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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Quality of Japanese Electric Wires and Cables.

Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Target X-14 of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. J.H. Norwood, USNR, assisted by Capt. M.S. Zaslow, AUS, as interpreter and translator.

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Captain, USN

QUALITY OF JAPANESE ELECTRIC WIRES AND CABLES

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-14

NOVEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MISCELLANEOUS TARGETS

QUALITY OF JAPANESE ELECTRIC WIRES AND CABLES

This report evaluates the quality of Japanese electric wires and cables. In the field of conductors Japanese standards are similar to the conventional pre-war U.S. standards. The plastic-type, covered conductors (polyvinyl chlorides, etc.) have not been extensively developed by the Japanese. In the field of resistance wires no nickel was available, thus outlawing the conventional Nichrome types and forcing the substitution of inferior Fe-Cr alloys. In general, the quality of Japanese wires and cables is definitely lower than those in the UNITED STATES. Copper, although fairly high in quality, was very short in supply and high-grade conductors were used for only the most pressing applications, such as aircraft.

TABLE OF CONTENTS

REFERENCES

Location of Target:

Copper Section, Non-Ferrous Metals Division, Department of Patents and Standards, TOKYO.

Metals Industry Control Association, Electric Wire Division, TOKYO.

Japanese Personnel Assisting in Gathering Documents:

A. NAKAYAMA, Copper Section, Non-Ferrous Metals Division, Department of Patents and Standards, TOKYO.

Japanese Personnel Interviewed:

T. SUZUKI, Chief, Technical Bureau, Metals Industry Control Association, Non-Ferrous Metals Division (14 years' engineering experience, very capable engineer).

K. KATO, Chief, Production Division, Metals Industry Control Association (no technical experience).

K. MATSUDA and I. FUKUYAMA, Special Alloys Division, Department of Patents and Standards (approximately 12 years' experience as technical men, average capabilities).

LIST OF ENCLOSURES

(A) List of Japanese Specifications for Wire and Cable forwarded through ATIS to WDC Library.

INTRODUCTION

Although Japanese electrolytic copper is of high purity and its conductivity therefore good, the Japanese apparently have not developed extensively the newer methods of plastic wire and cable covering, such as the polyvinyl chlorides. In the field of resistance wires, the development of a high quality alloy was severely hampered by the critical shortage of nickel, which forbade the use of even a substitute type "nichrome" wire containing a low percentage of nickel. All of the alloys in actual use were of the Fe-Cr type. Rationing of wire was very strict and often specifications could not be met. The policy was simply to make the best product with the limited raw materials available and allocate it for the most important uses regardless of whether or not it met the desired standards.

THE REPORT

PART I CONDUCTORS

1. In considering the quality of Japanese wires and cables the first item of importance is the purity of the raw materials, copper in particular. The chemical analysis of high-grade Japanese electrolytic copper is given in Table I.

TABLE I
CHEMICAL ANALYSIS OF COPPER WIRE

Cu	99.9800
Ag	0.000017
Al	0.000007
O_2	0.012
S	0.0015
Fe	0.0037
As	0.0007
Sb	0.0005
Bi	--
Pb	--
Ni	0.0005
Se and Te	0.0006
P	--
Si	--

2. The resistivity of this material is 0.15436 ohms at 20°C (max.) or, conversely, a conductivity of not less than 99.3%. The thermal conductivity of this metal is approximately 100% or 0.93 $cal/cm^2/cm/sec/^oC$. The density is 8.4-8.7 gm/cc but may reach a maximum of 8.92 upon sufficient cold work. Tensile strength ranges from 30,000-36,000 psi in the hot-rolled or annealled condition, but reaches as high as 70,000 psi upon cold working, The temperature coefficient of electrical resistance for this material is about 0.00393 per °C at 20°C.

3. The electrolytic lead used by the Japanese cable makers is quite high grade. The analysis is given in Table II.

TABLE II
CHEMICAL ANALYSIS OF LEAD

Au	0.000070
Ag	0.000011
Cu	.0009
Pb	99.99474
As	--
Sb	0.0021
Ni	--
Fe	0.0005
Bi	0.0002
S	--
Zn	.0004

4. The resistivity of this material is 20.65 micro-ohms per cubic cm. The temperature coefficient of electrical resistivity is 0.00421 in the 0-100°C range. The tensile strength is 1700 psi, elongation 65% and reduction of area 98%. The yield point of this material is 750 psi.

5. In the field of insulation the status of Japanese industry is approximately that of the United States in 1937-38. Rubber, cotton, rayon, cambric, paper, paint, and wax are the principal insulating materials in use. Their method of employment was a conventional one. The weights of materials are shown in Tables III, IV, V, and VI.

Table III - See page 9
Table IV - See page 10
Table V - See Below
Table VI - See page 11

TABLE V
SINGLE-CORE PAPER-COVERED LEAD CABLE - WEIGHT KG/KM
(MODIFIED)

CONDUCTOR (Area of cross section mm^2)	COPPER	PAPER INSULATION	OIL INSULATION		LEAD
			Bright Stock	Turpentine	
1000	10,007	351	376	161.1	4,800
850	8,219	320	329	141.0	4,240
725	7,170	300	301	128.8	3,830
600	5,889	274	264	113.3	3,370
500	4,806	249	231	99.5	2,950
400	3,947	228	205	88.0	2,590
325	3,174	161.9	151.6	65.0	2,180
250	2,483	144.6	146.3	55.8	1,888
200	1,906	128.7	111.2	47.6	1,691
150	1,492	84.1	76.4	32.7	1,384
125	1,218	76.5	67.4	28.9	1,196
100	978.7	69.3	59.2	25.4	1,102
80	766.0	62.1	51.4	22.0	939
60	579.2	55.0	44.0	18.84	851
50	469.3	50.2	39.2	16.82	772

TABLE III
600 V.-FIRST TYPE CAMBRIC COVERED CABLE - WEIGHTS Kg/km

Conductor-Area of Cross-Section (mm^2)		Copper	Tin	Cloth Insulation	Sealing Bright Stock	Mixture Turpentine	Rubberized Cotton Tape						Black Twisted Thread	
							Cotton Cloth	Live Rubber	Parrafin	ZnO2	Lithpone	Other Mixtures		
1,000	(127/50/0.45)	10,088	333	689	65.7	21.9	31.9	3.15	0.090	0.32	0.32	5.04	2/#10	76.1
850	(91/59/0.45)	8,529	282	638	60.8	20.3	29.6	2.94	0.084	0.29	0.29	4.70	2/#10	70.8
725	(91/50/0.45)	7,228	239	590	56.3	18.75	27.6	2.73	0.078	0.27	0.27	4.37	2/#10	66.0
600	(61/62/0.45)	6,008	198.6	541	51.6	17.19	25.4	2.52	0.072	0.25	0.25	4.03	2/#10	61.0
500	(61/52/0.45)	5,039	166.5	411	39.2	13.07	23.1	2.28	0.065	0.23	0.23	3.65	2/#10	55.4
400	(61/41/0.45)	3,973	131.3	368	35.1	11.70	20.8	2.06	0.059	0.21	0.21	3.30	2/#10	50.2
325	(37/55/0.45)	3,203	105.8	334	31.9	10.62	19.05	1.89	0.054	0.19	0.19	3.02	2/#10	46.0
250	(37/43/0.45)	2,504	82.7	299	28.5	9.52	17.22	1.71	0.049	0.17	0.17	2.74	2/#16	35.6
200	(37/34/0.45)	1,980	65.4	210	20.0	6.68	15.04	1.49	0.043	0.15	0.15	2.38	2/#16	31.2
150	(37/25/0.45)	1,455	48.1	183.0	17.44	5.82	13.26	1.32	0.038	0.13	0.13	2.11	2/#16	27.7
125	(19/41/0.45)	1,226	40.5	169.4	16.16	5.39	12.38	1.22	0.035	0.12	0.12	1.95	2/#16	25.9
100	(19/33/0.45)	986.5	32.6	154.1	14.69	4.90	11.38	1.12	0.032	0.11	0.11	1.79	2/#20	19.80
80	(19/27/0.45)	807.2	26.7	140.4	13.39	4.46	10.48	1.04	0.030	0.10	0.10	1.66	2/#20	18.32
60	(19/20/0.45)	597.9	19.75	124.1	11.84	3.95	9.42	0.93	0.027	0.093	0.093	1.49	2/#20	16.53
50	(19/16/0.45)	478.4	15.81	80.9	7.71	2.57	8.07	0.80	0.023	0.080	0.080	1.28	2/#20	14.26
38	(7/34/0.45)	374.5	12.38	72.1	6.87	2.29	7.29	0.72	0.021	0.072	0.072	1.15	2/#20	12.97
30	(7/27/0.45)	297.4	9.83	65.3	6.22	2.07	6.70	0.67	0.019	0.067	0.067	1.07	2/#20	11.98
22	(7/20/0.45)	220.3	7.28	57.8	5.51	1.84	6.50	0.61	0.018	0.061	0.061	0.98	2/#20	10.89
14	(91/0.45)	141.8	4.69	43.5	4.15	1.38	4.82	0.48	0.014	0.048	0.048	0.77	2/#32	7.74
8	(50/0.45)	77.16	2.55	35.3	3.38	1.13	4.11	0.41	0.012	0.041	0.041	0.66	2/#32	6.69
5.5	(35/0.45)	54.01	1.79	31.3	2.98	0.99	3.75	0.37	0.011	0.037	0.037	0.59	2/#32	6.16
3.5	(22/0.45)	33.95	1.12	27.2	2.59	0.86	3.40	0.34	0.0097	0.034	0.034	0.54	2/#32	5.63
2.0	(12/0.45)	18.52	0.61	24.2	2.31	0.77	2.99	0.29	0.0083	0.029	0.029	0.46	2/#32	5.02
1.4	(9/0.45)	13.89	0.46	22.7	2.17	0.72	2.87	0.29	0.0083	0.029	0.029	0.46	2/#32	4.84
0.9	(7/0.40)	8.539	0.31	19.79	1.89	0.63	2.63	0.27	0.0077	0.027	0.027	0.43	2/#44	3.89

TABLE IV
3000 V. FIRST TYPE CAMBRIC COVERED CABLE - WEIGHTS Kg/km

Conductor-Area of Cross-Section (mm^2)		Copper	Tin	Cloth Insulation	Sealing Mixture		Rubberized Cotton Tape						Black twisted Thread	
					Coloring Matter	Turpentine	Cotton Cloth	Live Rubber	Parrafin	ZnO_2	Lithpone	Other Mixtures		
1,000	(127/50/0.45)	10,088	333	812	77.4	25.8	32.5	3.22	0.092	0.32	0.32	5.15	2/#40	77.5
850	(91/59/0.45)	8,529	282	752	71.7	23.9	30.3	2.99	0.086	0.30	0.30	4.78	2/#40	72.2
725	(91/50/0.45)	7,228	239	696	66.4	22.1	28.1	2.79	0.080	0.28	0.28	4.46	2/#40	67.4
600	(61/62/0.45)	6,008	198.6	639	60.9	20.3	25.9	2.58	0.074	0.26	0.26	4.13	2/#40	62.4
500	(61/52/0.45)	5,039	166.5	500	47.7	15.90	23.7	2.34	0.067	0.23	0.23	3.74	2/#40	56.8
400	(61/41/0.45)	3,973	131.3	449	42.8	14.26	21.4	2.12	0.061	0.21	0.21	3.39	2/#40	51.6
325	(37/55/0.45)	3,203	115.8	408	38.9	12.96	19.64	1.94	0.056	0.19	0.19	3.10	2/#40	47.4
250	(37/43/0.45)	2,504	82.7	366	34.9	11.62	17.81	1.76	0.050	0.18	0.18	2.82	2/#40	43.1
200	(37/34/0.45)	1,980	65.4	329	31.4	10.46	16.22	1.61	0.046	0.16	0.16	2.58	2/#16	33.6
150	(37/25/0.45)	1,455	48.1	288	27.5	9.16	14.45	1.44	0.041	0.14	0.14	2.30	2/#16	30.1
125	(19/41/0.45)	1,226	40.5	268	25.5	8.51	13.56	1.34	0.038	0.13	0.13	2.14	2/#16	28.3
100	(19/33/0.45)	986.5	32.6	245	23.3	7.78	12.56	1.24	0.036	0.12	0.12	1.98	2/#16	26.3
80	(19/27/0.45)	807.2	26.7	224	21.4	7.13	11.66	1.16	0.033	0.12	0.12	1.86	2/#20	20.3
60	(19/20/0.45)	597.9	19.75	199.8	19.05	6.35	10.60	1.05	0.030	0.11	0.11	1.68	2/#20	18.51
50	(19/16/0.45)	478.4	15.81	182.2	17.37	5.79	9.83	0.97	0.028	0.097	0.097	1.55	2/#20	17.23
38	(7/34/0.45)	374.5	12.38	164.5	15.37	5.23	9.07	0.90	0.026	0.090	0.090	1.44	2/#20	15.94
30	(7/27/0.45)	297.4	9.83	150.9	14.39	4.80	8.47	0.84	0.024	0.084	0.084	1.34	2/#20	14.95
22	(7/20/0.45)	220.3	7.28	135.9	12.96	4.32	7.83	0.78	0.022	0.078	0.078	1.25	2/#20	13.86
14	(91/0.45)	141.8	4.69	107.4	10.24	3.41	6.59	0.66	0.019	0.066	0.066	1.06	2/#20	11.78
8	(50/0.45)	77.16	2.55	91.1	8.69	2.90	5.88	0.59	0.017	0.059	0.059	0.94	2/#20	10.59
5.5	(35/0.45)	54.01	1.785	82.9	7.91	2.64	5.52	0.55	0.016	0.055	0.055	0.88	2/#32	8.80
3.5	(22/0.45)	33.95	1.122	74.8	7.13	2.38	5.17	0.51	0.015	0.051	0.051	0.82	2/#32	8.27
2.0	(19/0.45)	18.52	0.612	66.4	6.33	2.11	4.76	0.48	0.014	0.048	0.048	0.77	2/#32	7.66
1.4	(9/0.45)	13.89	0.459	63.7	6.08	2.03	4.64	0.46	0.013	0.046	0.046	0.74	2/#32	7.48
0.9	(7/0.45)	8.539	0.306	58.1	5.55	1.85	4.40	0.43	0.012	0.043	0.043	0.69	2/#32	7.13

TABLE VI

600 V-JUTE-ENCLOSED PAPER COVERED CABLE(PROVISIONAL)-WEIGHT Kg/km

Conductor Area of Cross-Section (mm^2)	Copper	Paper Insulation	Oil Insulation		Lead	Paper	Jute	First Outer Covering				2nd Outer Covering		Chalk	Total Paper Insulation
			Bright Stock	Turpentine				Brown Asphalt	Staight Asphalt	Kerosene Pitch	Heavy Oil	Artificial Pitch	Heavy Oil		
1,000	10,007	351	376	161.1	3,020	65.6	283	205	146.6	88.0	146.6	411	176.0	43.4	416.6
850	8,219	320	329	141.0	2,770	60.4	262	189.5	135.3	81.2	135.3	379	162.4	40.2	380.4
725	7,170	300	300	128.8	2,450	57.0	248	179.1	127.9	76.8	127.9	358	153.5	38.1	357.0
600	5,889	274	264	113.3	2,100	52.5	229	165.7	118.3	71.0	118.3	331	142.0	35.4	326.5
500	4,806	249	232	99.5	1,929	48.3	156.8	119.7	85.5	51.3	85.5	239	102.6	32.0	297.3
400	3,947	228	205	88.0	1,649	44.6	145.4	110.9	79.2	47.5	79.2	222	95.1	29.8	272.6
325	3,174	161.9	151.6	65.0	1,343	39.6	129.9	99.0	70.7	42.4	70.7	198.0	84.9	26.7	201.5
250	2,483	144.6	130.1	55.8	1,216	35.9	118.5	90.2	64.4	38.6	64.4	180.4	77.3	24.5	180.5
200	1,906	128.7	111.2	47.6	1,003	32.7	108.6	82.5	59.0	35.4	59.0	165.1	70.8	22.5	161.4
150	1,492	84.1	76.4	32.7	870	28.5	95.6	72.5	51.8	31.1	51.8	144.9	62.1	20.0	112.6
125	1,218	76.5	67.4	28.9	801	26.2	88.5	67.0	47.9	28.7	47.9	134.0	57.4	18.57	102.7
100	978.7	69.3	59.2	25.4	665	24.3	82.6	62.5	44.6	26.8	44.6	124.9	53.5	17.40	93.6
80	766.0	62.1	51.4	22.0	607	22.4	76.6	57.9	41.3	24.8	41.3	115.7	49.6	16.24	84.5
60	579.2	55.0	44.0	18.84	548	20.4	70.7	53.3	38.1	22.8	38.1	106.6	45.7	15.07	75.4
50	469.3	50.2	39.2	16.82	509	19.15	66.8	50.3	35.9	21.5	35.9	100.5	43.1	14.30	69.35

6. Test specifications for conductors are quite complete; the following tests were listed for jute-covered SL cable:

a. Insulation Test - 100V DC X 60 sec
b. Insulation Breakdown Test - 50-60 cycles X 10 min

OPERATING VOLTAGE	TEST VOLTAGE
11,000V	25,000V
22,000V	44,000V
33,000V	63,000V

c. Resistance Test - 20°C
d. Heating Test - 1m long specimen held at 100°C X 120 min, then exposed to voltage in b. for 1 min
e. Bend Test - Specimen 40 X O.D. dipped in H_2O for 2 hrs. at 5°-10°C, then bent 4 times around tube 12 X O.D.

7. Test results for 11,000 and 22,000 and 33,000V types are shown in Tables VII, VIII, IX below.

TABLE VII
TEST RESULTS
JUTE-WRAPPED SL CABLE - 11,000V

CONDUCTOR		THICKNESS OF INSULATION (mm)	LEAD COVERING (mm)	YELLOW TAPE THICKNESS (mm)	JUTE THICKNESS (mm)	OUTER DIAMETER (mm)	WEIGHT (kg/km)	MAXIMUM CONDUCTOR RESISTANCE 20°C (/km)	MAXIMUM ELECTROSTATIC CAPACITY 20°C (F/km)
Area of Cross Section (mm^2)	No.Strands O.D.Strand (mm)								
400	61/2.9	4.5	2.5	2	2	97	28,000	0.04497	0.8
325	61/2.6	"	2.4	"	"	91	24,100	0.05594	0.7
250	61/2.3	"	2.3	"	"	85	20,400	0.07149	"
200	37/2.6	"	2.2	"	"	79	17,200	0.09133	0.6
150	37/2.3	"	2.1	"	"	74	14,700	0.1167	"
125	19/2.9	"	2.0	"	"	70	12,900	0.1430	0.5
100	19/2.6	"	"	"	"	67	11,600	0.1779	"
80	19/2.3	"	"	"	"	63	10,400	0.2273	0.4
60	19/2.0	"	"	"	"	60	9,200	0.3006	"
50	19/1.8	"	"	"	"	58	8,500	0.3711	"
38	7/2.6	"	"	"	"	55	7,700	0.4828	0.3
30	7/2.3	"	"	"	"	54	7,200	0.6169	"

TABLE VIII
TEST RESULTS
JUTE-WRAPPED SL CABLE - 22,000V

CONDUCTOR		THICKNESS OF INSULATION (mm)	LEAD COVERING (mm)	YELLOW TAPE THICKNESS (mm)	JUTE THICKNESS (mm)	OUTER DIAMETER (mm)	WEIGHT (kg/km)	MAXIMUM CONDUCTOR RESISTANCE 20°C (/km)	MAXIMUM ELECTRO-STATIC CAPACITY 20°C (F/km)
Area of Cross Section (mm^2)	No.Strands O.D.Strand (mm)								
325	61/2.6	6.0	2.5	2	2	98	26,200	0.05594	0.6
250	61/2.3	"	2.4	"	"	91	22,400	0.07149	0.5
200	37/2.6	"	2.3	"	"	86	19,100	0.09133	"
150	37/2.3	"	2.2	"	"	81	16,500	0.1167	0.4
125	19/2.9	"	"	"	"	77	15,000	0.1430	"
100	19/2.6	"	2.1	"	"	74	13,300	0.1779	"
80	19/2.3	"	2.0	"	"	70	11,700	0.2273	"
60	19/2.0	6.5	"	"	"	69	11,000	0.3006	0.3
50	19/1.8	"	"	"	"	67	10,300	0.3711	"
38	7/2.6	7.0	"	"	"	66	9,900	0.4828	"
30	7/2.3	"	"	"	"	64	9,300	0.6169	"

TABLE IX
TEST RESULTS
JUTE-WRAPPED SL CABLE - 33,000V

CONDUCTOR		THICKNESS OF INSULATION (mm)	LEAD COVERING (mm)	YELLOW TAPE THICKNESS (mm)	JUTE THICKNESS (mm)	OUTER DIAMETER (mm)	WEIGHT (kg/km)	MAXIMUM CONDUCTOR RESISTANCE 20°C (/km)	MAXIMUM ELECTRO-STATIC CAPACITY 20°C (F/km)
Area of Cross Section (mm^2)	No.Strands O.D.Strand (mm)								
250	61/2.3	8.5	2.6	2	2	103	26,800	0.07149	0.4
200	37/2.6	"	2.5	"	"	97	23,200	0.09133	"
150	37/2.3	9.0	"	"	"	95	21,600	0.1167	0.3
125	19/2.9	"	2.4	"	"	91	19,400	0.1430	"
100	19/2.6	"	2.3	"	"	87	17,500	0.1779	"
80	19/2.3	"	"	"	"	84	16,100	0.2273	"
60	19/2.0	9.5	"	"	"	83	15,400	0.3006	"
50	19/1.8	"	2.2	"	"	80	14,200	0.3711	"

8. Test specifications for cambric cable include a tensile strength of 3.0kg/mm^2 lengthwise and 2.0kg/mm^2 crosswise. Minimum elongation is 3.0% lengthwise and 10.0% crosswise. Insulation tests at 60 cycles x 10 min are tabulated below:

OPERATING VOLTAGE	TEST VOLTAGE
600V	3,000V
3,000V	9,000V
6,000V	17,000V
10,000V	26,000V

Resistance test results are shown in Tables X and XI.

TABLE X
TYPE I CAMBRIC CABLE (TIN-PLATED, MILD COPPER, TWISTED WIRE)
RESISTANCE

AREA OF CROSS SECTION (mm^2)	NO.STRANDS/DIAMETER STRAND (mm)	O.D. (mm)	TOTAL AREA (mm)	RESISTANCE OF CONDUCTOR (/km) 20°C
1,000	127/50/0.45	47.7	1009.0	0.01908
850	91/59/0.45	43.9	853.9	0.02257
725	91/50/0.45	40.4	723.7	0.02663
600	61/62/0.45	36.8	601.5	0.03204
500	61/52/0.45	33.8	504.5	0.03820
400	61/41/0.45	30.0	397.8	0.04845
325	37/55/0.45	27.0	323.7	0.05896
250	37/43/0.45	23.9	253.0	0.07541
200	37/34/0.45	21.2	200.1	0.09538
150	37/25/0.45	18.2	147.1	0.0297
125	19/41/0.45	16.7	123.9	0.1540
100	19/33/0.45	15.0	99.72	0.1914
80	19/27/0.45	13.5	81.59	0.2339
60	19/20/0.45	11.7	60.44	0.3158
50	19/16/0.45	10.4	48.35	0.3947
38	7/34/0.45	9.1	37.85	0.5041
30	7/27/0.45	8.1	30.06	0.6348
22	7/20/0.45	7.0	22.27	0.8570
14	91 '0.45	4.9	14.47	1.293
8.0	50/0.45	3.7	7.952	2.353
5.5	35/0.45	3.1	5.567	3.361
3.5	22/0.45	2.5	3.499	5.347
2.0	12/0.45	1.8	1.909	9.803
1.4	9/0.45	1.6	1.431	13.07
0.9	7/0.45	1.2	0.8797	21.27

TABLE XI
TYPE II CAMBRIC CABLE - RESISTANCE

AREA OF CROSS SECTION (mm^2)	NO.STRANDS/DIAMETER STRAND (mm)	O.D. (mm)	TOTAL AREA (mm^2)	RESISTANCE OF CONDUCTOR (/km) 20°C
500	37/17/1.0	35.0	494.0	0.03782
400	19/27/1.0	30.8	402.9	0.04638
325	19/22/1.0	30.0	328.3	0.05692
250	19/19/1.0	25.0	253.7	0.07366
200	19/14/1.0	22.1	208.9	0.08944
150	19/10/1.0	20.0	149.2	0.1252
125	159/1.0	14.7	124.9	0.1488
100	127/1.0	13.0	99.75	0.1855
80	102/1.0	12.0	80.11	0.2309
60	120/0.8	10.2	60.32	0.3099
50	100/0.8	9.6	50.27	0.3719
38	75/0.8	8.2	37.70	0.4958
30	61/0.8	7.2	30.66	0.6096
22	44/0.8	6.4	22.12	0.8452
14	27/0.8	4.9	13.57	1.364
8.0	16/0.8	3.8	8.043	2.302
5.5	12/0.8	3.3	6.032	3.069

9. Although pre-war Japanese wires and cables were approximately equal to U.S. standard types (1937-38) wartime shortages lowered quality and affected Japanese cable makers' output. Copper itself, though still of good quality, became short in supply. Even more severe were the shortages of insulating materials, such as paint, waterproofing compounds, and rubber. Synthetic rubber uas used only to a limited degree due to the inability of the synthetic industry to produce it in large quantities. Its use was limited to oil-resisting cable. None of the newer methods of wire covering such as the extruded polyvinyl chlorides and other plastics were used except in very limited applications in aircraft high-frequency. Lead was critically short and tin, with which Japanese were apparently well-supplied, was substituted. Another hold-up in production was lack of coal for vulcanization. The specifications for wartime rubber-insulated wires are shown in Tables XII and XIII.

TABLE XII
WARTIME RUBBER-INSULATED WIRE SPECIFICATIONS
(TWISTED STRANDS)

CONDUCTOR				THICKNESS OF RUBBER (mm)	THICKNESS OF TAPE (mm)	RESISTANCE OF INSULATION (200C) (M /km)	TEST VOLTAGE (V)	REMARKS				
Diameter									Weight (kg/km)			
Mild or Hard Copper-Wire	Hard Al Wire	MKl Al Wire	Area of Cross Section (mm^2)					O.D. (mm)	Mild or Hard Cu Wire	Al Wire *	Length of One Wrapping (m)	Method of Packing
5.0	--	--	19.64	1.4	0.25	500	2000	8.4	220	--	200	Bundle
4.0	--	4.0	12.57	1.1	0.25	600	1500	6.8	145	73	300	"
3.2	3.2	3.2	8.042	1.1	0.25	600	1500	6.0	100	52	300	"
2.6	2.6	2.6	5.309	1.1	0.25	600	1500	5.4	73	40	300	"
2.0	2.0	--	3.142	1.1	0.25	600	1500	4.8	50	30	300	"
1.6	1.6	--	2.011	1.1	0.25	600	1500	4.4	37	25	300	"
1.2	--	--	1.131	1.1	0.25	600	1500	4.0	27		300	"

*Hard Aluminum or mark "I" Aluminum Alloy Wire

10. Summarized, Japanese pre-war wire and cable conductors were approximately equal to U.S. types of 1937-38. However, severe wartime shortages of copper, lead, and insulating materials severely reduced that quality. Specifications could not be met consistently. The wartime policy was not to design a wire or cable to meet a specific standard but to use the best product available for each use. High priority items had first call on the best quality material until it was exhausted, when the next best substitute was pressed into use.

TABLE XIII
WARTIME RUBBER INSULATED WIRE SPECIFICATIONS (TWISTED STRANDS)

CONDUCTOR										REMARKS					
	No. Strands-O.D. Strands (mm)									Estimated Wt. kg/km		Length of single strand		Packing	
Area of Gross Section (mm^2)	Mild or Hard Cu. Wire	Hard Al. Wire	Mark I Al. Alloy Wire	OVERALL AREA (mm^2)	OUTER DIAMETER (mm)	THICKNESS OF RUBBER (mm)	THICKNESS OF TAPE (mm)	RESISTANCE OF INSULATION 20°C (MΩ/km)	TEST VOLTAGE	O.D. (mm)	Mild or Hard Cu. Wire	Hard Al. or Mark I Al. Alloy Wire	Mild or Hard Cu. Wire	Hard Al. or Mark I Al. Alloy Wire	Mild or Hard Cu. Wire	Hard Al. or Mark I Al. Alloy Wire
325	61/2.5	61/2.6		323.8	23.4	2.9	0.35	300	3,000	30.0	3,400	1,400	200	200	rod	rod
250	61/2.3			253.5	20.7	2.9	0.35	300	3,000	27.3	2,700		200		rod	rod
200	37/2.6	37/2.6		196.4	18.2	2.9	0.25	300	3,000	24.6	2,100	930	300	300	rod	rod
150	37/2.3	37/2.3		153.7	16.1	2.3	0.25	300	3,000	21.3	1,650	700	300	300	rod	rod
125	19/2.9			125.5	14.5	2.3	0.25	300	3,000	19.7	1,400		300		rod	rod
100	19/2.6	19/2.6		100.9	13.0	2.3	0.25	300	3,000	18.2	1,150	510	300	150	rod	bundle
80	19/2.3			78.75	11.5	1.8	0.25	400	2,500	15.7	870		300		rod	bundle
60	19/2.0	19/2.0		57.70	10.0	1.8	0.25	400	2,500	14.2	680	300	300	200	rod	bundle
50	19/1.8			48.36	9.0	1.8	0.25	400	2,500	13.2	570		300		rod	bundle
38	7/2.6	7/2.6	7/2.6	37.16	7.8	1.4	0.25	500	2,000	11.2	430	200	150	300	bundle	bundle
22	7/2.0	7/2.0	7/2.0	21.99	8.0	1.4	0.25	500	2,000	9.4	270	135	200	300	bundle	bundle
14	7/1.6	7/1.6		14.09	4.8	1.1	0.25	600	1,500	7.6	175	86	300	300	bundle	bundle
8	7/1.2			7.917	3.6	1.1	0.25	600	1,500	6.4	110		300		bundle	
5.5	7/1.0			5.498	3.0	1.1	0.25	600	1,500	5.8	81		300		bundle	
3.5	7/0.8			3.519	2.4	1.1	0.25	600	1,500	5.2	58		300		bundle	
2.0	7/0.6			1.979	1.8	1.1	0.25	600	1,500	4.6	40		300		bundle	
0.7	7/0.4			0.8799	1.2	1.1	0.25	600	1,500	4.0	25		300		bundle	

PART II RESISTANCE WIRES

1. The conventional "nichrome" type resistance wires were considered the best by the Japanese. However, the extreme shortage of nickel did not permit their manufacture or use during the war period. A 78% and a 60% nickel type are examined in Table XIV.

TABLE XIV
NICHROME WIRES - CHEMICAL COMPOSITION

TYPE	Ni	Cr	Mn	Si	Fe	IMPURITIES
Nichrome I	78	19	1.5	0.2	1.0	---
Nichrome II	60	15	1.5	0.2	22	1.3

2. The nickel shortage led to the development of the Iron-Chrome series as substitute materials. This series is examined in Table XV.

TABLE XV
IRON-CHROME WIRES - CHEMICAL COMPOSITION

TYPE	Cr	Al	C	Fe	IMPURITIES
Iron-Chrome I(Special)	28-30	5-7	.07	Bal.	.4
Iron-Chrome I	23-25	4-6	.10	"	.4
Iron-Chrome II	18-20	2-4	.10	"	.4
Iron-Chrome III	14-16	1-3	.20	"	.4

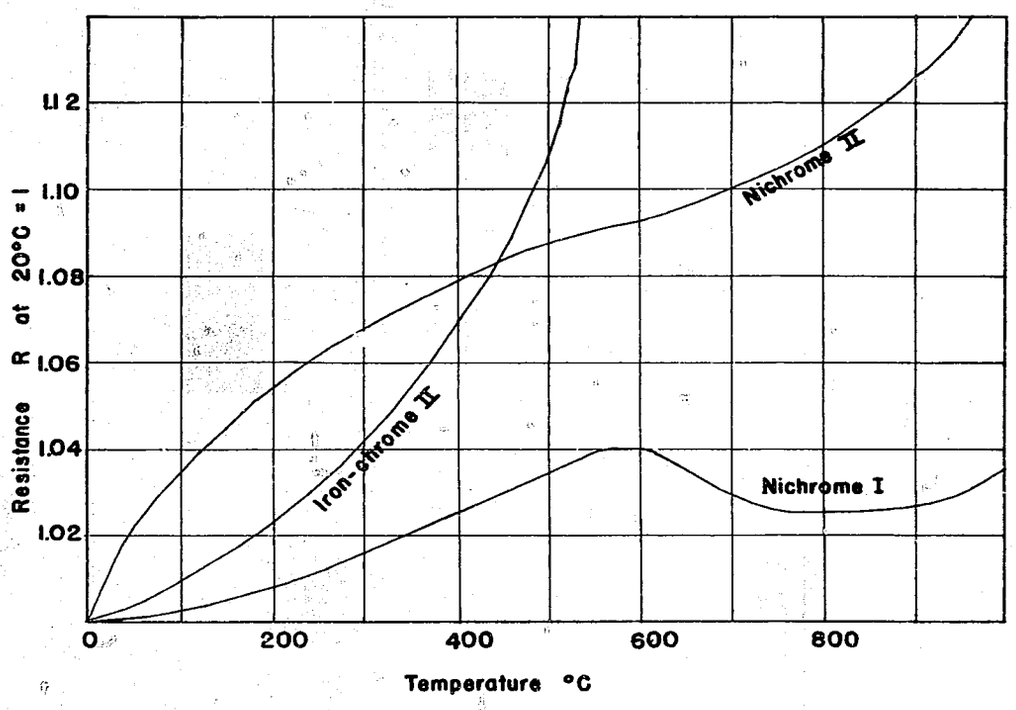
3. The maximum temperatures allowable in service for the various types are shown in Table XVI.

TABLE XVI
MAXIMUM TEMPERATURE ALLOWABLE

Nichrome I	1600°C
Nichrome II	1000°C
Iron-Chrome I(Special)	1100°C
Iron-Chrome I	950°C
Iron-Chrome II	600°C
Iron-Chrome III	550°C

4. Temperature-Resistance Curves are shown in Table XVIII.

TABLE XVII
TEMPERATURE-RESISTANCE CURVES
FOR RESISTANCE WIRES



5. Physical properties of the various types are shown in Table XVII.

TABLE XVIII
PHYSICAL PROPERTIES OF RESISTANCE WIRES

TYPE	TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTIVITY 20°C-100°C	TENSILE STRENGTH kg/mm^2	ELONGATION %
Nichrome I	0.00013	755	10
Nichrome II	0.00020	755	12
Iron-Chrome I (Special)	0.00018	753	10
Iron-Chrome I	0.00025	753	14
Iron-Chrome II	0.00030	750	20
Iron-Chrome III	0.00050	740	25

6. From the data presented it is apparent that the Iron-Chrome series is a markedly inferior substitute for the nichrome-type resistance wires. The best of the Iron-Chrome series was considered to be Iron-Chrome I (Special). However, due to the shortage of chromium this first-line substitute could not be used except in the most pressing applications. The type principally used was Iron-Chrome II, definitely a make-shift alloy. Summarized, the quality of Japanese resistance wires is considerably lower than the standard types common in the United States.

ENCLOSURE (A)

LIST OF JAPANESE SPECIFICATIONS FOR WIRE AND CABLE
FORWARDED THROUGH ATIS TO WDC LIBRARY

A. Standard Specifications for Materials Used in Electric Wires - Approved August 1943. Metals Industry Control Association.

NAVTECHJAP DOCUMENT NO. ND-25-0027
ATIS DOCUMENT NO. 3006

1. Insulated Wire

a. First Type Insulated Electric Wire (JEC-14) Single Wire
b. First Type Insulated Electric Wire (JEC-14) Twisted Wire
c. Second Type Insulated Electric Wire (JEC-14) Single Wire
d. Second Type Insulated Electric Wire (JEC-14) Twisted Wire
e. Provisional Second Type Insulated Electric Wire (JEC-51) Single Wire
f. Provisional Second Type Insulated Electric Wire (JEC-51) Twisted Wire

2. Ordinary Rubber Insulated Wire

a. Third Type Insulated Electric Wire (JEC-14) Single Wire
b. Third Type Insulated Electric Wire (JEC-14) Twisted Wire
c. Fourth Type Insulated Electric Wire (JEC-14) Single Wire
d. Fourth Type Insulated Electric Wire (JEC-14) Twisted Wire
e. Provisional Low Tension Fourth Type Insulated Electric Wire (JEC-51) Single Wire
f. Provisional Low Tension Fourth Type Insulated Electric Wire (JEC-51) Twisted Wire

3. Flexible Covered Wire

a. First Type Flexible Covered Wire (Cotton wrapped)
b. First Type Flexible Covered Wire (Silk wrapped)
c. Third Type (A) Twistable Covered Wire
d. Second Type Flexible Covered Wire (Cotton wrapped)
e. Second Type Flexible Covered Wire (Silk wrapped)
f. Third Type (B) Flexible Covered Wire (Wrapped core)
g. Second Type Flexible Covered Wire (Cotton wrapped, cotton tape covered core)
h. Second Type Flexible Covered Wire (Silk wrapped, cotton tape covered core)
i. Third Type (B) Flexible Covered Wire (Cotton tape covered core)
j. Provisional pressed cord (Cotton wrapped)
k. Provisional pressed cord (Rayon wrapped)
l. Provisional pressed cord (Moisture resisting)
m. Provisional double twist cord (Cotton wrapped)
n. Provisional double twist cord (Rayon wrapped)
o. Provisional double twist cord (Moisture resisting)

4. Wrapped Wire

a. Single Cotton Wrapped Copper Wire
b. Double Cotton Wrapped Copper Wire
c. Single Silk Wrapped Copper Wire
d. Double Silk Wrapped Copper Wire

ENCLOSURE (A), continued

5. Enameled Wrapped Wire

a. Enameled Single Cotton Wrapped Copper Wire (First Type)
b. Enameled Single Cotton Wrapped Copper Wire (Second Type)
c. Enameled Double Cotton Wrapped Copper Wire (First Type)
d. Enameled Double Cotton Wrapped Copper Wire (Second Type)
e. Enameled Single Silk Wrapped Copper Wire (First Type)
f. Enameled Single Silk Wrapped Copper Wire (Second Type)
g. Enameled Double Silk Wrapped Copper Wire (First Type)
h. Enameled Double Silk Wrapped Copper Wire (Second Type)

6. Cloth-Insulated Wire

a. 600V First Type Cambric Covered Cable
b. 300V First Type Cambric Covered Cable
c. 6,000V First Type Cambric Covered Cable
d. 10,000V First Type Cambric Covered Cable
e. 600V Second Type Cambric Covered Cable
f. 3,000V Second Type Cambric Covered Cable
g. 6,000V Second Type Cambric Covered Cable
h. 10,000V Second Type Cambric Covered Cable

7. Rubber Communications Wire

a. Rubber-Covered Communications Wire
b. Single Rubber-Covered Wire (Wrapped)
c. Twisted Rubber-Covered Wire (Wrapped)

8. "Cabtire" Rubber Wire

a. CL Model Single Core "Cabtire" Cable
b. CL Model Double Core "Cabtire" Cable
c. CL Model Triple Core "Cabtire" Cable
d. CL Model Quadruple Core "Cabtire" Cable
e. CR Model Single Core "Cabtire" Cable
f. CR Model Double Core "Cabtire" Cable
g. CR Model Triple Core "Cabtire" Cable
h. CR Model Quadruple Core "Cabtire" Cable
i. CC Model Double Core "Cabtire" Cable
j. CC Model Triple Core "Cabtire" Cable
k. CC Model Quadruple Core "Cabtire" Cable
l. Electric Welding Machine "Cabtire" Cable
m. Safety Lamp "Cabtire" Cord (CTH)
n. Mine Mark 1 "Cabtire" Cable (Double Core)
o. Mine Mark 1 "Cabtire" Cable (Triple Core)
p. Mine Mark 1 "Cabtire" Cable (Quadruple Core)
q. Mine Mark 2 "Cabtire" Cable (Double Core)
r. Mine Mark 2 "Cabtire" Cable (Triple Core)
s. Mine Mark 2 "Cabtire" Cable (Quadruple Core)
t. Mine Mark 3 "Cabtire" Cable (Quadruple Core)
u. Mine Mark 3 "Cabtire" Cable (Quintuple Core)
v. Mine Mark 4 "Cabtire" Cable (Quadruple Core)

9. Rubber-Covered Lead Wire

a. Single Core Rubber-Covered Lead Wire
b. Double Core Rubber-Covered Lead Wire
c. Triple Core Rubber-Covered Lead Wire
d. Quadruple Core Rubber-Covered Lead Wire

ENCLOSURE (A), continued

10. Electric Cables

a. 600V Single Core Paper Covered Lead Cable (Modified Method)
b. 600V Single Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
c. 600V Single Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
d. 600V Double Core Paper Covered Lead Cable (Modified Method)
e. 600V Double Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
f. 600V Double Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
g. 600V Triple Core Paper Covered Lead Cable (Modified Method)
h. 600V Triple Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
i. 600V Triple Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
j. 3,000V Single Core Paper Covered Lead Cable (Modified Method)
k. 3,000V Single Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
l. 3,000V Double Core Paper Covered Lead Cable (Modified Method)
m. 3,000V Double Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
n. 3,000V Double Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
o. 3,000V Triple Core Paper Covered Lead Cable (Modified Method)
p. 3,000V Triple Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
q. 3,000V Triple Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
r. 6,000V Single Core Paper Covered Lead Cable (Modified Method)
s. 6,000V Single Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
t. 6,000V Triple Core Paper Covered Lead Cable (Modified Method)
u. 6,000V Triple Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
v. 6,000V Triple Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
w. 10,000V Single Core Paper Covered Lead Cable (Modified Method)
x. 10,000V Single Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
y. 10,000V Triple Core Paper Covered Lead Cable (Modified Method)
z. 10,000V Triple Core Jute Enclosed Paper Covered Cable (Second Provisional Method)
aa. 10,000V Triple Core Steel Enclosed Paper Covered Cable (Second Provisional Method)
bb. 15,000V Single Core Paper Covered Lead Cable (Modified Method)
cc. 15,000V Single Core Jute Enclosed Paper Covered Cable (Modified Method)
dd. 10,000V Lead Covered SL Cable (JEC-43Z, JEA-105Z)
ee. 10,000V Jute Enclosed SL Cable (JEC-43Z, JEA-105Z)
ff. 10,000V Steel Enclosed SL Cable (JEC-43Z, JEA-105Z)
gg. 20,000V Lead Covered SL Cable (JEC-43Z, JEA-105Z)
hh. 20,000V Jute Enclosed SL Cable (JEC-43Z, JEA-105Z)
ii. 20,000V Steel Enclosed SL Cable (JEC-43Z, JEA-105Z)
jj. 30,000V Lead Covered SL Cable (JEC-43Z, JEA-105Z)
kk. 30,000V Jute Enclosed SL Cable (JEC-43Z, JEA-105Z)
ll. 30,000V Steel Enclosed SL Cable (JEC-43Z, JEA-105Z)

ENCLOSURE (A), continued

11. Telephone Cable

a. Urban Cable
b. Banded Urban Cable
c. Urban Telephone Lead-Covered Cable
d. Urban Telephone Lead-Covered Cable (All Wool)
e. Urban Telephone Lead-Covered Cable (Steel Covered)

12. Special Dry Paper Telephone Cable

a. Star Model Urban Cable
b. Star Model Urban Cable (Banded)
c. Star Model Rural Cable (AB)
d. Star Model Rural Cable (Cloth) (AB)
e. Star Model Rural Cable (Banded) (AB)
f. Star Model Rural Cable (Wire) (AB)
g. Heavy Communications Cable (AB)
h. Heavy Communications Cable (AB) (Cloth)
i. Heavy Communications Cable (AB) (Banded)
j. Heavy Communications Cable (AB) (Wire)
k. Carrier Communications Cable (AB)
l. Carrier Cloth Cable (AB)
m. Carrier Banded Cable (AB)
n. Carrier Wire Cable (A)
o. Carrier Wire Cable (A) (Submarine)
p. Special Carrier (AB) Cable
q. Special Carrier (AB) Cable (Cloth)
r. Special Carrier (AB) Cable (Banded)
s. Special Carrier (A) Cable (Wire)
t. Special Carrier (A) Cable (Submarine)

13. Interdepartmental Cable

a. Soaked Interdepartmental Cable
b. Tin Plated Interdepartmental Cable
c. Enameled Interdepartmental Cable
d. 0.9mm Enameled Interdepartmental Cable
e. Paper Interdepartmental Cable
f. Lead Covered Interdepartmental Cable
g. Heavy Communications Interdepartmental Cable
h. Telegraph Interdepartmental Cable
i. Carrier Interdepartmental Cable
j. Special Carrier (AB) Interdepartmental Cable
k. Special Carrier (C) Interdepartmental Cable

B. Standard Specifications for Electric Wire Material (Supplement) 1945.

NAVTECHJAP DOCUMENT NO. ND25-0025
ATIS DOCUMENT NO. 3004

1. Paper Wrapped Copper Wire
2. Rice Paper Wrapped Copper Wire
3. Rice Paper Wrapped Copper Wire (Enameled)
4. Covered Binder Copper Wire
5. Covered Binder Iron Wire
6. Cotton Wrapped Copper Wire
7. Cotton Wrapped Copper Wire (Braided)
8. Silk Wrapped Copper Wire
9. Paraffin Copper Wire
10. Varnish Copper Wire
11. Cellulose Copper Wire
12. Communications Copper Wire
13. Paraffin Copper Wire (Cotton Wrapped)

ENCLOSURE (A), continued

C. Wartime Standard Specifications for Wire

NAVTECHJAP DOCUMENT NO. ND25-0024
ATIS DOCUMENT NO. 3003

1. Insulated Electric Wire
2. Rubber Moulded Wire
3. Aluminum Wire
4. Control Wire
5. Farm Wire
6. Rubber Insulated Wire
7. Belt Paper Wire

D. Standard Specifications, Japan Electrical Industrial Committee

NAVTECHJAP DOCUMENT NO. ND25-0026
ATIS DOCUMENT NO. 3005

1. Method of Designating Electric Wire Metal Types
2. Wire Standards
3. Type 4 Flexible Wire
4. Outdoor Flexible Wire
5. Paper Insulated Ground Cable
6. Overhead Transmission Line
7. Standard voltage
8. SL Model Paper-Covered Cable
9. SL Model Paper-Covered Cable (Provisional)
10. Cord for Machines
11. Neon Electric Wire
12. Cambric Cable
13. Insulated Aluminum Wire
14. Insulated Aluminum Wire (Provisional)
15. Insulated Aluminum Wire (Type II)
16. Insulated Aluminum Wire (Connections)
17. Mark I Aluminum Wire (Alloy)
18. Aluminum Wire
19. Mark I Aluminum Wire (Insulated)
20. Moulded Rubber Wire
21. Prov. Al Connectors
22. Al Conserving Cable

E. Standard Specifications, Electric Wire Technical Committee, Metal Industry Control Association.

NAVTECHJAP DOCUMENT NO. ND25-0023
ATIS DOCUMENT NO. 3002

1. Paper Tape
2. Insulating Paper
3. Copper Releases and Connections
4. Copper Releases and Connections (Alloy)
5. Copper Releases and Connections (Tin plated)
6. Paper Cable
7. Insulating Mixtures
8. Insulating Mixtures
9. Junction Boxes
10. Wire for Vehicles
11. 600V Rubber Insulated Wire
12. 600V Jumper Wire
13. 1500V Jumper Wire
14. Rectangular Copper Wire
15. Leather Covered Copper Wire

ENCLOSURE (A), continued

16. Glass Covered Copper Wire
17. Cotton and Silk Covered Copper Wire
18. Double Silk Covered Copper Wire
19. Glass Braided Copper Wire
20. Double Silk Covered Copper Wire
21. Mk 1 Paper
22. Power Cable
23. Signal Cable
24. Varnished Electric Wire
25. Varnished Electric Wire (Rubber Covered)
26. Varnished Electric Wire (Cellulose Covered)
27. Oil Paper Cable
28. Oil Paper Cable (Safety)
29. Al Cable (Temp)
30. Tin Plate
31. Packing Reel
32. Packing Reel (Small)
33. Cd Copper Cable
34. Silicon Bronze Wire
35. Aluminum Wire (Rubber Covered)
36. Rubber Tape
37. Connectors
38. Silk Covered Wire
39. Al Wire (Safety)
40. Al Cable (Safety)
41. Signal Cable
42. Paper Tape
43. Paper Tape (Japanese)
44. Signal Cable (Tin Covered)
45. Signal Cable (Tin Covered) (Al)
46. Rubber Wire Covering
47. Al Cable Connections
48. Low Tension Electric Wire
49. High Tension Electric Wire
50. Soft Copper Wire
51. Frosted Copper Wire
52. Al Machine Wire
53. Cd Copper Wire
54. Cd Copper Wire
55. Silicon Bronze Wire
56. Enameled Wire
57. Special Enameled Wire
58. Rectangular Copper Wire
59. Welding Wire
60. Wartime Rubber Wire
61. Insulating Oil (Heavy)
62. Insulating Oil (Mineral)
63. Insulating Oil (Rubber Threaded)
64. Rubber Covered Wire (Wartime)
65. Mixture Ratios
66. Mixture Ratios (Rubber)