	4.22	3.38	2.81	2.41	2.11	1.88	1.69	1.40	1.20	1.05
.125	4.38	3.52	2.93	2.51	2.19	1.95	1.76	1.46	1.25	1.09
.120	4.58	3.66	3.05	2.61	2.29	2.04	1.83	1.52	1.30	1.14
.115	4.78	3.82	3.18	2.73	2.39	2.12	1.91	1.59	1.36	1.19
.110	5.00	4.00	3.23	2.85	2.50	2.22	2.00	1.61	1.42	1.25
.105	5.24	4.19	3.48	2.98	2.62	2.32	2.09	1.74	1.49	1.31
.100	5.48	4.40	3.66	3.14	2.74	2.44	2.20	1.83	1.57	1.37
.095	5.79	4.63	3.85	3.30	2.89	2.57	2.31	1.92	1.65	1.44
.090	6.30	4.88	4.17	3.49	3.15	2.71	2.44	2.08	1.74	1.57
.085	6.46	5.17	4.31	3.69	3.23	2.87	2.58	2.15	1.84	1.61
.080	6.86	5.50	4.58	3.92	3.43	3.05	2.75	2.29	1.96	1.71
.075	7.32	5.86	4.88	4.19	3.66	3.26	2.93	2.44	2.09	1.83
.0725	7.58	6.06	5.05	4.33	3.79	3.37	3.03	2.52	2.16	1.89
.070	7.84	6.28	5.23	4.48	3.92	3.49	3.14	2.61	2.24	1.91
.0675	8.14	6.51	5.42	4.65	4.07	3.62	3.25	2.71	2.32	2.03
.065	8.44	6.76	5.64	4.83	4.22	3.76	3.38	2.82	2.41	2.11
.0625	8.80	7.04	5.86	5.02	4.40	3.91	3.52	2.93	2.51	2.20
.060	9.14	7.32	6.10	5.23	4.57	4.07	3.66	3.05	2.61	2.28
.055	9.98	7.99	6.65	5.71	4.99	4.44	3.99	3.32	2.85	2.49
.050	10.98	8.79	7.32	6.27	5.49	4.88	4.39	3.66	3.13	2.74
.045	12.20	9.76	8.13	6.97	6.10	5.42	4.88	4.06	3.48	3.05
.040	13.72	10.98	9.15	7.84	6.86	6.11	5.49	4.57	3.92	3.43
.035	15.68	12.55	10.46	8.96	7.84	6.98	6.27	5.23	4.48	3.92
.030	18.3	14.65	12.19	10.45	9.16	8.14	7.32	6.09	5.22	4.58
.025	22.0	17.58	14.63	12.55	10.98	9.76	8.79	7.31	6.27	5.49
.020	27.4	22.0	18.29	15.68	13.72	12.20	11.00	9.14	7.84	6.86

TOPHET A®

COLD ROLLED FURNACE STRIP

Surface Area in Square Inches Per Lineal Foot.

Thickness Inches	WIDTH IN INCHES									
	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
.130	15.12	18.12	21.12	24.12	27.12	30.12	33.12	39.12	45.12	51.12
.125	15.00	18.00	21.00	24.00	27.00	30.00	33.00	39.00	45.00	51.00
.120	14.88	17.88	20.88	23.88	26.88	29.88	32.88	38.88	44.88	50.88
.115	14.76	17.76	20.76	23.76	26.76	29.76	32.76	38.76	44.76	50.76
.110	14.64	17.64	20.64	23.64	26.64	29.64	32.64	38.64	44.64	50.64
.105	14.52	17.52	20.52	23.52	26.52	29.52	32.52	38.52	44.52	50.52
.100	14.40	17.40	20.40	23.40	26.40	29.40	32.40	38.40	44.40	50.40
.095	14.28	17.28	20.28	23.28	26.28	29.28	32.28	38.28	44.28	50.28
.090	14.16	17.16	20.16	23.16	26.16	29.16	32.16	38.16	44.16	50.16
.085	14.04	17.04	20.04	23.04	26.04	29.04	32.04	38.04	44.04	50.04
.080	13.92	16.92	19.92	22.92	25.92	28.92	31.92	37.92	43.92	49.92
.075	13.80	16.80	19.80	22.80	25.80	28.80	31.80	37.80	43.80	49.80
.0725	13.74	16.74	19.74	22.74	25.74	28.74	31.74	37.74	43.74	49.74
.070	13.68	16.68	19.68	22.68	25.68	28.68	31.68	37.68	43.68	49.68
.0675	13.62	16.62	19.62	22.62	25.62	28.62	31.62	37.62	43.62	49.62
.065	13.56	16.56	19.56	22.56	25.56	28.56	31.56	37.56	43.56	49.56
.0625	13.50	16.50	19.50	22.50	25.50	28.50	31.50	37.50	43.50	49.50
.060	13.44	16.44	19.44	22.44	25.44	28.44	31.44	37.44	43.44	49.44
.055	13.32	16.32	19.32	22.32	25.32	28.32	31.32	37.32	43.32	49.32
.050	13.20	16.20	19.20	22.20	25.20	28.20	31.20	37.20	43.20	49.20
.045	13.08	16.08	19.08	22.08	25.08	28.08	31.08	37.08	43.08	49.08
.040	12.96	15.96	18.96	21.96	24.96	27.96	30.96	36.96	42.96	48.96
.035	12.84	15.84	18.84	21.84	24.84	27.84	30.84	36.84	42.84	48.84
.030	12.72	15.72	18.72	21.72	24.72	27.72	30.72	36.72	42.72	48.72
.025	12.60	15.60	18.60	21.60	24.60	27.60	30.60	36.60	42.60	48.60
.020	12.48	15.48	18.48	21.48	24.48	27.48	30.48	36.48	42.48	48.48

For Surface Areas of Ribbon and Wire see Pages 93 and 92.

TOPHET C®

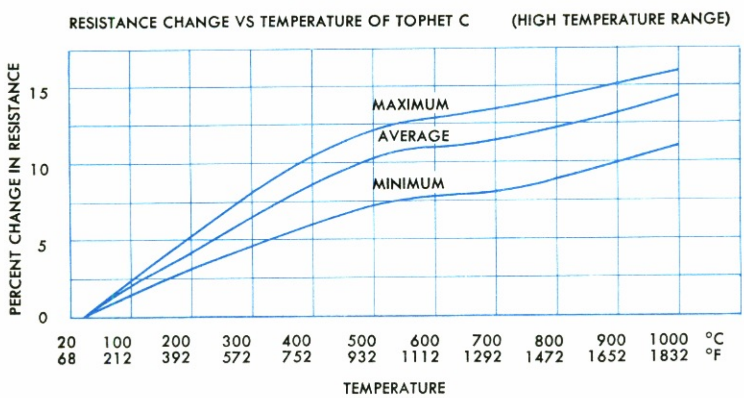
Tophet C is a nickel-chromium-iron alloy of 60% Nickel, 16% Chromium and balance Iron. It has excellent heat resisting properties up to 1700° F.

Tophet C has earned a reputation as the most suitable element for domestic appliances where operating temperatures do not require the high heat resisting properties of Tophet A.

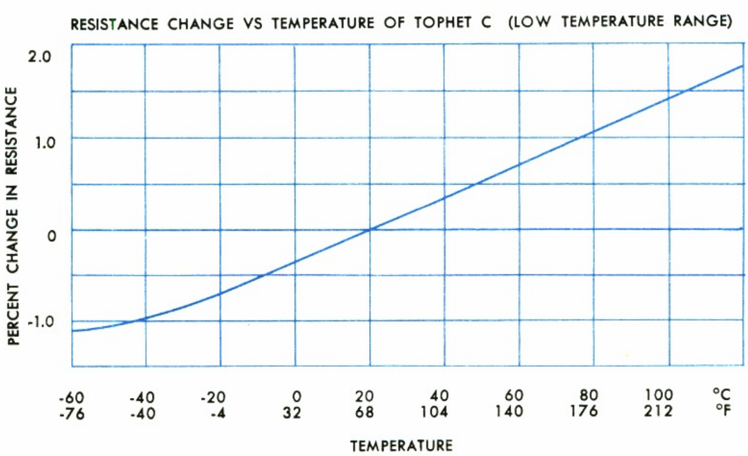
Tophet C, because of its ability to withstand high overloads, is particularly suited for heavy duty rheostats and controls. Because of its high electrical resistance and strength in fine sizes, it is widely used in electronic and other types of resistors where space is a factor.

Tophet C is subjected to the same close control in the manufacturing processes as Tophet A.

Tophet C is supplied both in wire and ribbon with a bright, smooth finish. It is also produced with silk, nylon, cotton, glass, and enamel insulation.



The maximum curve is for SMALL sizes.
The average curve is for MEDIUM popular sizes.
The minimum curve is for HEAVY sizes.
For extreme accuracy it is advisable to run tests to determine hot and cold resistance.



TOPHET C®

Resistance, Weight and Price of Wire

Resistivity 675 Ohms Per Circular Mil Foot at 20°C. (68°F.)

Wt. Per Cubic Inch .2979 Lbs. *Specific Gravity 8.247*

Temperature °C.	20	100	200	300	400	500	600	700	800	900	1000
Temperature °F.	68	212	392	572	752	932	1112	1292	1472	1652	1832
Factor	**1.000**	**1.019**	**1.043**	**1.065**	**1.085**	**1.093**	**1.110**	**1.114**	**1.123**	**1.132**	**1.143**

*These figures will vary slightly with various sizes of wire due to rate of cooling.

B & S	Dia. in Inches	Ohms Per Ft. at 68°F. (20°C.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
000	.410	.004015	.008507	2.119	472.0	$ 2.28
00	.365	.005067	.01354	2.673	374.1	2.28
0	.325	.006391	.02155	3.372	296.6	2.28
1	.289	.008082	.03446	4.264	234.5	2.28
2	.258	.01014	.05425	5.350	186.9	2.28
3	.229	.01287	.08737	6.789	147.3	2.28
4	.204	.01622	.1387	8.554	116.9	2.28
5	.182	.02038	.2191	10.75	93.01	2.28
6	.162	.02572	.3490	13.57	73.69	2.28
7	.144	.03255	.5589	17.17	58.23	2.28
8	.128	.04120	.8957	21.74	46.00	2.28
9	.114	.05194	1.423	27.40	36.49	2.32
10	.102	.06488	2.221	34.23	29.21	2.36
11	.091	.08151	3.506	43.01	23.25	2.38
12	.081	.1029	5.586	54.29	18.42	2.44
13	.072	.1302	8.942	68.68	14.56	2.48
14	.064	.1648	14.33	86.96	11.50	2.54
15	.057	.2078	22.77	109.6	9.123	2.60
16	.051	.2595	35.53	136.9	7.304	2.64
17	.045	.3333	58.63	175.9	5.686	2.72
18	.040	.4219	93.91	222.6	4.493	2.80
19	.036	.5208	143.1	274.8	3.639	2.92
20	.032	.6592	229.3	347.8	2.875	3.06
21	.0285	.8310	364.3	438.4	2.281	3.22
22	.0253	1.055	587.1	556.5	1.797	3.48
23	.0226	1.322	921.9	697.4	1.434	3.74
24	.0201	1.671	1,473.	881.8	1.134	4.08
25	.0179	2.107	2,341.	1,111.	.8997	4.42
26	.0159	2.670	3,773.	1,413.	.7099	4.76
27	.0142	3.348	5,913.	1,766.	.5662	5.10
28	.0126	4.251	9,535.	2,243.	.4458	5.44
29	.0113	5.286	14,740.	2,789.	.3586	5.78
30	.010	6.750	24,040.	3,561.	.2808	6.12
31	.0089	8.523	38,320.	4,496.	.2224	6.46
32	.008	10.55	58,710.	5,565.	.1797	6.80
33	.0071	13.39	94,560.	7,062.	.1416	7.30
34	.0063	17.00	152,600.	8,977.	.1114	7.98
35	.0056	21.52	244,500.	11,360.	.08806	8.84
36	.005	27.00	384,800.	14,250.	.07020	10.02
37	.0045	33.33	586,300.	17,590.	.05686	11.56
38	.004	42.19	939,100.	22,260.	.04493	13.42
39	.0035	55.10	1,602,000.	29,070.	.03440	15.80
40	.0031	70.24	2,603,000.	37,060.	.02698	18.70
	.00275	89.29	4,204,000.	47,080.	.02124	22.10
	.0025	108.0	6,154,000.	56,980.	.01755	27.20
	.00225	133.4	9,381,000.	70,320.	.01422	34.00
	.002	168.8	15,030,000.	89,050.	.01123	42.50
	.00175	220.6	25,656,000.	116,300.	.00860	54.40
	.0015	300.0	47,490,000.	158,300.	.006318	68.00
	.0014	344.4	62,580,000.	181,700.	.005504	85.00
	.0013	399.4	84,150,000.	210,700.	.004746	110.50
	.0012	468.7	115,900,000.	247,300.	.004044	136.00
	.0011	557.8	164,200,000.	294,300.	.003398	170.00
	.001	675.0	240,400,000.	356,100.	.002808	212.50
	.0009	833.3	366,000,000.	439,000.	.002277	261.36
	.0008	1,054.6	587,000,000.	557,000.	.001796	339.76
	.0007	1,377.5	1,002,000,000.	727,000.	.001378	433.18

TOPHET C®

Current Temperature Characteristics of Straight Wire

Chart Shows Amperes Necessary to Raise to a Given Temperature, a Straight Wire in Air.

B & S	Dia. in Inches	100 212	200 392	300 572	400 752	500 932	600 1112	700 1292	800 1472	900 1652	1000 1832	1100°C. 2012°F.
1	.289		74.5	101.0	128.5	157.9	194.0	233.0	279.3	328.5	376.0	426.0
2	.258		61.7	85.2	107.9	132.2	162.8	196.0	235.3	275.5	318.5	360.0
3	.229		51.0	71.5	90.2	112.8	136.3	165.8	194.0	233.3	264.5	301.0
4	.204		43.2	60.5	75.4	94.0	115.0	139.0	163.2	194.2	223.0	251.0
5	.182		36.6	50.8	64.2	79.6	95.0	115.8	138.1	163.2	186.2	213.0
6	.162		30.4	41.8	53.4	66.1	80.0	97.6	115.8	136.8	157.0	180.0
7	.144		25.5	35.6	45.0	55.8	67.6	81.9	97.7	113.8	132.4	149.0
8	.128		21.7	29.8	37.9	45.6	57.4	69.6	80.8	94.5	110.9	125.0
9	.114		18.3	25.5	32.4	39.2	48.7	58.5	69.6	80.4	93.7	106.0
10	.102		16.0	21.7	27.6	33.3	40.7	49.0	58.3	68.6	79.9	88.5
11	.091		13.6	18.1	22.7	27.9	33.4	41.7	49.1	58.4	67.0	75.4
12	.081		11.8	15.5	19.4	23.7	29.0	34.1	41.8	48.5	56.3	64.6
13	.072		10.1	13.2	16.7	20.2	23.5	29.0	34.1	40.2	44.6	51.9
14	.064		8.9	11.4	14.5	17.3	20.6	24.7	29.1	34.1	37.2	44.0
15	.057		7.8	9.8	12.5	14.8	17.9	21.1	24.8	29.0	33.6	37.4
16	.051		6.86	8.62	10.8	12.60	15.3	17.9	21.2	24.5	28.6	32.9
17	.045		5.97	7.43	9.20	11.00	13.0	15.3	17.9	21.1	24.4	27.2
18	.040		5.15	6.33	7.82	9.30	11.1	13.0	15.4	17.9	20.8	23.1
19	.036		4.41	5.40	6.65	7.95	9.44	11.1	13.1	15.3	17.7	20.0
20	.032		3.77	4.61	5.68	6.75	8.04	9.50	11.2	13.0	15.1	17.0
21	.0285	2.51	3.23	3.97	4.85	5.78	6.95	8.13	9.65	11.00	12.80	14.50
22	.0253	2.16	2.79	3.48	4.16	5.00	5.87	7.15	8.22	9.40	10.95	12.35
23	.0226	1.86	2.40	3.04	3.62	4.36	5.00	6.17	7.15	8.20	9.50	10.70
24	.0201	1.65	2.12	2.69	3.33	3.82	4.55	5.29	6.22	7.10	8.14	9.20
25	.0179	1.40	1.81	2.30	2.84	3.33	3.92	4.55	5.34	6.16	7.01	7.90
26	.0159	1.220	1.58	1.96	2.43	2.84	3.33	3.87	4.56	5.30	5.97	6.75
27	.0142	1.050	1.36	1.71	2.09	2.50	2.89	3.45	3.97	4.60	5.20	5.83
28	.0126	.915	1.18	1.50	1.80	2.14	2.55	2.98	3.48	3.98	4.46	5.00
29	.0113	.814	1.06	1.32	1.59	1.91	2.25	2.59	3.06	3.38	3.91	4.36
30	.010	.685	.881	1.13	1.37	1.63	1.93	2.23	2.62	2.90	3.35	3.72
31	.0089	.572	.755	.970	1.20	1.37	1.64	1.93	2.23	2.50	2.86	3.17
32	.008	.490	.646	.843	1.03	1.19	1.39	1.66	1.91	2.18	2.46	2.71
33	.0071	.432	.565	.715	.900	1.03	1.19	1.39	1.63	1.81	2.10	2.32
34	.0063	.351	.490	.617	.775	.900	1.04	1.29	1.39	1.57	1.79	1.98
35	.0056	.323	.421	.528	.665	.784	.901	1.05	1.22	1.34	1.54	1.69
36	.005	.273	.361	.480	.577	.686	.784	.930	1.06	1.18	1.31	1.45
37	.0045	.235	.314	.422	.510	.606	.686	.814	.910	1.03	1.14	1.24
38	.004	.204	.274	.372	.441	.510	.600	.695	.794	.881	.980	1.07
39	.0035	.186	.245	.333	.382	.441	.510	.597	.676	.755	.842	.91
40	.0031	.165	.216	.284	.333	.382	.441	.510	.578	.637	.715	.76
	.00275	.147	.194	.240	.290							
	.0025	.127	.180	.212	.251							
	.00225	.113	.159	.183	.220							
	.002	.098	.138	.169	.190							
	.00175	.086	.113	.139	.168							
	.00150	.077	.100	.122	.146							
	.00125	.069	.088	.108	.129							
	.001	.059	.078	.095	.115							

TOPHET C®

Current Temperature Characteristics of Coiled Wire

Chart shows amperes necessary to raise to a given temperature in air, a coil of stated arbor size when stretched twice the close-wound length.

B & S	Dia. in Inches	Arbor Size	200 392	300 572	400 752	500 932	600 1112	700 1292	800 1472	900 1652	1000 1832	1100 °C. 2012 °F.
11	.091	3/16	8.20	12.0	16.0	20.8	25.5	31.0	37.0	42.7	49.5	57.0
12	.081	3/16	7.00	10.0	13.3	17.0	21.8	26.1	31.5	36.2	42.0	48.0
13	.072	3/16	5.90	8.4	11.2	14.5	18.0	22.0	26.5	30.3	35.0	40.5
14	.064	3/16	4.95	7.1	9.6	12.2	15.2	18.7	22.1	25.3	29.5	34.0
15	.057	3/16	4.10	6.0	8.0	10.2	12.9	15.5	18.5	21.3	24.7	28.0
16	.051	3/16	3.45	5.00	6.60	8.60	10.8	13.0	15.6	18.0	21.0	24.0
17	.045	3/16	2.85	4.10	5.50	7.20	9.00	10.8	13.0	15.0	17.5	20.0
18	.040	1/8	2.35	3.30	4.50	5.80	7.40	9.00	10.8	12.7	15.0	16.7
19	.036	1/8	1.94	2.80	3.70	4.90	6.20	7.60	9.20	10.8	12.8	14.0
20	.032	1/8	1.60	2.30	3.10	4.10	5.20	6.40	7.80	9.20	10.8	12.0
21	.0285	1/8	1.35	1.90	2.60	3.40	4.40	5.40	6.50	7.60	9.00	10.0
22	.0253	1/8	1.12	1.60	2.20	2.90	3.70	4.50	5.50	6.40	7.60	8.50
23	.0226	1/8	.940	1.30	1.80	2.40	3.10	3.80	4.60	5.50	6.40	7.10
24	.0201	1/8	.780	1.10	1.50	2.00	2.60	3.20	3.90	4.60	5.40	6.00
25	.0179	1/8	.650	.970	1.30	1.70	2.20	2.70	3.30	3.90	4.50	5.10
26	.0159	1/8	.540	.800	1.10	1.40	1.80	2.30	2.80	3.30	3.80	4.30
27	.0142	1/8	.450	.660	.920	1.20	1.50	1.90	2.30	2.70	3.20	3.60
28	.0126	1/8	.380	.560	.760	1.00	1.30	1.60	1.90	2.20	2.60	3.00
29	.0113	1/8	.320	.460	.640	.840	1.10	1.30	1.60	1.90	2.20	2.50
30	.010	1/8	.260	.380	.530	.700	.900	1.10	1.40	1.60	1.90	2.10
31	.0089	1/16	.200	.300	.420	.570	.730	.910	1.10	1.30	1.60	1.80
32	.008	1/16	.160	.240	.340	.460	.600	.760	.920	1.10	1.30	1.50
33	.0071	1/16	.130	.190	.280	.370	.490	.620	.760	.900	1.10	1.20
34	.0063	1/16	.099	.150	.220	.300	.400	.500	.630	.740	.880	1.00
35	.0056	1/16	.071	.120	.180	.250	.320	.420	.520	.620	.730	.850
36	.005	1/32	.064	.100	.150	.200	.270	.350	.430	.510	.610	.700
37	.0045	1/32	.053	.084	.120	.170	.220	.280	.360	.420	.500	.580
38	.004	1/32	.044	.070	.100	.140	.190	.240	.300	.350	.420	.480
39	.0035	1/32	.037	.059	.084	.120	.150	.200	.250	.290	.350	.400
40	.0031	1/32	.031	.050	.070	.100	.130	.160	.210	.250	.290	.330

TOPHET C®

Resistance of Ribbon in Ohms Per Foot at 20°C. (68°F.)

Resistivity = 530 Ohms Per Square Mil Foot at 20°C. (68°F.)

Thickness		WIDTH IN INCHES												
B & S	Inches	1/64 .015625	1/32 .03125	3/64 .046875	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102								.02211	.01386	.01039	.008314	.006928	.005196
11	.091								.02478	.01553	.01165	.009319	.007766	.005824
12	.081								.02784	.01745	.01309	.01047	.008724	.006543
13	.072								.03132	.01963	.01472	.01178	.009815	.007361
14	.064							.04699	.03524	.02208	.01656	.01325	.01104	.008281
15	.057							.05276	.03957	.02480	.01860	.01488	.01240	.009298
16	.051							.05897	.04422	.02771	.02078	.01663	.01386	.01039
17	.045							.06682	.05012	.03141	.02356	.01884	.01570	.01178
18	.040						.1128	.07518	.05638	.03533	.02650	.02120	.01767	.01325
19	.036						.1253	.08350	.06265	.03926	.02944	.02356	.01963	.01472
20	.032						.1410	.09397	.07048	.04417	.03313	.02650	.02208	.01656
21	.0285						.1583	.1055	.07914	.04959	.03719	.02975	.02480	.01860
22	.0253						.1783	.1189	.08915	.05586	.04190	.03352	.02793	.02095
23	.0226						.1996	.1251	.09381	.06254	.04690	.03752	.03127	.02345
24	.0201			.5984	.4488	.2992	.2244	.1406	.1055	.07032	.05274	.04219	.03516	.02637
25	.0179			.6720	.5040	.3360	.2520	.1579	.1184	.07896	.05922	.04737	.03948	.02961
26	.0159			.7565	.5674	.3783	.2837	.1778	.1333	.08889	.06667	.05333	.04444	.03333
27	.0142			.8471	.6353	.4235	.3177	.1991	.1493	.09953	.07465	.05972	.04977	.03732
28	.0126			.9546	.7160	.4773	.3580	.2243	.1683	.1122	.08413	.06730	.05608	.04206
29	.0113			1.064	.7983	.5322	.3992	.2501	.1876	.1251	.09381	.07504	.06254	.04690
30	.010	3.609	1.804	1.203	.9021	.6014	.4511	.2827	.2120	.1413	.1060	.08480	.07067	.05300
31	.0089	4.055	2.027	1.352	1.014	.6758	.5068	.3176	.2382	.1588	.1191	.09528	.07940	.05955
32	.008	4.511	2.255	1.504	1.128	.7518	.6386	.3533	.2650	.1767	.1325	.1060	.08833	.06625
33	.0071	5.082	2.541	1.694	1.271	.8471	.7195	.3981	.2986	.1991	.1493	.1194	.09953	.07465
34	.0063	5.728	2.864	1.909	1.432	.9546	.8109	.4487	.3365	.2243	.1683	.1346	.1122	.08413
35	.0056	6.444	3.222	2.148	1.611	1.216	.9122	.5048	.3786	.2524	.1893	.1514	.1262	.09464
36	.005	7.217	3.609	2.406	1.804	1.362	1.022	.5653	.4240	.2827	.2120	.1696	.1413	.1060
37	.0045	8.019	4.009	2.673	2.005	1.514	1.135	.6281	.4711	.3141	.2356	.1884	.1570	.1178
38	.004	9.021	4.511	3.007	2.554	1.703	1.277	.7067	.5300	.3533	.2650	.2120	.1767	.1325
39	.0035	10.31	5.155	3.437	2.919	1.946	1.460	.8076	.6057	.4038	.3029	.2423	.2019	.1514
40	.0031	11.64	5.820	4.394	3.296	2.197	1.648	.9118	.6839	.4559	.3419	.2735	.2280	.1710
	.00275	13.12	6.560	4.954	3.715	2.477	1.858	1.028	.7709	.5139	.3855	.3084	.2570	.1927
	.0025	14.43	7.217	5.449	4.087	2.725	2.044	1.131	.8480	.5653	.4240	.3392	.2827	.2120
	.00225	16.04	8.019	6.054	4.541	3.027	2.271	1.256	.9422	.6281	.4711	.3769	.3141	.2356
	.002	18.04	10.22	6.811	5.108	3.406	2.554	1.413	1.060	.7067	.5300	.4240	.3533	.2650
	.00175	20.62	11.68	7.784	5.838	3.892	2.919	1.615	1.211	.8076	.6057	.4846	.4038	.3029
	.0015	24.06	13.62	9.082	6.811	4.541	3.406	1.884	1.413	.9422	.7067	.5653	.4711	.3533
	.00125	28.87	16.35	10.90	8.174	5.449	4.087	2.261	1.696	1.131	.8480	.6784	.5653	.4240
	.001	40.87	20.43	13.62	10.22	6.811	5.108	2.827	2.120	1.413	1.060	.8480	.7067	.5300

All sizes to the left of the double line are rolled with round edges. Resistances of these sizes are calculated according to the method advocated by the American Society for Testing Materials. That is, if the width to thickness ratio of a round edged strip is less than 15 to 1, the cross sectional area shall be considered 6% less than a true rectangle when calculating the resistance.

If the width to thickness ratio is greater than 15 to 1, the cross sectional area shall be considered 17% less than a true rectangle.

Resistances to the right of the double line are figured for square edged strip.

All resistances below the solid black line are for sizes with a width to thickness ratio greater than 15 to 1.

TOPHET C®

Feet Per Pound of Ribbon

Thickness		WIDTH IN INCHES												
B & S	Inches	1/64 .015625	1/32 .03125	3/64 .046875	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102								11.67	7.317	5.484	4.387	3.656	2.742
11	.091								13.08	8.200	6.149	4.918	4.098	3.073
12	.081								14.70	9.206	6.905	5.525	4.605	3.453
13	.072							22.35	16.53	10.36	7.768	6.216	5.181	3.884
14	.064							24.80	18.59	11.66	8.740	6.991	5.828	4.370
15	.057							27.84	20.88	13.09	9.818	7.852	6.542	4.906
16	.051							31.12	23.34	14.63	10.97	8.778	7.311	5.484
17	.045							35.27	26.45	16.58	12.43	9.942	8.285	6.216
18	.040						59.51	39.68	29.75	18.65	13.98	11.19	9.324	6.991
19	.036						66.11	44.08	33.06	20.72	15.53	12.43	10.36	7.768
20	.032						74.40	49.58	37.20	23.31	17.48	13.98	11.66	8.740
21	.0285						83.54	55.68	41.77	26.19	19.62	15.70	13.09	9.818
22	.0253						94.10	62.73	47.05	29.48	22.11	17.69	14.74	11.06
23	.0226						105.4	66.01	49.51	33.00	24.76	19.80	16.50	12.37
24	.0201		473.7	315.8	236.8	157.9	118.4	74.24	55.65	37.11	27.84	22.27	18.55	13.91
25	.0179		532.0	354.7	266.0	177.3	133.0	83.33	62.50	41.67	31.25	25.00	20.83	15.63
26	.0159		598.7	399.2	299.4	199.6	149.7	93.84	70.35	46.92	35.18	28.14	23.45	17.60
27	.0142		670.5	447.0	335.3	223.5	167.6	105.1	78.76	52.52	39.39	31.51	26.27	19.70
28	.0126		755.6	503.7	377.8	251.9	188.9	118.4	88.77	59.20	44.41	35.52	29.60	22.20
29	.0113		842.7	561.7	421.4	266.2	210.6	132.0	99.03	66.01	49.51	39.60	33.00	24.76
30	.010	1904.	952.4	634.7	475.9	317.3	238.1	149.1	111.9	74.56	55.95	44.76	37.29	27.97
31	.0089	2140.	1070.	713.3	534.9	356.7	267.4	167.6	125.7	83.81	62.84	50.28	41.90	31.43
32	.008	2381.	1190.	793.2	595.1	396.8	337.0	186.5	139.8	93.24	69.91	55.95	46.61	34.97
33	.0071	2683.	1341.	893.9	670.7	447.0	379.7	210.1	157.6	105.1	78.76	63.04	52.52	39.39
34	.0063	3023.	1512.	1008.	755.5	503.7	427.9	236.7	177.6	118.4	88.77	71.03	59.20	44.41
35	.0056	3401.	1700.	1133.	850.0	641.9	481.3	266.4	199.7	133.2	99.90	79.94	66.58	49.95
36	.005	3809.	1904.	1270.	952.4	718.8	539.1	298.4	223.7	149.1	111.9	89.47	74.56	55.95
37	.0045	4232.	2115.	1411.	1058.	798.8	598.9	331.5	248.6	165.8	124.3	99.42	82.85	62.16
38	.004	4762.	2382.	1587.	1348.	898.7	674.1	372.9	279.7	186.5	139.8	111.9	93.24	69.91
39	.0035	5440.	2720.	1814.	1540.	1027.	770.4	426.3	319.7	213.1	159.8	127.9	106.6	79.94
40	.0031	6144.	3072.	2319.	1739.	1160.	869.6	481.1	361.0	240.6	180.4	144.3	120.3	90.19
	.00275	6925.	3462.	2614.	1960.	1308.	980.7	542.5	406.9	271.2	203.4	162.7	135.6	101.7
	.0025	7617.	3809.	2875.	2157.	1438.	1078.	596.8	447.6	298.4	223.7	179.0	149.1	111.9
	.00225	8465.	4228.	3196.	2397.	1597.	1199.	663.2	497.4	331.5	248.6	198.9	165.8	124.3
	.002	9524.	5391.	3594.	2696.	1797.	1348.	745.6	559.5	372.9	279.7	223.7	186.5	139.8
	.00175	10883.	6163.	4108.	3081.	2054.	1540.	852.1	639.5	426.3	319.7	255.7	213.1	159.8
	.0015	12699.	7188.	4793.	3594.	2397.	1797.	994.2	745.6	497.4	372.9	298.4	248.6	186.5
	.00125	15239.	8629.	5750.	4313.	2875.	2157.	1139.0	894.7	596.8	447.6	358.0	298.4	223.7
	.001	21573.	10781.	7188.	5391.	3594.	2696.	1491.0	1119.0	745.6	559.5	447.6	372.9	279.7

TOPHET C®

List Price Per Pound of Ribbon

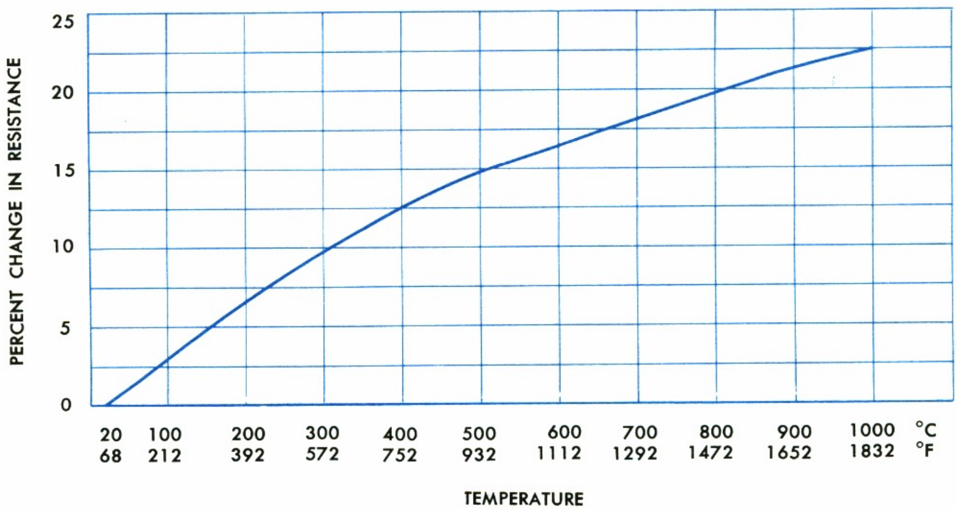
Thickness		WIDTH IN INCHES									
B & S	Inches	1/64 .0156	1/32 .03125	3/64 .046875	1/16 .0625	1/8 .1250	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	3/4 to 1 3/4
14	.064						2.96	2.96	2.96	2.80	2.80
15	.057						2.96	2.96	2.96	2.88	2.88
16	.051						2.96	2.96	2.96	2.88	2.88
17	.045						2.96	2.96	2.96	2.88	2.88
18	.040						2.96	2.96	2.96	2.96	2.96
19	.036						3.06	2.96	2.96	2.96	2.96
20	.032					3.56	3.14	3.06	3.06	3.06	3.06
21	.0285					3.56	3.22	3.14	3.14	3.14	3.14
22	.0253					3.56	3.30	3.22	3.22	3.22	3.22
23	.0226					3.56	3.40	3.30	3.30	3.30	3.30
24	.0201			4.38	3.64	3.56	3.48	3.40	3.40	3.40	3.40
25	.0179			4.50	3.74	3.64	3.56	3.48	3.48	3.48	3.48
26	.0159			4.58	3.82	3.74	3.64	3.56	3.56	3.56	3.56
27	.0142			4.68	3.90	3.82	3.74	3.64	3.64	3.64	3.64
28	.0126			4.88	4.08	3.90	3.82	3.74	3.74	3.74	3.74
29	.0113			5.10	4.24	3.98	3.90	3.82	3.82	3.82	3.82
30	.010		6.62	5.30	4.42	4.08	3.98	3.90	3.90	3.90	3.90
31	.0089		6.80	5.50	4.58	4.16	4.08	4.08	4.08	4.08	4.08
32	.008	10.88	6.96	5.74	4.76	4.24	4.16	4.24	4.24	4.24	4.24
33	.0071	11.38	7.30	5.90	4.92	4.42	4.32	4.42	4.42	4.42	4.42
34	.0063	11.90	7.64	6.12	5.10	4.66	4.58	4.76	4.76	4.76	4.76
35	.0056	12.74	8.16	6.42	5.26	4.92	5.00	5.26	5.26	5.26	5.26
36	.005	13.60	8.66	6.78	5.52	5.26	5.44	5.94	5.94	5.94	5.94
37	.0045	14.44	9.18	7.24	5.94	5.60	5.94	6.80	6.80	6.80	6.80
38	.004	15.72	9.86	8.02	6.80	6.12	6.80	7.86	7.86	7.86	7.86
39	.0035	17.42	10.88	9.44	8.50	7.64	8.50	9.76	9.76	9.76	9.76
40	.0031	19.54	12.32	11.04	10.20	9.34	10.20	11.90	11.90	11.90	11.90
	.00275	21.66	14.02	12.74	11.90	11.04	12.24	12.92	13.60	14.28	15.88
	.0025	24.22	15.72	14.44	13.60	12.74	14.86	16.48	18.36	20.40	22.68
	.00225	26.76	17.84	17.02	16.14	15.30	19.34	21.50	23.88	26.52	29.48
	.002	29.74	20.40	19.88	19.54	18.70	24.56	27.28	30.26	33.66	37.40
	.00175	33.14	24.22	24.22	24.22	24.64	29.74	33.06	36.72	40.80	45.30
	.0015	36.54	28.04	28.04	28.04	33.40	37.14	41.30	45.90	51.00	56.68
	.00125	48.86	42.06	42.06	42.06	49.12	54.22	57.02	60.08	63.24	70.28
	.001	64.60	56.10	56.10	56.10	63.92	67.32	70.80	73.60	77.52	86.10

TOPHET D®

Tophet D is an alloy of 35% nickel and 18½% chromium. It is chiefly used for electric furnace heating element applications. It is not as resistant to chemical media as Tophet C although it is entirely rust proof at room temperature.

For electric furnace heating element applications in general, Tophet A is the standard for the industry. However, on some applications where the element is heated to the critical temperature of 1750°F in some protective atmospheres, Tophet A is subject to an inter-granular type of corrosion called "green rot". *Tophet D* is immune to this type of corrosion, so if a furnace is to be operated with a protective atmosphere all the time and if the atmosphere is known to be harmful to Tophet A, then *Tophet D* is offered as an alternative material. Both Tophet A and *Tophet D* pick up carbon from certain furnace atmospheres, but *Tophet D* does so to a greater degree; hence, elements made from it will eventually become brittle when cold.

RESISTANCE CHANGE VS TEMPERATURE OF TOPHET D



TOPHET D®

COLD ROLLED FURNACE STRIP

Resistivity: 471 Ohms Per Sq. Mil Ft. at 68°F.

Weight Per Cu. Inch: 0.2872 lbs. *Specific Gravity 7.95*

Factors for Determining Resistance at Various Temperatures

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
Temperature °F	68	212	392	572	752	932	1112	1292	1472	1652	1832	2012
Factor	**1.000**	**1.028**	**1.065**	**1.100**	**1.125**	**1.155**	**1.178**	**1.196**	**1.212**	**1.228**	**1.244**	**1.260**

Thickness Inches	**OHMS PER FOOT**										**List Price Per Lb. All Widths**
	WIDTH IN INCHES										
	½	**⅝**	**¾**	**⅞**	**1**	**1⅛**	**1¼**	**1½**	**1¾**	**2**	
.130	.00724	.00580	.00483	.00414	.00362	.00322	.00290	.00242	.00207	.001812	$2.24
.125	.00754	.00603	.00502	.00431	.00377	.00335	.00303	.00251	.00215	.001883	2.24
.120	00785	.00628	.00523	.00449	.00393	.00349	.00314	.00262	.00224	.001962	2.24
.115	.00819	.00655	.00546	.00468	.00410	.00364	.00328	.00273	.00234	.00205	2.24
.110	.00856	.00685	.00571	.00490	.00428	.00380	.00343	.00286	.00245	.00214	2.24
.105	.00897	.00718	.00598	.00513	.00448	.00398	.00359	.00299	.00258	.00224	2.24
.100	.00942	.00754	.00628	.00538	.00471	.00418	.00376	.00314	.00269	.00235	2.24
.095	.00992	.00794	.00661	.00567	.00496	.00440	.00397	.00331	.00283	.00248	2.24
.090	.01407	.00838	.00698	.00598	.00524	.00465	.00419	.00349	.00299	.00262	2.24
.085	.01108	.00887	.00739	.00634	.00554	.00492	.00443	.00370	.00317	.00277	2.24
.080	.01178	.00942	.00785	.00674	.00589	.00523	.00471	.00393	.00337	.00294	2.24
.075	.01256	.01005	.00837	.00718	.00628	.00558	.00502	.00419	.00359	.00314	2.24
.0725	.01299	.01040	.00866	.00743	.00650	.00577	.00520	.00433	.00371	.00325	2.24
.070	.01345	.01077	.00897	.00770	.00673	.00598	.00538	.00448	.00385	.00336	2.24
.0675	.01395	.01117	.00930	.00798	.00698	.00620	.00558	.00465	.00399	.00349	2.24
.065	.01449	.01160	.00966	.00828	.00725	.00644	.00580	.00483	.00414	.00362	2.24
.0625	.01508	.01206	.01005	.00862	.00754	.00669	.00603	.00502	.00431	.00377	2.34
.060	.01570	.01256	.01047	.00897	.00785	.00697	.00628	.00524	.00449	.00393	2.34
.055	.01712	.01370	.01142	.00979	.00856	.00761	.00685	.00571	.00490	.00428	2.34
.050	.01883	.01508	.01256	.01078	.00942	.00836	.00754	.00628	.00538	.00471	2.34
.045	.0209	.01675	.01395	.01197	.01047	.00930	.00837	.00698	.00598	.00523	2.34
.040	.0236	.01885	.01570	.01346	.01178	.01046	.00942	.00785	.00673	.00589	2.34
.035	.0269	.0215	.01794	.01539	.01346	.01195	.01078	.00898	.00769	.00673	2.34
.030	.0314	.0251	.0209	.01795	.01570	.01384	.01257	.01047	.00897	.00785	2.52
.025	.0377	.0302	.0251	.0215	.01884	.01673	.01507	.01256	.01078	.00942	2.60
.020	.0471	.0377	.0314	.0269	.0236	.0209	.01885	.01570	.01345	.01178	2.70

TOPHET D®

POUNDS PER FOOT

Thickness	WIDTH IN INCHES									
Inches	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
.130	.2240	.2800	.3360	.3920	.4480	.5040	.5600	.6720	.7840	.8960
.125	.2154	.2692	.3231	.3769	.4308	.4846	.5384	.6461	.7538	.8615
.120	.2068	.2585	.3101	.3618	.4135	.4652	.5169	.6203	.7237	.8270
.115	.1981	.2477	.2972	.3462	.3963	.4458	.4954	.5944	.6935	.7926
.110	.1895	.2369	.2843	.3317	.3791	.4264	.4738	.5686	.6634	.7581
.105	.1809	.2261	.2714	.3166	.3618	.4071	.4523	.5427	.6332	.7237
.100	.1723	.2154	.2585	.3015	.3446	.3877	.4308	.5169	.6031	.6892
.095	.1637	.2046	.2455	.2864	.3274	.3683	.4092	.4911	.5729	.6547
.090	.1551	.1938	.2326	.2714	.3101	.3489	.3877	.4652	.5427	.6203
.085	.1465	.1831	.2197	.2563	.2929	.3295	.3661	.4394	.5126	.5858
.080	.1378	.1723	.2068	.2412	.2757	.3101	.3446	.4135	.4824	.5514
.075	.1292	.1615	.1938	.2261	.2585	.2908	.3231	.3877	.4523	.5169
.0725	.1249	.1561	.1874	.2186	.2498	.2811	.3123	.3748	.4372	.4997
.070	.1206	.1508	.1809	.2111	.2412	.2714	.3015	.3618	.4221	.4824
.0675	.1163	.1454	.1745	.2035	.2326	.2617	.2908	.3489	.4071	.4652
.065	.1120	.1400	.1680	.1960	.2240	.2520	.2800	.3360	.3920	.4480
.0625	.1077	.1346	.1615	.1885	.2154	.2423	.2692	.3231	.3769	.4308
.060	.1034	.1292	.1551	.1809	.2068	.2326	.2585	.3101	.3618	.4135
.055	.0948	.1185	.1421	.1658	.1895	.2132	.2369	.2843	.3317	.3791
.050	.0862	.1077	.1292	.1508	.1723	.1938	.2154	.2585	.3015	.3446
.045	.0775	.0969	.1163	.1357	.1551	.1745	.1938	.2326	.2714	.3101
.040	.0689	.0862	.1034	.1206	.1378	.1551	.1723	.2063	.2412	.2757
.035	.0603	.0754	.0905	.1055	.1206	.1357	.1508	.1809	.2111	.2412
.030	.0517	.0646	.0775	.0905	.1034	.1163	.1292	.1551	.1809	.2068
.025	.0431	.0538	.0646	.0754	.0862	.0969	.1077	.1292	.1508	.1723
.020	.0345	.0431	.0517	.0603	.0689	.0775	.0862	.1034	.1206	.1378

TOPHET D®

Surface Area in Square Inches Per Lineal Foot

Thickness	WIDTH IN INCHES									
Inches	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
.130	15.12	18.12	21.12	24.12	27.12	30.12	33.12	39.12	45.12	51.12
.125	15.00	18.00	21.00	24.00	27.00	30.00	33.00	39.00	45.00	51.00
.120	14.88	17.88	20.88	23.88	26.88	29.88	32.88	38.88	44.88	44.88
.115	14.76	17.76	20.76	23.76	26.76	29.76	32.76	38.76	44.76	50.76
.110	14.64	17.64	20.64	23.64	26.64	29.64	32.64	38.64	44.64	50.64
.105	14.52	17.52	20.52	23.52	26.52	29.52	32.52	38.52	44.52	50.52
.100	14.40	17.40	20.40	23.40	26.40	29.40	32.40	38.40	44.40	50.40
.095	14.28	17.28	20.28	23.28	26.28	29.28	32.28	38.28	44.28	50.28
.090	14.16	17.16	20.16	23.16	26.16	29.16	32.16	38.16	44.16	50.16
.085	14.04	17.04	20.04	23.04	26.04	29.04	32.04	38.04	44.04	50.04
.080	13.92	16.92	19.92	22.92	25.92	28.92	31.92	37.92	43.92	49.92
.075	13.80	16.80	19.80	22.80	25.80	28.80	31.80	37.80	43.80	49.80
.0725	13.74	16.74	19.74	22.74	25.74	28.74	31.74	37.74	43.74	49.74
.070	13.68	16.68	19.68	22.68	25.68	28.68	31.68	37.68	43.68	49.68
.0675	13.62	16.62	19.62	22.62	25.62	28.62	31.62	37.62	43.62	49.62
.065	13.56	16.56	19.56	22.56	25.56	28.56	31.56	37.56	43.56	49.56
.0625	13.50	16.50	19.50	22.50	25.50	28.50	31.50	37.50	43.50	49.50
.060	13.44	16.44	19.44	22.44	25.44	28.44	31.44	37.44	43.44	49.44
.055	13.32	16.32	19.32	22.32	25.32	28.32	31.32	37.32	43.32	49.32
.050	13.20	16.20	19.20	22.20	25.20	28.20	31.20	37.20	43.20	49.20
.045	13.08	16.08	19.08	22.08	25.08	28.08	31.08	37.08	43.08	49.08
.040	12.96	15.96	18.96	21.96	24.96	27.96	30.96	36.96	42.96	48.96
.035	12.84	15.84	18.84	21.84	24.84	27.84	30.84	36.84	42.84	48.84
.030	12.72	15.72	18.72	21.72	24.72	27.72	30.72	36.72	42.72	48.72
.025	12.60	15.60	18.60	21.60	24.60	27.60	30.60	36.60	42.60	48.60
.020	12.48	15.48	18.48	21.48	24.48	27.48	30.48	36.48	42.48	48.48

EVANOHM®

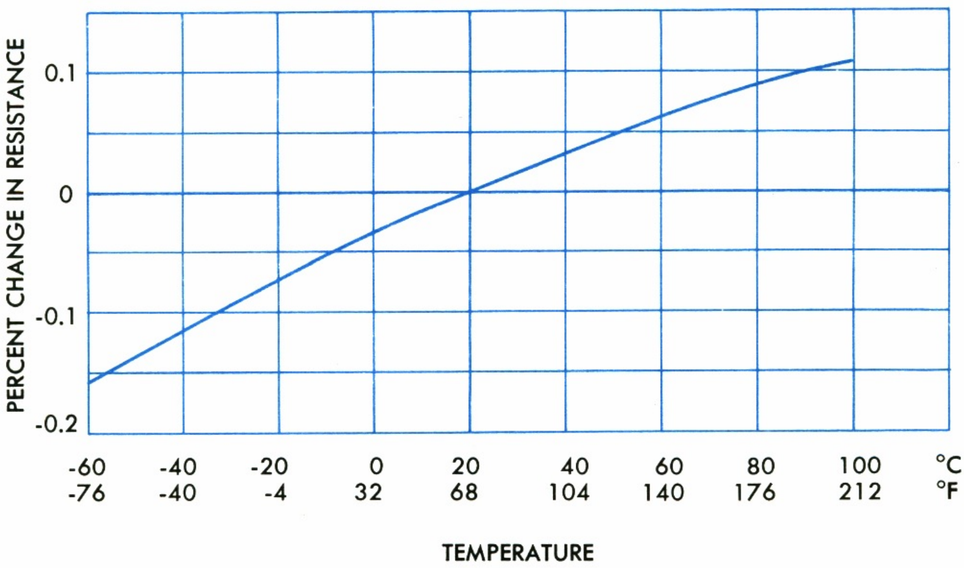
Evanohm is an alloy with a nominal composition of 74.50% Nickel, 20% Chromium, 2.75% Aluminum and 2.75% Copper.

Evanohm has a resistivity of 800 ohms per circular mil foot and a temperature coefficient of plus or minus .00002 per degree C, and a very low thermal emf vs copper. *Evanohm* possesses a high tensile strength in fine sizes, a high resistance to corrosion and is non-magnetic. Its principal application is in fine sizes for precision wound resistors.

It is supplied in wire form and insulated with enamel, silk, nylon, cotton and glass.

The chart below shows the resistance change with temperature from minus 60°C. to plus 100°C.

RESISTANCE CHANGE VERSUS TEMPERATURE OF EVANOHM.



EVANOHM®

Resistance weight and price of wire

Resistivity 800 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .293 lbs. *Specific Gravity 8.10*

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
15	.057	.2462	27.48	111.6	8.961	$ 5.18
16	.051	.3076	42.85	139.3	7.179	5.28
17	.045	.3951	70.56	178.6	5.599	5.40
18	.040	.5000	113.0	226.0	4.425	5.56
19	.036	.6173	172.7	279.8	3.574	5.76
20	.032	.7813	276.7	354.1	2.824	6.00
21	.0285	.9849	439.7	446.4	2.240	6.34
22	.0253	1.250	707.9	566.3	1.766	6.80
23	.0226	1.566	1,112.0	709.8	1.409	7.26
24	.0201	1.980	1,777.0	897.4	1.114	7.84
25	.0179	2.497	2,827.0	1,132.0	.8834	8.42
26	.0159	3.164	4,537.0	1,434.0	.6974	9.00
27	.0142	3.967	7,133.0	1,798.0	.5562	9.56
28	.0126	5.039	11,509.0	2,284.0	.4378	10.16
29	.0113	6.265	17,786.0	2,839.0	.3522	10.72
30	.010	8.000	29,008.0	3,626.0	.2758	11.30
31	.0089	10.10	46,228.0	4,577.0	.2185	11.88
32	.008	12.50	70,813.0	5,665.0	.1765	12.46
33	.0071	15.87	114,137.0	7,192.0	.1390	13.38
34	.0063	20.16	184,162.0	9,135.0	.1095	14.54
35	.0056	25.51	294,921.0	11,561.0	.08650	16.16
36	.005	32.00	464,064.0	14,502.0	.06896	18.24
37	.0045	39.51	707,387.0	17,904.0	.05585	20.78
38	.004	50.00	1,133,000.0	22,660.0	.04413	23.78
39	.0035	65.31	1,932,980.0	29,597.0	.03379	27.72
40	.0031	83.25	3,140,778.0	37,727.0	.02651	32.34
	.00275	105.8	5,072,264.0	47,942.0	.02086	36.96
	.0025	128.0	7,425,280.0	58,010.0	.01724	43.88
	.00225	158.0	11,315,486.0	71,617.0	.01376	55.44
	.002	200.0	18,128,000.0	90,640.0	.01103	69.30
	.00175	261.3	30,934,523.0	118,387.0	.008466	87.78
	.0015	355.6	57,300,673.0	161,138.0	.006206	110.88
	.0014	408.2	75,508,836.0	184,980.0	.005406	138.60
	.0013	473.4	101,559,922.0	214,533.0	.004661	180.18
	.0012	555.0	139,736,790.0	251,778.0	.003972	221.76
	.0011	661.2	198,119,984.0	299,637.0	.003337	277.20
	.001	800.0	290,048,800.0	362,561.0	.002758	346.50
	.0009	987.7	442,100,446.0	447,606.0	.002234	490.42
	.0008	1250.0	708,127,500.0	566,502.0	.001765	
	.0007	1633.0	1,208,289,360.0	739,920.0	.001351	

MANGANIN

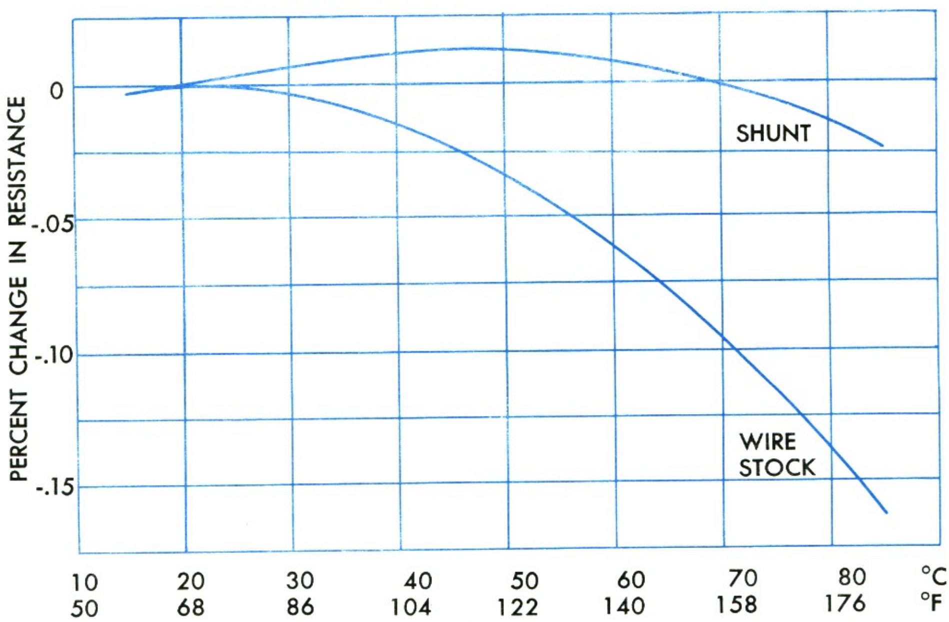
Manganin is an alloy of copper, manganese and nickel. It is used for resistors in precision built electrical apparatus such as Wheatstone bridges, decade boxes and potentiometers.

Manganin has a resistivity of 290 ohms per circular mil foot and a low thermal emf vs copper (not exceeding .0025 mv per degree between 0 and 100°C) and a nominal temperature coefficient of resistance of .000015 per degree C between 15 and 35°C. The peak in the resistance temperature coefficient curve is approximately 25°C.

When winding *Manganin* resistors, strains are set up in the wire which must be relieved to obtain stability. It has been found necessary to artificially age resistors by baking at temperatures of from 250°F to 280°F from 24 to 48 hours.

Manganin is available in all sizes of wire and ribbon, and in wire form can be insulated with enamel, silk, nylon, cotton or glass.

RESISTANCE CHANGE VS TEMPERATURE OF MANGANIN.



MANGANIN

Resistance, Weight and Price of Wire

Resistivity 290 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch .296 Lbs. *Specific Gravity 8.193*

B & S	Dia. in Inches	Ohms Per Ft. at 68°F. (20°C.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
000	.410	.001725	.003678	2.132	469.0	
00	.365	.002177	.005856	2.690	371.7	
0	.325	.002746	.009317	3.393	294.7	
1	.289	.003472	.01490	4.292	233.0	$ 1.73
2	.258	.004357	.02346	5.385	185.7	1.73
3	.229	.005530	.03780	6.835	146.3	1.73
4	.204	.006968	.05002	8.613	116.1	1.73
5	.182	.008755	.09473	10.82	92.42	1.73
6	.162	.01105	.1509	13.66	73.22	1.73
7	.144	.01399	.2419	17.29	57.85	1.73
8	.128	.01770	.3873	21.88	45.71	1.73
9	.114	.02231	.6153	27.58	36.26	1.76
10	.102	.02787	.9601	34.45	29.03	1.79
11	.091	.03502	1.516	43.29	23.10	1.81
12	.081	.04420	2.414	54.61	18.31	1.85
13	.072	.05594	3.869	69.16	14.46	1.91
14	.064	.07080	6.194	87.49	11.43	1.93
15	.057	.08926	9.845	110.3	9.065	1.97
16	.051	.1115	15.36	137.8	7.257	2.01
17	.045	.1432	25.35	177.0	5.650	2.07
18	.040	.1813	40.61	224.0	4.464	2.13
19	.036	.2238	61.88	276.5	3.616	2.20
20	.032	.2832	99.12	350.0	2.857	2.27
21	.0285	.3570	157.5	441.3	2.266	2.33
22	.0253	.4531	253.7	559.9	1.786	2.40
23	.0226	.5678	398.5	701.8	1.425	2.47
24	.0201	.7178	636.9	887.3	1.127	2.53
25	.0179	.9051	1,013.0	1,119.0	.8939	2.67
26	.0159	1.147	1,626.0	1,418.0	.7053	2.80
27	.0142	1.438	2,555.0	1,777.0	.5626	3.00
28	.0126	1.826	4,123.0	2,258.0	.4429	3.20
29	.0113	2.271	6,375.0	2,807.0	.3563	3.40
30	010	2.900	10,390.0	3,584.0	.2790	3.60
31	.0089	3.662	16,570.0	4,525.0	.2210	3.87
32	.008	4.531	25,370.0	5,599.0	.1786	4.13
33	.0071	5.754	40,920.0	7,112.0	.1406	4.40
34	.0063	7.305	65,990.0	9,033.0	.1107	4.93
35	.0056	9.247	105,700.0	11,430.0	.08749	6.00
36	.005	11.60	166,300.0	14,340.0	.06975	7.33
37	.0045	14.32	253,500.0	17,700.0	.05650	9.33
38	.004	18.13	406,100.0	22,400.0	.04464	12.00
39	.0035	23.67	692,600.0	29,260.0	.03418	16.00
40	.0031	30.18	1,126,000.0	37,300.0	.02681	21.33
	.00275	38.36	1,818,000.0	47,390.0	.02110	28.00
	.0025	46.40	2,661,000.0	57,340.0	.01744	36.00
	.00225	57.31	4,059,000.0	70,820.0	.01412	46.66
	.002	72.50	6,497,000.0	89,610.0	.01116	60.00
	.00175	94.69	11,078,730.0	117,000.0	.008544	74.00
	.0015	128.9	20,560,000.0	159,500.0	.006278	92.63
	.0014	148.0	27,070,000.0	182,900.0	.005468	
	.0013	171.6	36,400,000.0	212,100.0	.004715	
	.0012	201.4	50,130,000.0	248,900.0	.004018	
	.0011	239.7	71,000,000.0	296,200.0	.003376	
	.001	290.0	103,900,000.0	358,400.0	.002790	

MANGANIN SHUNT STRIP

The composition of Manganin shunt strip is essentially the same as that of wire with slight modifications. Its principal use is for shunts in DC ammeters.

Specific Resistance { 180 ohms per sq. mil ft. @ 20° C.
230 ohms per cir. mil ft. @ 20° C. }

Specific Gravity, 8.192.

Lbs. per cubic inch, .2960

Thermal E. M. F. against copper not over .003 millivolts per degree C. between 0°—100° C.

Temperature coefficient of resistance, ±.000015 between 40–60° C.

RESISTANCE OF SHUNT MANGANIN

No. B. & S.	Thickness in Inches	Ohms per Ft. 1 Inch Width	Lbs. per 1000 Ft. 1 Inch Width
10	.102	.001765	362.3
11	.091	.001978	323.3
12	.081	.002221	287.7
13	.072	.002498	255.8
14	.064	.002812	227.3
15	.057	.003158	202.5
16	.051	.003529	181.2
17	.045	.003999	159.8
18	.040	.004500	142.1
19	.036	.004998	127.9
20	.032	.005625	113.7
21	.0285	.006316	101.2
22	.0253	.007115	89.9
23	.0226	.007965	80.3
24	.0201	.008937	71.4

CUPRON®

Cupron is an alloy of 55% Copper and 45% Nickel. It is widely known as Constantan because of its practically unvarying resistance over a wide temperature range.

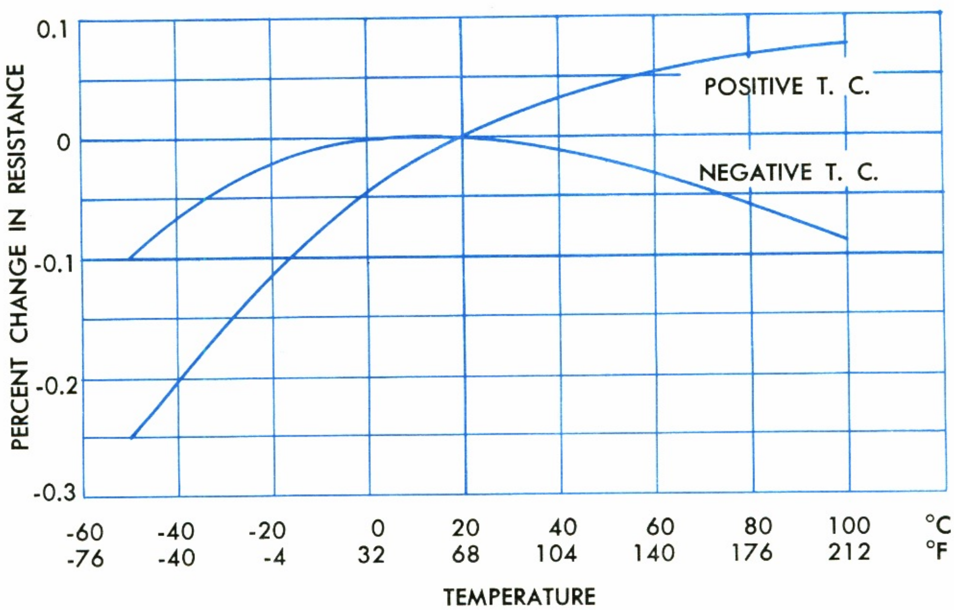
Cupron is used in rheostats and controls where maximum operating temperature does not exceed 1000°F. Because of its low coefficient of electrical resistance and stability, *Cupron* is used in fine sizes in resistors for electrical instruments.

Care must be exercised when *Cupron* is joined to copper because of the high thermal emf generated between these metals. Both terminals must be at the same temperature.

The range of temperature coefficient of resistance of *Cupron* is plus or minus .00004 per degree C between 0 and 100°C. Lower values can be supplied when specified.

Cupron is available in all sizes of wire, ribbon and strip. It is also available in wire form, insulated with enamel, silk, nylon, cotton and glass.

RESISTANCE CHANGE VS TEMPERATURE OF CUPRON (LOW TEMPERATURE RANGE)



CUPRON®

Resistance, Weight and Price of Wire

Resistivity 294 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .321 lbs. *Specific Gravity 8.9*

Temperature coefficient practically nil

B & S	Dia. in Inches	Ohms Per Ft. @ 20°C. (68°F.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
000	.410	.0017	.003	1.96	509.0	$1.30
00	.365	.0022	.006	2.48	404.0	1.30
0	.325	.0028	.009	3.13	320.0	1.30
1	.289	.0035	.013	3.95	253.0	1.30
2	.258	.0044	.021	4.95	202.0	1.30
3	.229	.0056	.034	6.29	158.0	1.30
4	.204	.0070	.055	7.92	126.0	1.30
5	.182	.0088	.087	9.96	104.0	1.30
6	.162	.0112	.137	12.50	80.0	1.30
7	.144	.0142	.222	15.90	62.8	1.30
8	.128	.0180	.359	20.10	49.7	1.30
9	.114	.0226	.556	25.30	39.5	1.32
10	.102	.0283	.887	31.70	31.5	1.34
11	.091	.0355	1.39	39.80	25.1	1.36
12	.081	.0448	2.20	50.20	19.9	1.39
13	.072	.0567	3.56	63.60	15.7	1.42
14	.064	.0717	5.71	80.50	12.4	1.45
15	.057	.0905	8.98	101.00	9.90	1.48
16	.051	.1130	14.2	126.00	7.93	1.51
17	.045	.1452	23.4	162.00	6.17	1.55
18	.040	.1837	37.6	206.00	4.85	1.60
19	.036	.2268	57.4	254.00	3.93	1.65
20	.032	.2871	92.4	322.00	3.10	1.70
21	.0285	.3619	146.0	406.00	2.46	1.75
22	.0253	.4590	234.0	515.00	1.94	1.80
23	.0226	.5756	371.0	646.00	1.54	1.85
24	.0201	.7280	599.0	820.00	1.22	1.90
25	.0179	.9176	943.0	1,029.00	.971	2.00
26	.0159	1.163	1,513.0	1,305.00	.766	2.10
27	.0142	1.458	2,372.0	1,636.00	.611	2.25
28	.0126	1.852	3,844.0	2,078.00	.481	2.40
29	.0113	2.302	5,943.0	2,584.00	.386	2.55
30	.010	2.940	9,702.0	3,300.00	.303	2.70
31	.0089	3.710	15,455.0	4,166.00	.240	2.90
32	.008	4.594	23,666.0	5,156.00	.193	3.10
33	.0071	5.833	38,163.0	6,546.00	.152	3.30
34	.0063	7.408	61,523.0	8,314.00	.120	3.70
35	.0056	9.375	98,591.0	10,522.00	.095	4.50
36	.005	11.76	154,440.0	13,200.00	.075	5.50
37	.0045	14.52	236,292.0	16,296.00	.061	7.00
38	.004	18.37	377,437.0	20,625.00	.048	9.00
39	.0035	24.00	646,512.0	26,938.00	.037	12.00
40	.0031	30.59	1,050,533.0	34,339.00	.029	16.00
	.00275	38.87	1,696,131.0	43,636.00	.022	21.00
	.0025	47.04	2,483,712.0	52,800.00	.019	27.00
	.00225	58.07	3,785,292.0	65,185.00	.015	34.50
	.002	73.50	6,063,750.0	82,500.00	.012	43.25
	.00175	96.00	10,334,480.0	107,755.00	.0093	55.50
	.0015	130.66	19,163,379.0	147,060.00	.0068	69.50
	.0014	150.00	25,200,000.0	169,492.00	.0059	87.00
	.0013	174.00	34,266,000.0	196,078.00	.0051	113.25
	.0012	204.00	46,400,000.0	227,273.00	.0044	139.50
	.0011	243.00	65,600,100.0	270,270.00	.0037	174.50
	.001	294.00	97,820,000.0	330,000.00	.00303	218.25

CUPRON®

Current Temperature Characteristics of Straight Wire

Chart Shows Amperes Necessary to Raise to a Given Temperature, a Straight Wire in Air.

B & S	Dia. in Inches	100°C. 212°F.	200°C. 392°F.	300°C. 572°F.	400°C. 752°F.	500°C. 932°F.	600°C. 1112°F.
1	.289	59.5	113.0	173.0	236.0	297.0	355.0
2	.258	51.0	96.5	148.0	200.0	250.0	300.0
3	.229	43.5	81.5	124.0	168.0	210.0	251.0
4	.204	37.2	69.0	105.0	141.0	176.0	210.0
5	.182	31.8	58.8	89.0	120.0	148.0	178.0
6	.162	27.3	50.0	75.0	100.0	125.0	149.0
7	.144	23.3	42.2	63.0	84.5	104.0	125.0
8	.128	20.0	36.0	53.0	70.5	88.0	105.0
9	.114	17.0	30.5	44.8	59.5	73.3	88.0
10	.102	14.5	25.8	38.0	50.0	61.5	74.0
11	.091	12.4	21.9	32.0	42.0	51.8	62.0
12	.081	10.6	18.5	26.8	35.2	43.2	52.0
13	.072	9.50	15.7	22.6	29.5	36.2	43.0
14	.064	7.70	13.2	19.0	24.7	30.3	36.0
15	.057	6.60	11.2	16.0	20.8	25.4	30.2
16	.051	5.65	9.6	13.7	17.7	21.6	25.7
17	.045	4.92	8.25	11.7	15.2	18.4	22.0
18	.040	4.32	7.18	10.2	13.1	15.9	18.9
19	.036	3.85	6.32	8.90	11.5	13.9	16.4
20	.032	3.38	5.50	7.70	9.90	11.9	14.2
21	.0285	2.98	4.82	6.70	8.60	10.4	12.3
22	.0253	2.62	4.18	5.76	7.40	8.90	10.5
23	.0226	2.32	3.66	5.02	6.42	7.75	9.15
24	.0201	2.03	3.20	4.36	5.55	6.70	7.90
25	.0179	1.78	2.78	3.78	4.79	5.76	6.78
26	.0159	1.57	2.42	3.27	4.12	4.98	5.83
27	.0142	1.38	2.11	2.84	3.58	4.30	5.08
28	.0126	1.21	1.83	2.44	3.08	3.69	4.32
29	.0113	1.07	1.61	2.15	2.70	3.22	3.80
30	.010	.945	1.40	1.85	2.30	2.75	3.22
31	.0089	.825	1.21	1.58	1.98	2.37	2.76
32	.008	.732	1.06	1.39	1.72	2.06	2.41
33	.0071	.642	.928	1.20	1.49	1.78	2.15
34	.0063	.552	.808	1.03	1.28	1.53	1.79
35	.0056	.498	.700	.900	1.11	1.32	1.54
36	.005	.440	.615	.780	.963	1.14	1.33
37	.0045	.390	.542	.686	.840	1.00	1.17
38	.004	.342	.462	.592	.730	.870	1.01
39	.0035	.297	.404	.505	.616	.735	.855
40	.0031	.260	.350	.434	.530	.630	.730

CUPRON®

Resistance of Ribbon in Ohms Per Foot at 20°C. (68°F.)

Resistivity = 231 Ohms Per Square Mil Foot at 20°C. (68°F.)

Thickness		WIDTH IN INCHES										
B & S	Inches	1/64 .015625	1/32 .03125	1/16 .0625	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102											
11	.091											
12	.081											
13	.072											
14	.064								.0072	.0057	.0048	.0036
15	.057								.0081	.0064	.0054	.0040
16	.051								.0091	.0072	.0061	.0045
17	.045								.0103	.0082	.0069	.0051
18	.040								.0115	.0092	.0077	.0058
19	.036								.0128	.0102	.0086	.0064
20	.032		.246	.122	.0614	.0409	.0307	.0192	.0144	.0115	.0096	.0072
21	.0285		.276	.137	.0689	.0459	.0344	.0216	.0162	.0129	.0108	.0081
22	.0253		.311	.155	.0777	.0518	.0388	.0243	.0183	.0146	.0122	.0091
23	.0226		.348	.173	.0869	.0545	.0410	.0272	.0204	.0164	.0136	.0102
24	.0201		.391	.196	.0982	.0613	.0450	.0307	.0230	.0184	.0154	.0115
25	.0179		.440	.219	.1098	.0688	.0516	.0344	.0258	.0206	.0172	.0129
26	.0159		.495	.247	.1236	.0775	.0580	.0387	.0290	.0232	.0194	.0145
27	.0142		.554	.276	.1384	.0868	.0650	.0435	.0326	.0260	.0218	.0163
28	.0126		.625	.312	.1560	.0978	.0735	.0490	.0366	.0293	.0244	.0183
29	.0113		.697	.347	.1739	.1090	.0820	.0545	.0409	.0327	.0272	.0204
30	.010	1.573	.786	.393	.1966	.1232	.0924	.0616	.0462	.0370	.0308	.0231
31	.0089	1.767	.883	.442	.2209	.1384	.1038	.0692	.0519	.0415	.0346	.0260
32	.008	1.966	.983	.491	.2783	.1540	.1155	.0770	.0578	.0462	.0385	.0289
33	.0071	2.215	1.108	.554	.3136	.1735	.1301	.0868	.0651	.0521	.0434	.0325
34	.0063	2.496	1.248	.624	.3534	.1956	.1467	.0978	.0733	.0587	.0489	.0367
35	.0056	2.808	1.404	.702	.3976	.2200	.1650	.1100	.0825	.0660	.0550	.0413
36	.005	3.146	1.573	.786	.4453	.2644	.1848	.1232	.0924	.0739	.0616	.0462
37	.0045	3.495	1.748	.874	.4949	.2738	.2053	.1369	.1027	.0821	.0684	.0513
38	.004	3.932	1.966	1.113	.5566	.3080	.2310	.1540	.1155	.0924	.0770	.0578
39	.0035	4.494	2.247	1.272	.6362	.3520	.2640	.1760	.1320	.1056	.0880	.0660
40	.0031	5.073	2.537	1.436	.7183	.3974	.2981	.1987	.1490	.1192	.0994	.0745
	.00275	5.719	2.860	1.619	.8097	.4480	.3360	.2240	.1680	.1344	.1120	.0840
	.0025	6.291	3.146	1.781	.8909	.4928	.3696	.2464	.1848	.1478	.1232	.0924
	.00225	6.990	3.495	1.979	.9897	.5476	.4107	.2738	.2053	.1643	.1369	.1027
	.002	7.864	4.453	2.227	1.113	.6160	.4620	.3080	.2310	.1848	.1540	.1155
	.00175	8.987	5.089	2.545	1.272	.7040	.5280	.3520	.2640	.2112	.1760	.1320
	.0015	10.485	5.937	2.969	1.484	.8213	.6160	.4107	.3080	.2464	.2053	.1540
	.00125	12.582	7.125	3.563	1.781	.9856	.7392	.4928	.3696	.2957	.2464	.1848
	.001	17.813	8.906	4.453	2.227	1.232	.9240	.6160	.4620	.3696	.3080	.2310

All sizes to the left of the double line are rolled with round edges. Resistances of these sizes are calculated according to the method advocated by the American Society for Testing Materials. That is, if the width to thickness ratio of a round edged strip is less than 15 to 1, the cross sectional area shall be considered 6% less than a true rectangle when calculating the resistance.

If the width to thickness ratio is greater than 15 to 1, the cross sectional area shall be considered 17% less than a true rectangle.

Resistances to the right of the double line are figured for square edged strip.

All resistances below the solid black line are for sizes with a width to thickness ratio greater than 15 to 1.

CUPRON®

Feet Per Pound of Ribbon

Thickness		WIDTH IN INCHES										
B & S	Inches	1/64 .015625	1/32 .03125	1/16 .0625	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1" 1.000
10	.102											
11	.091											
12	.081											
13	.072											
14	.064								8.1	6.4	5.4	4.0
15	.057								9.1	7.2	6.0	4.5
16	.051								10.1	8.1	6.7	5.0
17	.045								11.5	9.2	7.6	5.7
18	.040								12.9	10.3	8.6	6.4
19	.036								14.4	11.5	9.6	7.2
20	.032		276	139	69.0	46.0	34.5	21.6	16.2	12.9	10.8	8.1
21	.0285		310	155	77.5	51.7	38.7	24.3	18.2	14.5	12.1	9.1
22	.0253		350	174	87.3	58.2	43.6	27.3	20.5	16.4	13.6	10.2
23	.0226		391	195	97.8	61.2	45.9	30.6	22.9	18.4	15.3	11.4
24	.0201		440	221	110.0	69.2	51.9	34.6	25.9	20.7	17.3	12.9
25	.0179		494	247	123.0	77.4	58.0	38.7	29.0	23.2	19.3	14.5
26	.0159		557	278	139.0	87.0	65.3	43.5	32.6	26.1	21.7	16.3
27	.0142		623	311	155.0	97.4	73.1	48.7	36.6	29.2	24.3	18.2
28	.0126		703	350	176.0	109.8	82.4	54.9	41.2	32.9	27.5	20.6
29	.0113		783	391	195.0	122.6	91.9	61.3	45.9	36.7	30.7	23.0
30	.010	1,770	884	449	221.0	138.4	103.0	69.2	51.9	41.5	34.6	26.0
31	.0089	1,989	993	496	248.0	155.6	116.0	77.8	58.3	46.7	39.0	29.2
32	.008	2,213	1,105	552	313.0	173.2	129.0	86.6	65.0	52.0	43.3	32.5
33	.0071	2,493	1,245	622	352.0	195.0	146.0	97.5	73.2	58.7	49.5	36.6
34	.0063	2,810	1,403	699	397.0	218.0	164.0	109.0	82.5	66.0	55.0	41.2
35	.0056	3,161	1,579	789	447.0	246.0	185.0	123.0	92.8	74.3	62.0	46.4
36	.005	3,540	1,768	884	500.0	276.0	207.0	138.0	104.0	83.3	69.3	52.0
37	.0045	3,934	1,965	982	556.0	306.0	230.0	153.0	115.5	92.5	77.0	57.7
38	.004	4,426	2,211	1,252	626.0	346.0	259.0	173.0	130.0	104.0	86.7	65.0
39	.0035	5,058	2,526	1,430	715.0	394.0	296.0	197.0	148.5	119.0	99.0	74.2
40	.0031	5,710	2,855	1,617	808.5	447.3	335.5	223.7	167.7	134.2	111.8	83.9
	.00275	6,437	3,219	1,823	911.3	504.2	378.2	252.1	189.1	151.3	126.1	94.5
	.0025	7,081	3,540	2,005	1,000.3	554.7	416.0	277.3	208.0	166.4	138.7	104.0
	.00225	7,868	3,934	2,228	1,114.0	616.3	462.2	308.1	231.1	184.9	154.1	115.6
	.002	8,851	5,012	2,506	1,253.0	693.3	520.0	346.7	260.0	208.0	173.3	130.0
	.00175	10,116	5,728	2,864	1,432.0	792.4	594.3	396.2	297.1	237.7	198.1	148.6
	.0015	11,802	6,683	3,341	1,670.7	924.4	693.3	462.2	346.7	277.3	231.1	173.3
	.00125	14,162	8,019	4,010	2,004.8	1,109.3	832.0	554.7	416.0	332.8	277.3	208.0
	.001	20,049	10,024	5,012	2,506.0	1,386.7	1,040.0	693.3	520.0	416.0	346.7	260.0

CUPRON®

List Price Per Pound of Ribbon

Thickness		WIDTH IN INCHES								
B & S	Inches	1/64 .015625	1/32 .03125	1/16 .0625	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	3/4 to 1 3/4
10	.102									
11	.091									
12	.081									
13	.072									
14	.064			2.25	2.05	2.05	1.85	1.85	1.65	1.65
15	.057			2.25	2.05	2.05	1.85	1.85	1.65	1.65
16	.051			2.30	2.10	2.10	1.90	1.90	1.70	1.70
17	.045			2.30	2.10	2.10	1.90	1.90	1.70	1.70
18	.040			2.35	2.15	2.15	1.95	1.95	1.75	1.75
19	.036			2.35	2.15	2.15	1.95	1.95	1.75	1.75
20	.032			2.40	2.20	2.20	2.00	2.00	1.80	1.80
21	.0285			2.45	2.25	2.25	2.05	2.05	1.85	1.85
22	.0253			2.50	2.30	2.30	2.10	2.10	1.90	1.90
23	.0226			2.55	2.35	2.35	2.15	2.15	1.95	1.95
24	.0201			2.60	2.40	2.40	2.20	2.20	2.00	2.00
25	.0179			2.70	2.50	2.50	2.30	2.30	2.05	2.05
26	.0159		4.57	2.80	2.60	2.60	2.40	2.40	2.10	2.10
27	.0142		4.73	2.90	2.70	2.70	2.50	2.50	2.20	2.20
28	.0126		4.89	3.00	2.80	2.80	2.60	2.60	2.30	2.30
29	.0113		5.05	3.10	2.90	2.90	2.70	2.70	2.40	2.40
30	.010		5.25	3.20	3.00	3.00	2.80	2.80	2.50	2.50
31	.0089		5.35	3.30	3.10	3.10	2.90	2.90	2.60	2.60
32	.008	9.10	5.45	3.40	3.20	3.20	3.00	3.00	2.80	2.80
33	.0071	9.55	5.75	3.50	3.30	3.30	3.20	3.20	3.00	3.00
34	.0063	10.05	6.10	3.70	3.50	3.50	3.40	3.40	3.20	3.20
35	.0056	10.90	6.60	3.90	3.70	3.70	3.60	3.60	3.40	3.40
36	.005	11.75	7.15	4.20	4.00	4.00	3.90	3.90	3.70	3.70
37	.0045	12.45	7.50	4.50	4.40	4.40	4.30	4.30	4.20	4.20
38	.004	13.45	7.95	5.10	5.10	5.10	5.00	5.00	5.00	5.00
39	.0035	14.45	8.35	6.10	6.10	6.45	6.60	6.80	6.95	7.65
40	.0031	16.35	9.60	7.60	7.60	7.85	8.20	8.65	8.85	10.25
	.00275	18.35	11.20	9.20	8.40	9.50	10.15	10.80	11.40	12.95
	.0025	20.70	12.75	10.80	10.00	11.95	13.50	15.25	17.15	19.30
	.00225	23.10	14.75	13.15	12.35	16.15	18.20	20.40	22.85	25.65
	.0020	25.90	17.15	16.35	15.55	21.05	23.60	26.35	29.55	33.05
	.00175	29.10	20.70	20.70	21.10	25.90	29.00	32.40	36.25	40.45
	.0015	32.25	24.30	24.30	29.30	32.80	36.70	41.00	45.80	51.10
	.00125	41.55	37.45	37.45	44.05	48.80	51.45	54.30	57.25	63.85
	.001	56.25	50.55	50.55	57.85	61.05	64.30	66.95	70.60	78.65

LOW RESISTANCE ALLOYS

No. 30, No. 60, No. 90 and No. 180 Alloys are composed of copper and nickel.

They provide resistances between that of copper and Cupron. The number of the alloy signifies the ohms per circular mil foot. All of these alloys are supplied in wire, ribbon and strip, or in the wire form insulated with enamel, silk, nylon, cotton or glass.

RESISTANCE CHANGE VS TEMPERATURE OF RADIO ALLOYS (HIGH TEMPERATURE RANGE)

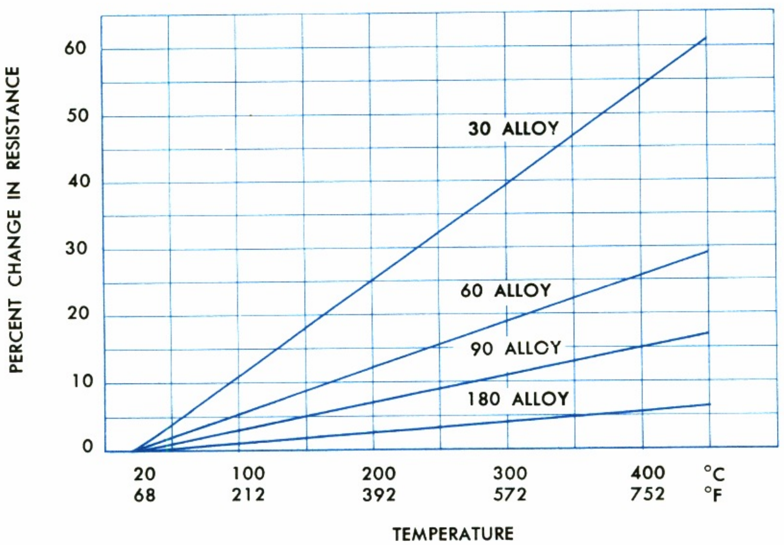
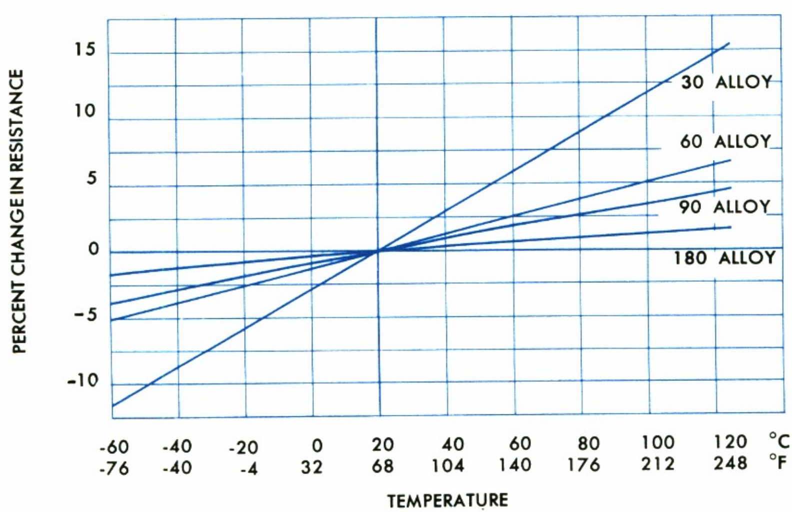


Chart below shows resistance changes in temperatures from —70° C. to +100° C.

RESISTANCE CHANGE VS TEMPERATURE OF RADIO ALLOYS (LOW TEMPERATURE RANGE)



No. 30 ALLOY

Resistance, Weight and Price of Wire

Resistivity 30 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .321 lbs. *Specific Gravity 8.92*

Factors for Determining Resistance at Various Temperatures

Temperature °C.	20	100	150	200	250	300	350	400	450
Temperature °F.	68	212	302	392	482	572	662	752	842
Factor	**1.000**	**1.120**	**1.175**	**1.250**	**1.325**	**1.395**	**1.470**	**1.540**	**1.612**

B & S	Dia. in Inches	Ohms Per Ft. @ 20°C. (68°F.)	Ohms Per Pound	Feet Per Pound	Pounds Per M Feet	List Price Per Pound Bare Wire
11	.091	.00362	.143	39.7	25.1	1.36
12	.081	.00457	.228	50.1	19.9	1.39
13	.072	.00578	.366	63.4	15.7	1.42
14	.064	.00732	.587	80.2	12.4	1.45
15	.057	.00923	.932	101.	9.90	1.48
16	.051	.0115	1.44	126.	7.93	1.51
17	.045	.0148	2.39	162.	6.17	1.55
18	.040	.0187	3.83	205.	4.87	1.60
19	.036	.0231	5.84	253.	3.95	1.65
20	.032	.0292	9.37	321.	3.11	1.70
21	.0285	.0369	14.9	404.	2.47	1.75
22	.0253	.0468	24.0	513.	1.94	1.80
23	.0226	.0587	37.7	643.	1.55	1.85
24	.0201	.0750	61.6	822.	1.21	1.90
25	.0179	.0936	96.0	1,026.	.974	2.00
26	.0159	.118	153.	1,300.	.769	2.10
27	.0142	.148	241.	1,631.	.613	2.25
28	.0126	.189	392.	2,078.	.481	2.40
29	.0113	.234	602.	2,575.	.388	2.55
30	.010	.300	986.	3,289.	.304	2.70
31	.0089	.387	1,606.	4,152.	.240	2.90
32	.008	.468	2,405.	5,139.	.194	3.10
33	.0071	.595	3,881.	6,524.	.153	3.30
34	.0063	.755	6,255.	8,286	.120	3.70
35	.0056	.956	10,025.	10,487.	.095	4.50
36	.005	1.20	15,787.	13,156.	.076	5.50
37	.0045	1.49	24,199.	16,241.	.061	7.00
38	.004	1.87	38,439.	20,556.	.048	9.00
39	.0035	2.44	65,509.	26,848.	.037	12.00
40	.0031	3.12	106,778.	34,224.	.029	16.00

No. 60 ALLOY

Resistance, Weight and Price of Wire

Resistivity 60 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .321 lbs. *Specific Gravity 8.92*

Factors for Determining Resistance at Various Temperatures

Temperature °C.	20	100	150	200	250	300	350	400	450
Temperature °F.	68	212	302	392	482	572	662	752	842
Factor	**1.000**	**1.085**	**1.132**	**1.185**	**1.235**	**1.285**	**1.340**	**1.390**	**1.445**

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound	Feet Per Pound	Pounds Per M Feet	List Price Per Pound Bare Wire
11	.091	.00724	.288	39.80	25.5	1.36
12	.081	.00914	.459	50.25	19.9	1.39
13	.072	.0115	.731	63.60	15.7	1.42
14	.064	.0146	1.17	80.50	12.4	1.45
15	.057	.0184	1.85	101.00	9.9	1.48
16	.051	.0230	2.89	126.00	7.93	1.51
17	.045	.0296	4.79	162.00	6.17	1.55
18	.040	.0375	7.72	206.00	4.85	1.60
19	.036	.0462	11.7	254.00	3.93	1.65
20	.032	.0585	18.8	322.00	3.10	1.70
21	.0285	.0738	29.9	406.00	2.46	1.75
22	.0253	.0937	48.2	515.00	1.94	1.80
23	.0226	.118	76.2	646.00	1.54	1.85
24	.0201	.150	123.0	825.00	1.21	1.90
25	.0179	.187	192.0	1,029.00	.971	2.00
26	.0159	.238	310.0	1,305.00	.766	2.10
27	.0142	.297	485.0	1,636.00	.611	2.25
28	.0126	.377	783.0	2,078.00	.481	2.40
29	.0113	.469	1,216.0	2,584.00	.386	2.55
30	.010	.600	1,980.0	3,300.00	.303	2.70
31	.0089	.757	3,153.0	4,166.00	.240	2.90
32	.008	.937	4,831.0	5,156.00	.193	3.10
33	.0071	1.19	7,789.0	6,546.00	.152	3.30
34	.0063	1.51	12,554.0	8,314.00	.120	3.70
35	.0056	1.91	20,097.0	10,522.00	.095	4.50
36	.005	2.40	31,680.0	13,200.00	.075	5.50
37	.0045	2.96	48,236.0	16,296.00	.061	7.00
38	.004	3.75	77,343.0	20,625.00	.048	9.00
39	.0035	4.89	131,726.0	26,938.00	.037	12.00
40	.0031	6.24	214,275.0	34,339.00	.029	16.00

No. 90 ALLOY

Resistance, Weight and Price of Wire

Resistivity 90 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .323 lbs. *Specific Gravity 8.96*

Factors for Determining Resistance at Various Temperatures

Temperature °C.	20	100	150	200	250	300	350	400	450
Temperature °F.	68	212	302	392	482	572	662	752	842
Factor	**1.000**	**1.030**	**1.050**	**1.070**	**1.090**	**1.110**	**1.130**	**1.150**	**1.170**

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound	Feet Per Pound	Pounds Per M Feet	List Price Per Pound Bare Wire
11	**.091**	.0109	.430	39.5	25.3	1.36
12	**.081**	.0137	.683	49.9	20.0	1.39
13	**.072**	.0173	1.09	63.2	15.8	1.42
14	**.064**	.0219	1.75	80.0	12.5	1.45
15	**.057**	.0277	2.77	100.0	10.0	1.48
16	**.051**	.0346	4.35	126.0	7.94	1.51
17	**.045**	.0444	7.14	161.0	6.21	1.55
18	**.040**	.0562	11.4	204.0	4.90	1.60
19	**.036**	.0694	17.4	252.0	3.96	1.65
20	**.032**	.0879	28.1	320.0	3.12	1.70
21	**.0285**	.111	44.7	403.0	2.48	1.75
22	**.0253**	.139	71.1	512.0	1.95	1.80
23	**.0226**	.176	112.0	641.0	1.56	1.85
24	**.0201**	.223	182.0	819.0	1.22	1.90
25	**.0179**	.281	287.0	1,023.0	.977	2.00
26	**.0159**	.356	461.0	1,296.0	.771	2.10
27	**.0142**	.446	724.0	1,625.0	.615	2.25
28	**.0126**	.567	1,174.0	2,071.0	.482	2.40
29	**.0113**	.705	1,809.0	2,567.0	.389	2.55
30	**.010**	.900	2,950.0	3,278.0	.305	2.70
31	**.0089**	1.14	4,717.0	4,138.0	.241	2.90
32	**.008**	1.41	7,226.0	5,121.0	.195	3.10
33	**.0071**	1.78	11,573.0	6,502.0	.153	3.30
34	**.0063**	2.27	18,747.0	8,259.0	.121	3.70
35	**.0056**	2.87	29,997.0	10,452.0	.095	4.50
36	**.005**	3.60	47,203.0	13,112.0	.076	5.50
37	**.0045**	4.44	71,870.0	16,187.0	.061	7.00
38	**.004**	5.62	115,136.0	20,487.0	.048	9.00
39	**.0035**	7.41	153,824.0	26,759.0	.037	12.00
40	**.0031**	9.36	319,269.0	34,110.0	.029	16.00

No. 180 ALLOY

Resistance, Weight and Price of Wire

Resistivity 180 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .322 lbs. *Specific Gravity 8.95*

Factors for Determining Resistance at Various Temperatures

Temperature °C.	20	100	150	200	250	300	350	400	450
Temperature °F.	68	212	302	392	482	572	662	752	842
Factor	**1.000**	**1.010**	**1.018**	**1.025**	**1.032**	**1.040**	**1.047**	**1.057**	**1.060**

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound	Feet Per Pound	Pounds Per M Feet	List Price Per Pound Bare Wire
11	.091	.0217	.857	39.5	25.3	1.36
12	.081	.0274	1.367	49.9	20.0	1.39
13	.072	.0347	2.193	63.2	15.8	1.42
14	.064	.0439	3.512	80.0	12.5	1.45
15	.057	.0554	5.540	100.0	10.0	1.48
16	.051	.0692	8.719	126.0	7.94	1.51
17	.045	.0888	14.2	161.0	6.21	1.55
18	.040	.1125	22.9	204.0	4.90	1.60
19	.036	.1388	34.9	252.0	3.96	1.65
20	.032	.1757	56.2	320.0	3.12	1.70
21	.0285	.2216	89.3	403.0	2.48	1.75
22	.0253	.2812	143.9	512.0	1.95	1.80
23	.0226	.3524	225.0	641.0	1.56	1.85
24	.0201	.4455	368.0	819.0	1.22	1.90
25	.0179	.5617	574.0	1,023.0	.977	2.00
26	.0159	.7119	922.0	1,296.0	.771	2.10
27	.0142	.8926	1,450.0	1,625.0	.615	2.25
28	.0126	1.1337	2,347.0	2,071.0	.482	2.40
29	.0113	1.4096	3,610.0	2,567.0	.389	2.55
30	.010	1.8000	5,900.0	3,278.0	.305	2.70
31	.0089	2.2724	9,400.0	4,138.0	.241	2.90
32	.008	2.8125	14,400.0	5,121.0	.195	3.10
33	.0071	3.5707	23,216.0	6,502.0	.153	3.30
34	.0063	4.5351	37,450.0	8,259.0	.121	3.70
35	.0056	5.7397	59,990.0	10,452.0	.095	4.50
36	.005	7.2000	94,400.0	13,112.0	.076	5.50
37	.0045	8.8888	143,880.0	16,187.0	.061	7.00
38	.004	11.250	230,470.0	20,487.0	.048	9.00
39	.0035	14.693	393,160.0	26,759.0	.037	12.00
40	.0031	18.730	638,880.0	34,110.0	.029	16.00

BALCO®

Balco is an alloy of 70% Nickel and 30% Iron.

Balco is used in thermometer bulbs and other applications that require a high temperature coefficient of resistance. It has a temperature coefficient comparable to that of commercially Pure Nickel, and twice the resistivity. The slope of the temperature resistance curve is almost straight from minus 70 to 600°C.

It is supplied in wire and ribbon, and in wire form it can be insulated with enamel, silk, nylon, cotton or glass.

RESISTANCE CHANGE VS TEMPERATURE OF BALCO (HIGH TEMPERATURE RANGE)

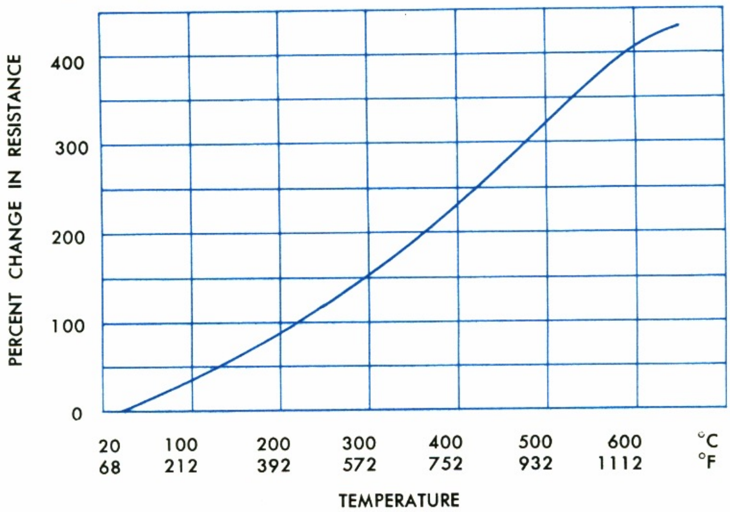
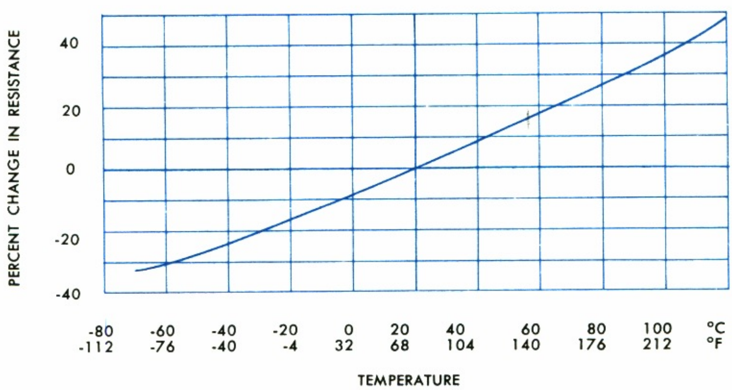


Chart below shows resistance changes in temperatures ranging from —70°C to +100°C.

RESISTANCE CHANGE VS TEMPERATURE OF BALCO (LOW TEMPERATURE RANGE)



BALCO®

Resistance Weight and Price of Wire

Resistivity 120 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .305 Lbs. *Specific Gravity 8.46*

Factors for Determining Resistance at Various Temperatures

Temperature °C.	20	100	200	300	400	500	600	700
Temperature °F.	68	212	392	572	752	932	1112	1292
Factor	**1.00**	**1.40**	**1.97**	**2.65**	**3.33**	**3.93**	**4.48**	**4.98**

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
1	.289	.001437	.006015	4.186	238.9	$ 1.60
2	.258	.001803	.009424	5.227	191.3	1.60
3	.229	.002288	.01517	6.631	150.8	1.60
4	.204	.002884	.02411	8.361	119.6	1.60
5	.182	.003622	.03807	10.51	95.14	1.60
6	.162	.004572	.06062	13.26	75.41	1.60
7	.144	.005788	.09712	16.78	59.59	1.60
8	.128	.007324	.1556	21.24	47.07	1.60
9	.114	.009234	.2471	26.76	37.37	1.62
10	.102	.01153	.3856	33.44	29.90	1.64
11	.091	.01449	.6066	41.86	23.89	1.66
12	.081	.01829	.9696	53.02	18.86	1.69
13	.072	.02314	1.553	67.11	14.90	1.72
14	.064	.02930	2.489	84.96	11.77	1.75
15	.057	.03694	3.960	107.2	9.332	1.78
16	.051	.04614	6.174	133.8	7.474	1.81
17	.045	.05926	10.19	171.9	5.818	1.85
18	.040	.07500	16.32	217.6	4.596	1.90
19	.036	.09260	24.84	268.3	3.727	1.95
20	.032	.1171	39.78	339.7	2.944	2.00
21	.0285	.1477	63.75	431.6	2.317	2.10
22	.0253	.1860	101.9	547.9	1.825	2.20
23	.0226	.2350	160.1	681.2	1.468	2.30
24	.0201	.2970	258.3	869.6	1.150	2.45
25	.0179	.3746	396.3	1,087.0	.9201	2.60
26	.0159	.4746	653.5	1,377.0	.7262	2.75
27	.0142	.5952	1,027.0	1,725.0	.5797	2.95
28	.0126	.7556	1,648.0	2,181.0	.4585	3.20
29	.0113	.9398	2,606.0	2,773.0	.3606	3.45
30	.010	1.2000	4,177.0	3,481.0	.2873	3.70
31	.0089	1.515	6,657.0	4,394.0	.2276	4.00
32	.008	1.875	10,200.0	5,438.0	.1839	4.30
33	.0071	2.380	16,440.0	6,906.0	.1448	4.60
34	.0063	3.022	26,510.0	8,772.0	.1140	5.20
35	.0056	3.826	42,090.0	11,000.0	.09011	6.40
36	.005	4.800	66,820.0	13,920.0	.07184	8.00
37	.0045	5.926	101,900.0	17,190.0	.05816	10.00
38	.004	7.500	163,100.0	21,750.0	.04598	13.00
39	.0035	9.796	278,500.0	28,430.0	.03517	17.00
40	.0031	12.49	452,900.0	36,260.0	.02758	22.00
	.00275	15.86	730,342.0	46,029.0	.02172	28.88
	.0025	19.20	1,069,363.0	55,696.0	.01795	37.13
	.00225	23.70	1,629,612.0	68,760.0	.01454	47.44
	.002	30.00	2,610,750.0	87,025.0	.01149	59.47
	.00175	39.18	4,453,394.0	113,665.0	.00879	76.31
	.0015	53.33	8,250,737.0	154,711.0	.00646	95.56
	.0014	61.22	10,872,794.0	177,602.0	.00563	119.63
	.0013	71.01	14,626,355.0	205,976.0	.00485	155.72
	.0012	83.33	20,143,860.0	241,736.0	.00413	191.81
	.0011	99.17	28,530,584.0	287,685.0	.00347	239.94
	.001	120.00	41,772,000.0	348,100.0	.00287	300.09

PURE NICKEL

Grade "A"

Typical chemical analysis of commercially pure nickel:

Nickel	99.45%	
Copper	.10	.20 max.
Iron	.15	.30
Carbon	.10	.20
Manganese	.20	.35
Silicon	.05	.20
Sulphur	.005	.008

GENERAL CHARACTERISTICS

"A" Nickel is a commercially pure wrought nickel produced by melting and deoxidizing electrolytic nickel. It is easily drawn and worked, welds and silver solders readily, and its resistance to corrosion is of a high order. Oxidation at high temperatures is low and the scale is tightly adherent. Sufficient strength is retained at bombarding temperatures to prevent deformation during out-gassing. Its modulus of elasticity and damping factor are high, minimizing vibrational and microphonic effects. The electrical resistivity is moderate, about 60 ohms per circular mil ft., at 32° F., but the temperature coefficient is high so that it is easily spot welded and heated by induction, yet the conductivity at moderate temperatures is high enough to render it suitable as a current carrying lead. The high magnetostriction coefficient of nickel makes it useful in devices employing this principle. "A" Nickel is appropriate for many electrical and electronic applications. Nickel is magnetic at room temperature and becomes non-magnetic near 670° F.

TYPICAL USES

Support wires and rods
Grid side rods
Base pins
Getter tabs
Plates (anodes)
Cathode shields in rectifier tubes
Woven wire mesh for grids
Plates in high voltage vacuum condensers
Circuit breaker contacts

Commutator conductor discs
Lead-ins (welded to Dumet)
"Feeler wires" in electronic blankets
Torsion wires in magnetic pick-ups
Oscillator plates
Sliding contacts
Spark gaps
Magnetostriction devices

Pure Nickel is supplied in round wire, ribbon, and strip. The strip can be supplied in all widths up to 6″ and in thicknesses from .125″ to .0015″.

Pure Nickel strip is also supplied with a carbonized finish.

2½ and 4% Manganese Nickel are also supplied.

PURE NICKEL

Resistance Weight and Price of Wire

Resistivity 60 Ohms Per Circular Mil Foot at 20°C. (68°F.)
Wt. Per Cubic Inch = .321 Lbs. *Specific Gravity 8.9*

Temperature °C.	20	100	200	300	400	500
Temperature °F.	68	212	392	572	752	932
Factor	1.00	1.38	1.97	2.70	3.55	4.20

B & S	Dia. in Inches	Ohms Per Ft. at 20°C. (68°F.)	Ohms Per Pound Bare Wire	Feet Per Pound Bare Wire	Pounds Per M Feet	List Price Per Pound Bare Wire
000	.410	.0003569	.0004886	1.966	508.5	$ 1.50
00	.365	.0004504	.001122	2.491	401.5	1.50
0	.325	.0005680	.001786	3.144	318.1	1.50
1	.289	.0007184	.002868	3.992	250.5	1.50
2	.258	.0009014	.004495	4.987	200.5	1.50
3	.229	.001144	.007238	6.327	158.1	1.50
4	.204	.001442	.01150	7.974	125.4	1.50
5	.182	.001811	.01815	10.02	99.82	1.50
6	.162	.002286	.02890	12.64	79.09	1.50
7	.144	.002894	.04630	16.00	62.49	1.50
8	.128	.003662	.07419	20.26	49.37	1.50
9	.114	.004617	.1179	25.53	39.17	1.52
10	.102	.005767	.1839	31.89	31.35	1.54
11	.091	.007246	.2891	39.90	25.06	1.56
12	.081	.009145	.4625	50.57	19.77	1.59
13	.072	.01157	.7406	64.01	15.62	1.62
14	.064	.01465	1.187	81.00	12.35	1.65
15	.057	.01847	1.886	102.1	9.788	1.68
16	.051	.02307	2.946	127.7	7.836	1.71
17	.045	.02963	4.856	163.9	6.100	1.75
18	.040	.03750	7.778	207.4	4.822	1.80
19	.036	.04630	11.85	256.0	3.906	1.85
20	.032	.05859	18.99	324.1	3.085	1.90
21	.0285	.07387	30.39	411.4	2.430	1.95
22	.0253	.09374	48.16	513.8	1.946	2.00
23	.0226	.1175	76.32	649.5	1.539	2.05
24	.0201	.1485	121.9	821.0	1.218	2.10
25	.0179	.1873	194.0	1,036.0	.9655	2.20
26	.0159	.2373	311.6	1,313.0	.7619	2.30
27	.0142	.2976	489.8	1,646.0	.6076	2.45
28	.0126	.3778	789.6	2,090.0	.4786	2.60
29	.0113	.4699	1,241.0	2,642.0	.3785	2.75
30	.010	.6000	1,991.0	3,318.0	.3014	2.90
31	.0089	.7576	3,174.0	4,189.0	.2387	3.10
32	.008	.9375	4,861.0	5,185.0	.1929	3.30
33	.0071	1.190	7,834.0	6,583.0	.1519	3.50
34	.0063	1.511	12,640.0	8,364.0	.1196	3.90
35	.0056	1.913	20,240.0	10,580.0	.09451	4.70
36	.005	2.400	31,850.0	13,270.0	.07534	5.70
37	.0045	2.963	48,580.0	16,400.0	.06100	7.20
38	.004	3.750	77,700.0	20,740.0	.04822	9.20
39	.0035	4.898	132,800.0	27,110.0	.03689	12.00
40	.0031	6.243	215,800.0	34,570.0	.02893	16.00
	.00275	7.937	347,958.0	43,840.0	.02281	21.00
	.0025	9.600	509,280.0	53,050.0	.01885	27.00
	.00225	11.85	776,530.0	65,530.0	.01526	35.00
	.002	15.00	1,243,770.0	82,918.0	.01206	45.00
	.00175	19.59	2,120,000.0	108,200.0	.00924	60.00
	.0015	26.66	3,932,083.0	147,490.0	.00678	80.00

Unless otherwise specified material listed above will be supplied soft temper. Prices of Enameled, Cotton and Silk covered Wires furnished on request. Pure Nickel is also furnished in Ribbon, Strip and Sheet. For prices of "Manganese Nickel" add 5c net to Pure Nickel net.

PREMIUM POTENTIOMETER WIRE

Special facilities and processes are used for the manufacture of precision potentiometer wire. Wire designated for this end use is processed separately under close control to insure premium quality.

A thorough study of this field has provided information on how to produce and control the special properties which are required in potentiometer wire. A partial list of these properties follows.

Controlled Resistance: In addition to the control of resistance limits as close as plus or minus 3% within a shipment and less than 1% within a spool of wire, potentiometer manufacturers are interested in repeatable resistance within the wire at smaller intervals. We employ several methods for measuring this property termed linearity. One method compares the resistance ratios measured at two points separated by 5% of a 1,000 ft. length of wire. The largest difference between these ratios is held to .0001. Another method compares resistance readings at one foot intervals at several points throughout a sample. The processing of potentiometer wire is closely controlled throughout drawing, annealing, spooling and enameling to meet these linearity requirements.

Clean Surfaces: Potentiometer wire must have a surface free of oxides and other foreign material which might impair the electrical pickup between the wire surface and the contact material. Potentiometer wire is drawn in diamond dies and annealed and heat treated in protective atmospheres to insure a clean bright surface. Special cleaning operations can be used to meet premium applications.

Controlled Elongation: All potentiometer wire is produced with controlled elongation to meet customer specifications. Since many potentiometer manufacturers request wire in a relatively hard condition, processing methods have been perfected wherein very low elongation can be produced in wire having full resistance and temperature coefficient properties. For special applications wire can be produced with full electrical properties and a tensile strength greater than in the hard drawn condition.

Out-Of-Roundness: Premium wire is produced to very tight out-of-round tolerances. For example, potentiometer wire .003″ diameter and smaller is held to a maximum out-of-round of .0001″.

Alloys: Evanohm, Tophets, Cupron and 90 Alloy are the alloys most frequently used for potentiometer wire applications. Other alloys are also used, and new alloys are being developed for this specialized field. Test data is available on "noise" and life characteristics of these alloys when used with standard contact materials.

INSULATED WIRE

We have a fully equipped insulating section to produce enamel, silk, nylon, glass or cotton insulated wires, either single or double covered. Formvar and liquid nylon insulation can also be supplied, the latter in colors if desired.

The use of glass insulation is rapidly gaining favor. Some of the advantages of glass insulation are:

1. Withstands high temperatures (750°F.)
2. High dielectric strength and insulation resistance
3. Non-hygroscopic; unaffected by moisture
4. High resistance to acids and corrosive vapors
5. Bonded with high grade insulating varnish if specified
6. Good heat conductivity
7. High resistance to abrasion

The following insulations are available with the desired size limitation shown:

Enameled, .0253 and finer
Formvar, .0113 and finer
Liquid Nylon (colors available), .0113 and finer
Silk, single or double, .001 and heavier
Glass, single or double, .002 and heavier
Nylon, single or double, .001 and heavier
Cotton, single or double, .002 and heavier

The following tables have been prepared showing the nominal outside diameters and other data on insulated wire. These tables are approximate and are intended to act as a guide to engineers in selecting the proper insulation for their specific requirements.

We welcome inquiries on all types of insulated resistance wire.

TOPHET C®

Enameled Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Enamel Min.	Normal	Max.	Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
20	.032	.6592	.033	.0334	.0338	345.0	227.0	30.0
21	.0285	.8310	.0295	.0299	.0303	440.0	366.0	33.4
22	.0253	1.055	.0263	.0267	.0271	555.0	586.0	37.4
23	.0226	1.322	.0236	.0238	.0244	692.0	915.0	42.0
24	.0201	1.671	.0209	.0213	.0218	880.0	1,470.0	47.0
25	.0179	2.107	.0188	.0191	.0196	1,100.0	2,320.0	52.4
26	.0159	2.670	.0168	.01685	.0173	1,400.0	3,740.0	58.3
27	.0142	3.348	.0149	.01515	.0155	1,750.0	5,860.0	66.0
28	.0126	4.251	.0133	.01355	.0140	2,190.0	9,320.0	73.7
29	.0113	5.286	.0120	.01225	.0126	2,800.0	14,800.0	81.7
30	.010	6.750	.0107	.01095	.0113	3,510.0	23,500.0	91.4
31	.0089	8.523	.0095	.00970	.0100	4,430.0	27,800.0	103.0
32	.008	10.55	.0086	.00880	.0091	5,480.0	57,800.0	113.0
33	.0071	13.39	.0076	.00775	.0080	6,960.0	93,100.0	129.0
34	.0063	17.00	.0068	.00695	.0072	8,880.0	150,000.0	144.0
35	.0056	21.52	.0060	.00615	.0064	11,200.0	241,000.0	162.0
36	.005	27.00	.0054	.00555	.0058	14,000.0	378,000.0	180.0
37	.0045	33.33	.0048	.00495	.0052	17,300.0	576,000.0	202.0
38	.004	42.19	.0043	.00455	.0048	21,900.0	965,000.0	224.0
39	.0035	55.10	.0037	.004	.0043	28,500.0	1,570,000.0	260.0
40	.0031	70.24	.0033	.0036	.0039	36,300.0	2,540,000.0	290.0
	.00275	89.29	.00277	.00306	.00335	46,500.0	4,150,000.0	328.0
	.0025	108.00	.0027	.0029	.0031	55,300.0	5,970,000.0	357.0
	.00225	133.40	.00244	.00265	.00285	68,200.0	9,100,000.0	392.0
	.002	168.80	.0022	.0024	.0026	84,250.0	14,200,000.0	435.0
	.00175	220.60	.00186	.00205	.00225	109,000.0	24,000,000.0	513.0
	.0015	300.00	.0016	.0018	.002	139,000.0	41,700,000.0	587.0
	.0014	344.40	.0015	.0017	.0019	168,000.0	57,800,000.0	625.0
	.0013	399.40	.0014	.0016	.0018	194,000.0	77,500,000.0	667.0
	.0012	468.70	.0013	.0015	.0017	227,000.0	106,400,000.0	714 0
	.0011	557.80	.0012	.0014	.0016	268,000.0	149,000,000.0	769.0
	.001	675.00	.0011	.0013	.0015	323,000.0	218,000,000.0	833.0

Turns per inch are based on the normal diameter of enameled wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920 For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Single Silk Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Silk			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0267	.0268	.0273	552.0	583.0	37.3
23	.0226	1.322	.0240	.0242	.0246	687.0	909.0	41.3
24	.0201	1.671	.0215	.0217	.0221	872.0	1,410.0	46.0
25	.0179	2.107	.0193	.0195	.0199	1,085.0	2,290.0	51.2
26	.0159	2.670	.0173	.0175	.0179	1,368.0	2,650.0	57.8
27	.0142	3.348	.0156	.0158	.0162	1,720.0	5,760.0	63.2
28	.0126	4.251	.0140	.0142	.0146	2,170.0	9,250.0	70.3
29	.0113	5.286	.0127	.0129	.0133	2,720.0	14,400.0	77.5
30	.010	6.750	.0114	.0116	.0120	3,390.0	22,900.0	86.2
31	.0089	8.523	.0103	.0105	.0109	4,260.0	36,300.0	95.2
32	.008	10.55	.0093	.0095	.0100	5,340.0	56,400.0	104.0
33	.0071	13.39	.0085	.0087	.0091	6,650.0	89,100.0	115.0
34	.0063	17.00	.0077	.0079	.0083	8,250.0	140,500.0	126.5
35	.0056	21.52	.0070	.0072	.0076	10,380.0	223,000.0	139.0
36	.005	27.00	.0064	.0066	.0070	12,880.0	348,000.0	151.5
37	.0045	33.33	.0059	.0061	.0065	15,700.0	522,500.0	164.0
38	.004	42.19	.0054	.0056	.0060	19,100.0	805,000.0	178.5
39	.0035	55.10	.0049	.0051	.0055	22,900.0	1,260,000.0	196.0
40	.0031	70.24	.0045	.0047	.0051	27,900.0	1,957,000.0	212.0
	.00275	89.29	.00415	.00430	.00475	33,500.0	2,999,000.0	232.0
	.0025	108.00	.00390	.00405	.00450	38,000.0	4,110,000.0	247.0
	.00225	133.40	.00365	.00380	.00425	44,000.0	5,875,000.0	263.0
	.002	168.80	.00340	.00355	.00400	50,000.0	8,400,000.0	282.0
	.00175	220.60	.00315	.00330	.00375	58,200.0	12,800,000.0	303.0
	.0015	300.00	.00290	.00300	.00350	63,200.0	18,950,000.0	333.0
	.0014	344.40	.00280	.00295	.00340	71,500.0	24,600,000.0	339.0
	.0013	399.40	.00270	.00285	.00330	75,600.0	30,200,000.0	350.0
	.0012	468.70	.00260	.00275	.00320	80,100.0	37,500,000.0	363.0
	.0011	557.80	.00250	.00265	.00310	84,800.0	47,400,000.0	377.0
	.001	675.00	.00240	.00255	.00300	89,900.0	60,700,000.0	392.0

Turns per inch are based on the normal diameter of S.S.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Double Silk Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Silk			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0278	.0283	.0290	540.0	570.0	35.4
23	.0226	1.322	.0251	.0256	.0263	670.0	887.0	39.1
24	.0201	1.671	.0226	.0231	.0238	850.0	1,420.0	43.2
25	.0179	2.107	.0204	.0209	.0216	1,050.0	2,220.0	47.8
26	.0159	2.670	.0184	.0189	.0196	1,330.0	3,420.0	52.8
27	.0142	3.348	.0167	.0172	.0179	1,660.0	6,560.0	58.2
28	.0126	4.251	.0151	.0156	.0163	2,080.0	8,850.0	64.0
29	.0113	5.286	.0138	.0143	.0150	2,590.0	13,700.0	70.0
30	.010	6.750	.0125	.0130	.0137	3,280.0	22,150.0	77.0
31	.0089	8.523	.0114	.0119	.0126	3,990.0	34,000.0	84.0
32	.008	10.55	.0105	.0110	.0117	4,820.0	50,800.0	91.0
33	.0071	13.39	.0096	.0101	.0108	5,975.0	80,000.0	99.0
34	.0063	17.00	.0088	.0093	.0100	7,320.0	124,000.0	107.5
35	.0056	21.52	.0081	.0086	.0093	9,100.0	196,000.0	116.0
36	.005	27.00	.0075	.0080	.0087	11,000.0	297,000.0	125.0
37	.0045	33.33	.0070	.0075	.0082	13,450.0	448,000.0	133.0
38	.004	42.19	.0065	.0070	.0077	15,900.0	670,000.0	143.0
39	.0035	55.10	.0060	.0065	.0072	18,400.0	1,015,000.0	154.0
40	.0031	70.24	.0056	.0061	.0068	21,400.0	1,500,000.0	164.0
	.00275	89.29	.00525	.00575	.00645	28,600.0	2,555,000.0	174.0
	.0025	108.00	.0050	.0055	.0062	32,500.0	3,510,000.0	182.0
	.00225	133.40	.00475	.00525	.00595	37,600.0	5,020,000.0	190.0
	.002	168.80	.0045	.0050	.0057	45,000.0	7,600,000.0	200.0
	.00175	220.60	.00425	.00475	.00545	49,700.0	10,900,000.0	210.0
	.0015	300.00	.0040	.0045	.0052	55,500.0	16,600,000.0	222.0
	.0014	344.10	.0039	.0044	.0051	61,000.0	21,000,000.0	227.0
	.0013	399.40	.0038	.0043	.0050	64,500.0	25,800,000.0	232.0
	.0012	468.70	.0037	.0042	.0049	68,500.0	32,200,000.0	238.0
	.0011	557.80	.0036	.0041	.0048	72,500.0	40,300,000.0	244.0
	.001	675.00	.0035	.0040	.0047	77,500.0	52,300,000.0	250.0

Turns per inch are based on the normal diameter of D.S.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Single Silk Enameled Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over S.S.E.			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0279	.0281	.0288	546.0	576.0	35.6
23	.0226	1.322	.0245	.0253	.0260	683.0	905.0	40.8
24	.0201	1.671	.0221	.0227	.0234	857.0	1,430.0	45.2
25	.0179	2.107	.0199	.0205	.0212	1,072.0	2,260.0	48.7
26	.0159	2.670	.0179	.0184	.0191	1,358.0	3,620.0	54.3
27	.0142	3.348	.0161	.0167	.0174	1,690.0	5,660.0	59.8
28	.0126	4.251	.0145	.0150	.0157	2,110.0	8,970.0	66.7
29	.0113	5.286	.0131	.0137	.0144	2,695.0	14,250.0	73.0
30	.010	6.750	.0118	.0123	.0130	3,320.0	22,400.0	81.2
31	.0089	8.523	.0107	.0112	.0119	4,130.0	36,700.0	89.2
32	.008	10.55	.0098	.0103	.0110	5,180.0	54,700.0	97.0
33	.0071	13.39	.0087	.0093	.0100	6,920.0	92,600.0	107.5
34	.0063	17.00	.0080	.0084	.0091	8,020.0	136,000.0	119.0
35	.0056	21.52	.0072	.0076	.0084	11,200.0	249,000.0	131.5
36	.005	27.00	.0065	.0070	.0077	12,200.0	329,000.0	143.0
37	.0045	33.33	.0060	.0064	.0071	15,120.0	504,000.0	156.0
38	.004	42.19	.0055	.0059	.0066	18,100.0	762,000.0	169.0
39	.0035	55.10	.0049	.0053	.0060	21,750.0	1,198,000.0	188.5
40	.0031	70.24	.0045	.0049	.0056	26,600.0	1,588,000.0	204.0

Turns per inch are based on the normal diameter of S.S.E. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01

TOPHET C®

Double Silk Enameled Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over D.S.E.			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0286	.0297	.0304	534.0	564.0	33.6
23	.0226	1.322	.0257	.0269	.0276	665.0	880.0	37.2
24	.0201	1.671	.0233	.0244	.0251	836.0	1,395.0	41.0
25	.0179	2.107	.0211	.0221	.0228	1,038.0	2,180.0	45.2
26	.0159	2.670	.0191	.0200	.0207	1,280.0	3,420.0	50.0
27	.0142	3.348	.0173	.0183	.0190	1,580.0	5,500.0	54.6
28	.0126	4.251	.0157	.0166	.0173	2,020.0	8,600.0	60.2
29	.0113	5.286	.0143	.0154	.0161	2,480.0	13,100.0	65.0
30	.010	6.750	.0130	.0139	.0146	3,130.0	21,100.0	72.0
31	.0089	8.523	.0119	.0129	.0136	3,950.0	33,600.0	77.5
32	.008	10.55	.0110	.0119	.0126	4,800.0	50,700.0	84.0
33	.0071	13.39	.0100	.0109	.0116	5,900.0	79,000.0	91.7
34	.0063	17.00	.0092	.0100	.0107	7,220.0	122,700.0	100.0
35	.0056	21.52	.0084	.0092	.0099	8,900.0	191,000.0	108.7
36	.005	27.00	.0078	.0086	.0093	10,600.0	286,000.0	116.0
37	.0045	33.33	.0072	.0080	.0087	13,300.0	443,000.0	125.0
38	.004	42.19	.0067	.0075	.0082	15,600.0	657,000.0	133.0
39	.0035	55.10	.0061	.0069	.0076	18,300.0	964,000.0	145.0
40	.0031	70.24	.0057	.0065	.0071	20,600.0	1,448,000.0	154.0

Turns per inch are based on the normal diameter of D.S.E. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Single Cotton Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Cotton			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0293	.0298	.0303	534.0	564.0	33.5
23	.0226	1.322	.0266	.0271	.0276	665.0	880.0	36.9
24	.0201	1.671	.0241	.0246	.0251	836.0	1,395.0	40.7
25	.0179	2.107	.0219	.0224	.0229	1,038.0	2,180.0	44.6
26	.0159	2.670	.0199	.0204	.0209	1,295.0	3,460.0	49.0
27	.0142	3.348	.0182	.0187	.0192	1,635.0	5,470.0	53.5
28	.0126	4.251	.0166	.0171	.0176	2,020.0	8,600.0	58.5
29	.0113	5.286	.0152	.0158	.0163	2,560.0	13,500.0	63.2
30	.010	6.750	.0140	.0145	.0151	3,120.0	21,000.0	68.0
31	.0089	8.523	.0129	.0134	.0139	3,860.0	33,000.0	74.5
32	.008	10.55	.0120	.0125	.0131	4,780.0	50,500.0	80.0
33	.0071	13.39	.0111	.0116	.0121	5,860.0	78,400.0	86.2
34	.0063	17.00	.0102	.0108	.0113	7,060.0	120,000.0	92.5
35	.0056	21.52	.0095	.0101	.0106	8,500.0	183,000.0	99.0
36	.005	27.00	.0085	.0090	.0095	10,700.0	289,000.0	111.0
37	.0045	33.33	.0080	.0085	.0090	12,650.0	424,000.0	117.5
38	.004	42.19	.0075	.0080	.0085	14,650.0	617,000.0	125.0
39	.0035	55.10	.0070	.0075	.0080	16,950.0	934,000.0	133.0
40	.0031	70.24	.0066	.0071	.0076	19,400.0	1,360,000.0	142.0

Turns per inch are based on the normal diameter of S.C.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Double Cotton Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Cotton			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0333	.0338	.0343	520.0	549.0	29.6
23	.0226	1.322	.0306	.0311	.0316	642.0	850.0	32.2
24	.0201	1.671	.0281	.0286	.0291	802.0	1,340.0	35.0
25	.0179	2.107	.0259	.0264	.0269	987.0	2,080.0	37.9
26	.0159	2.670	.0239	.0244	.0249	1,216.0	3,240.0	41.0
27	.0142	3.348	.0222	.0227	.0232	1,540.0	5,150.0	44.0
28	.0126	4.251	.0206	.0211	.0216	1,870.0	7,950.0	47.3
29	.0113	5.286	.0193	.0198	.0203	2,300.0	12,150.0	50.5
30	.010	6.750	.0180	.0185	.0190	3,120.0	21,100.0	54.0
31	.0089	8.523	.0169	.0174	.0179	3,860.0	32,800.0	57.5
32	.008	10.55	.0160	.0165	.0170	4,170.0	44,000.0	60.5
33	.0071	13.39	.0151	.0156	.0161	4,930.0	66,000.0	64.0
34	.0063	17.00	.0143	.0148	.0153	5,760.0	98,000.0	67.5
35	.0056	21.52	.0136	.0141	.0146	7,160.0	154,000.0	71.0
36	.005	27.00	.0125	.0130	.0135	7,640.0	206,000.0	77.0
37	.0045	33.33	.0120	.0125	.0130	9,700.0	323,000.0	80.0
38	.004	42.19	.0115	.0120	.0125	11,400.0	480,000.0	83.3
39	.0035	55.10	.0110	.0115	.0120	12,400.0	683,000.0	87.0
40	.0031	70.24	.0106	.0111	.0116	16,400.0	1,150,000.0	90.0

Turns per inch are based on the normal diameter of D.C.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Single Nylon Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Nylon			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	**.0253**	1.055	.0263	.027	.0278	543.0	580.0	37.0
23	**.0226**	1.322	.0237	.024	.0250	683.0	907.0	41.7
24	**.0201**	1.671	.0212	.022	.0225	860.0	1,440.0	45.4
25	**.0179**	2.107	.0190	.0196	.0203	1,075.0	2,260.0	51.0
26	**.0159**	2.670	.0170	.0175	.0183	1,365.0	3,620.0	57.1
27	**.0142**	3.348	.0154	.0159	.0165	1,700.0	5,860.0	63.0
28	**.0126**	4.251	.0138	.0143	.0149	2,160.0	9,200.0	70.0
29	**.0113**	5.286	.0125	.0130	.0136	2,670.0	14,100.0	77.0
30	**.010**	6.750	.0112	.0117	.0123	3,400.0	23,000.0	89.5
31	**.0089**	8.523	.0101	.0106	.0112	4,260.0	36,200.0	94.5
32	**.008**	10.55	.0092	.0097	.0103	5,330.0	56,300.0	103.0
33	**.0071**	13.39	.0083	.0088	.0094	6,650.0	89,000.0	113.5
34	**.0063**	17.00	.0075	.008	.0086	8,370.0	142,500.0	125.0
35	**.0056**	21.52	.0068	.0073	.0079	10,500.0	226,000.0	137.0
36	**.005**	27.00	.0062	.0067	.0073	12,800.0	346,000.0	149.0
37	**.0045**	33.33	.0057	.0062	.0068	15,400.0	513,000.0	161.0
38	**.004**	42.19	.0052	.0057	.0063	19,190.0	810,000.0	175.0
39	**.0035**	55.10	.0047	.0052	.0058	24,500.0	1,350,000.0	192.0
40	**.0031**	70.24	.0043	.0046	.0054	29,900.0	2,100,000.0	218.0

Turns per inch are based on the normal diameter of S.N.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Double Nylon Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Nylon			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	**.0253**	1.055	.0276	.0288	.0300	530.0	560.0	34.7
23	**.0226**	1.322	.0250	.026	.0272	660.0	875.0	38.4
24	**.0201**	1.671	.0225	.0236	.0247	830.0	1,390.0	42.3
25	**.0179**	2.107	.0202	.0213	.0225	1,040.0	2,190.0	47.0
26	**.0159**	2.670	.0183	.0194	.0205	1,300.0	3,470.0	51.5
27	**.0142**	3.348	.0167	.0177	.0187	1,640.0	5,500.0	56.5
28	**.0126**	4.251	.0151	.0161	.0171	2,070.0	8,750.0	62.0
29	**.0113**	5.286	.0138	.0148	.0158	2,530.0	13,400.0	67.5
30	**.010**	6.75	.0125	.0135	.0145	3,190.0	21,500.0	74.0
31	**.0089**	8.523	.0114	.0124	.0134	3,980.0	24,200.0	80.5
32	**.008**	10.055	.0105	.0115	.0125	4,920.0	49,200.0	87.0
33	**.0071**	13.39	.0096	.0106	.0116	6,200.0	83,000.0	93.4
34	**.0063**	17.00	.0088	.098	.0108	7,600.0	129,000.0	102.0
35	**.0056**	21.52	.0081	.091	.0101	9,250.0	199,000.0	110.0
36	**.005**	27.00	.0075	.085	.0095	11,550.0	312,000.0	117.5
37	**.0045**	33.33	.0070	.080	.0090	13,450.0	448,000.0	125.0
38	**.004**	42.19	.0065	.075	.0085	16,000.0	657,500.0	133.0
39	**.0035**	55.10	.0060	.070	.0080	19,100.0	1,050,000.0	143.0
40	**.0031**	70.24	.0056	.066	.0076	22,300.0	1,560,000.0	151.5

Turns per inch are based on the normal diameter of D.N.C. wire. To find the approximate number of feet per pound of CUPRON, No. 30, No. 60, No. 90, and No. 180 ALLOY, multiply by .920. For TOPHET A .975 and EVANOHM 1.01.

TOPHET C®

Single Glass Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Glass			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0278	.0283	.0290	523.0	552.0	35.4
23	.0226	1.322	.0251	.0256	.0263	647.0	855.0	39.1
24	.0201	1.671	.0226	.0231	.0238	810.0	1,352.0	43.2
25	.0179	2.107	.0204	.0209	.0216	1,012.0	2,130.0	47.8
26	.0159	2.670	.0184	.0189	.0196	1,270.0	3,390.0	52.8
27	.0142	3.348	.0167	.0172	.0179	1,567.0	5,250.0	58.2
28	.0126	4.251	.0151	.0156	.0163	1,972.0	8,380.0	64.0
29	.0113	5.286	.0138	.0143	.0150	2,410.0	12,750.0	70.0
30	.010	6.750	.0125	.0130	.0137	3,035.0	20,400.0	77.0
31	.0089	8.523	.0114	.0119	.0126	3,760.0	32,000.0	84.0
32	.008	10.55	.0105	.0110	.0117	4,565.0	48,100.0	91.0
33	.0071	13.39	.0096	.0101	.0108	5,670.0	76,000.0	99.0
34	.0063	17.00	.0088	.0093	.0100	7,025.0	119,400.0	107.5
35	.0056	21.52	.0081	.0086	.0093	8,610.0	185,200.0	116.0
36	.005	27.00	.0075	.0080	.0087	10,520.0	284,000.0	125.0
37	.0045	33.33	.0070	.0075	.0082	12,680.0	422,000.0	133.0
38	.004	42.19	.0065	.0070	.0077	15,100.0	636,000.0	143.0
39	.0035	55.10	.0060	.0065	.0072	18,800.0	1,037,000.0	154.0
40	.0031	70.24	.0056	.0061	.0068	23,100.0	1,640,000.0	164.0

TOPHET C®

Double Glass Covered Wire

B & S	Dia. in Inches Bare Wire	Ohms Per Foot	Diameter Over Glass			Approximate Feet Per Pound	Approximate Ohms Per Pound	Approximate Turns Per Inch
			Min.	Normal	Max.			
22	.0253	1.055	.0298	.0313	.0333	484.0	510.0	31.9
23	.0226	1.322	.0271	.0286	.0306	597.0	788.0	35.0
24	.0201	1.671	.0246	.0261	.0281	743.0	1,240.0	38.3
25	.0179	2.107	.0224	.0239	.0259	920.0	1,940.0	41.8
26	.0159	2.670	.0204	.0219	.0239	1,140.0	3,040.0	45.6
27	.0142	3.348	.0187	.0202	.0222	1,395.0	4,670.0	49.5
28	.0126	4.251	.0171	.0186	.0206	1,730.0	7,350.0	53.7
29	.0113	5.286	.0158	.0173	.0193	2,190.0	11,580.0	57.8
30	.010	6.750	.0145	.0160	.018	2,590.0	17,500.0	62.4
31	.0089	8.523	.0134	.0149	.0169	3,160.0	26,900.0	67.1
32	.008	10.55	.0125	.0140	.0160	3,780.0	39,900.0	71.4
33	.0071	13.39	.0116	.0131	.0151	4,510.0	60,300.0	76.4
34	.0063	17.00	.0108	.0123	.0143	5,620.0	95,400.0	81.3
35	.0056	21.52	.0101	.0116	.0136	6,750.0	145,200.0	85.2
36	.005	27.00	.0095	.011	.0130	8,050.0	217,000.0	91.0
37	.0045	33.33	.009	.0105	.0125	9,570.0	319,000.0	95.1
38	.004	42.19	.0085	.010	.0120	11,360.0	478,000.0	100.0
39	.0035	55.10	.008	.0095	.0115	13,670.0	754,000.0	105.2
40	.0031	70.24	.0075	.0091	.0111	16,400.0	1,189,000.0	110.0

ELECTRONIC METALS AND ALLOYS

These metals and alloys are produced for the following applications: cathodes, anodes, grid wire, glass to metal sealing alloys, and metals for leads, welds and supports.

Cathode Metals and Alloys

For the directly heated cathodes wire and ribbon are produced. Strip is supplied for the indirectly heated cathodes. The surfaces of wire, ribbon and strip is processed so it will be receptive to a coating of barium and strontium salts.

Alloys for Directly Heated Cathodes

These are generally referred to as Filament Alloys and the important properties are: good formability, strength at high temperatures, controlled resistance and weights and in some cases the presence of a reducing agent to speed up activation of the cathode. Filament Alloys are made from the purest metals and are melted in an Ajax Northrup Induction Furnace. The melting practice is closely controlled to insure uniformity. We originated what we term the "Melt System". When a new melt of a given alloy is made, a sample is submitted to the customer for his tests. If he approves the melt, it is held exclusively for his use. An accurate record of stock is kept and before the supply from a melt is exhausted, samples of new melts are submitted. This system assures the user of a constant and uniform source of supply and eliminates one important variable in the manufacture of radio and television tubes. Specifications are issued for each melt which assists in duplicating quality. In addition to the established alloys in this group, we are actively making use of the most modern equipment, including vacuum melting, to develop new alloys for this use.

The Filament Alloys are supplied in ribbon form and in ribbon with a channeled groove to add structural strength. Although pure or ballast nickel will serve as excellent cathode materials, cobalt or silicon or aluminum or titanium additions serve to enhance activation of the cathode.

The following tables show the composition and some of the properties of these alloys.

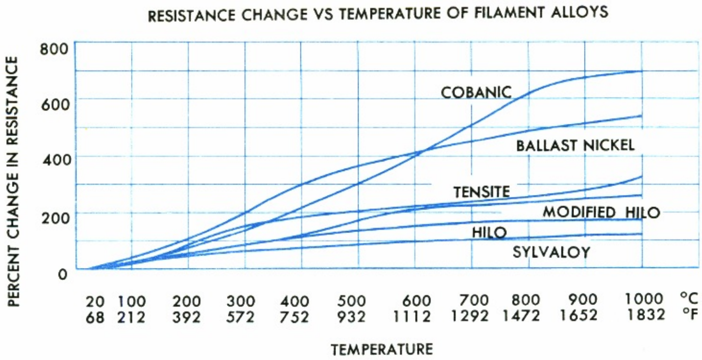
COMPOSITION

Material	Composition							Melt Point °C	Spec. Grav.	Resistivity Microhm-Cm		Tensile Strength Kg/Cm^2	
	Ni	Co	Si	Mn	Fe	Ti	Al			20°C	800°C	20°C	850°C
Ballast Nickel	99.70	0.08		nil	0.17			1455	8.90	8.30	48.0	3,960	740
Sylvaloy	97.0		3.0	nil				1420	8.61	26.5	51.0	5,370	1,115
Hilo	75.0	18.0		.25	5.0	2.0		1450	8.56	42.0	114.0	7,480	1,840
Modified Hilo	78.0	20.0	1.0	.25	0.5	0.3		1450	8.71	23.0	78.0	5,790	1,540
Cobanic	55.0	45.0						1500	8.84	12.5	81.2	6,050	1,255
Tensite	98.0						2.0	1425	8.76	15.0	54.8	3,990	965

PROPERTIES

Material	Diameter		Elong. Per Cent in 3 In.	Tensile Data: Cold (Room Temp.)			Tensile Data: Hot			
				Bkg. Strn. kg.	Tensile Strength		Temp. °C.	Bkg. Strn. kg.	Tensile Strength	
	Inch	Cm.			lb./sq. in.	kg./cm.²			lb./sq. in.	kg./cm.²
Ballast Nickel	0.1252	0.318	38.5 39.6	315 313	56,500 56,200	3,975 3,950	865 865	57.2 59.3	10,270 10,620	722 747
Sylvaloy	0.1253	0.318	35.5 34.1	420 423	75,300 75,800	5,290 5,450	875 870	86.3 91.0	15,450 16,300	1,085 1,145
Hilo	0.1262	0.320	32.4 31.2	601 603	106,000 106,500	7,460 7,500	890 880	144.0 153.0	25,840 27,050	1,790 1,900
Modified Hilo	0.1245	0.316	37.5 41.0	455 452	82,800 82,100	5,810 5,770	850 850	119.0 122.0	21,600 22,200	1,520 1,560
Cobanic	0.1250	0.317	39.5 37.8	475 478	85,700 86,400	6,030 6,070	875 865	98.3 99.4	17,700 17,900	1,245 1,259
Tensite	0.1266	0.321	31.2 29.0	324 323	57,000 56,700	4,000 3,980	850 870	79.8 76.4	14,010 13,420	985 945

The graph shows the resistance change versus temperature in air atmosphere:



Alloys for Indirectly Heated Cathodes

These nickel alloys are supplied in three types: passive, normal and active with the degree of "activity" being controlled by the amount of deoxidizers present.

The melt system is also used in this group of alloys and once a melt has been approved by a customer, it is reserved for his individual use.

In addition to closely controlled analysis limits, these alloys are required in accurate gauge. With three Sendzimir Mills, we can produce crown-free strip accurate to ten-thousandths of an inch.

ANODE PLATE MATERIALS

Four types of anode materials are produced: Nickel (Type 330); nickel clad steel; nickel plated steel; and aluminum clad iron.

The first three types of materials are supplied with a carbonized coating which produces high thermal emissivity. This coating is deeply engrained and will withstand all the normal firing operations used in degassification. Special carbonized finishes can be produced to withstand abnormally high firing temperatures. The carbonized finish is supplied in four classes as follows:

> *Radiocarb* is the designation given to carbonized nickel from which all the excess carbon has been removed without creating a sheen. The surface has a dull black appearance.
>
> *Duocarb* is carbonized nickel from which all excess carbon has been removed and both surfaces polished.
>
> *Policarb* is carbonized nickel from which the excess carbon has been removed from one side, leaving a dull black surface. The reverse side is polished leaving a shiny black surface.
>
> *Britecarb* is carbonized nickel with the carbon completely removed from one side.

Aluminum clad iron with a finish designed for anode applications is supplied bright in all standard plate thicknesses and widths. As used for anode parts, this material has high thermal emissivity. In some tube types, this material serves as a "getter".

GRID WIRE

Mangrid, an alloy of 4.5 to 5% manganese, balance nickel is supplied as a grid wire. It has a nominal resistivity of 110 ohms per circular mil foot at 20°C (68°F) and is precision drawn to meet milligramic weight limits. The drawing practice on this wire is designed to produce controlled elongation and yield strength. It is also supplied with a silver plated finish to grid wire specifications. This finish minimizes secondary emission and increases the temperature range at which the grid can be used.

The following table lists the sizes, weights and tolerances:

Diameter in Inches	Weight in mg. per 200 mm.	Weight Tolerance
.0012	1.276	±5%
.002	3.544	±4%
.0025	5.538	±4%
.003	8.10	±4%
.0033	9.65	±4%
.0035	10.85	±4%
.004	14.40	±4%
.0045	17.96	±4%
.005	22.65	±4%
.006	32.30	±4%

NICKEL WIRE

Another important component for radio and television tubes is Grade A nickel wire used for side supports and welds.

Nickel wire is drawn through diamond dies and held to close dimensional tolerances. It is strand annealed in hydrogen type atmospheres at constant speed and closely controlled temperature. This assures a uniform temper throughout and a surface free of foreign substances.

RODAR®

Rodar, an alloy for sealing metal to hard glass, is our response to the demands of the industry for additional materials to meet a specialized requirement. Our engineers and metallurgists assure effective control in the production of this alloy.

Rodar produces a permanent vacuum-tight seal with simple oxidation procedure and resists attack by mercury. It is readily machined and fabricated, and can be welded, soldered or brazed.

Rodar can be supplied in all forms of wire, strip and bar to customers' specifications.

PROPERTIES OF RODAR

Composition (Nominal)

Nickel	29%	Manganese	.30%
Cobalt	17%	Iron	Balance

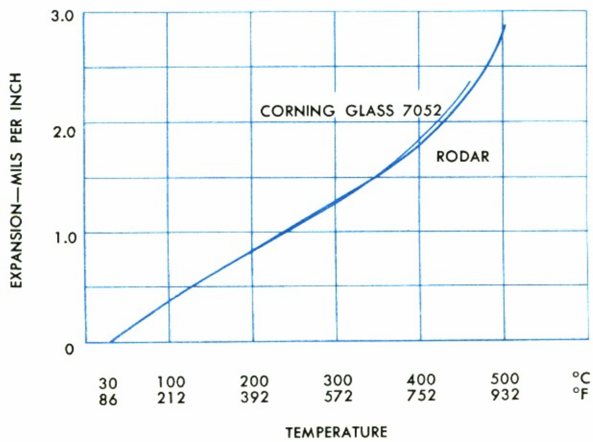
Melting Point	1450° C. (Approx.)
Specific Gravity	8.36
Weight Per Cubic Inch	.302 lb.
Electrical Resistivity	294 Ohms C.M.F.
Tensile Strength	80,000 PSI
Hardness	82 B Rockwell
Elongation	30% (2″ gauge length)

Coefficient of Linear Expansion

Temperature Range		Average Thermal Expansion, *Cm/Cm/°Cx10^{-6}	
30° To	200 C.	4.33 To	5.30
30	300	4.41	5.17
30	400	4.54	5.08
30	450	5.03	5.37
30	500	5.71	6.21

NOTE: As determined from cooling curves, after annealing in hydrogen for one hour at 900° C. and for 15 minutes at 1100° C.

THERMAL EXPANSION OF RODAR



MONEL

Monel is an alloy approximately ⅔ Nickel and ⅓ Copper. The following chemical analysis is typical:

Nickel	67.0%	Manganese	1.0%
Copper	30.0%	Silicon	.10
Iron	1.4	Carbon	.15

Physical Properties

Density grams per cubic centimeter	8.80
Pounds per cubic inch	.318
Thermal expansion (25—100° C)	.000014
(25—300° C)	.000015
Heat conductivity 0—100° C, C.G.S.	.06
Tensile strength psi	60—80,000
Yield point	30—40,000
Brinell hardness (3000 Kg)	125—150

Monel affords an unusual combination of properties: inherent resistance to corrosion, high tensile strength and toughness. It is particularly adapted for use with the corrosives most frequently encountered: common salt, dilute sulfuric acid, and strong caustic soda. Monel is not resistant to certain corrosives: nitric acid, sulfurous acid, and ferric chloride.

We have many years experience in the manufacture of Monel and are equipped to supply all sizes of wire ¼ inch diameter and finer. The production of wire for the wire cloth industry is one of our specialties. We also supply Monel in strip and ribbon and wire in straightened and cut lengths.

NILSTAIN®

Nilstain is our registered trade name for stainless steel alloys. While there are available today upwards of 60 different compositions of stainless steels, we have concentrated our efforts only on those more popular types, the production of which requires precision and the constant application of technical skill at every step in the manufacturing process.

Stainless quality in steels is derived principally through the addition of chromium, resulting in the formation by this alloy of a protective oxide film which is impervious to further oxidation. Chromium in excess of eleven percent assures a protective oxide film, and additions up to thirty percent result in proportional protection. The addition of nickel to chrome-iron alloys further improves their ability to resist corrosion.

Nickel, when added to chromium, substantially increases resistance to corrosion—the resulting protective film then contains both nickel and chromium, affording far greater protection than the straight chromium oxide.

In chromium-nickel stainless steel alloys the range of nickel is approximately seven to twenty percent and the chromium content in general varies from seventeen to twenty-eight percent. The best example of this type of stainless steel alloy is the popular "18-8", a composition of eighteen percent chromium and eight percent nickel.

Nickel additions in sufficient amounts make these alloys non-magnetic, non-hardening by heat treatment, work-harden rapidly, and unusually ductile in all normal conditions. They possess excellent welding characteristics, and in high temperature applications they retain a high degree of ductility. These properties, combined with that of outstanding corrosion resistance, make chromium-nickel type stainless steel alloys entirely suitable for a wide variety of uses.

Carbon in chromium-nickel steels is a determining factor. Its presence is quite noticeable if the steel is heated within the sensitization range of 1000 to 1600°F. Treated in this manner, it becomes sensitive and no longer resists severe corroding conditions. Sensitization is caused by the precipitation of normally dissolved carbon at the metal grain boundaries in the form of chromium-rich carbides. Such carbides cause a depletion of chromium adjacent to the grain boundaries which may lead to intercrystalline corrosive attack and eventually to physical disintegration.

Chromium-nickel steels improve in corrosion resistance as the carbon content decreases. Since there is a strong affinity between carbon, iron and chromium, these steel alloys always contain some residual carbon originating from raw materials. For many applications carbon contents up to .25 percent are not detrimental. In cases where carbon as a sensitizing agent is pronounced, a stainless steel containing .08 percent carbon or less is necessary, or it is necessary to anneal the material to dissolve the carbon to restore it to maximum corrosion resistance. It may be necessary to apply grades immune to sensitization.

NILSTAIN, Continued

Columbium renders chromium-nickel stainless steels immune to sensitization thereby preventing intergranular corrosion. Columbium fixes carbon in the form of columbium carbides uniformly dispersed throughout the steel. It prevents the formation of grain-boundary carbides. Columbium is a stabilizer since it renders the material stable in relation to carbides regardless of thermal treatment. Additions of columbium should amount to at least eight times the carbon content of the steel in order to produce complete immunity. The columbium content usually ranges from .70 to 1.00 percent. Columbium does not materially affect working, fabricating, or physical properties of the steel. Columbium-bearing grades have established themselves as indispensable in a number of applications.

Molybdenum is added to impart improved resistance to corrosive media which attack chrome-nickel stainless steels. This element also imparts increased strength, toughness and resistance to creep-deformation in high temperature service. Additions from 2 to 4 percent have been found necessary to produce the desired results. Molybdenum is particularly beneficial if associated with a low carbon content. These steels possess attractive fabricating and welding properties.

Corrosion resistance of the stainless steels depends on the nature of the numerous factors involved surrounding the corrosive condition of the particular application; therefore, only broad general statements can be made. In acid solutions, the resistance to corrosion depends on the oxidizing capacity of the solution. Austenitic stainless steels are extremely resistant to acids such as nitric, that have a high hydrogen-ion concentration and are strongly oxidizing in character. The presence of oxidizers such as ferric and cupric sulphates in acid solutions permits these alloys to resist dilute acid solutions that show high acidity and relatively low oxidizing power. Hydrochloric acid differs somewhat from the other acids and it is difficult to make the stainless steels passive in this medium. An increase in temperature, particularly when it alters the oxidizing capacity of the acid, will increase the corrosion rate.

Stainless steels, as indicated above, may or may not resist sulphuric acid, depending on the temperature, concentration and oxidizing capacity of the solution. Cold concentrated sulphuric acid will not attack stainless steel, but hot concentrated acid will. Additions of molybdenum such as in Types 316 and 317 greatly improves their resistance to sulphuric acid. This is also true of acetic acid, which will resist up to the boiling point, at which point the steels need the addition of molybdenum. Type 316 is used in great quantities in the paper industry, where the addition of molybdenum greatly improves the resistance to impure sulphurous acids, although in the pure state these acids do not attack stainless steel.

Austenitic stainless steels are particularly effective for the food industry since fruit acids, beer, meat juices, milk and a host of other foods and food products show negligible attack. They are also very satisfactory for handling both weak and strong alkaline solutions at room temperature. They are subject to a pitting type of corrosion from oxidizing acid chloride salts such as dichromates and chromates. Continued

NILSTAIN, Continued

exposure to sea water subjects austenitic stainless steels to a pit type of corrosion, although general corrosion is extremely low. This pitting corrosion is effectively decreased through the use of molybdenum containing steels.

NILSTAIN SPRING WIRE

In addition to supplying soft and partially cold worked Nilstain for the various weaving and wire forming applications, we also supply Nilstain Spring Wire.

Nilstain Spring Wire is especially processed and controlled to give maximum satisfaction for automatic coiling of springs. Lead coating is supplied as a lubricant to facilitate coiling and is cold processed to meet A.I.S.I. temper requirements.

Nilstain Spring Wire, in addition to being inherently free from corrosion, will operate accurately at temperatures beyond the working limit of steel or bronze. This wire is normally supplied in the Type 302 and Type 304 grades, but can also be supplied in Type 316. The tensile strength of Type 316 will be about 75% of those listed for Types 302 and 304. (See Table).

Nilstain Spring Wire has a modulus of elasticity in tension of 28,000,000 PSI and in torsion of 10,000,000 PSI.

Tensile Strength of Types 302 and 304

Diameter of Wire, Inch	Tensile Strength Lbs./Square Inch	Diameter of Wire, Inch	Tensile Strength Lbs./Square Inch
0.0181	304,000—334,000	0.072	245,000—275,000
0.0204	299,000—329,000	0.080	240,000—270,000
0.0230	294,000—324,000	0.0915	234,000—264,000
0.0258	288,000—318,000	0.1055	227,000—257,000
0.0286	283,000—313,000	0.1205	221,000—251,000
0.0317	278,000—308,000	0.135	213,000—243,000
0.0348	275,000—305,000	0.1483	207,000—237,000
0.041	269,000—299,000	0.162	201,000—231,000
0.0475	262,000—292,000	0.177	195,000—225,000
0.054	258,000—288,000	0.192	189,000—219,000
0.0625	251,000—281,000		

NILSTAIN®

(Stainless Steel)

Typical Properties of Annealed Wire (Average All Sizes up to 5/16″)

Type No.:	302	304	305	308	309	310	316	317	347	430
Chemical Analysis: Percent										
Chromium	17—19	18—20	17—19	19—21	22—24	24—26	16—18	18—20	17—19	14—18
Nickel	8—10	8—11	10—13	10—12	12—15	19—22	10—14	11—14	9—12	.50 max.
Carbon	.08—.20	.08 max.	.12 max.	.08 max.	.20 max.	.25 max.	.10 max.	.10 max.	.08 max.	.35 max.
Manganese	2.00 max.	2.00 max.	2.00 max.	2.00 max.	2.00 max.	2.00 max.	2.00 max.	2.00 max.	2.00 max.	1.50 max.
Silicon	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.50 max.	1.00 max.	1.00 max.	1.00 max.	1.00 max.
Molybdenum							2.00—3.00	3.00—4.00		
Other Elements									Cb 10x C min.	
Physical Properties										
Density—lbs./cu. in.	.29	.29	.29	.29	.29	.29	.29	.29	.29	.28
Specific Heat—Btu/°F./lb. (32°—212°F.)	.12	.12	.12	.12	.12	.12	.12	.12	.12	.11
Thermal Conductivity—Btu/ft²/hr./°F.-ft.										
212°F.	9.4	9.4	9.4	8.8	9.0	8.0	9.4	9.4	9.3	...
932°F.	12.4	12.4	12.4	12.5	10.8	10.8	12.4	12.4	12.8	...
Mean Coefficient of Thermal Expansion in./in./°F. x 10^{-6}										
68°—212°F.	8.0	8.0	8.0	9.0	8.0	8.0	8.8	8.8	8.3	5.7
68°—indicated temp.	10.6 (1700°)	10.6 (1700°)	10.6 (1700°)	10.6 (1700°)	10.9 (2100°)	10.9 (2100°)	10.6 (1700°)	10.6 (1700°)	10.6 (1700°)	...
Mechanical Properties										
Yield Strength—psi	50,000	50,000	35,000	50,000	45,000	45,000	40,000	40,000	40,000	50,000
Ultimate Strength—psi	105,000	105,000	90,000	100,000	100,000	100,000	100,000	100,000	95,000	85,000

TYPE 304 NILSTAIN®

Pounds Per Foot and Feet Per Pound of Wire
Density .287 Lbs. Per Cubic Inch

Diameter Inches	Pounds Per Foot	Feet Per Pound	Diameter Inches	Pounds Per Foot	Feet Per Pound
.002	.0000108	92,593	**.058**	.009099	110
.003	.0000243	41,152	**.059**	.009415	106
.004	.000043	23,256	**.060**	.009737	103
.005	.000068	14,706	**.061**	.010064	99
.006	.000097	10,309	**.062**	.010397	96
.007	.000133	7,519	**.063**	.010735	93
.008	.000173	5,780	**.064**	.011079	90
.009	.000219	4,566	**.065**	.011428	88
.010	.000270	3,703	**.066**	.011782	85
.011	.000327	3,058	**.067**	.012142	82
.012	.000389	2,570	**.068**	.012507	80
.013	.000457	2,188	**.069**	.012878	78
.014	.000530	1,888	**.070**	.013254	75
.015	.000608	1,644	**.071**	.013635	73
.016	.000692	1,445	**.072**	.014022	71
.017	.000781	1,280	**.073**	.014414	69
.018	.000876	1,141	**.074**	.014812	68
.019	.000976	1,024	**.075**	.015215	65.7
.020	.001081	925	**.076**	.015623	64.0
.021	.001192	839	**.077**	.016037	62.3
.022	.001309	764	**.078**	.016456	60.7
.023	.001430	699	**.079**	.016881	59.2
.024	.001558	642	**.080**	.017311	57.7
.025	.001690	592	**.081**	.017746	56.3
.026	.001828	547	**.082**	.018187	54.9
.027	.001971	507	**.083**	.018634	53.6
.028	.002120	472	**.084**	.019085	52.3
.029	.002274	440	**.085**	.019543	51.1
.030	.002434	411	**.086**	.020005	49.9
.031	.002599	385	**.087**	.020473	48.8
.032	.002769	361	**.088**	.020946	47.7
.033	.002945	340	**.089**	.021425	46.6
.034	.003126	320	**.090**	.021909	45.6
.035	.003313	302	**.091**	.022399	44.6
.036	.003505	285	**.092**	.022894	43.6
.037	.003703	270	**.093**	.023394	42.7
.038	.003905	256	**.094**	.023900	41.8
.039	.004114	243	**.095**	.024411	40.9
.040	.004327	231	**.096**	.024928	40.1
.041	.004546	220	**.097**	.025450	39.2
.042	.004771	210	**.098**	.025978	38.4
.043	.005001	200	**.099**	.026510	37.7
.044	.005236	191	**.100**	.027049	36.9
.045	.005477	183	**.104**	.029256	34.1
.046	.005723	175	**.109**	.031866	31.3
.047	.005975	167	**.125**	.042264	23.6
.048	.006232	160	**.140**	.053016	18.8
.049	.006494	154	**.156**	.065826	15.1
.050	.006762	148	**.171**	.079094	12.643
.051	.007035	142	**.187**	.094588	10.572
.052	.007314	137	**.203**	.111466	8.971
.053	.007598	132	**.218**	.128548	7.779
.054	007887	127	**.234**	.148110	6.752
.055	.008182	122	**.250**	.169057	5.915
.056	.008482	118			
.057	.008788	114			

NOTE: These figures are very close for all the Type 300 grades of Nilstain. Type 430 Nilstain will be approximately 2% more feet per pound.

*NILSTAIN C-20®

A Sulphuric Acid Resisting Stainless Steel

We are pleased to present a new addition to our evergrowing list of alloys, Nilstain C-20. It is obtainable in all wire and flat wire sizes as well as ribbon and offers many opportunities for economy and safety in all phases of the chemical industry.

A typical analysis of the alloy:

Carbon	0.07%	max.
Manganese	0.75	
Silicon	1.00	
Chromium	20.00	
Nickel	29.00	
Molybdenum	2.00	min.
Copper	3.00	min.

Nilstain C-20 in addition to its excellent resistance to a broad list of corrosive agents, has essentially all the good mechanical properties of the 18-8 stainless alloys and can be fabricated with comparative ease. Maximum corrosion resistance is obtained by water quenching from 2100° F. Nilstain C-20 is subject to carbide precipitation when heated or slow cooled through the sensitizing range of 900 to 1600°F. and such treatment should be avoided.

Some of the widespread applications where Nilstain C-20 will find extensive usage are in the manufacture of synthetic rubber, high octane gasoline, solvents, explosives, plastics, synthetic fibres, heavy chemicals, organic chemicals and food processing. Typical uses include wire cloth, screws, nuts, rivets, bolts, springs, wire forms as well as mixing tanks and heat exchangers.

One of the outstanding features of Nilstain C-20 is its good resistance to hot sulphuric acid; this permits its use in 60° Be. (78%) sulphuric acid solutions at temperatures of about 50° C (125°F.). It is also satisfactory in 65 and 93% sulphuric acid solutions.

The corrosion resistance (IPY) of Nilstain C-20 to various concentrations of sulphuric acid at 80°C. (176°F.) and at boiling temperatures is shown in Fig. 1 and Fig. 2. Broad "band" curves are used to illustrate the variations in laboratory corrosion testing even though tests are made under identical conditions, as a variety of line curves can be drawn through any set of plotted data with many interpretations of each curve.

The advantage of using Nilstain C-20 to resist the corrosive effects of sulphuric acid at temperatures at 80°C. (176°F.) is graphically demonstrated by Fig. 2. The danger zone, indicated by the "hump", is in the range of 65 to 93% sulphuric acid at 80°C. (176°F.). In this range, the conventional 18-8 Cr-Ni-Mo austenitic steels (Types 316 and 317) show corrosion rates many times greater than illustrated. While Nilstain C-20 shows accelerated corrosion, it is far superior to the 18-8 grades and is deemed satisfactory for most of this concentration range.

NILSTAIN C-20, Continued

Many factors influence the resistance of Nilstain C-20 in service. The factors which must be given consideration in corrosion service are temperature, concentration, aeration, influence of inhibiting or accelerating contaminants, influence of recirculation, solids in suspension, velocity, continuity or frequency of use and equipment design.

Inhibitors are usually oxidizing agents, such as ferric sulphate, nitric acid, or copper sulphate. When present, in even small amounts may reduce the corrosion rate to as low as .01% of the rate when such inhibitant is not present. Nilstain C-20 is especially resistant to nitric-sulphuric acid mixtures. On the other hand such contaminants as ferric chloride may greatly accelerate the corrosion rate. Certain halides and hydrochloric acid when present in sulphuric acid will accelerate the corrosion rate also.

FIGURE 1.

NILSTAIN C-20 CORROSION RATE

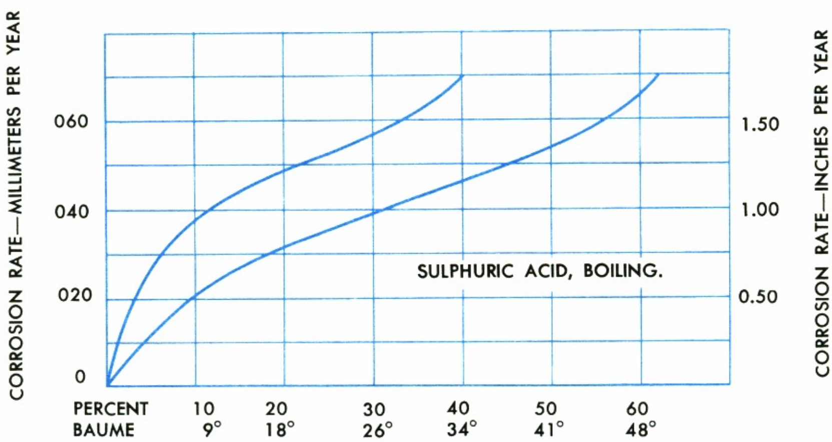
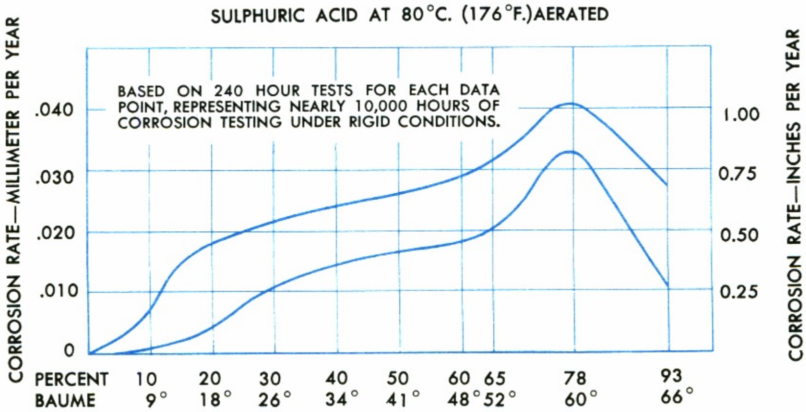


FIGURE 2

NILSTAIN C-20 CORROSION RATE

SULPHURIC ACID AT 80°C. (176°F.)AERATED



NILSTAIN C-20, Continued

Physical Constants

Density:	lbs. per cu. in.	0.289
	grams per cu. cm.	8
Specific Heat:	Btu. per lb. per °F. (32-212°F.)	.12
	Gram-calories per gram per °C. (0-100°C.)	.12

Specific Electrical Resistance at Room Temperature:

Ohms per cir. mil. ft.	451
Microhms per centimeter cube	75

Coefficient of Thermal Expansion:

Mean between 68°F. and 1200°F.	9.4×10^{-6}
Mean between 20°C. and 650°C.	16.9×10^{-6}

Nominal Mechanical Properties

1″ Round bar—annealed 1950°F. and water quenched:

Yield strength, .2% Offset p.s.i.	35,000
	(kg. per sq. cm. 2,460)
Tensile strength, lbs. per sq. in.	85,000
	(kg. per sq. cm. 5,975)
Elongation in 2″ (5.08 cm.)	50%
Reduction of area	65%
Brinell hardness	160
Rockwell hardness	B-84

Mechanical Properties of Cold Drawn Nilstain C-20

Nilstain C-20 can be supplied cold drawn in coils to tensile properties as shown in this table. When ordered in straightened and cut lengths, the tensile strength will be about 10% less than the values shown here. We can furnish cold drawn high tensile wire in round sizes starting from .125 to .010″ inclusive. Such material may be used for the manufacture of springs, and for similar applications where high strength is required.

Wire Diameter Inch	Tensile Strength Pounds Per Square Inch	
	Min.	Max.
.050	196,000	216,000
.0625	192,000	212,000
.125	182,000	202,000

When Nilstain C-20 is cold drawn in larger sizes, the mechanical properties are similar to those of Type 302.

*Carpenter Patent No. 2,553,330.
Durimet 20 Analysis licensed by the Duriron Company, Inc.

BERALOY®

Beraloy is our trade name for beryllium copper alloys supplied in two grades: *Beraloy A* and *Beraloy D*, which differ in beryllium content. Their nominal analysis is as follows:

1. BERALOY A	—	1.80—2.05% beryllium
2. BERALOY D	—	1.60—1.80% beryllium

Available in Strip, Round Wire and Flat Wire.

Beraloy A is manufactured in accordance with A.S.T.M. Specifications B-194-51T and B-197-51T, and because of its outstanding properties *Beraloy A* is widely used in diaphragms and springs where exceptional properties are obtained in its high electrical conductivity, high resistance to fatigue, and very low hysteresis or drift. The ease with which *Beraloy A* is formed in the annealed condition makes it ideal for use in lightweight and intricate parts. These parts are then heat-treated to obtain high strength and rigidity. Its corrosion resistance and particularly its fatigue resistance under corrosive conditions influence its selection for important uses. High mechanical properties can be obtained by using material cold rolled after the solution anneal. However, cold worked material may not lend itself to fabricating certain parts as readily as solution annealed material.

Beraloy D is a modification of the standard *Beraloy A* and can be handled in the same manner. It has an advantage of lower cost where the top mechanical properties of the standard alloy are not required.

On the following page, we list typical mechanical properties of *Beraloy* strip and flat wire and also typical mechanical properties of *Beraloy* wire.

TYPICAL MECHANICAL PROPERTIES OF BERALOY STRIP AND FLAT WIRE

Alloy	Temper	Heat Treatment	Tensile Strength PSI	Rockwell Hardness	
				B Scale	30T Scale
Beraloy A	Solution Annealed	None	60,000— 78,000	45—78	46—67
	¼ Hard	None	75,000— 88,000	68—90	62—75
	½ Hard	None	85,000—100,000	88—96	74—79
	Hard	None	100,000—120,000	96—102	78—83
				C-Scale	30N Scale
	Solution Annealed	3 hrs. @ 600°F.	160,000—190,000	34—40	55—61
	¼ Hard	2½ hrs. @ 600°F.	170,000—200,000	36—42	57—63
	½ Hard	2 hrs. @ 600°F.	180,000—210,000	38—44	59—65
	Hard	2 hrs. @ 600°F.	185,000—215,000	39—45	60—66

TYPICAL MECHANICAL PROPERTIES OF BERALOY WIRE

Alloy	Temper	Heat Treatment	Tensile Strength-PSI
Beraloy A	Solution Annealed		58,000— 78,000
	¼ Hard		90,000—115,000
	½ Hard		110,000—135,000
	¾ Hard		130,000—155,000
	Solution Annealed	3 hrs. @ 600°F.	160,000—190,000
	¼ Hard	2 hrs. @ 600°F.	175,000—205,000
	½ Hard	1½ hrs. @ 600°F.	185,000—215,000
	¾ Hard	1 hr. @ 600°F.	190,000—230,000

Beraloy D will have the same properties as *Beraloy A* in the various as-rolled and drawn temper categories; however, heat treated properties are lower; tensile strength is approximately 10% less.

Beraloy, heat treated, has an electrical conductivity of 25 to 30% I.A.C.S.

BERALOY®

Weight of Wire

Density .2965 lbs./Cubic Inch

Brown & Sharpe Gauge No.	Decimal Equivalent	Pounds Per M Foot	Feet Per Pound
000	.410	469.2	2.130
00	.365	372.0	2.688
0	.325	294.3	3.392
1	.289	234.0	4.275
2	.258	185.6	5.387
3	.229	146.7	6.832
4	.204	116.7	8.609
5	.182	92.55	10.79
6	.162	73.40	13.60
7	.144	58.20	17.21
8	.128	46.20	21.65
9	.114	36.61	27.35
10	.102	29.03	34.41
11	.091	23.02	43.45
12	.081	18.28	54.60
13	.072	14.51	68.89
14	.064	11.51	87.40
15	.057	9.092	109.6
16	.051	7.261	137.1
17	.045	5.726	174.5
18	.040	4.541	221.0
19	.036	3.601	277.5
20	.032	2.856	350.9
21	.0285	2.268	440.9
22	.0253	1.801	555.2
23	.0226	1.427	699.8
24	.0201	1.131	884.5
25	.0179	.8960	1,115.0
26	.0159	.7108	1,408.0
27	.0142	.5635	1,775.0
28	.0126	.4470	2,240.0
29	.0113	.3543	2,807.0
30	.010	.2811	3,560.0
31	.0089	.2212	4,525.0
32	.008	.1791	5,585.0
33	.0071	.1410	7,093.0
34	.0063	.1111	9,010.0
35	.0056	.08753	11,410.0
36	.005	.06981	14,320.0
37	.0045	.05652	17,690.0
38	.004	.04466	22,190.0
39	.0035	.03421	29,200.0
40	.0031	.02686	37,210.0

BERALOY®

Weight of Beraloy Strip

Pounds per lineal foot

Thickness Inches	B & S Gauge	STRIP WIDTH						
		⅛″	¼″	½″	1″	2″	3″	4″
.0508	16	.023	.046	.091	.183	.366	.549	.732
.0453	17	.020	.041	.082	.163	.326	.489	.652
.0403	18	.018	.036	.073	.145	.290	.435	.580
.0359	19	.016	.032	.065	.129	.258	.388	.517
.032	20	.014	.029	.058	.115	.230	.346	.461
.0285	21	.013	.026	.051	.103	.205	.308	.410
.0254	22	.011	.023	.046	.091	.183	.274	.366
.0226	23	.010	.020	.041	.081	.163	.244	.325
.0201	24	.009	.018	.036	.072	.144	.217	.289
.0179	25	.008	.016	.032	.064	.129	.193	.258
.0159	26	.007	.014	.029	.057	.114	.172	.229
.015		.007	.014	.027	.054	.108	.162	.216
.0142	27	.006	.012	.026	.051	.102	.153	.204
.0126	28	.006	.011	.023	.045	.091	.136	.181
.012		.005	.011	.022	.043	.086	.130	.173
.0113	29	.005	.010	.020	.041	.081	.122	.163
.010	30	.005	.009	.018	.036	.072	.108	.144
.0089	31	.004	.008	.016	.032	.064	.096	.128
.008	32	.004	.007	.014	.029	.058	.086	.115
.0075		.003	.007	.014	.027	.054	.081	.108
.0071	33	.003	.006	.013	.026	.051	.077	.102
.0063	34	.003	.006	.011	.023	.045	.068	.091
.006		.003	.005	.011	.022	.043	.065	.086
.0056	35	.003	.005	.010	.020	.040	.060	.081
.005	36	.002	.005	.009	.018	.036	.054	.072
.0045	37	.002	.004	.008	.016	.032	.049	.065
.004	38	.002	.004	.007	.014	.029	.043	.058
.0035	39	.002	.003	.006	.013	.025	.038	.050
.0031	40	.001	.003	.006	.011	.022	.033	.045
.003		.001	.003	.005	.011	.022	.032	.043
.0028	41	.001	.003	.005	.010	.020	.030	.040
.0025	42	.001	.002	.005	.009	.018	.027	.036
.0022	43	.001	.002	.004	.008	.016	.024	.032
.002	44	.001	.002	.004	.007	.014	.022	.029
.0018	45	.001	.002	.003	.006	.013	.019	.026
.0016	46	.001	.001	.003	.006	.012	.017	.023
.0014	47	.001	.001	.003	.005	.010	.015	.020
.0012	48	.001	.001	.002	.004	.009	.013	.017
.0011	49	.001	.001	.002	.004	.008	.012	.016
.001	50	.001	.001	.002	.004	.007	.011	.014

COBENIUM®

Cobenium is a heat treatable, high cobalt alloy. It was developed after years of research for an alloy that would have as good or better properties than watch main-spring steel, and in addition be highly corrosion resistant, the main cause of main-spring failures.

While it was primarily developed as a spring material, its unusual corrosion resistance and non-magnetic properties coupled with extremely high strength at normal and elevated temperatures, make it a general purpose rather than a specialized alloy. It is completely corrosion resistant to atmospheric conditions, including extremely high humidity, and tests have proven it to be more resistant to corrosives than stainless steels (see comparative corrosion table). It is completely non-magnetic and cannot be magnetized. No residual magnetism was detected with a 71 Gauss search coil, after a sample was subjected to a 2000 Gauss magnetic field.

Cobenium, generally speaking, has no notch sensitivity and as a spring material has proven to have considerably higher resistance to set and fatigue than mainspring steel. It will, at elevated temperatures, retain its elastic properties to a much greater degree and to somewhat higher temperatures than 18/8 stainless steel.

Cobenium is a heat treatable alloy readily formed and blanked in the cold worked condition; responding to a simple thermal treatment. The hardening temperatures range from 900° to 1100°F. with time at temperature varying with the temperature employed. In general, it has been found that five hours at 1050°F. has been most satisfactory for fully cold worked material for most applications. Where precise tolerances are to be held on intricate parts, it is advisable to fixture heat treat. The thermal treatment will cause a slight warpage or distortion.

The nature of the alloy is such that it will not respond to heat treatment from the solution annealed state. It must have some degree of cold work in order to be hardened to higher values than the already high cold worked properties. Naturally a greater amount of cold work within its workable limits, will produce a correspondingly greater response. For maximum mechanical and spring properties it has been found that a cold reduction in area of 85% for strip, particularly in the thinner gauges, has been most satisfactory. Wire with a cold reduction in area of 48% has proven best. *Cobenium,* unless otherwise specified for a particular application, will be supplied automatically in these tempers, for optimum properties in wire and strip.

TYPICAL PROPERTIES OF COBENIUM®

A. CHEMICAL COMPOSITION:

Cobalt	40%	Manganese	2%
Chromium	20%	Beryllium	.04%
Nickel	15%	Carbon	.15%
Molybdenum	7%	Iron	Bal.

B. MECHANICAL PROPERTIES AS HEAT TREATED:

Ultimate Strength	360,000 psi.
Yield Strength	280,000 psi.
Proportional Limit	233,000 psi.
Modulus of Elasticity	29,500,000 psi.
Shear Modulus (Torsion)	11,000,000 psi.
Rockwell Hardness	C-55-60

C. PHYSICAL PROPERTIES:

Density	.300 Lbs./Cu. In.
Specific Gravity	8.3
Coefficient of Linear Expansion	12.7 x 10^{-6}Per °C (0-50°C)
Thermoelasticity	-39.6 x 10^{-5}Per °C (0-50°C)

D. CORROSION PROPERTIES:

Salt Spray Test —No Evidence of Corrosion After 500 Hours

Acids and Salts —See Listing Below

Galvanic Action (In 10% Sulphuric Acid Electrolyte)

Metal	Voltage
Silver	—0.29
Cobenium	—0.27
Copper	—0.20
Brass	—0.13
Lead	0.00
Steel (1%C)	+0.30
Zinc	+0.71

The following table summarizes the results of laboratory tests of the chemical resistance of Cobenium. The tests consisted of refluxing the metal specimen totally immersed in the chemical solution for approximately 50 hours. Duplicate tests showed good agreement of the corrosion rate.

Chemical	Temp. °F.	Cobenium	Loss in Mg./Sq. In./Hr. 18-8 Mo.	17% Chrome
Acetic acid				
Glacial	246	0.000	0.014 (1)	2.53
50%	223	0.000	0.018 (1)	0.013 (1)
10%	218	0.000	0.015 (1)	0.018 (1)
Ammonium Chloride				
50%	235	0.000	—	—
10%	220	0.000	0.005	0.020
Ammonium Sulfate				
10%	220	0.000	—	—
Calcium Chloride				
10%	218	0.000	0.02 (1)	0.004
Chromic Acid				
10%	224	1.17	—	—
Citric Acid				
10%	222	0.000	0.023 (1)	0.007

PROPERTIES OF COBENIUM, Continued

Chemical	Temp. °F.	Cobenium	Loss in Mg./Sq. In./Hr. 18-8 Mo.	17% Chrome
Cupric Chloride				
10%	215	0.86	33.6 (2)	78.7 (2)
Ferric Chloride				
10%	216	27.55 (3)	109.43 (3)	202.90 (3)
10%	75	0.00000 (4)	0.00004 (4)	0.00018 (4)
Hydrochloric Acid				
Concentrated	230	29.4	639.23	4166.0
50% solution	230	34.2	679.46	3355.0
10% solution	216	44.7	38.09	588.0
Lactic Acid				
10%	219	0.000	0.002	0.005
Mercuric Chloride				
10%	214	0.003	30.9 (2)	198
Nitric Acid				
Concentrated	254	0.37	0.193	1.15
50% solution	240	0.09	0.06	0.28
10% solution	224	0.007	0.005	0.05
Oxalic Acid				
10%	216	0.067	0.876	4.422
Phenol				
10%	219	0.000	0.000	0.000
Phosphoric Acid				
Concentrated	330	20.40	8.86	639.40
50% solution	242	0.30	3.43	0.18
10% solution	225	0.00	0.16	0.02
Sodium Chloride				
10%	218	0.000	0.000	0.000
Sodium Cyanide				
10%	218	0.000	0.000	0.000
Sodium Sulfide				
10%	220	0.000	0.000	0.000
Sodium Sulfite				
10%	220	0.000	0.0005	0.0008
Stannous Chloride				
10%	216	0.000	0.009	+0.342 (5)
Sulfuric Acid				
Concentrated	498	1.75	4.61	5.62
50%	302	637.86	2990.	334.96
10%	221	1.85	48.3	2598.49
Tartaric Acid				
10%	219	0.000	0.018 (1)	0.007
Zinc Chloride				
10%	217	0.000	0.003 (1)	0.003 (1)

Notes:

(1) All the loss occurred during the first 8 hour period.

(2) On account of contamination of reduced metals and difficulty of cleaning these losses are probably greater than the values reported.

(3) These tests run about 10 hours; others approximately 50 hours.

(4) These tests run for 72 days at room temperature.

(5) This specimen gained weight due to accumulation of reduced tin.

HEATING ELEMENT DESIGN

Satisfactory heating element design requires consideration of several factors whose relative importance varies with the proposed application of the heater.

In this regard there is no substitute for experience. However, it is practical to examine the factors most frequently used and consider solutions for the problems encountered.

Quantity of heat produced in a heating element may be expressed either as British thermal units (abbreviated Btu.), calories, or watts.

1 watt = 860.01 (gram) calories = 3.413 Btu.

For a given quantity of heat, the wattage is always the same, but the temperature of the heated element is determined by the rapidity with which the medium surrounding the element conducts heat away.

A heater well insulated against heat loss and passing only a moderate current may operate at a bright yellow temperature in one instance, but while passing the same current with the heater exposed to a blast of cold air, the heater remains unchanged in appearance from that at room temperature.

Maximum operating temperature determines the choice of the proper alloy for forming the heating element. The following table is offered as a guide in this selection:

Maximum Safe Operating Temp. °F.	°C.	Alloy
2100	1149	Tophet A
1700	927	Tophet C

For approximate temperature difference between coiled and straight wire in air for given amperes, see *current temperature characteristics* of Tophet A and Tophet C.

While the same general information applies to heater elements of all descriptions, by far the greatest number of designs involve the use of round wire, close wound on a mandrel, and then stretched, to form a helix at least twice the close-wound length.

The electrical resistance given in the wire tables for the alloys listed, shows the resistance of the wire at 68°F. When, however, the temperature of the wire is above 68°F the resistance increases to some new value.

For convenience in calculating resistance values for a specific application, the electrical resistance is most usefully expressed in terms of per cent increase over that at 68°F. This is shown by the table immediately under the heading listing the alloy concerned.

From the foregoing it becomes apparent that heater element design begins by setting forth the quantity of heat required, and expressing this in terms of watts.

Next, it is necessary to know the voltage at which the element will be operated, and lastly, the space dimensions within which the element is to be mounted.

Many manufacturers of heating elements have based the safe operation of their units on watts dissipated per square inch of wire or ribbon surface under certain conditions. We are unable to give these figures because they vary anywhere from 12 watts per square inch, the generally accepted value for furnace strip, to 50 watts per square inch in flat-iron elements. On page 19 a table of surface areas per lineal foot of furnace strip is given. On pages 92 and 93 the surface areas of wire and ribbon are given.

Because of the care exercised in manufacture and handling alloy wire, it will be found in almost every case that aside from damage through accident or abuse, premature failure of a heating element is caused by poor design or faulty construction.

To illustrate the use of the data available in this handbook, suppose for example it is desired to design a heater coil to furnish 2200 Btu. per hour when connected to 115 volt direct current or single-phase alternating current power source. First, the Watt Hour equivalent of the Btu. is found by dividing 2200 by 3.413. This gives approximately 645 watts.

OHM'S LAW APPLIED: The relationship between watts, volts, amperes and ohms resistance is a group of simple ratios. In particular, the ratio between resistance, volts and amperes is called OHM'S LAW.

Using letters to represent these quantities, let

R = resistance (called ohms)
E = electromotive force (called volts)
I = current (called amperes)

Then $I = \frac{E}{R}$ or by transposing the letters

$$R = \frac{E}{I} \text{ and } E = I \times R$$

The ratio between watts and any two of the above factors may be expressed in several ways as follows: Let W = watts, then

$$W = \frac{E \times E}{R} \text{ or by transposing } R = \frac{E \times E}{W}$$

$$W = I \times E \text{ or by transposing } E = \frac{W}{I}$$

In the present instance watts = 645 and volts = 115, hence to find the resistance of the heater we use the ratio $R = \frac{E \times E}{W}$ or $\frac{115 \times 115}{645}$ which gives approximately 20.5 ohms for the resistance of the coil when heated.

It now becomes necessary to decide on the alloy which will be used. If it is assumed that the heater element will get quite hot, say about 1800°F, Tophet A is the indicated choice.

COLD RESISTANCE: Since the calculated resistance of the heater at 1800°F. was found above to be 20.5 ohms, its resistance at room temperature will be found by using the resistance temperature table located immediately under the heading of the Tophet A wire table.

This shows that at 1832°F. the factor 1.071 is used. This is equivalent to saying that at 68°F. the resistance shown in the wire table was taken as 100% and at 1800°F. had increased about 7%, so that we have 1.00 plus .07 = 1.07 as the factor to be used. In other words, 20.5 ohms at 1800°F. equals 1.07 times the resistance at 68°F. Therefore,

$\frac{20.5}{1.07}$ = 19.16 which is the value of the resistance of the heater at 68°F.

On page 89 a table lists minimum wire size recommended for given wattages. Since it is good practice to use a heavier gauge than the recommended minimum, No. 21 wire is selected in this case.

Assume now that the space in which the coil will be mounted consists of a spiral groove 32″ long. This limits the maximum length of the helix.

Because the helix should be at least twice the length of the close-wound coil previously mentioned, the maximum length of the close-wound coil cannot exceed 16″. Dividing the total resistance of the heater by the length of the close-wound coil, i.e., $\frac{19.16}{16}$ gives the permissible resistance per inch of the close-wound coil, in this instance 1.1975 ohms.

For all practical purposes where the heating element operates above 1000°F. an increase of 7% in resistance can be allowed for Tophet A and 12% for Tophet C.

On pages 90 and 91 a table is given showing a number of coil sizes of Tophet A and Tophet C with the corresponding resistance per inch of close-wound coil for the indicated B & S gauge. Here the value 1.261 is shown for No. 21 B & S gauge close-wound with an outside diameter of coil of .200″. As such a coil will be only 15.2″ long when its total resistance is 19.16 ohms, it will serve. It would be preferable to use a larger outside diameter, say .250″ which is shown to have a close-wound resistance of 1.628 ohms per inch. The total length of close-wound coil would then be only 11.8″ and when stretched to 32″, the distance between adjacent turns would conform with good practice, which allows a space of at least one and one-half the wire diameter. Heaters operating at lower temperatures may use a somewhat closer spacing.

LENGTH OF COIL CALCULATION: The length of wire, resistance per inch of close-wound coil, and outside diameter of coil for wire and mandrel sizes not shown in the above cited table may be found by interpolation with sufficient accuracy for most work, but if it is found desirable to calculate the size or value of such a coil this may readily be done:

1. Add together the diameter of the wire and the diameter of the mandrel in inches.
2. Multiply the sum obtained by 3.1416.

The result will be the length of one turn of wire about the mandrel. The total number of turns will give the total length of wire used. The resistance per inch of close-wound coil is readily found by multiplying the length of one turn by the resistance per foot of the size wire being used, and then dividing the amount thus obtained by twelve times the diameter of the wire.

As previously calculated, the ohms per inch of close-wound coil divided into the total resistance required gives the length of the close-wound coil.

When wire is wound on a mandrel, a springing away occurs as soon as the winding tension is released. On average coils with diameters up to .300″, .004 to .005 inch should be allowed. For diameters greater than .300″ a greater allowance must be made, and is best determined by testing.

RIBBON: Heater elements fashioned from ribbon are better suited to some applications than the coil form discussed above. In any event, the relationship between watts, volts and ohms remains unchanged and the same symbols are used as before.

The length of the ribbon will have to be worked out from the dimensions of the shape of the heater and the available mounting space.

Suppose for illustration that a 645 watt heater is required to operate as previously described and that the length of the ribbon will be about 25 feet. Calculating for use of Tophet A alloy operating at 1800°F. as before, the same cold resistance will be required, viz. 19.16 ohms. This divided by the total length of 25 feet shows that the ribbon will need to have a cold resistance of .7664 ohms per foot. Consulting the table showing resistance of Tophet A ribbon, it will be found that 1/16 x .0113 ribbon has a nominal resistance of .7682 ohms per foot. This will provide the required resistance.

It is standard practice to hold the resistance per foot of ribbon to plus or minus 5%. Closer tolerance can be obtained if specified. Special sizes in other widths or thicknesses than those shown in the table can be rolled to meet special resistance requirements.

230 VOLT CIRCUITS: Heaters designed to operate on 230 volts will require four times the resistance needed for the same wattage elements operating on 115 volts. To fit the same heating space, a smaller size wire or thinner ribbon will have to be used. For this reason it is sometimes difficult to design a rugged element for 230 volts, particularly where the size of the appliance limits the available heating area.

DESIGN PRECAUTIONS: In the design of heating elements certain precautions should be taken and some of these will be outlined in brief.

When a coil is suspended on ceramic insulators or hooks, it is very important that the holes in the insulators be large enough to permit the coil to slide through freely to allow for expansion and contraction throughout the entire length of the coil. If a coil becomes caught in one of the insulators it will sag in this section and may cause a short circuit. Coils should be supported at frequent intervals.

A great many failures take place at the terminals due to poor contact. If brass bolts, nuts or washers are used to connect the element to the source of power and there is sufficient heat to cause oxidation at the connection, an arc will form which will burn through the element at this point. While mechanical contacts are sometimes satisfactory, it is better to have welded or brazed joints outside of the heat zone.

The selection of lead wire in an appliance is important. Copper should never be used where the temperature exceeds 300°F.

Nickel, Mangrid E or Monel asbestos covered wire should be used for temperatures up to 1000°F. It is sometimes advisable to double back the wire from the element itself to form the lead. In this case the loop formed at the end should not be cut.

THREE PHASE CIRCUITS: Elements made for operating on a 3-phase circuit are usually designed to provide a balanced load on each phase. There are two simple designs which accomplish this result, one is called a DELTA connection because it resembles the Greek letter Delta. This heater consists essentially of three single-phase elements all alike having their ends connected so as to form a triangle. One line wire is connected to each corner of the triangle where the coils are joined, and the voltage across each element is the full line voltage. Calculations for the individual coils are made exactly as previously outlined.

The second method is called a STAR or Y connection because the three elements are connected at one point so that they are shaped like the letter Y. One line wire is connected to each extremity of the Y. By inspection it is evident that the voltage between any two terminals of the Y is across two elements in series. Due to the phase difference of the voltage in the line wires, however, the voltage across any one element to the center connection is not one-half of the rated line voltage, i.e. $\frac{E}{2}$ but is $\frac{E}{1.732}$.

To design a Y connected element for a three-phase system, say 230 volts, three single-phase elements all alike are designed for $\frac{230}{1.732}$ or 133 volts. Calculations for the individual elements are made exactly as previously outlined.

The difference in the DELTA and Y form of construction is emphasized by the difference in the voltage across the individual elements. Advantage is taken of this fact to afford two-heat control. A set of elements designed for DELTA connection may be wired to a suitable switch so that when the switch is operated, the terminals are changed from DELTA to Y connection. This will reduce the wattage of the system to one-third the power of the DELTA connection. The factor 1.732 is used for determining watts in either the DELTA or Y connection, viz.

$$\text{Watts} = \text{line voltage} \times \text{current} \times 1.732$$

TABLE FOR COLD RESISTANCE AND MINIMUM RECOMMENDED WIRE SIZES

Watts Rating	TOPHET A Resistance at 20°C. (68°F.) 115 V.	230 V.	TOPHET C Resistance at 20°C. (68°F.) 115 V.	230 V.	Minimum Recommended B & S Sizes 115 V.	230 V.	Watts Rating
25	494.09	1976.34	472.40	1889.59	32	35	25
50	247.04	988.17	236.20	944.79	31	34	50
75	164.69	658.78	157.46	629.86	31	34	75
100	123.52	494.09	118.10	472.40	30	33	100
150	82.35	329.39	78.74	314.93	30	33	150
200	61.77	247.04	59.05	236.20	29	32	200
250	49.41	197.63	47.24	188.96	28	31	250
300	41.17	164.69	39.36	157.46	28	31	300
350	35.30	141.16	33.75	134.97	27	30	350
400	30.88	123.52	29.52	118.10	26	29	400
450	27.45	109.80	26.25	104.98	24	27	450
500	24.70	98.82	23.62	94.48	24	27	500
550	22.46	89.83	21.48	85.89	23	26	550
600	20.59	82.35	19.68	78.74	23	26	600
650	19.01	76.01	18.17	72.67	23	26	650
700	17.64	70.58	16.87	67.48	22	25	700
750	16.47	65.88	15.74	62.98	22	25	750
800	15.44	61.77	14.76	59.05	22	25	800
850	14.53	58.12	13.90	55.57	21	24	850
900	13.72	54.90	13.12	52.49	21	24	900
950	13.00	52.01	12.43	49.72	21	24	950
1000	12.36	49.41	11.81	47.24	20	23	1000
1050	11.77	47.05	11.25	44.99	20	23	1050
1100	11.23	44.92	10.73	42.94	20	23	1100
1150	10.74	42.96	10.27	41.08	19	22	1150
1200	10.29	41.17	9.84	39.36	19	22	1200
1250	9.88	39.53	9.45	37.79	18	21	1250
1300	9.50	38.00	9.08	36.34	18	21	1300
1350	9.15	36.60	8.75	35.00	17	20	1350
1400	8.83	35.30	8.44	33.75	17	20	1400
1450	8.52	34.07	8.14	32.58	16	19	1450
1500	8.24	32.94	7.88	31.50	16	19	1500
1750	7.06	28.23	6.75	27.00	15	18	1750
2000	6.17	24.70	5.90	23.62	14	17	2000
2500	4.94	19.76	4.72	18.90	13	16	2500
2750	4.49	17.97	4.30	17.18	12	15	2750
3000	4.12	16.47	3.94	15.74	12	15	3000

TOPHET A®

Ohms Per Inch of Close-Wound Coils

Outside Dia. in Inches		.750	.625	.500	.375	.300	.250	.225	.200	.175	.150	.125	.090	.060	.030
Wire Sizes															
B & S	Dia. in Inches														
8	.128	.0505	.0403	.0301											
9	.114	.0730	.0587	.0443											
10	.102	.104	.0839	.0638											
11	.091	.149	.121	.0923											
12	.081	.214	.174	.1341	.0941										
13	.072	.309	.252	.1949	.1380	.1038	.0810								
14	.064	.445	.364	.2830	.2018	.1532	.1207	.105	.088	.072					
15	.057	.636	.522	.4069	.2920	.223	.1771	.154	.131	.108					
16	.051	.897	.736	.5758	.4179	.319	.2550	.223	.191	.159	.127				
17	.045	1.32	1.082	.8494	.6160	.476	.3826	.336	.289	.243	.196	.149			
18	.040	1.89	1.555	1.222	.8905	.691	.5581	.492	.425	.359	.292	.226			
19	.036	2.60	2.147	1.692	1.235	.963	.7803	.689	.598	.507	.416	.325			
20	.032	3.66	3.029	2.389	1.750	1.368	1.111	.984	.856	.729	.601	.473			
21	.0285		4.384	3.465	2.546	1.996	1.628	1.444	1.261	1.077	.893	.709	.452		
22	.0253			4.994	3.679	2.891	2.39	2.102	1.838	1.575	1.312	1.049	.681		
23	.0226			7.033	5.191	4.088	3.35	2.982	2.614	2.246	1.877	1.509	.993		
24	.0201					5.866	4.82	4.293	3.770	3.246	2.722	2.199	1.465	.836	
25	.0179					8.371	6.89	6.146	5.404	4.662	3.920	3.179	2.140	1.250	
26	.0159						9.91	8.852	7.793	6.735	5.677	4.618	3.137	1.866	
27	.0142						14.033	12.544	11.058	9.570	8.082	6.594	4.510	2.726	
28	.0126						20.174	18.051	15.924	13.801	11.678	9.551	6.579	4.028	
29	.0113											13.408	9.279	5.743	2.203
30	.010											19.570	13.612	8.510	3.401

TOPHET C®

Ohms Per Inch of Close-Wound Coils

Wire Size B & S	Wire Size Dia. in Inches	Outside Dia. in Inches: .750	.625	.500	.375	.300	.250	.225	.200	.175	.150	.125	.090	.060	.030
8	.128	.0525	.0419	.0313											
9	.114	.0759	.061	.0461											
10	.102	.1082	.0873	.0664											
11	.091	.155	.126	.0960											
12	.081	.223	.181	.139	.0979										
13	.072	.321	.262	.203	.144	.108	.0842								
14	.064	.463	.379	.294	.210	.159	.1255	.1092	.0915	.075					
15	.057	.661	.543	.423	.304	.232	.1842	.1602	.136	.112					
16	.051	.933	.765	.599	.435	.332	.2652	.232	.199	.165	.132				
17	.045	1.373	1.125	.883	.641	.495	.3979	.349	.301	.253	.204	.155			
18	.040	1.966	1.617	1.271	.926	.719	.5804	.512	.442	.373	.304	.235			
19	.036	2.704	2.233	1.760	1.284	1.002	.8115	.717	.622	.527	.433	.338			
20	.032	3.806	3.150	2.485	1.82	1.423	1.155	1.023	.890	.758	.625	.492			
21	.0285		4.559	3.604	2.648	2.076	1.693	1.502	1.311	1.120	.929	.737	.470		
22	.0253			5.194	3.826	3.007	2.486	2.186	1.912	1.638	1.364	1.091	.708		
23	.0226			7.314	5.399	4.252	3.484	3.101	2.719	2.336	1.952	1.569	1.032		
24	.0201					6.101	5.013	4.465	3.921	3.376	2.831	2.287	1.524	.869	
25	.0179					8.706	7.166	6.392	5.620	4.848	4.077	3.306	2.226	1.300	
26	.0159						10.306	9.206	8.105	7.004	5.904	4.803	3.262	1.941	
27	.0142						14.594	13.046	11.500	9.953	8.405	6.858	4.690	2.835	
28	.0126						20.981	18.773	16.561	14.353	12.145	9.933	6.842	4.189	
29	.0113											13.944	9.650	5.973	2.291
30	.010											20.353	14.156	8.850	3.537

SURFACE AREAS OF ROUND WIRE

In Sq. In. Per Lineal Foot

B & S	Diameter in Inches	Surface Area
000	.410	15.4566
00	.365	13.7592
0	.325	12.2522
1	.289	10.8948
2	.258	9.7260
3	.229	8.6328
4	.204	7.6908
5	.182	6.8616
6	.162	6.1068
7	.144	5.4288
8	.128	4.8252
9	.114	4.2972
10	.102	3.8448
11	.091	3.4308
12	.081	3.0540
13	.072	2.7144
14	.064	2.4132
15	.057	2.1492
16	.051	1.9224
17	.045	1.6968
18	.040	1.5084
19	.036	1.3572
20	.032	1.2060
21	.0285	1.0740
22	.0253	.9540
23	.0226	.8520
24	.0201	.7572
25	.0179	.6744
26	.0159	.6000
27	.0142	.5352
28	.0126	.4752
29	.0113	.4260
30	.010	.3768
31	.0089	.3360
32	.008	.3012
33	.0071	.2676
34	.0063	.2376
35	.0056	.2112
36	.005	.1884
37	.0045	.1692
38	.004	.1512
39	.0035	.1308
40	.0031	.1164

SURFACE AREA OF RIBBON IN SQUARE INCHES PER LINEAL FOOT

Thickness		WIDTH IN INCHES												
B & S	Inches	1/64 .015625	1/32 .03125	3/64 .046875	1/16 .0625	3/32 .09375	1/8 .125	3/16 .1875	1/4 .250	3/8 .375	1/2 .500	5/8 .625	3/4 .750	1″ 1.000
10	.102								8.448	11.44	14.44	17.44	20.44	26.44
11	.091								8.184	11.18	14.18	17.18	20.18	26.18
12	.081								7.944	10.94	13.94	16.94	19.94	25.94
13	.072								7.728	10.72	13.72	16.72	19.72	25.72
14	.064							6.036	7.536	10.53	13.53	16.53	19.53	25.53
15	.057							5.868	7.368	10.36	13.36	16.36	19.36	25.36
16	.051						4.224	5.724	7.224	10.22	13.22	16.22	19.22	25.32
17	.045						4.080	5.580	7.080	10.08	13.08	16.08	19.08	25.08
18	.040						3.960	5.460	6.960	9.960	12.96	15.96	18.96	24.96
19	.036						3.864	5.364	6.864	9.864	12.86	15.86	18.86	24.86
20	.032						3.768	5.268	6.768	9.768	12.76	15.76	18.76	24.76
21	.0285						3.684	5.184	6.684	9.684	12.68	15.68	18.68	24.68
22	.0253						3.607	5.107	6.607	9.607	12.60	15.60	18.60	24.60
23	.0226						3.542	5.042	6.542	9.542	12.54	15.54	18.54	24.54
24	.0201			1.607	1.982	2.492	3.482	4.982	6.482	9.482	12.48	15.48	18.48	24.48
25	.0179			1.554	1.929	2.439	3.429	4.929	6.429	9.429	12.42	15.42	18.42	24.42
26	.0159			1.506	1.881	2.391	3.381	4.881	6.381	9.381	12.38	15.38	18.38	24.38
27	.0142			1.465	1.840	2.350	3.340	4.840	6.340	9.340	12.34	15.34	18.34	24.34
28	.0126			1.427	1.802	2.312	3.302	4.802	6.302	9.301	12.30	15.30	18.30	24.30
29	.0113			1.396	1.771	2.281	3.271	4.771	6.271	9.271	12.27	15.27	18.27	24.27
30	.010	.6150	.9900	1.365	1.740	2.250	3.240	4.740	6.240	9.240	12.24	15.24	18.24	24.24
31	.0089	.5886	.9636	1.338	1.713	2.223	3.213	4.713	6.213	9.213	12.21	15.21	18.21	24.21
32	.008	.5670	.9420	1.317	1.692	2.202	3.192	4.692	6.192	9.192	12.19	15.19	18.19	24.19
33	.0071	.5452	.9202	1.295	1.670	2.180	3.170	4.670	6.170	9.170	12.17	15.17	18.17	24.17
34	.0063	.5262	.9012	1.276	1.651	2.161	3.151	4.651	6.151	9.151	12.15	15.15	18.15	24.15
35	.0056	.5094	.8844	1.259	1.634	2.144	3.134	4.634	6.134	9.134	12.13	15.13	18.13	24.13
36	.005	.4950	.8700	1.245	1.620	2.130	3.120	4.620	6.120	9.120	12.12	15.12	18.12	24.12
37	.0045	.4830	.8580	1.233	1.608	2.118	3.108	4.608	6.108	9.108	12.10	15.10	18.10	24.10
38	.004	.4610	.8460	1.221	1.596	2.106	3.096	4.596	6.096	9.096	12.09	15.09	18.09	24.09
39	.0035	.4590	.8340	1.209	1.584	2.094	3.084	4.584	6.084	9.084	12.08	15.08	18.08	24.08
40	.0031	.4494	.8240	1.199	1.574	2.084	3.074	4.574	6.074	9.074	12.07	15.07	18.07	24.07

BARE COPPER WIRE TABLE

Weight and Resistance

		Weight		Resistance @ 20°C, 68°F.		
Size Awg	Nominal Diameter, Inches	Pounds Per 1000 Feet	Feet Per Pound	Ohms Per 1000 Feet	Ohms Per Pound	Size Awg
4/0	.4600	640.5	1.561	.04901	.00007652	4/0
3/0	.4096	507.9	1.968	.06180	.0001217	3/0
2/0	.3648	402.8	2.482	.07793	.0001935	2/0
1/0	.3249	319.5	3.130	.09827	.0003076	1/0
1	.2893	253.3	3.947	.1239	.0004891	1
2	.2576	200.9	4.977	.1563	.0007778	2
3	.2294	159.3	6.276	.1970	.001237	3
4	.2043	126.4	7.914	.2485	.001966	4
5	.1819	100.2	9.980	.3133	.003127	5
6	.1620	79.46	12.58	.3951	.004972	6
7	.1443	63.02	15.87	.4982	.007905	7
8	.1285	49.98	20.01	.6282	.01257	8
9	.1144	39.63	25.23	.7921	.01999	9
10	.1019	31.43	31.82	.9989	.03178	10
11	.09074	24.92	40.12	1.260	.05053	11
12	.08081	19.77	50.59	1.588	.08035	12
13	.07196	15.68	63.80	2.003	.1278	13
14	.06408	12.43	80.44	2.525	.2032	14
15	.05707	9.858	101.4	3.184	.3230	15
16	.05082	7.818	127.9	4.016	.5136	16
17	.04526	6.200	161.3	5.064	.8167	17
18	.04030	4.917	203.4	6.385	1.299	18
19	.03589	3.899	256.5	8.051	2.065	19
20	.03196	3.092	323.4	10.15	3.283	20
21	.02846	2.452	407.8	12.80	5.221	21
22	.02535	1.945	514.2	16.14	8.301	22
23	.02257	1.542	648.2	20.36	13.20	23
24	.02010	1.223	817.7	25.67	20.99	24
25	.01790	.9699	1,031	32.37	33.37	25
26	.01594	.7692	1,300	40.81	53.06	26
27	.01420	.6100	1,639	51.47	84.37	27
28	.01264	.4837	2,067	64.90	134.2	28
29	.01126	.3836	2,607	81.83	213.3	29
30	.01003	.3042	3,287	103.2	339.2	30
31	.008928	.2413	4,145	130.1	539.3	31
32	.007950	.1913	5,227	164.1	857.6	32
33	.007080	.1517	6,591	206.9	1,364	33
34	.006305	.1203	8,310	260.9	2,168	34
35	.005615	.09542	10,480	329.0	3,448	35
36	.005000	.07568	13,210	414.8	5,482	36
37	.004453	.06001	16,660	523.1	8,717	37
38	.003965	.04759	21,010	659.6	13,860	38
39	.003531	.03774	26,500	831.8	22,040	39
40	.003145	.02993	33,410	1,049	35,040	40
41	.002800	.02373	42,140	1,323	55,740	41
42	.002493	.01881	53,160	1,669	88,700	42
43	.002220	.01492	67,020	2,104	141,000	43
44	.001977	.01183	84,530	2,654	224,300	44
45	.001760	.009377	106,600	3,348	357,000	45
46	.001567	.007431	134,600	4,225	568,500	46

The above table is for reference only. We have had requests to insert in our handbook a table on copper wire inasmuch as copper is used in circuits with resistance wire. Wilbur B. Driver Company does not manufacture or supply copper wire.

MILLIMETER EQUIVALENTS

IN INCHES

MM	Inches	MM	Inches	MM	Inches
.01	.0004	.45	.0177	.89	.0350
.02	.0008	.46	.0181	.90	.0354
.03	.0012	.47	.0185	.91	.0358
.04	.0016	.48	.0189	.92	.0362
.05	.0020	.49	.0193	.93	.0366
.06	.0024	.50	.0197	.94	.0370
.07	.0028	.51	.0201	.95	.0374
.08	.0031	.52	.0205	.96	.0378
.09	.0035	.53	.0209	.97	.0382
.10	.0039	.54	.0213	.98	.0386
.11	.0043	.55	.0217	.99	.0390
.12	.0047	.56	.0221	1.00	.0394
.13	.0051	.57	.0224	2.00	.0787
.14	.0055	.58	.0228	3.00	.1181
.15	.0059	.59	.0232	4.00	.1575
.16	.0063	.60	.0236	5.00	.1969
.17	.0067	.61	.0240	6.00	.2362
.18	.0071	.62	.0244	7.00	.2756
.19	.0075	.63	.0248	8.00	.3150
.20	.0079	.64	.0252	9.00	.3543
.21	.0083	.65	.0256	10.00	.3937
.22	.0087	.66	.0260	11.00	.4331
.23	.0091	.67	.0264	12.00	.4724
.24	.0094	.68	.0268	13.00	.5118
.25	.0098	.69	.0272	14.00	.5512
.26	.0102	.70	.0276	15.00	.5906
.27	.0106	.71	.0280	16.00	.6299
.28	.0110	.72	.0284	17.00	.6693
.29	.0114	.73	.0287	18.00	.7087
.30	.0118	.74	.0291	19.00	.7480
.31	.0122	.75	.0295	20.00	.7847
.32	.0126	.76	.0299	21.00	.8268
.33	.0130	.77	.0303	22.00	.8661
.34	.0134	.78	.0307	23.00	.9055
.35	.0138	.79	.0311	24.00	.9449
.36	.0142	.80	.0315	25.00	.9843
.37	.0146	.81	.0319	26.00	1.0236
.38	.0150	.82	.0323	27.00	1.0630
.39	.0154	.83	.0327	28.00	1.1024
.40	.0158	.84	.0331	29.00	1.1417
.41	.0161	.85	.0335	30.00	1.1811
.42	.0165	.86	.0339	31.00	1.2205
.43	.0169	.87	.0343	32.00	1.2598
.44	.0173	.88	.0347	33.00	1.2992

TEMPERATURE CONVERSION TABLE

0 to 100						100 to 1000					
C.		F.	C.		F.	C.		F.	C.		F.
-17.8	**0**	32.0	10.0	**50**	122.0	38	**100**	212	260	**500**	932
-17.2	**1**	33.8	10.6	**51**	123.8	43	**110**	230	266	**510**	950
-16.7	**2**	35.6	11.1	**52**	125.6	49	**120**	248	271	**520**	968
-16.1	**3**	37.4	11.7	**53**	127.4	54	**130**	266	277	**530**	986
-15.6	**4**	39.2	12.2	**54**	129.2	60	**140**	284	282	**540**	1004
-15.0	**5**	41.0	12.8	**55**	131.0	66	**150**	302	288	**550**	1022
-14.4	**6**	42.8	13.3	**56**	132.8	71	**160**	320	293	**560**	1040
-13.9	**7**	44.6	13.9	**57**	134.6	77	**170**	338	299	**570**	1058
-13.3	**8**	46.4	14.4	**58**	136.4	82	**180**	356	304	**580**	1076
-12.8	**9**	48.2	15.0	**59**	138.2	88	**190**	374	310	**590**	1094
-12.2	**10**	50.0	15.6	**60**	140.0	93	**200**	392	316	**600**	1112
-11.7	**11**	51.8	16.1	**61**	141.8	99	**210**	410	321	**610**	1130
-11.1	**12**	53.6	16.7	**62**	143.6	100	**212**	413	327	**620**	1148
-10.6	**13**	55.4	17.2	**63**	145.4	104	**220**	428	332	**630**	1166
-10.0	**14**	57.2	17.8	**64**	147.2	110	**230**	446	338	**640**	1184
- 9.44	**15**	59.0	18.3	**65**	149.0	116	**240**	464	343	**650**	1202
- 8.89	**16**	60.8	18.9	**66**	150.8	121	**250**	482	349	**660**	1220
- 8.33	**17**	62.6	19.4	**67**	152.6	127	**260**	500	354	**670**	1238
- 7.78	**18**	64.4	20.0	**68**	154.4	132	**270**	518	360	**680**	1256
- 7.22	**19**	66.2	20.6	**69**	156.2	138	**280**	536	366	**690**	1274
- 6.67	**20**	68.0	21.1	**70**	158.0	143	**290**	554	371	**700**	1292
- 6.11	**21**	69.8	21.7	**71**	159.8	149	**300**	572	377	**710**	1310
- 5.56	**22**	71.6	22.2	**72**	161.6	154	**310**	590	382	**720**	1328
- 5.00	**23**	73.4	22.8	**73**	163.4	160	**320**	608	388	**730**	1346
- 4.44	**24**	75.2	23.3	**74**	165.2	166	**330**	626	393	**740**	1364
- 3.89	**25**	77.0	23.9	**75**	167.0	171	**340**	644	399	**750**	1382
- 3.33	**26**	78.8	24.4	**76**	168.8	177	**350**	662	404	**760**	1400
- 2.78	**27**	80.6	25.0	**77**	170.6	182	**360**	680	410	**770**	1418
- 2.22	**28**	82.4	25.6	**78**	172.4	188	**370**	698	416	**780**	1436
- 1.67	**29**	84.2	26.1	**79**	174.2	193	**380**	716	421	**790**	1454
- 1.11	**30**	86.0	26.7	**80**	176.0	199	**390**	734	427	**800**	1472
- 0.56	**31**	87.8	27.2	**81**	177.8	204	**400**	752	432	**810**	1490
0	**32**	89.6	27.8	**82**	179.6	210	**410**	770	438	**820**	1508
0.56	**33**	91.4	28.3	**83**	181.4	216	**420**	788	443	**830**	1526
1.11	**34**	93.2	28.9	**84**	183.2	221	**430**	806	449	**840**	1544
1.67	**35**	95.0	29.4	**85**	185.0	227	**440**	824	454	**850**	1562
2.22	**36**	96.8	30.0	**86**	186.8	232	**450**	842	460	**860**	1580
2.78	**37**	98.6	30.6	**87**	188.6	238	**460**	860	466	**870**	1598
3.33	**38**	100.4	31.1	**88**	190.4	243	**470**	878	471	**880**	1616
3.89	**39**	102.2	31.7	**89**	192.2	249	**480**	896	477	**890**	1634
4.44	**40**	104.0	32.2	**90**	194.0	254	**490**	914	482	**900**	1652
5.00	**41**	105.8	32.8	**91**	195.8				488	**910**	1670
5.56	**42**	107.6	33.3	**92**	197.6				493	**920**	1688
6.11	**43**	109.4	33.9	**93**	199.4				499	**930**	1706
6.67	**44**	111.2	34.4	**94**	201.2				504	**940**	1724
7.22	**45**	113.0	35.0	**95**	203.0				510	**950**	1742
7.78	**46**	114.8	35.6	**96**	204.8				516	**960**	1760
8.33	**47**	116.6	36.1	**97**	206.6				521	**970**	1778
8.89	**48**	118.4	36.7	**98**	208.4				527	**980**	1796
9.44	**49**	120.2	37.2	**99**	210.2				532	**990**	1814
			37.8	**100**	212.0				538	**1000**	1832

Read known temperature in bold face type. Corresponding temperature in degrees Fahrenheit will be found in column to the right. Corresponding temperature in degrees Centigrade will be found in column to the left.

TEMPERATURE CONVERSION TABLE

1000 to 2000

C.		F.	C.		F.
538	**1000**	1832	816	**1500**	2732
543	**1010**	1850	821	**1510**	2750
549	**1020**	1868	827	**1520**	2768
554	**1030**	1886	832	**1530**	2786
560	**1040**	1904	838	**1540**	2804
566	**1050**	1922	843	**1550**	2822
571	**1060**	1940	849	**1560**	2840
577	**1070**	1958	854	**1570**	2858
582	**1080**	1976	860	**1580**	2876
588	**1090**	1994	866	**1590**	2894
593	**1100**	2012	871	**1600**	2912
599	**1110**	2030	877	**1610**	2930
604	**1120**	2048	882	**1620**	2948
610	**1130**	2066	888	**1630**	2966
616	**1140**	2084	893	**1640**	2984
621	**1150**	2102	899	**1650**	3002
627	**1160**	2120	904	**1660**	3020
632	**1170**	2138	910	**1670**	3038
638	**1180**	2156	916	**1680**	3056
643	**1190**	2174	921	**1690**	3074
649	**1200**	2192	927	**1700**	3092
654	**1210**	2210	932	**1710**	3110
660	**1220**	2228	938	**1720**	3128
666	**1230**	2246	943	**1730**	3146
671	**1240**	2264	949	**1740**	3164
677	**1250**	2282	954	**1750**	3182
682	**1260**	2300	960	**1760**	3200
688	**1270**	2318	966	**1770**	3218
693	**1280**	2336	971	**1780**	3236
699	**1290**	2354	977	**1790**	3254
704	**1300**	2372	982	**1800**	3272
710	**1310**	2390	988	**1810**	3290
716	**1320**	2408	993	**1820**	3308
721	**1330**	2426	999	**1830**	3326
727	**1340**	2444	1004	**1840**	3344
732	**1350**	2462	1010	**1850**	3362
738	**1360**	2480	1016	**1860**	3380
743	**1370**	2498	1021	**1870**	3398
749	**1380**	2516	1027	**1880**	3416
754	**1390**	2534	1032	**1890**	3434
760	**1400**	2552	1038	**1900**	3452
766	**1410**	2570	1043	**1910**	3470
771	**1420**	2588	1049	**1920**	3488
777	**1430**	2606	1054	**1930**	3506
782	**1440**	2624	1060	**1940**	3524
788	**1450**	2642	1066	**1950**	3542
793	**1460**	2660	1071	**1960**	3560
799	**1470**	2678	1077	**1970**	3578
804	**1480**	2696	1082	**1980**	3596
810	**1490**	2714	1088	**1990**	3614
			1093	**2000**	3632

2000 to 3000

C.		F.	C.		F.
1093	**2000**	3632	1371	**2500**	4532
1099	**2010**	3650	1377	**2510**	4550
1104	**2020**	3668	1382	**2520**	4568
1110	**2030**	3686	1388	**2530**	4586
1116	**2040**	3704	1393	**2540**	4604
1121	**2050**	3722	1399	**2550**	4622
1127	**2060**	3740	1404	**2560**	4640
1132	**2070**	3758	1410	**2570**	4658
1138	**2080**	3776	1416	**2580**	4676
1143	**2090**	3794	1421	**2590**	4694
1149	**2100**	3812	1427	**2600**	4712
1154	**2110**	3830	1432	**2610**	4730
1160	**2120**	3848	1438	**2620**	4748
1166	**2130**	3866	1443	**2630**	4766
1171	**2140**	3884	1449	**2640**	4784
1177	**2150**	3902	1454	**2650**	4802
1182	**2160**	3920	1460	**2660**	4820
1188	**2170**	3938	1466	**2670**	4838
1193	**2180**	3956	1471	**2680**	4856
1199	**2190**	3974	1477	**2690**	4874
1204	**2200**	3992	1482	**2700**	4892
1210	**2210**	4010	1488	**2710**	4910
1216	**2220**	4028	1493	**2720**	4928
1221	**2230**	4046	1499	**2730**	4946
1227	**2240**	4064	1504	**2740**	4964
1232	**2250**	4082	1510	**2750**	4982
1238	**2260**	4100	1516	**2760**	5000
1243	**2270**	4118	1521	**2770**	5018
1249	**2280**	4136	1527	**2780**	5036
1254	**2290**	4154	1532	**2790**	5054
1260	**2300**	4172	1538	**2800**	5072
1266	**2310**	4190	1543	**2810**	5090
1271	**2320**	4208	1549	**2820**	5108
1277	**2330**	4226	1554	**2830**	5126
1282	**2340**	4244	1560	**2840**	5144
1288	**2350**	4262	1566	**2850**	5162
1293	**2360**	4280	1571	**2860**	5180
1299	**2370**	4298	1577	**2870**	5198
1304	**2380**	4316	1582	**2880**	5216
1310	**2390**	4334	1588	**2890**	5234
1316	**2400**	4352	1593	**2900**	5252
1321	**2410**	4370	1599	**2910**	5270
1327	**2420**	4388	1604	**2920**	5288
1332	**2430**	4406	1610	**2930**	5306
1338	**2440**	4424	1616	**2940**	5324
1343	**2450**	4442	1621	**2950**	5342
1349	**2460**	4460	1627	**2960**	5360
1354	**2470**	4478	1632	**2970**	5378
1360	**2480**	4496	1638	**2980**	5396
1366	**2490**	4514	1643	**2990**	5414
			1649	**3000**	5432

CONVERSION FORMULA

C° = 5/9 (F°—32)   F° = 9/5 C° + 32

INTERPOLATION VALUES FOR ABOVE TABLES

C°	1	2	3	4	5
F°	1.8	3.6	5.4	7.2	9.0
F°	1	2	3	4	5
C°	0.56	1.11	1.67	2.22	2.78

DECIMALS OF AN INCH

FOR EACH 64th

Fraction	1/64ths	Decimal	Millimeters	Fraction	1/64ths	Decimal	Millimeters
	1	.015625	.0397		33	.515625	13.097
1/32	2	.03125	.794	17/32	34	.53125	13.494
	3	.046875	1.191		35	.546875	13.891
1/16	4	.0625	1.588	9/16	36	.5625	14.288
	5	.078125	1.984		37	.578125	14.684
3/32	6	.09375	2.381	19/32	38	.59375	15.081
	7	.109375	2.778		39	.609375	15.478
1/8	8	.125	3.175	5/8	40	.625	15.875
	9	.140625	3.572		41	.640625	16.272
5/32	10	.15625	3.969	21/32	42	.65625	16.669
	11	.171875	4.366		43	.671875	17.066
3/16	12	.1875	4.763	11/16	44	.6875	17.463
	13	.203125	5.159		45	.703125	17.859
7/32	14	.21875	5.556	23/32	46	.71875	18.256
	15	.234375	5.953		47	.734375	18.653
1/4	16	.250	6.350	3/4	48	.750	19.050
	17	.265625	6.747		49	.765625	19.447
9/32	18	.28125	7.144	25/32	50	.78125	19.844
	19	.296875	7.541		51	.796875	20.241
5/16	20	.3125	7.938	13/16	52	.8125	20.638
	21	.328125	8.334		53	.828125	21.034
11/32	22	.34375	8.731	27/32	54	.84375	21.431
	23	.359375	9.128		55	.859375	21.828
3/8	24	.375	9.525	7/8	56	.875	22.225
	25	.390625	9.922		57	.890625	22.622
13/32	26	.40625	10.319	29/32	58	.90625	23.019
	27	.421875	10.716		59	.921875	23.416
7/16	28	.4375	11.113	15/16	60	.9375	23.813
	29	.453125	11.509		61	.953125	24.209
15/32	30	.46875	11.906	31/32	62	.96875	24.606
	31	.484375	12.303		63	.984375	25.003
1/2	32	.500	12.700	1	64	1.000	25.400

CHANGES IN ELECTRICAL UNITS

Revisions introduced by the National Bureau of Standard effective on January 1st, 1948, bring into use through adoption by the International Committee on Weights and Measures, revised values for electrical units that are derived from the fundamental mechanical units of length, mass and time.

Values of international units (U.S.) in terms of the absolute units adopted by the National Bureau of Standards are as follows:

1 international ohm	=	1.000495 absolute ohms
1 international volt	=	1.000330 absolute volts
1 international ampere	=	0.999835 absolute ampere
1 international coulomb	=	0.999835 absolute coulomb
1 international henry	=	1.000495 absolute henrys
1 international farad	=	0.999505 absolute farad
1 international watt	=	1.000165 absolute watts
1 international joule	=	1.000165 absolute joules

These factors should be used in converting values given in terms of international electrical units (U.S.) as maintained at the National Bureau of Standards to the absolute system.

For further information regarding these changes see Circular C459, issued by the National Bureau of Standards, Washington, D. C.

CUSTOM ALLOYS

We offer our completely integrated facilities for the production of custom or special purpose alloys and metals to anyone seeking help in this highly specialized field.

As mentioned elsewhere in this handbook, we have the most modern melting, hot rolling, cold drawing and cold rolling facilities as well as the necessary technical and manufacturing know-how.

For over thirty-five years we have cooperated with many nationally known concerns in placing alloys and metal products on a sound commercially manufacturing basis. Care and specialized handling of metals and alloys present problems to many of the larger metal, steel and alloy manufacturers. We have, in many instances, been very successful in solving these problems.

Our research and engineering departments welcome an opportunity to be of service to you.

MECHANICAL, ELECTRICAL AND HEAT EQUIVALENTS

Unit	Equivalents
1 Hp.	746 watts
1 Hp.	0.746 kw.
1 Hp.	33,000 ft.-lbs. per minute
1 Hp.	550 ft.-lbs. per second
1 Hp.	2,544 Btu. per hour
1 Hp.	42.4 Btu. per minute
1 Hp.	0.707 Btu. per second
1 Hp.	2.64 lbs. water evaporated per hour from and at 212°F.
1 Kw.	1,000 watts
1 Kw.	1.34 horsepower
1 Kw.	2,654,200 ft.-lbs. per hour
1 Kw.	44,240 ft.-lbs. per minute
1 Kw.	737.3 ft.-lbs. per second
1 Kw.	3,413 Btu. per hour
1 Kw.	56.9 Btu. per minute
1 Kw.	0.948 Btu. per second
1 Kw.	3.53 lbs. water evaporated per hour from and at 212°F.
1 Watt	1 joule per second
1 Watt	0.00135 horsepower
1 Watt	3.413 Btu. per hour
1 Watt	0.7373 ft.-lb. per second
1 Watt	0.0035 lb. water evaporated per hour
1 Watt	44.24 ft.-lbs. per minute
1 Hp.-hr.	0.746 kw. hours
1 Hp.-hr.	1,980,000 ft.-lbs.
1 Hp.-hr.	2,545 Btu.
1 Hp.-hr.	273,740 kilogram meters
1 Hp.-hr.	2.64 lbs. water evaporated from and at 212°F.
1 Hp.-hr.	17.0 lbs. water raised from 62°F. to 212°F.
1 Kw.-hr.	1,000 watt hours
1 Kw.-hr.	1.34 horsepower hours
1 Kw.-hr.	2,654,200 ft.-lbs.
1 Kw.-hr.	3,600,000 joules
1 Kw.-hr.	3,413 Btu.
1 Kw.-hr.	367,000 kilogram meters
1 Kw.-hr.	3.53 lbs. water evaporated from and at 212°F.
1 Kw.-hr.	22.75 lbs. water raised from 62°F. to 212°F.
1 Ft.-lb.	1,356 joules
1 Ft.-lb.	0.1383 k.g.m.
1 Ft.-lb.	0.000000377 kw. hours
1 Ft.-lb.	0.001285 Btu.
1 Ft.-lb.	0.0000005 hp hour

A.S.T.M. STANDARDS

that apply to Electrical-Heating, Resistance Alloys and Electronic Tube Materials.

B 63	Method of Test for Resistivity of Metallic Materials.
B 70	Method of Test for Change of Resistance with Temperature of Metallic Materials for Electrical Heating.
B 76	Method of Accelerated Life Test for Metallic Materials for Electrical Heating.
B 77	Method of Test for Thermoelectric Power of Electrical-Resistance Alloys.
B 82	Spec. for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical-Heating Elements.
B 83	Spec. for Drawn or Rolled Alloy, 60 per cent Nickel, 16 per cent Chromium, and Balance Iron, for Electrical-Heating Elements.
B 84	Method of Test for Temperature-Resistance Constants of Alloy Wires for Precision Resistors.
B 95	Method of Test for Linear Expansion of Metals.
B 106	Methods of Testing Thermostat Metals.
B 113	Method for Bend Testing of Wire (Wire for Radio Tubes and Incandescent Lamps).
B 114	Method of Test for Temperature-Resistance Constants of Sheet Materials for Shunts and Precision Resistors.
B 118 T.	Methods of Testing Nickel and Nickel-Alloy Wire and Ribbon for Electronic Tube Filaments (Tentative).
B 128	Methods of Testing Sleeves and Tubing for Radio Tube Cathodes.
B 155	Method of Test for Temper of Strip and Sheet Metals for Electronic Devices (Spring-Back Method).
B 156 T.	Methods of Testing Lateral Wire for Grids of Electronic Devices. (Tentative)
B 157	Methods of Testing Wire for Supports used in Electronic Devices and Lamps.
B 175	Spec. for Round Nickel Wire for Lamps and Electronic Devices.
B 180	Method of Test for Density of Fine Wire and Ribbon for Electronic Devices.
B 181	Method of Test for Effect of Controlled Atmospheres Upon Alloys in Electric Furnaces.
B 205	Method of Test for Diameter by Weighing of Fine Wire Used in Electronic Devices and Lamps.
E 38	Methods of Chemical Analysis of Metallic Materials for Electrical Heating.
B 219	Methods of Testing Fine Round and Flat Wire for Electronic Devices.
B 267 T.	High Resistivity, Low Temperature Coefficient Wire (Tentative).
E 21	Recommended Practice for Short-Time Elevated-Temperature Tension Tests of Metallic Materials.
E 22	Recommended Practice for Conducting Long-Time High-Temperature Tension Tests of Metallic Materials.
E 38	Methods of Chemical Analysis of Metallic Materials for Electrical Heating.

DEFINITIONS AND GLOSSARY

AGE-HARDENING (Precipitation Hardening)—A process for the heat-treatment of certain non-ferrous alloys to increase strength and hardness.

ANNEALING—Heating and cooling primarily (a) to induce softness, (b) to relieve internal stresses, (c) to obtain the optimum combination of strength and ductility, or (d) to reduce oxide. See "Stress-equalizing Annealing" and "Stress-relief Annealing."

BTU.—British Thermal Unit. The quantity of heat necessary to raise the temperature of one pound of water by 1°F.

CAMBER—Curvature in the plane of rolled sheet or strip.

COEFFICIENT—A number expressing the ratio of change under certain specified conditions such as temperature, length, volume, etc.

COMPRESSIVE YIELD STRENGTH—The stress in compression, (pushed together) at which a material exhibits a specified limiting set, commonly taken by the offset method as 0.20 per cent of the specimen's original length. Expressed as psi.

CORROSION—Gradual chemical or electrochemical attack on a metal by atmosphere, moisture or other agents.

CORROSION FATIGUE—The endurance limit of a material when in contact with a specified corrosive medium. See "Endurance Limit."

CREEP STRENGTH—The rate of continuous deformation under stress at a specified temperature. Generally expressed as psi. to produce 0.1 per cent elongation in 10,000 hours at the temperature indicated.

DENSITY—The weight of a metal, usually expressed in pounds per cubic inch or grams per cubic centimeter. Do not confuse with "Specific Gravity."

DUCTILITY—The property which permits deformation under tension without rupture. Values for "Elongation" and "Reduction of Area" generally are taken as the measure of ductility.

ELASTIC LIMIT—The maximum stress a material will stand without permanent deformation.

ELECTRICAL RESISTIVITY—The resistance of a material to passage through it of an electric current. Expressed as ohms (units of resistance) per mil ft. or as microhms (millionth of an ohm) per centimeter cube at a specified temperature.

ELONGATION—The amount of permanent stretch, after fracture in tension, expressed as percentage of the specimen's original length.

ENDURANCE LIMIT—A measure of the limit of safe loading for materials to be used under repeated, cyclic changes of stress. Expressed as psi. Properly, it is the maximum stress to which a metal can be subjected for indefinitely long periods without damage. In practice values are taken at a specified number of cyclic changes of stress (see "Fatigue Strength").

EROSION—The abrasion of metal or other material by liquid or gas, usually accelerated by pressure of solid particles of matter in suspension, and sometimes by corrosion.

FATIGUE STRENGTH—Usually synonymous with Endurance Limit but properly the stress to which a metal can be subjected for a specified number of cyclic changes of stress. Expressed as psi.

HARDNESS—Resistance to indentation, penetration, scratching or bending. Expressed by means of "Brinell," "Rockwell," "Scleroscope" or "Vickers" Hardness Numbers depending upon the testing machine used.

HEAT TRANSFER—The passage of heat from a hot to a cold body, by conduction through intervening layers of solid, liquid or gas. Overall rate of heat transfer through a given system of obstructions is expressed in units of heat, per unit of area of obstructions exposed, per unit of time, per unit of difference in temperature between the hot and cold bodies (Btu. per sq. ft. per hr. per °F). The amount of heat transferred is measured in units of heat per unit of time (Btu. per hr.). See "Thermal Conductivity."

HEAT-TREATING—An operation or combination of operations involving the heating and cooling of a metal to obtain certain desirable conditions or properties, and not for the sole purpose of mechanical working.

IMPACT STRENGTH—A measure of toughness. The stress to fracture a notched specimen with a single blow. Expressed in foot-pounds of energy absorbed. Designated as "Charpy" or "Izod" Impact Strength depending on the testing machine used.

IPY—Inches penetration per year. The average depth to which uniform corrosion would penetrate if a specimen were exposed to corrosion, on one side only, 24 hours per day for 365 days. Calculated from weight loss. See "Mdd."

MAGNETIC TRANSFORMATION POINT—The temperature at which a normally magnetic material becomes substantially non-magnetic. Also called the Curie Point.

MDD —Milligrams per square decimeter per day. The term for expressing average loss in weight from corrosion. A "day" is 24 hours. See "Ipy."

MODULUS OF ELASTICITY—The ratio, within the elastic limit, of stress to the corresponding strain. Expressed in psi, for four types of stress: tension, torsion, compression, shear.

PROOF STRESS—The stress that may be applied without leaving permanent elongation of more than 0.001 inch per inch of the specimen's original length after removal of that stress. Expressed in psi.

PROPORTIONAL LIMIT—The maximum, in psi., at which strain or deformation is directly proportional to stress.

PSI.—Pounds per square inch.

REDUCTION OF AREA—The difference between the original cross-sectional area of a specimen and the least cross-sectional area after rupture in tensile tests. Expressed in percentage of the original cross-sectional area.

SHEAR STRENGTH—The stress required to produce fracture when impressed vertically upon the cross-section of a material. Expressed in psi.

SPECIFIC GRAVITY—The ratio of the weight of a solid or liquid to the weight of an equal volume of water. See "Density."

SPECIFIC HEAT—The amount of heat necessary to raise the temperature of a substance by 1°F. Expressed as Btu. per pound per °F.

STRESS-EQUALIZING ANNEALING—Heating and cooling to homogenize stresses so as to afford the best possible combination of ductility and strength.

STRESS-RELIEF ANNEALING—Heating and cooling to effect partial softening. Also called Temper Annealing.

TENSILE STRENGTH—The stress required to rupture in tension (pull). Expressed in psi. Also called Breaking Strength, Ultimate Strength, and Ultimate Tensile Strength.

THERMAL CONDUCTIVITY—The measure of the heat a substance will conduct through itself. Expressed in Btu., per hour, per sq. ft. of exposed surface, per °F. difference between the adjacent hot and cold bodies, per inch thickness (or the metric equivalents). Do not confuse with "Heat Transfer."

THERMAL EMF—The electromotive force generated when the junction of two dissimilar metals is heated.

THERMAL EXPANSION—The increase in length caused by heating. Expressed in inches of increase, per inch of original length, per degrees of temperature.

THERMOCOUPLE—A device for measuring temperatures by the use of two dissimilar metals in contact; the junction of these metals gives rise to a measurable electrical potential with changes in temperature.

TORSIONAL PROPERTIES—Figures expressing values of a material when stressed by twisting.

TOUGHNESS—Resistance to impact. A combination of strength and ductility.

YIELD POINT—The stress necessary to produce an elongation under load of 0.50 per cent of the specimen's original length. Expressed as psi. Do not confuse with "Yield Strength."

YIELD STRENGTH—The stress at which a material exhibits a specified limiting set, commonly taken by the offset method as 0.20 per cent of the specimen's original length. Expressed as psi.

CONVERSION FACTORS

Area — Length — Power — Energy — Miscellaneous

AREA

To convert	Multiply By
Circular Mils to Square Inches	.0000007854
Circular Mils to Square Mils	.7854
Circular Mils to Square Millimeters	.0005066
Square Centimeters to Square Inches	.155
Square Feet to Square Meters	.0929
Square Inches to Circular Mils	1,273,240.
Square Inches to Square Centimeters	6.4516
Square Inches to Square Millimeters	645.16
Square Inches to Square Mils	1,000,000.
Square Meters to Square Feet	10.764
Square Millimeters to Square Inches	.00155
Square Millimeters to Circular Mils	1,973.51
Square Mils to Circular Mils	1.2732
Square Mils to Square Inches	.000001

LENGTH

Centimeters to Inches	.3937
Centimeters to Feet	.03281
Feet to Centimeters	30.48
Feet to Meters	.3048
Inches to Centimeters	2.54
Inches to Meters	.0254
Inches to Millimeters	25.4
Inches to Mils	1,000.
Kilometers to Miles	.6214
Meters to Feet	3.2808
Meters to Inches	39.3701
Meters to Yards	1.0936
Miles to Kilometers	1.6093
Millimeters to Inches	.03937
Millimeters to Mils	39.3701
Mils to Inches	.001
Mils to Millimeters	.0254
Yards to Meters	.9144

POWER

Foot-Pounds per Minute to Horsepower	.0000303
Foot-Pounds per Minute to Watts	.0226
Foot-Pounds per Second to Horsepower	.001818
Foot-Pounds per Second to Watts	1.356
Horsepower to Foot-Pounds per Minute	33,000.
Horsepower to Foot-Pounds per Second	550.
Horsepower to Watts	746.

POWER—Continued

To Convert	Multiply By
Kilogram-Meters per Second to Watts	9.807
Watts to Foot-Pounds per Minute	44.25
Watts to Foot-Pounds per Second	.7375
Watts to Horsepower	.001341
Watts to Kilogram-Meters per Second	.1020

ENERGY

British Thermal Units to Foot-Pounds	778.
British Thermal Units to Joules	1,055.
British Thermal Units to Watt-Hours	.293
Foot-Pounds to British Thermal Units	.001285
Foot-Pounds to Joules	1.356
Foot-Pounds to Kilogram-Meters	.1383
Gram Calories to Joules	4.186
Joules to British Thermal Units	.000947
Joules to Ergs	10^7
Joules to Foot-Pounds	.7375
Joules to Gram-Calories	.2388
Joules to Kilogram-Meters	.10198
Kilogram-Meters to Foot-Pounds	7.233
Kilogram-Meters to Joules	9.8117
Watt-Hours to British Thermal Units	3.4126

MISCELLANEOUS

Kilogram to Pounds	2.205
Kilograms per Kilometer to Pounds per 1000 Feet	.6719
Ohms per Kilometer to Ohms per 1000 Feet	.3048
Ohms per 1000 Feet to Ohms per Kilometer	3.2808
Ohms per 1000 Yards to Ohms per Kilometer	1.0936
Pounds to Kilograms	.4536
Pounds per 1000 Feet to Kilograms per Kilometer	1.488
Pounds per 1000 Yards to Kilograms per Kilometer	.4960
Pounds per 1000 Yards to Pounds per Kilometer	1.0936
Resistivity in Microhm Cent. to Ohms CMF	6.0153
Resistivity in Ohms CMF to Microhm Centimeters	.166
Specific Gravity to Pounds per Cubic Inch	.0361

STANDARD RESISTANCE TOLERANCE AND EXTRA CHARGE FOR WIRE AND RIBBON HAVING CLOSER RESISTANCE TOLERANCE THAN STANDARD

STANDARD RESISTANCE TOLERANCE

CLASS:

1.	Hot Rolled Ribbon and Rods: all widths and thicknesses	± 8%
2.	Cold Rolled Ribbon, Any Thickness or Width	± 5%
	Cold Drawn Round Wire:	
3.	Finer than .002	± 10%
4.	Finer than .005 to .002 incl.	± 8%
5.	Finer than .0226 to .005 incl.	± 5%
6.	Size .0226 and heavier	± 3%

EXTRAS FOR CLOSER TOLERANCE THAN ABOVE STANDARDS

1.	For tolerances ± 5%*	up to & incl. ± 7.9%	Add to net price	5%
2.	For tolerances ± 3%	up to & incl. ± 4.9%	Add to net price	5%
	For tolerances ± 1%*	up to & incl. ± 2.9%	Add to net price	10%
3.	For tolerances ± 5%*	up to & incl. ± 9.9%	Add to net price	10%
4.	For tolerances ± 5%	up to & incl. ± 7.9%	Add to net price	5%
	For tolerances ± 3%*	up to & incl. ± 4.9%	Add to net price	10%
5.	For tolerances ± 3%	up to & incl. ± 4.9%	Add to net price	5%
	For tolerances ± 1%*	up to & incl. ± 2.9%	Add to net price	10%
6.	For tolerances ± 2%	up to & incl. ± 2.9%	Add to net price	5%
	For tolerances ± 1%*	up to & incl. ± 1.9%	Add to net price	10%

* Closer Resistance Tolerance Than These Are Not Made.

Standard resistance per foot on any wire or ribbon shall be the value calculated from the cross-section of the wire or ribbon and the resistivity of the alloy.

On ribbon which is rolled from round wire, with a width to thickness ratio of 15 or less, the cross-section will be considered as being 6% less than a true rectangle.

For ribbon rolled with a width to thickness ratio of more than 15, the cross-section will be considered as being 17% less than a true rectangle.

WEIGHTS OF COILS AND SPOOLS

The following tables show approximate weights of wire in coils and on spools for the different sizes: (These figures are subject to some variation.)

WIRE

B & S Gauge	Packed	Spool No.	Spool Material	Head Diam.	Trav.	Barrel Diam.	Bore	Weight of Spool in lbs.	Approximate Wgt. in lbs.
#17 and Heavier	Coils								10-125
Finer than #17 to #22	Spools	#8	Metal Bound Wood	6″	3″	2¼″	⅝	1.22	4-15
Finer than #22 to #29	Spools	#5	Metal Bound Wood	4½″	3″	2″	⅝″	.80	2½-6
Finer than #29 to #34	Spools	#4 #3	Metal Bound Wood Steel	3″	3″	1¾″ 1½″	⅝″	.48 .30	½-2½
Finer than #34 to #40	Spools	#1	Aluminum Steel	2½″	3″	1¾″ 1½″	⅝″	.16	.15-1.50
Finer than #40	Spools	#1	Aluminum Steel	2½″	3″	1¾″ 1½″	⅝″	.16	.03- .50

RIBBON

Width	Packed	Spool No.	Spool Material	Head Diam.	Trav.	Barrel Diam.	Bore	Weight of Spool in lbs.	Approximate Wgt. in lbs.
Wider than ⅛″	Coils								5-125
⅛″ to 1/16″ Inc.	Spools	#9	Metal Bound Wood	6″	3″	4″	⅝″	1.50	2-7
Narrower than 1/16″	Spools	#11	Metal Bound Wood	5″	3″	4″	⅝″	1.18	½-2
Filament	Spools	#10	Aluminum	4½″	3″	4″	⅝″	.36	2000 ft.

The weight per spool of all ribbon .010″ and less in thickness is limited to about 3 lbs. to prevent shifting.

ALLOY COLOR CHART

TOPHET A—Yellow
TOPHET C—Red
TOPHET D—Blue

CUPRON—Pink
EVANOHM—Purple

PURE NICKEL—Green
MONEL—Brown
NILSTAIN—Silver

The colors (as found on our labels) were specified for these alloys by the American Society for Testing Materials.

Unless otherwise specified, wire will be furnished on spools as in above table.

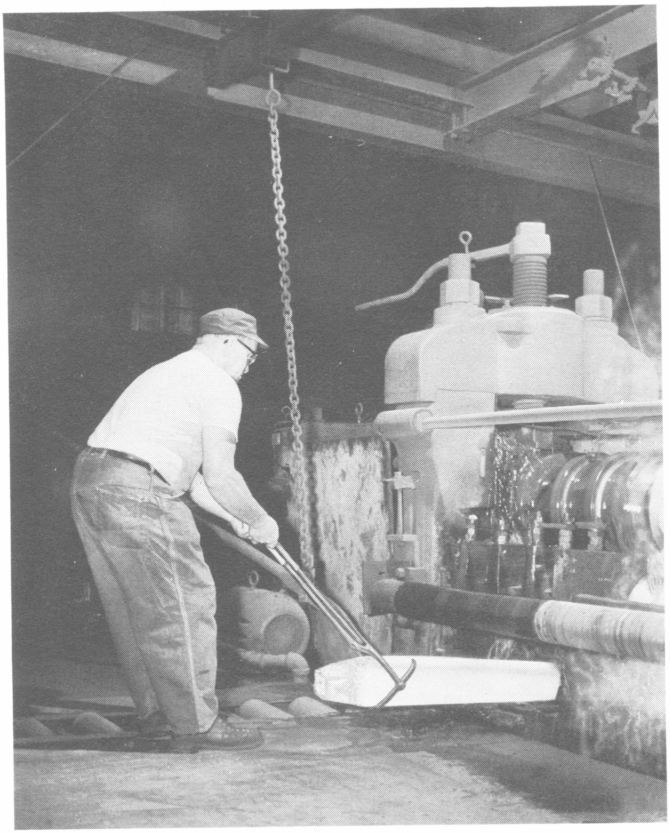
This picture section of the handbook is to acquaint customers and friends with some of our facilities and testing equipment.

Pictures cannot tell the entire story but we have tried to arrange them in sequence to give some idea of the operations required to produce wire, ribbon and strip.

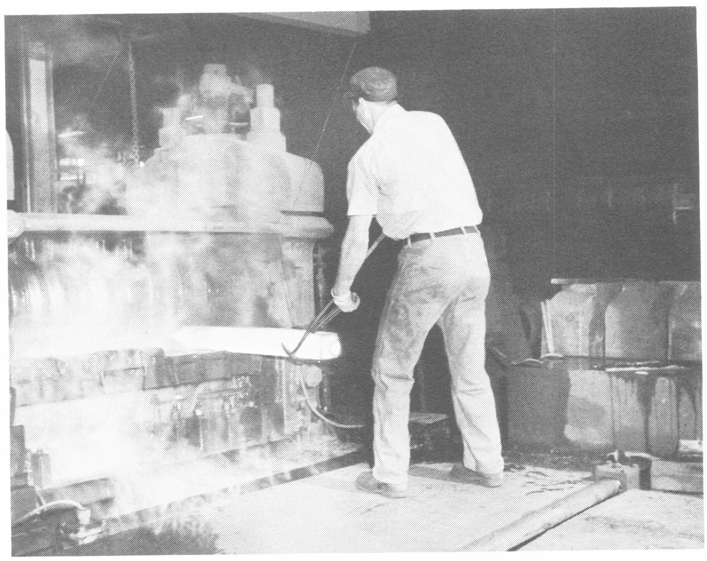
The close specifications in existence today require the most accurate and sensitive instruments obtainable. These were selected by our Engineering Department, after careful study and investigation. Some of this equipment is shown in these pictures.

The cooperation of our Engineering Department and the use of these facilities are at your service. We welcome the opportunity to work with you.

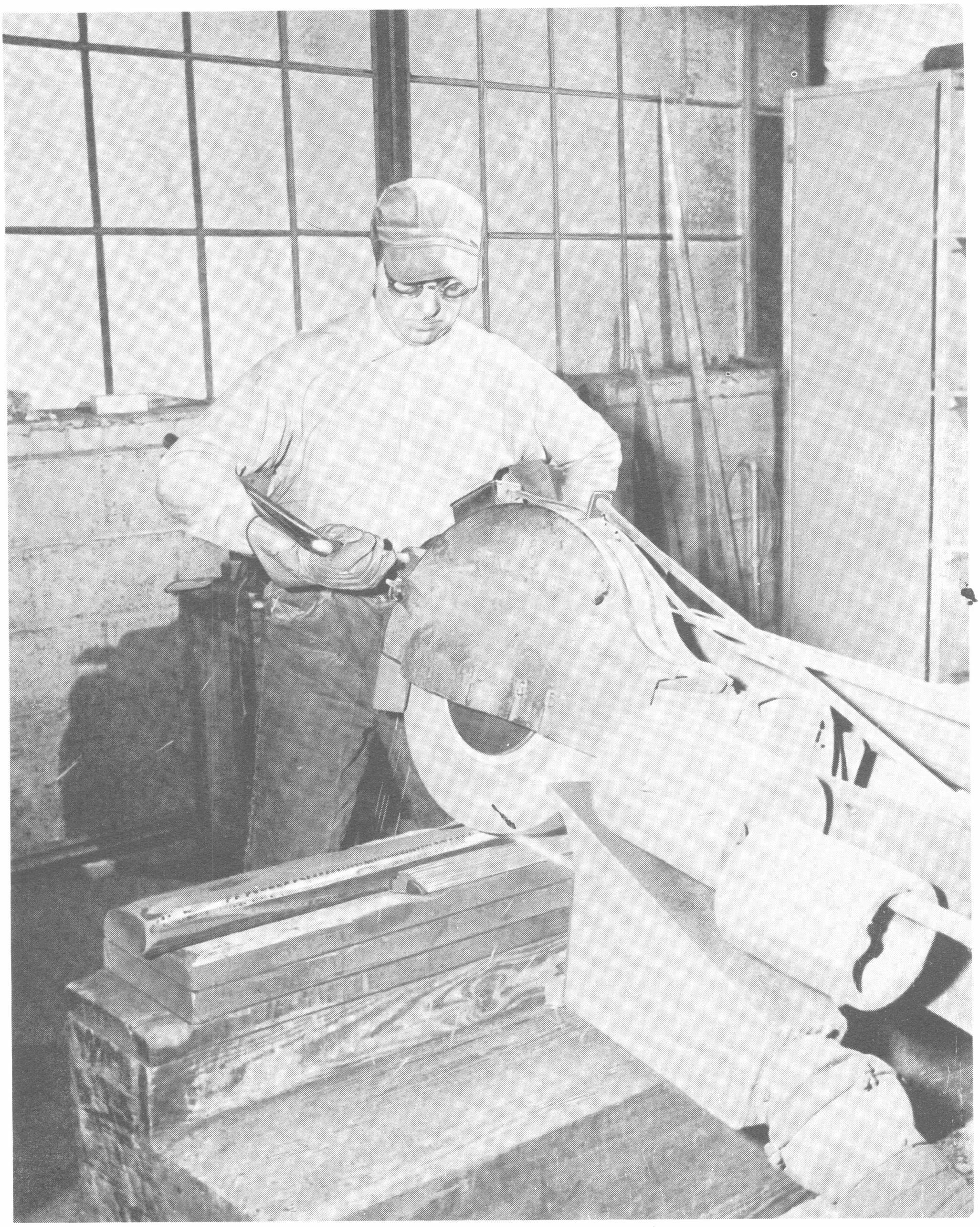
Melt Shop—Pouring molten metal into Ingot Molds.



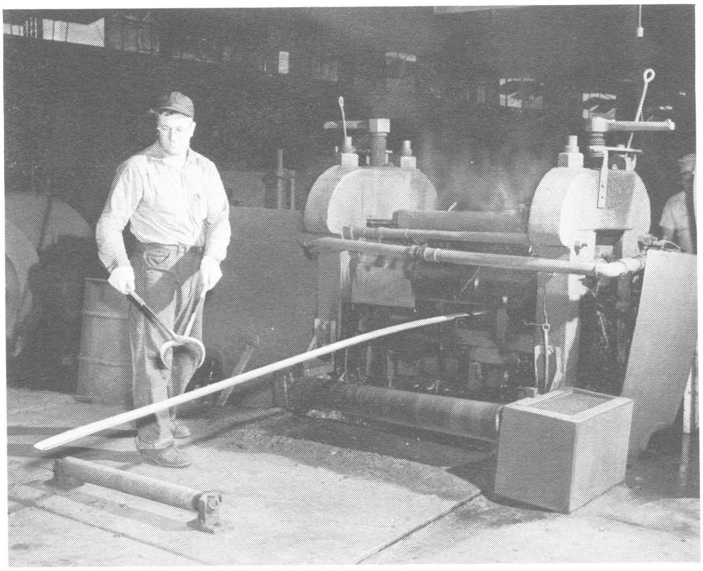
Cogging an Ingot.



Cogging an Ingot.

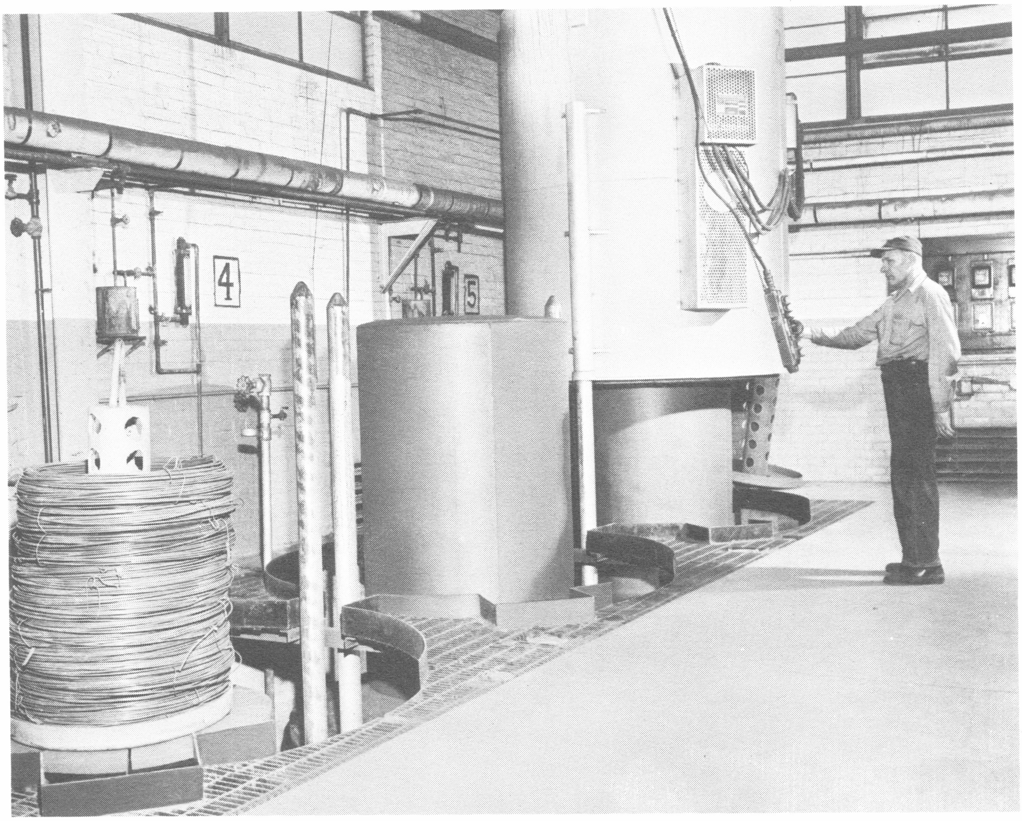


Billet Grinding—Preparing Billets from the Cogging Mill for Hot Rolling.

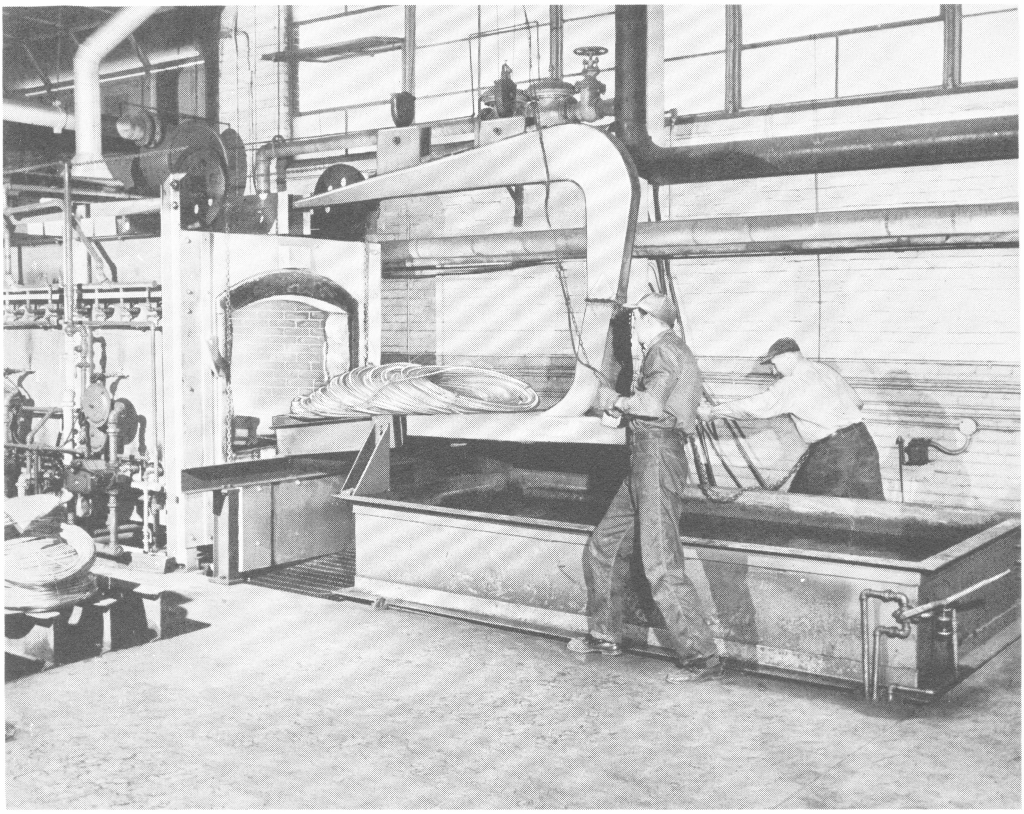


Hot Rolling.

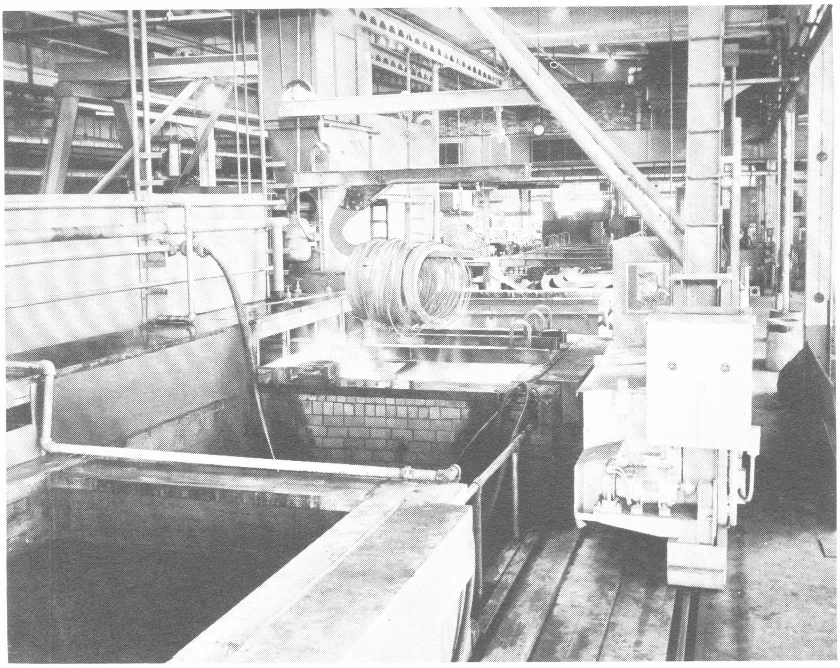
"Looping" Hot Rolled Rod.

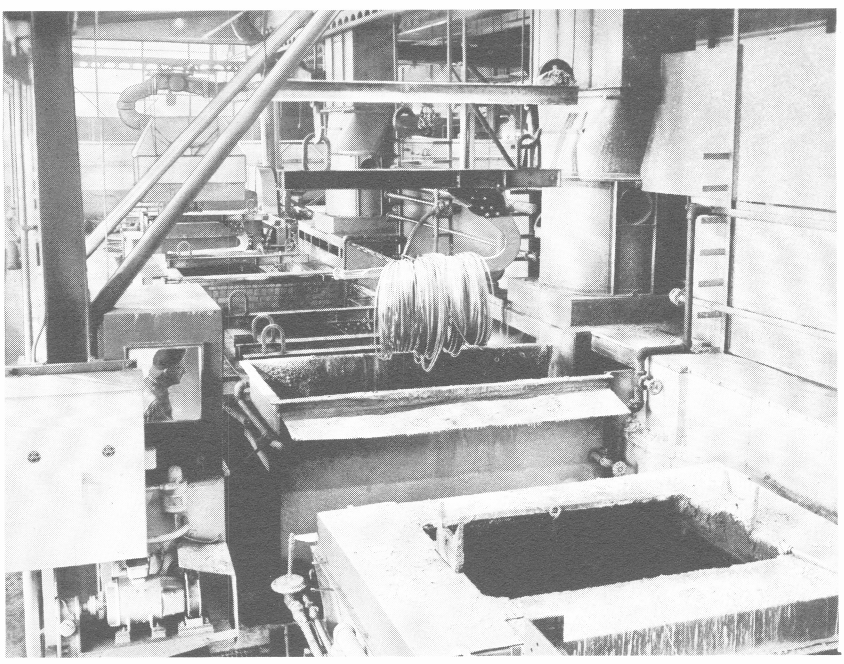


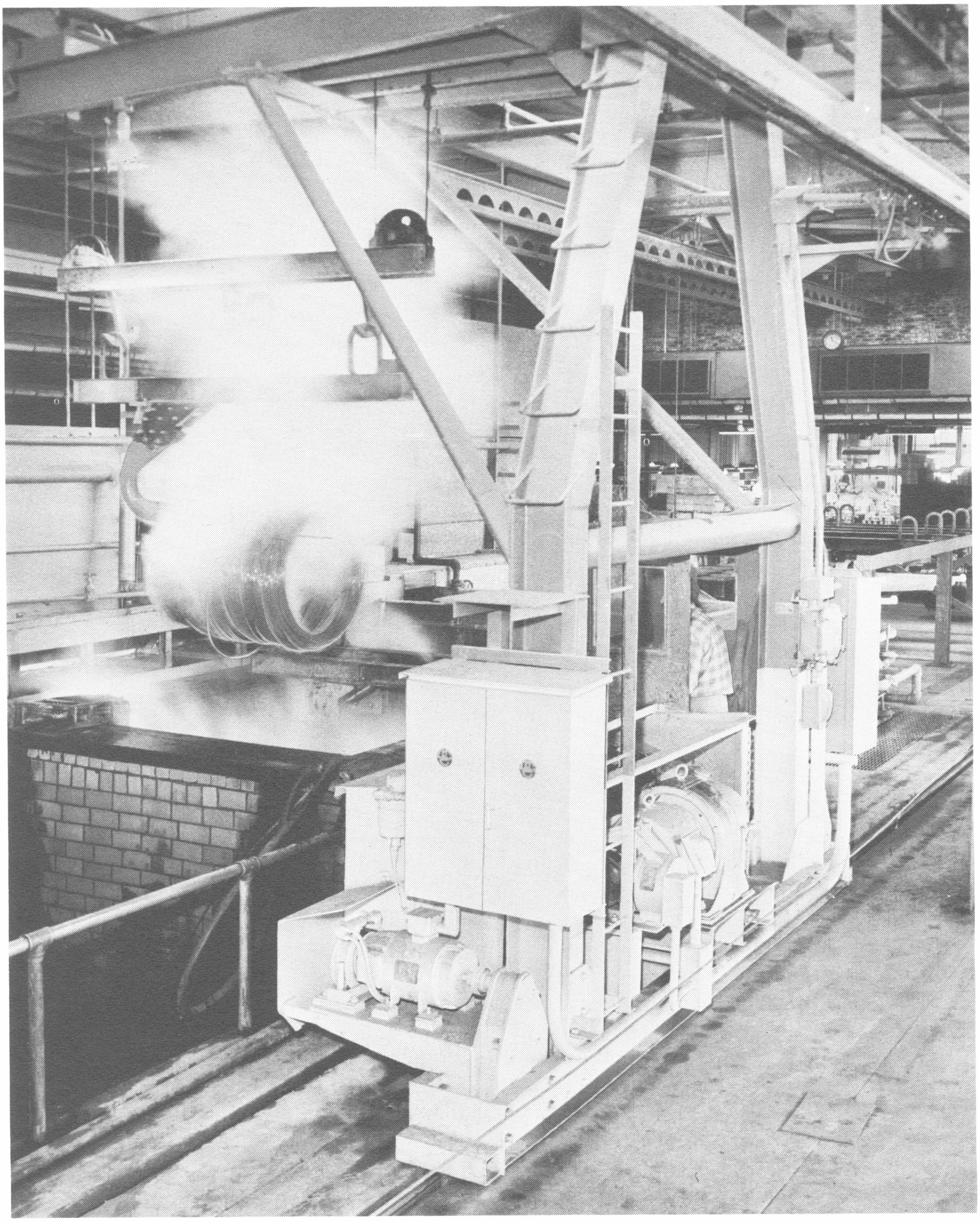
Annealing Hot Rolled Rod in Electric Bell Furnaces.



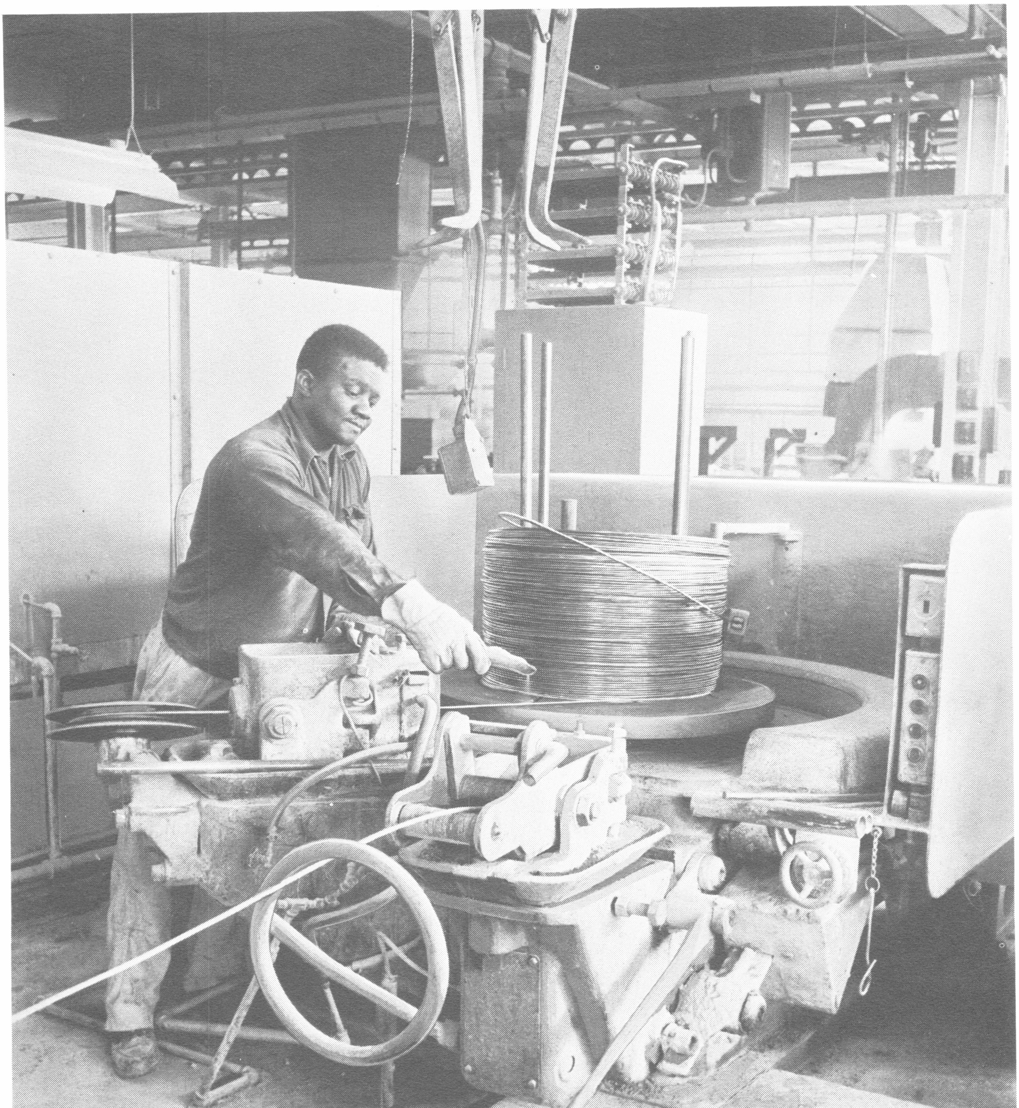
Annealing Hot Rolled Rod.


Pickling. These acid baths clean the Annealed Hot Rolled Rod.


Pickling.



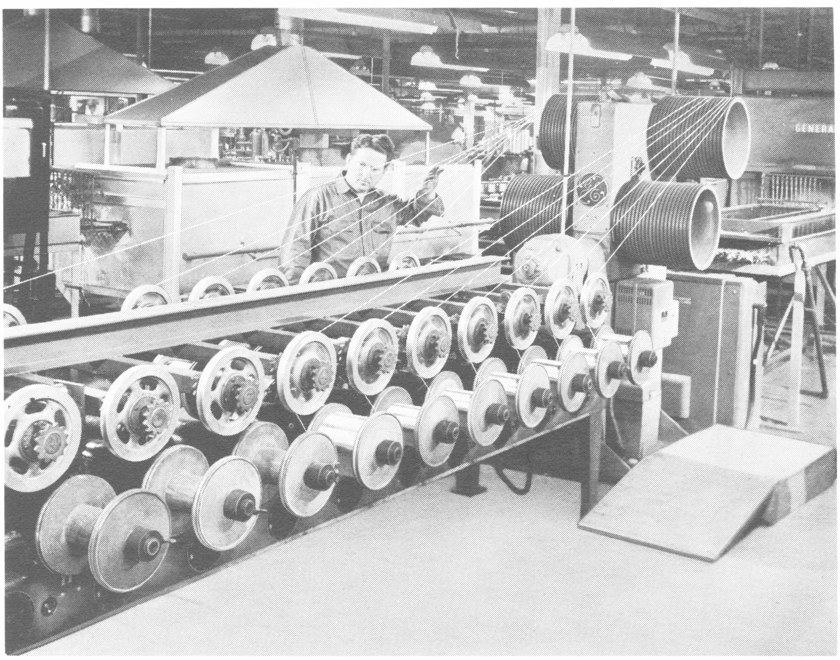
Pickling.



Reducing Rod to Wire.

Heavy Wire Department.

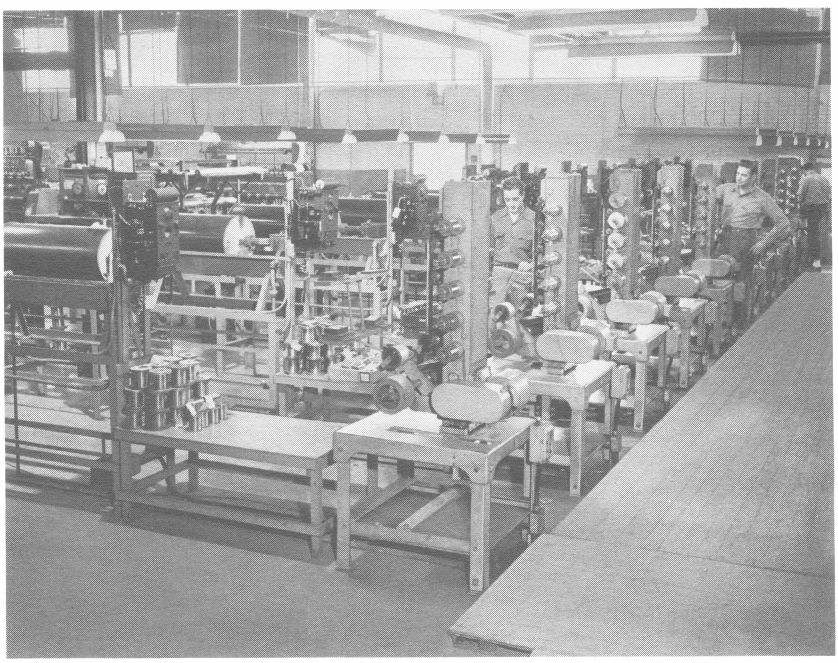
Strand Annealing Round Wire.

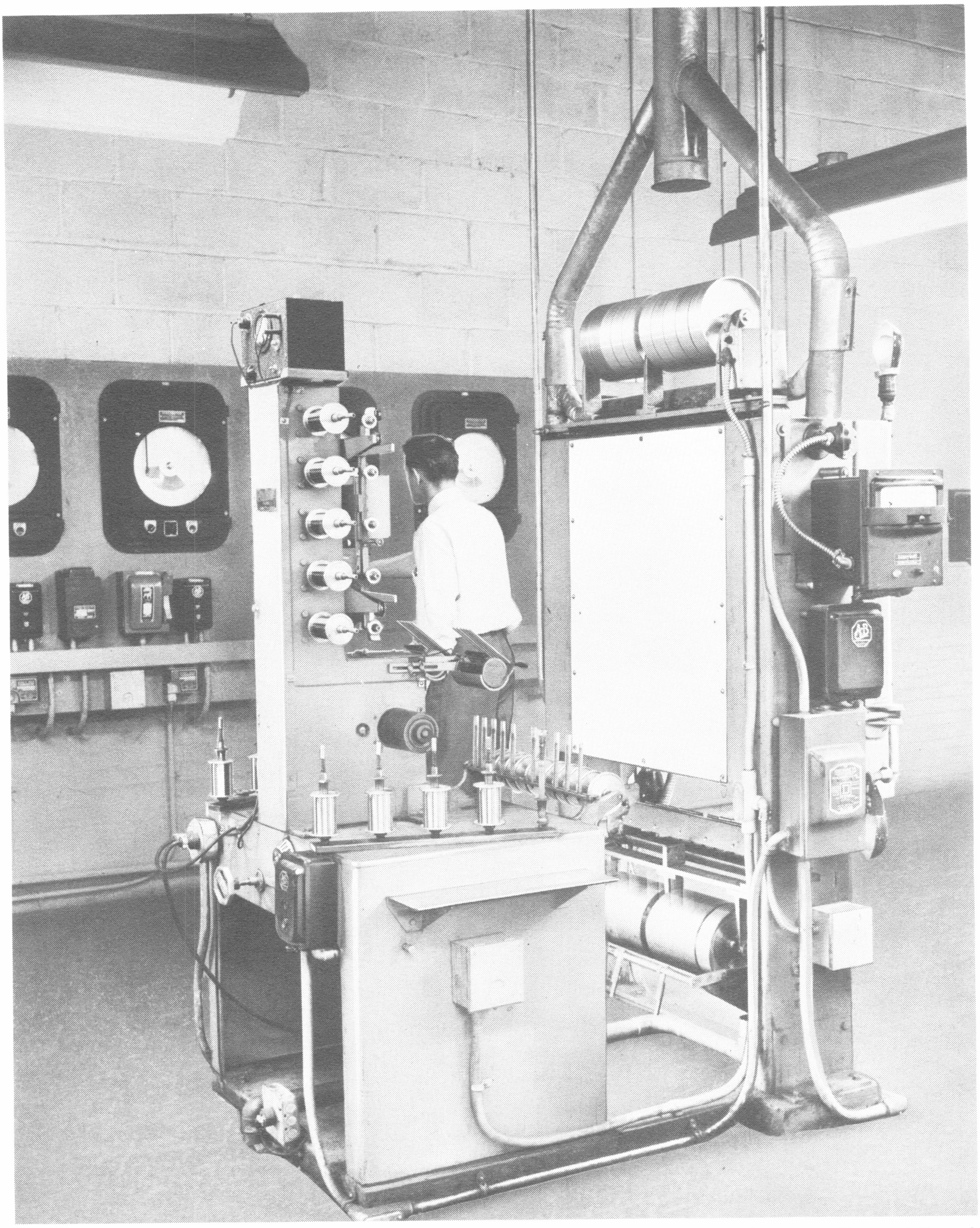


Strand Annealing Flat Wire—Ribbon.

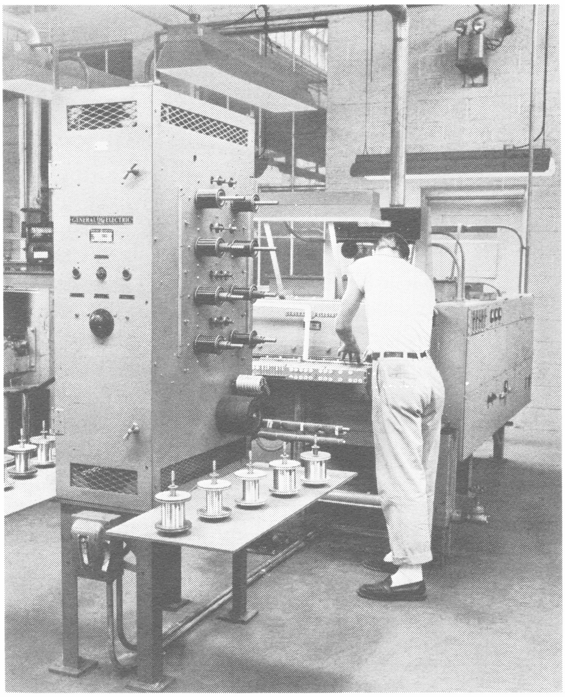
Fine Wire Drawing.

Fine Wire Annealing.





Enameling Machine and Viscosity Control Panel.



Liquid Nylon or Formex coating machine showing oven and takeup.

Textile Insulating of Wire.

General view of Inspection Dep't.

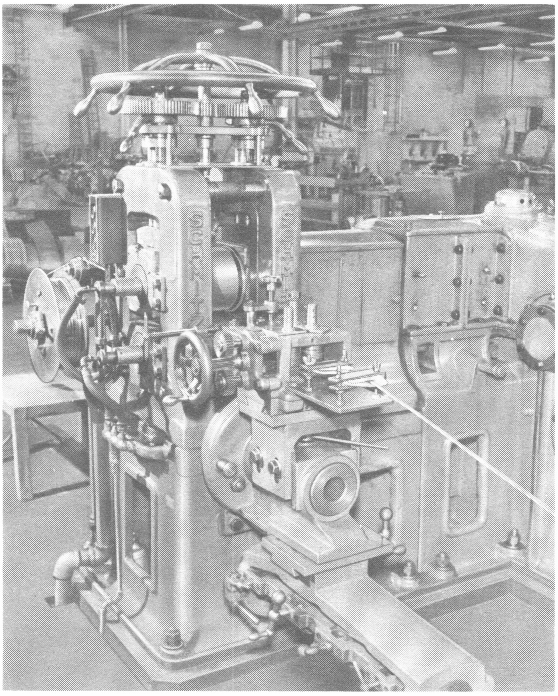
Inspection and Testing of Fine Wire.

Testing for Temperature Coefficient of Resistance.

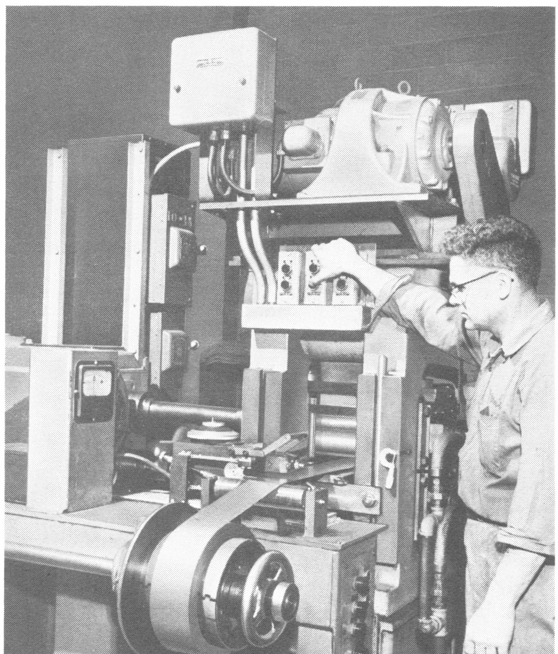
Inspecting and Testing of wire.

Sendzimir Mills.

Sendzimir Mill with work rolls removed for set-up of new work.



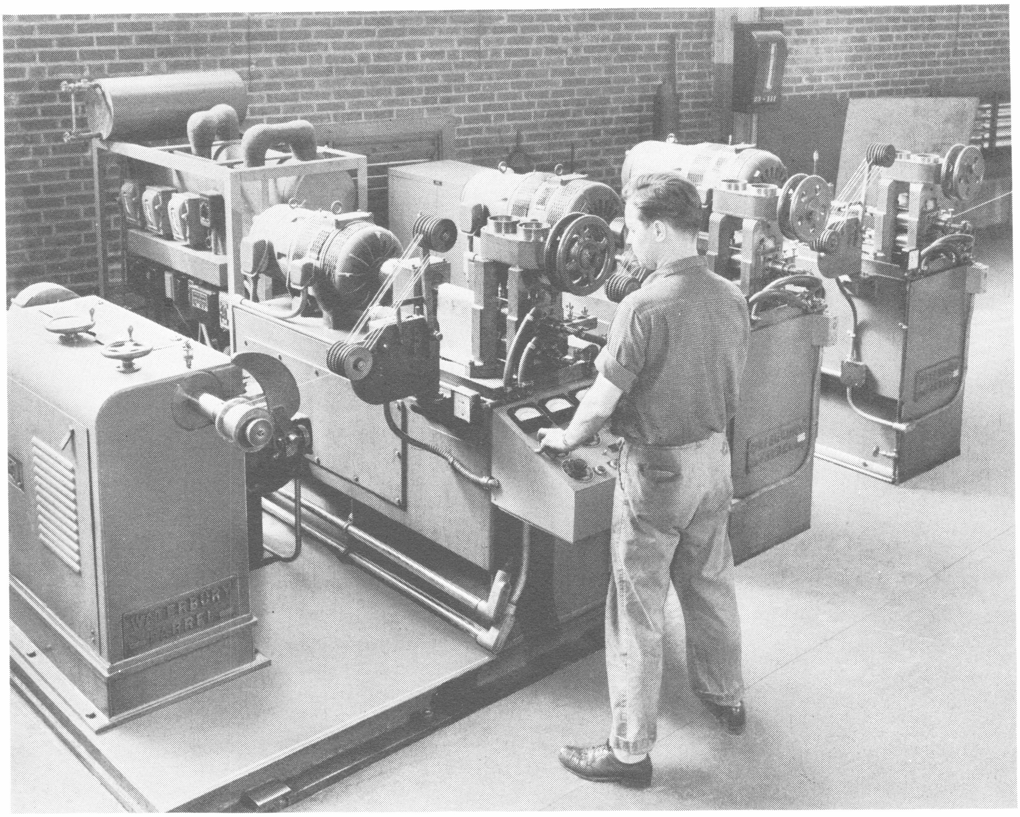
Edgerolling Resistance Strip.



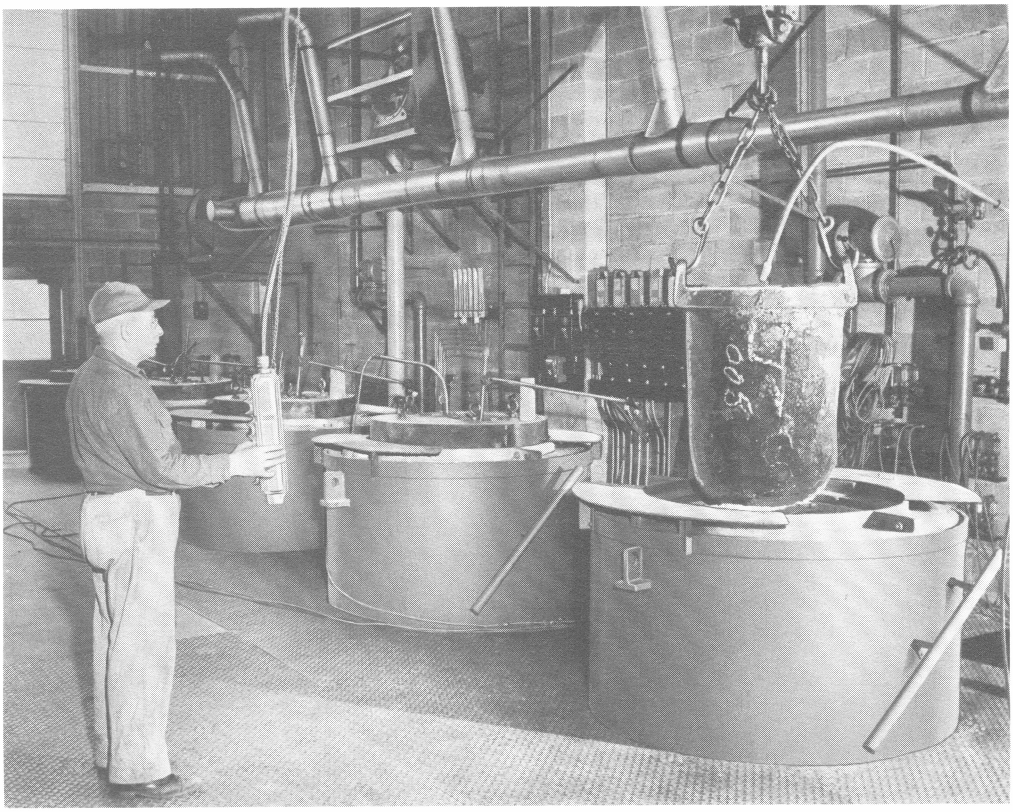
Power Screw Down Two High Rolling Mill with electronic micrometer gauge.

Slitting Strip.

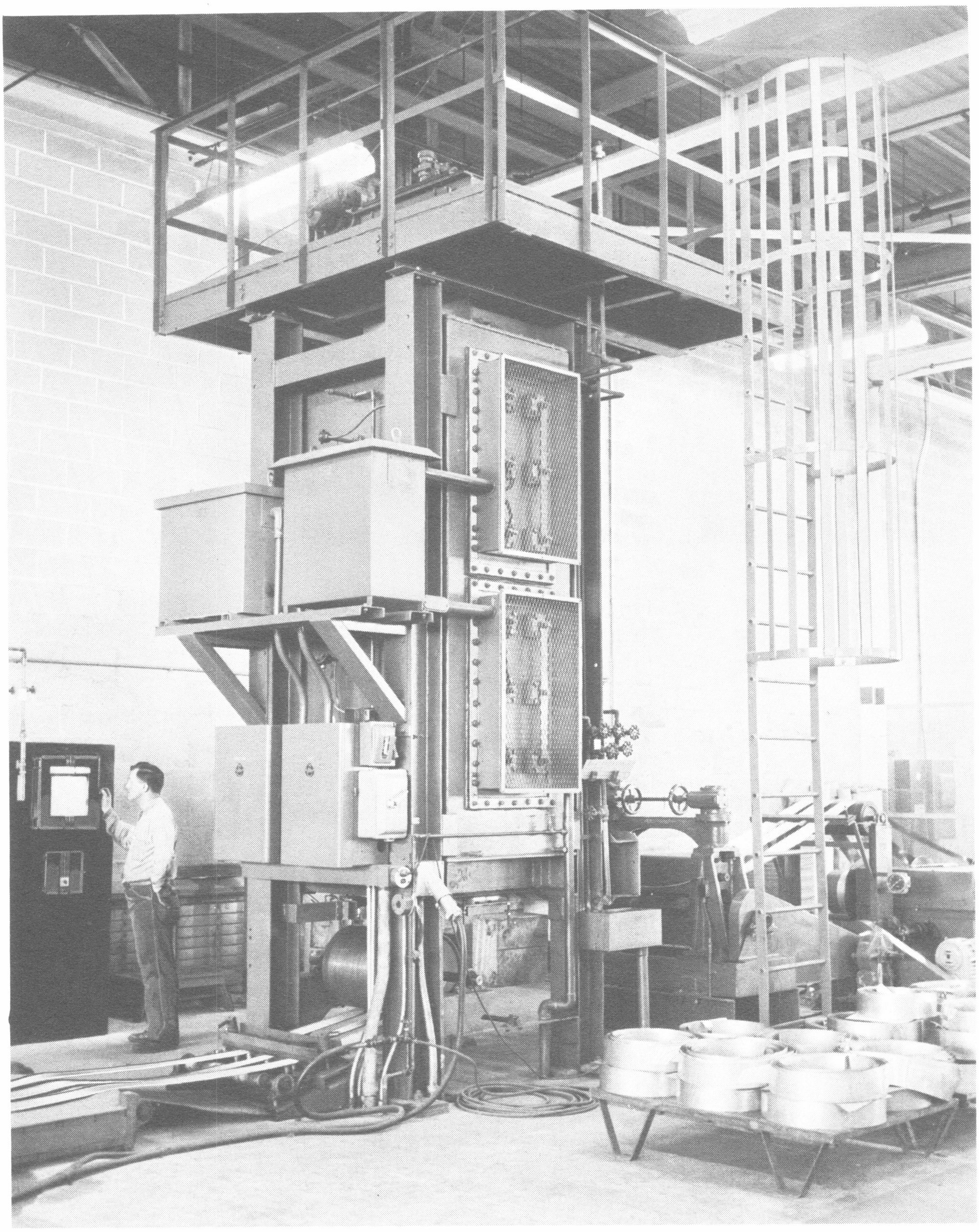
Fine Rolling Dep't.



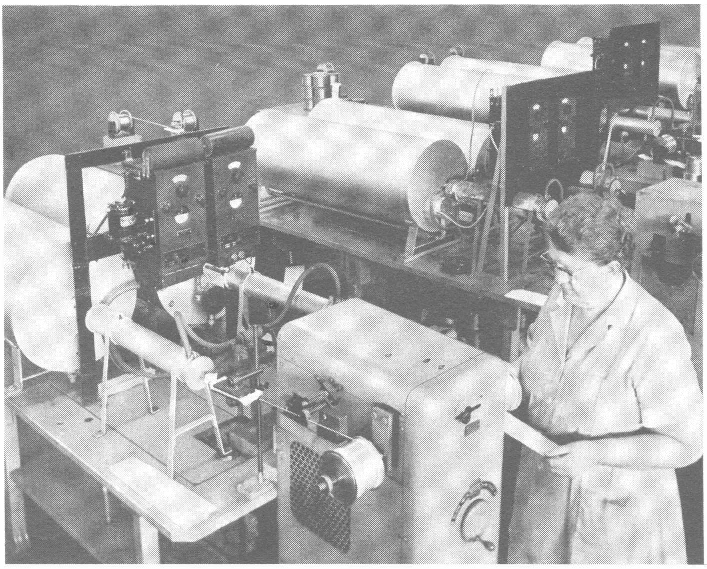
Tandem Rolling Mill for high speed production of precision flat wire.



Pot Annealing Batches of cold rolled Strip.



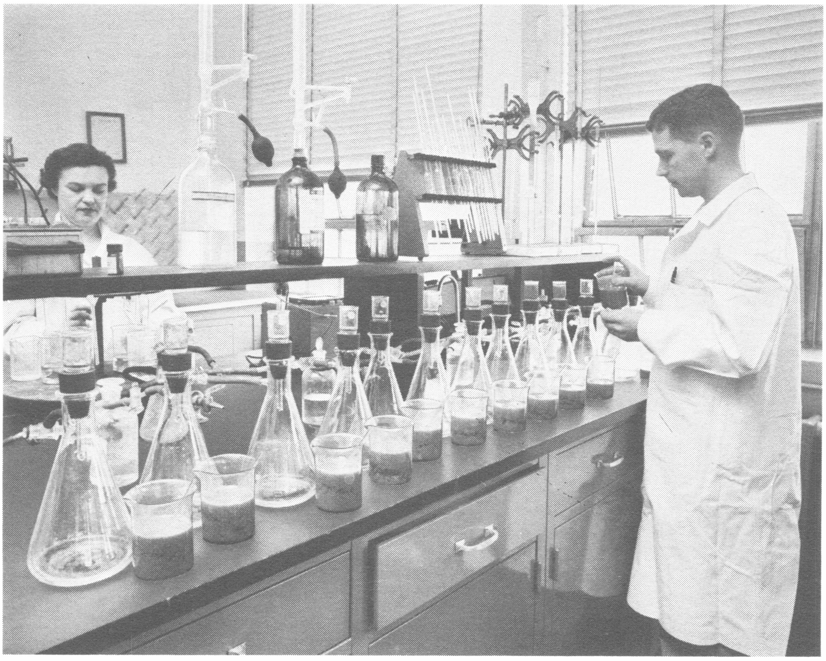
Electric Furnace for Strand Annealing cold rolled strip.



Annealing
Filament Ribbon.

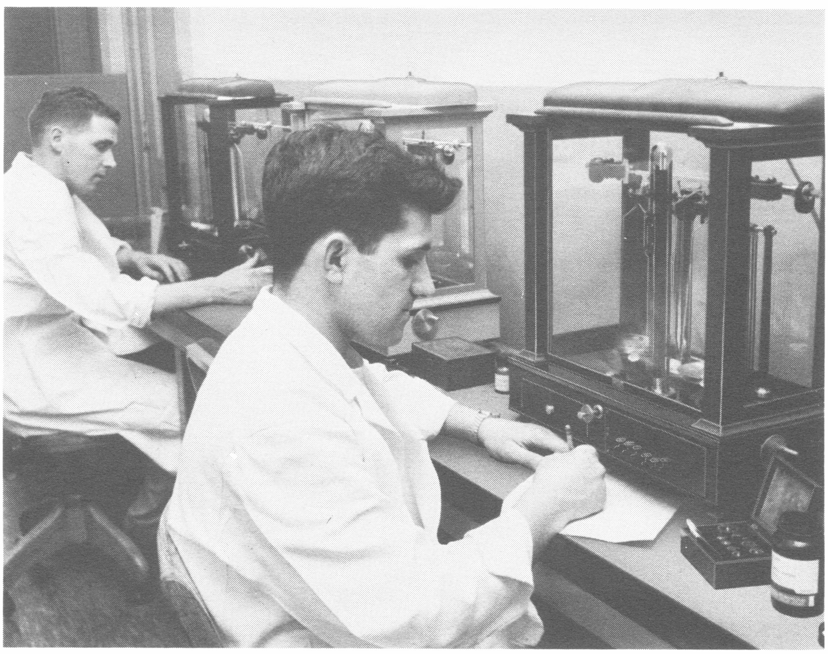
Weighing
Filament Ribbon.

Research & Engineering Bldg.

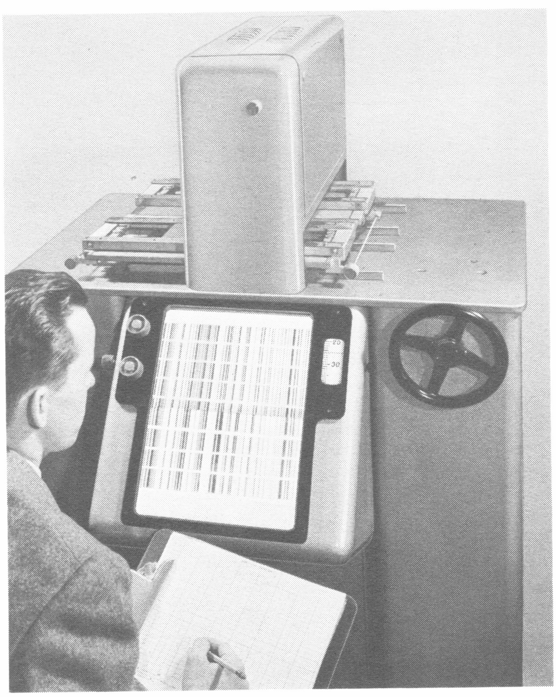


View of Chemical Laboratory.

Chemistry Laboratory—Precision Balances.

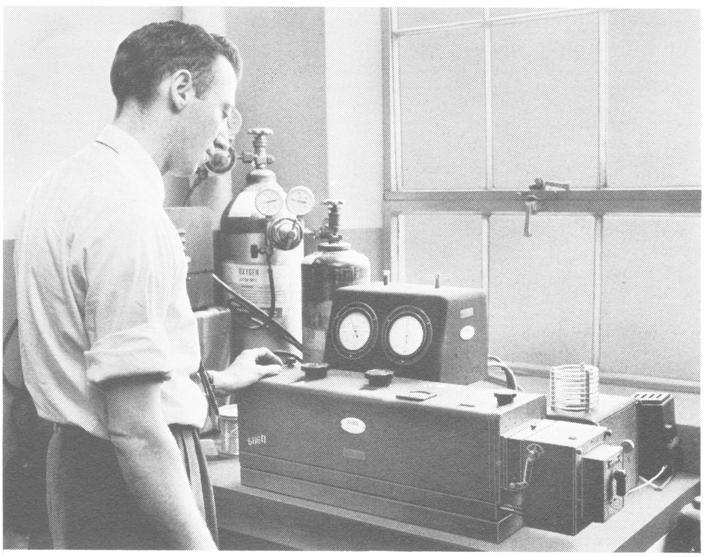


Spectrographic Laboratory
showing control panel.

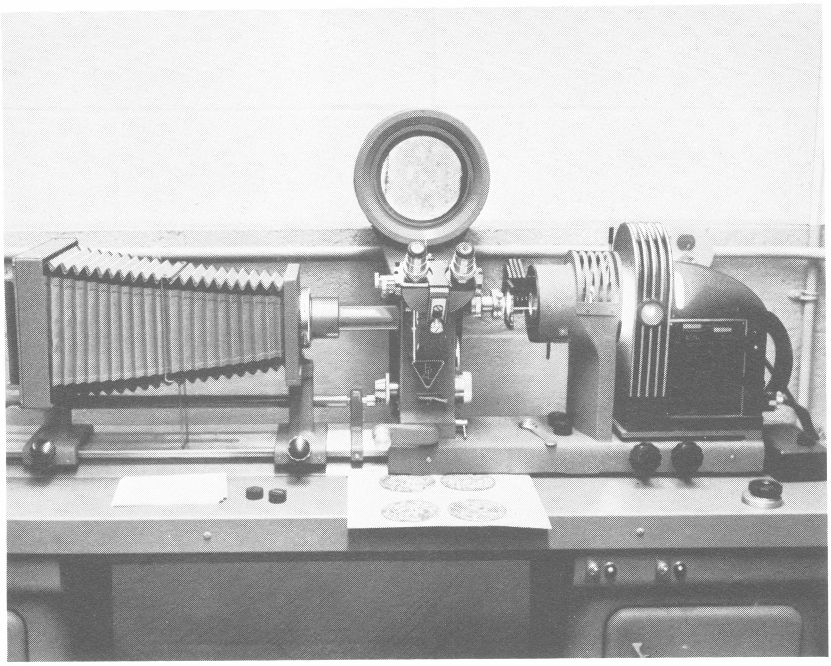


Spectrographic Laboratory
showing Microphotometer.

Engineering Laboratory—
Instron Testing Machine.

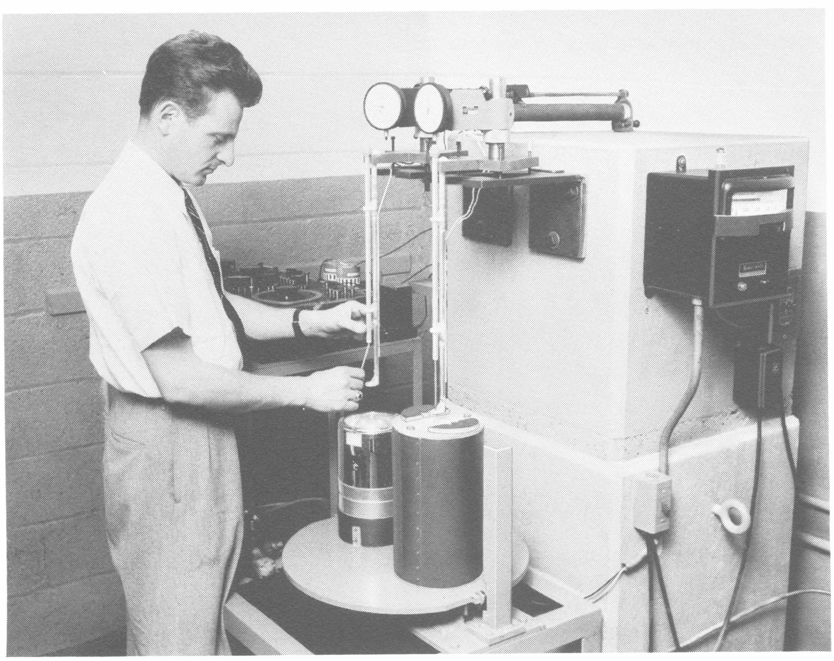


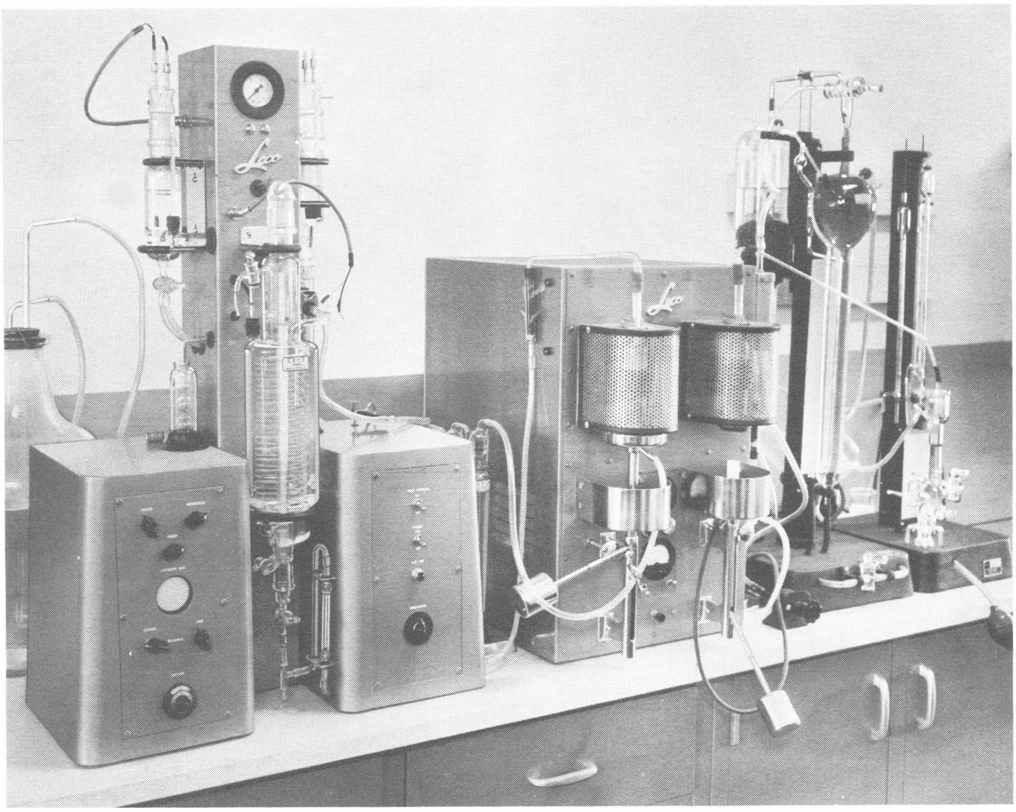
Chemistry
Laboratory—
Spectrophotometer.



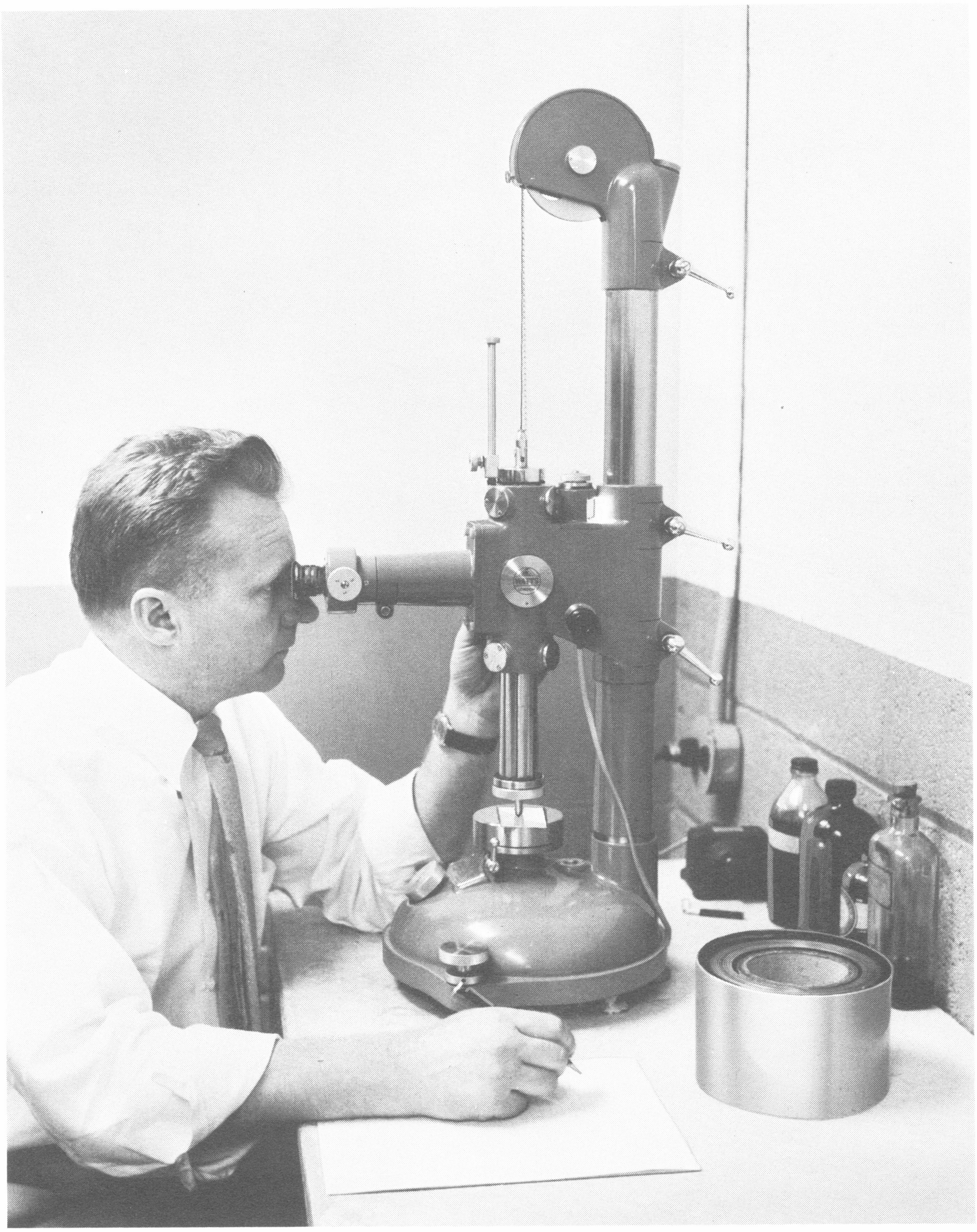
Engineering Laboratory—Metallograph.

Engineering Laboratory—
Dilatometer for determining coefficients of expansion.

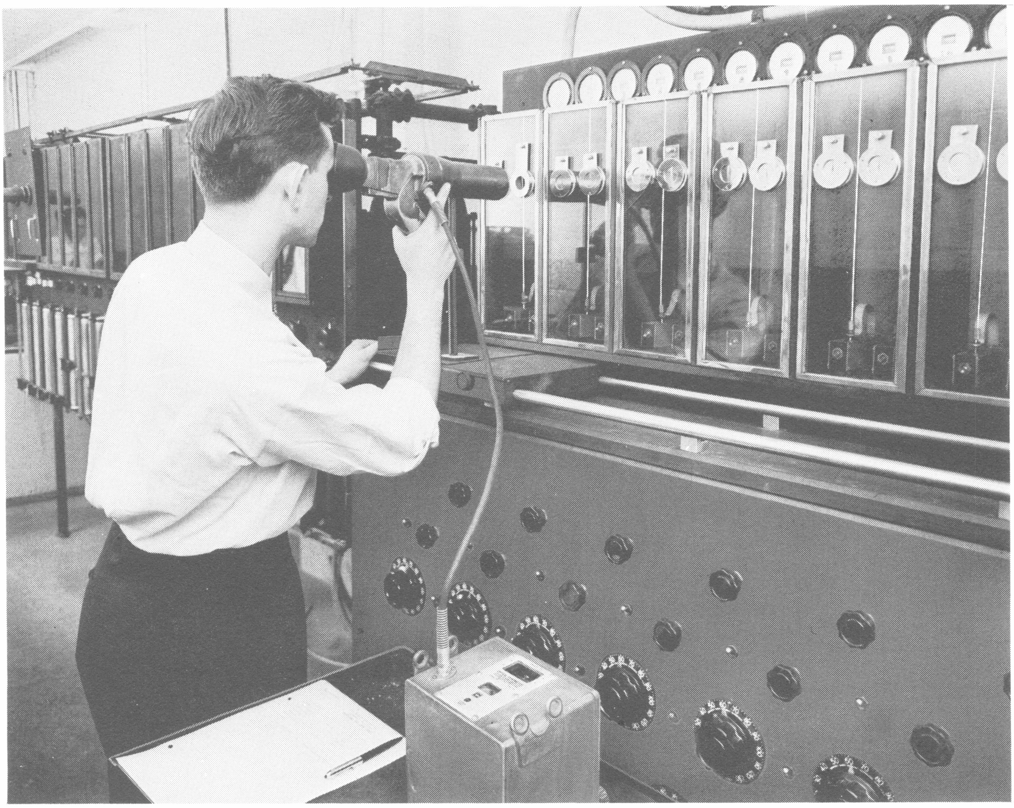




Chemistry Laboratory—Carbon and Sulphur determinator.



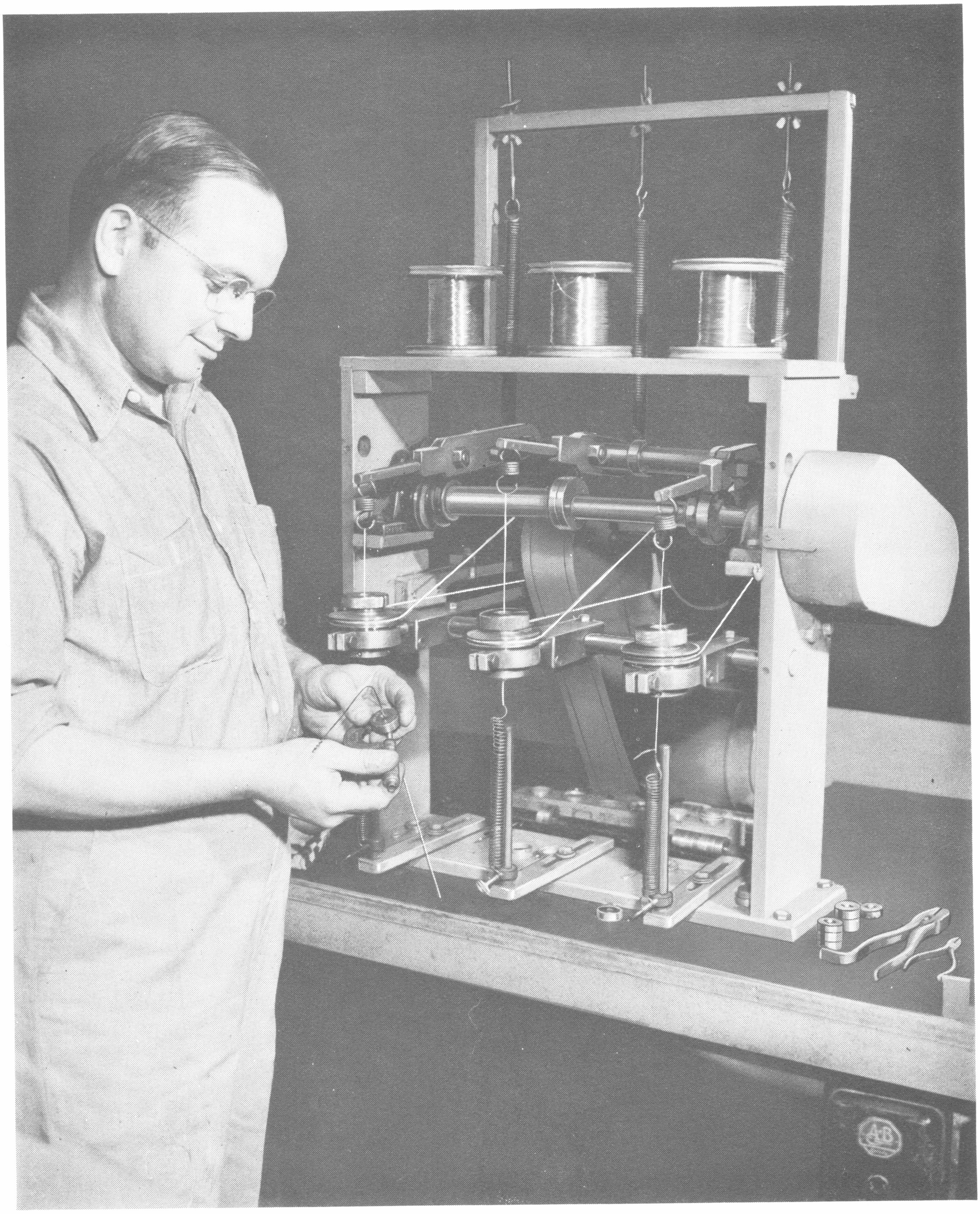
Engineering Laboratory—"Microptic" standard for gauge measurement.



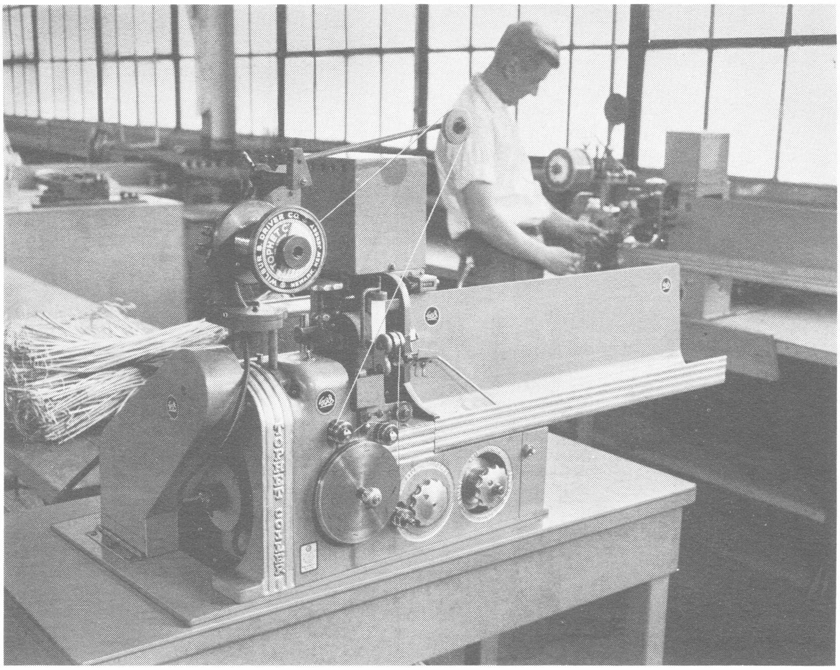
Engineering Laboratory—Life test panel.

Engineering Laboratory—
Experimental vacuum
melting furnace.

Engineering Laboratory—
Inside of vacuum
melting furnace.

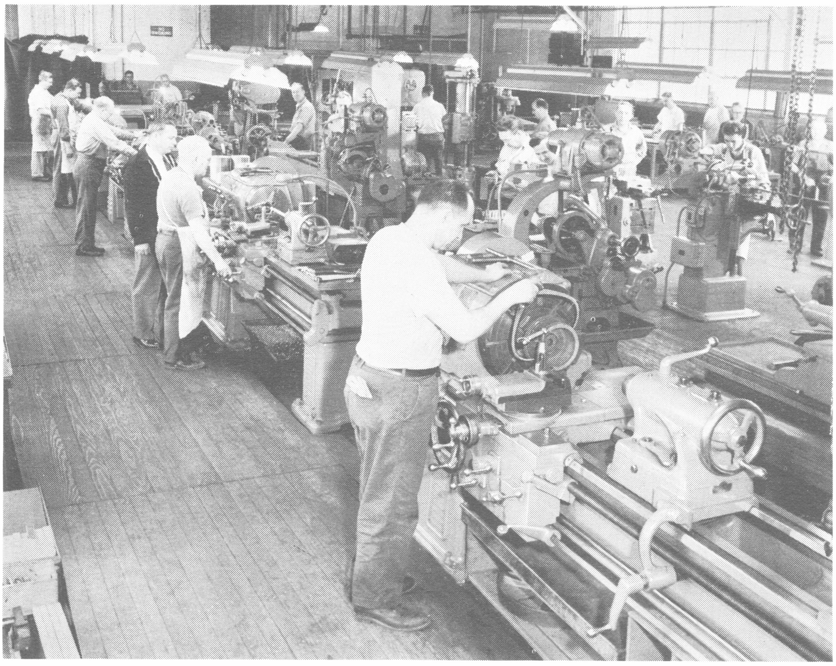


Diamond Die Department—Polishing.



Tophet Coiler.

General view of Machine Shop.



Sales Dep't.

Cold Rolling Mill.

Main Office Building.

Chicago Office and Warehouse.

Printed in the U.S.A.