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CLADMETALS

ROSSLYN METAL

A Stainless Metal with good heat conductivity

AMERICAN CLADMETALS CO.

P. O. Box 544 CARNEGIE, PA.

--MAKERS OF--

"Rosslyn Metal"

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AMERICAN CLADMETALS COMPANY

ROSSLYN METAL FOR HEAT RESISTING APPLICATIONS

Introduction

"ROSSLYN METAL" is a clad material consisting of a copper core, metallurgically bonded on both sides to stainless steel or Inconel. For heat resisting applications, the most popular stainless types are 310 (25-20) and 347 (18-8 with columbium). Other grades may be furnished when required. About 30% of copper is the usual proportion furnished in the core, although this can be varied to suit the application. The material is currently available in sheet form in standard gauges and widths.

The copper core imparts high heat conductivity throughout the entire sheet.

The attached chart shows that ROSSLYN METAL has higher thermal conductivity than any other commercially available heat resisting material.

This higher thermal conductivity is an invaluable property which provides better performance in commercial processes where transfer of heat is important.

Greater thermal conductivity is invaluable as it results in the elimination of buckling, warping and cracking which have caused so much trouble in parts such as combustion chamber liners for jet engines and other gas turbines, ram jets, guided missiles, rockets, tail cones stationary blades, exhaust manifolds, collector rings, etc.

The copper core spreads the heat so that "hot spots" or "heat zoning" is virtually eliminated in assemblies made from ROSSLYN METAL. At the same time the outstanding heat resisting properties of the exterior cladding are retained in full measure.

ROSSLYN METAL may be formed with ease. All the common types of welding have been applied to this material although special techniques are required in some cases. This will be discussed more fully. When necessary, the exposed edges of the copper may be protected readily from oxidation. It is not subject to high temperature embrittlement from the copper. Pertinent tests are also discussed separately.

A number of tests which have already been made confim outstanding qualities of this new metal for heat resisting service. One of the most significant was published by P. A. Haythorne in the September 23, 1948 issue of IRON AGE entitled "Sheet Metals for High Temperature Service". Several of the photographs and figures from this paper are shown herein. These point to the ability of ROSSLYN METAL to eliminate "hot spots" and the failures resulting therefrom.

Another series of tests has demonstrated the outstanding lateral conductivity of this clad material. This data is also attached.

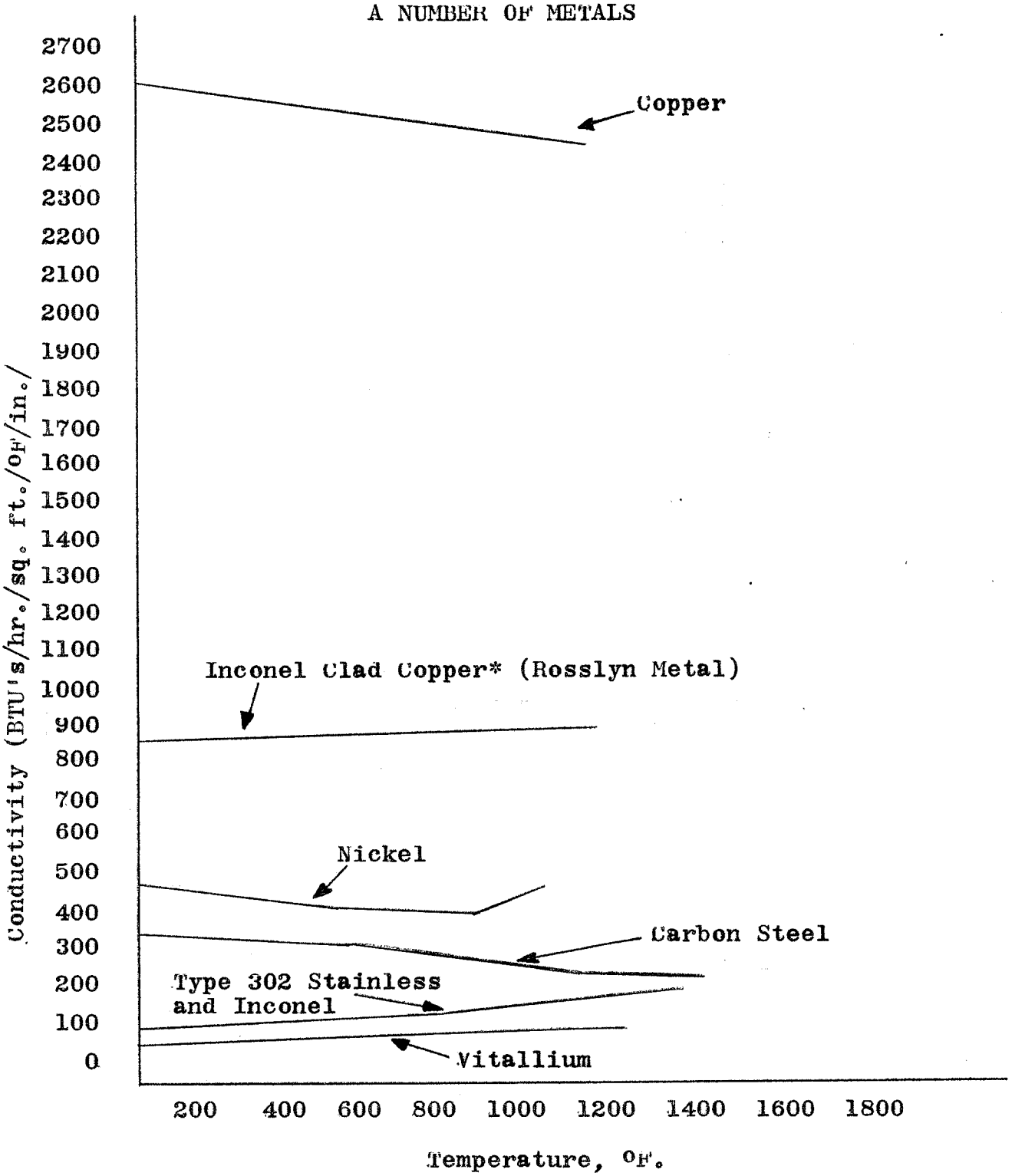
Subsequent sections cover the room temperature and high temperature physical properties of this material, forming and welding information, oxidation tests and embrittlement tests.

Additional queries regarding the character of this material, now commercially available, will receive prompt attention.

September 12, 1949

FIGURE #1

THERMAL CONDUCTIVITY AS IT VARIES WITH TEMPERATURE FOR A NUMBER OF METALS



June 27, 1949

C. T. Evans, Jr.
L. W. Townsend

*Calculated 30% copper

A STUDY OF LATERAL CONDUCTIVITY OF ROSSLYN METAL

July 12, 1949

Tests represented by the charts attached were made by Mr. C. T. Evans, Jr., Chief metallurgist of the Elliott Company, in collaboration with American Cladmetals' engineers. The test set-up is shown along with charts and these tests indicate that ROSSLYN METAL actually has higher lateral conductivity than pure copper under some conditions typical of service installations.

This is not too surprising when it is considered that heat transfer is usually not simply a matter of thermal conductivity. In the tests illustrated, a constant amount of heat was available to each sample. A given temperature in the furnace was no doubt reached more quickly by the pure copper than by any of the other metals tested because of the high conductivity. However, the measuring point was not in the Furnace, but approximately 4" from the Furnace hearth, so that radiation and emissivity effects of the material outside the Furnace were also important. These meant higher heat losses for the copper, whereas in the case of the ROSSLYN METAL, the stainless acted as "insulation", sealing in the heat as it travelled out through the composite piece.

It is believed that these tests accurately simulate the condition existing in, for example, a cooking utensil, wherein the bottom is soaking up heat from a relatively constant source, and it is desired to distribute that heat as quickly and evenly as possible to the other sections of the utensil. The 850°F. to 125°F. tests are particularly illustrative of the cooking utensil problem.

The 1250°F. to 200°F. tests and the 1500°F. to 200°F. tests are more applicable to the heat transfer requirements of combustion chamber liners for jet engines. At these high temperatures the thermal qualities of ROSSLYN METAL exceed by a wide margin those of other metals useful under the attendant oxidizing conditions which disqualify copper, and so it may be said that for all practical purposes ROSSLYN METAL alone offers the high thermal conductivity which is necessary to relieve thermal stresses at high temperatures.

Figure 1 is a chart showing the thermal conductivity of various base metals as it varies with temperatures. The tests described in the other charts, as discussed above, show that thermal conductivity alone may not be a true measure of lateral conductivity although it forms a useful guide.

To summarize, in ROSSLYN METAL we have a material which matches the lateral heat conductivity of copper and under certain conditions surpasses it. The relative thickness of the copper core of ROSSLYN METAL can be raised or lowered so as to meet conductivity refinements for particular applications.

Physical strength requirements and corrosive conditions should be taken into consideration and sufficient chrome nickel cladding thickness provided to meet needs, then enough copper core thickness should be specified to give necessary lateral heat conductivity, and thus the entire thickness of cross section of the ROSSLYN METAL will be determined.

The industries where the advantages of ROSSLYN METAL will be in demand appear to be food processing, baking, dairy, cooking, plastics pressing, chemicals, varnish and paint, ironers, stoves, gas turbin and aviation and wherever else sheet metal is required in high temperature service.

It has been ascertained through tests that a steam jacketed kettle incorporating ROSSLYN METAL in the interjacket will perform as well as a solid copper kettle and will cost less than a solid copper kettle. The Jacketed kettle supplying all the advantages of stainless steel and the performance of copper at a lower price should be most interesting in the processing of chemicals, plastics, and food.

These same characteristics applied to the refrigeration industry could also be very attractive to manufacturers of refrigeration equipment.

A STUDY OF LATERAL CONDUCTIVITY OF ROSSLYN METAL AND A STUDY ON THE EFFECT OF THE PERCENTAGE OF COPPER IN ROSSLYN METAL AND A COMPARISON OF ROSSLYN METAL WITH SOLID STAINLESS, PURE COPPER AND THREE-PLY STAINLESS CLAD MILD STEEL CENTER

A= Type 302 ROSSLYN METAL; 22.5% copper; .095" x 2"x 26¼"; #1 Finish

B= Type 302 ROSSLYN METAL; 28.2% copper; .082" x 2"x 26¼"; Planish Finish

C= Type 302 ROSSLYN METAL; 58.0% copper; .088" x 2"x 26¼"; "1 Finish

D= Type 302 Stainless Steel; 0% copper; .078" x 2" x 26¼"; #1 Finish

E= Double Armor 3 ply Stainless Clad Mild Steel Center; Type 304; 61.5% mild steel; .078" x 2" x 26¼"; Ht K4565; Test S-1719

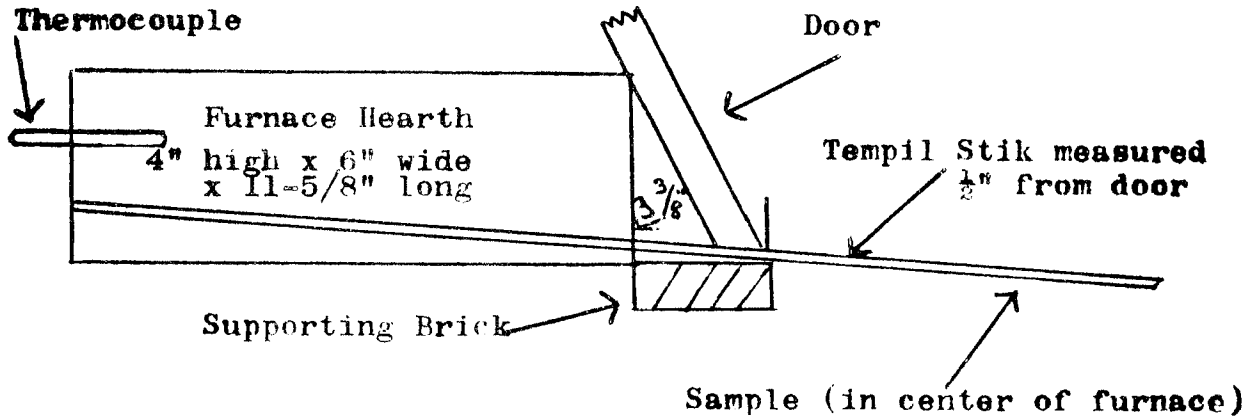
F= Pure Copper; .082" x 2" x 26¼"

Numbers in parentheses after seconds = temp. x 100 in °F reached by end of sample in furnace.

✓= Readings discarded because surface had not been previously "conditioned" by oxidation.

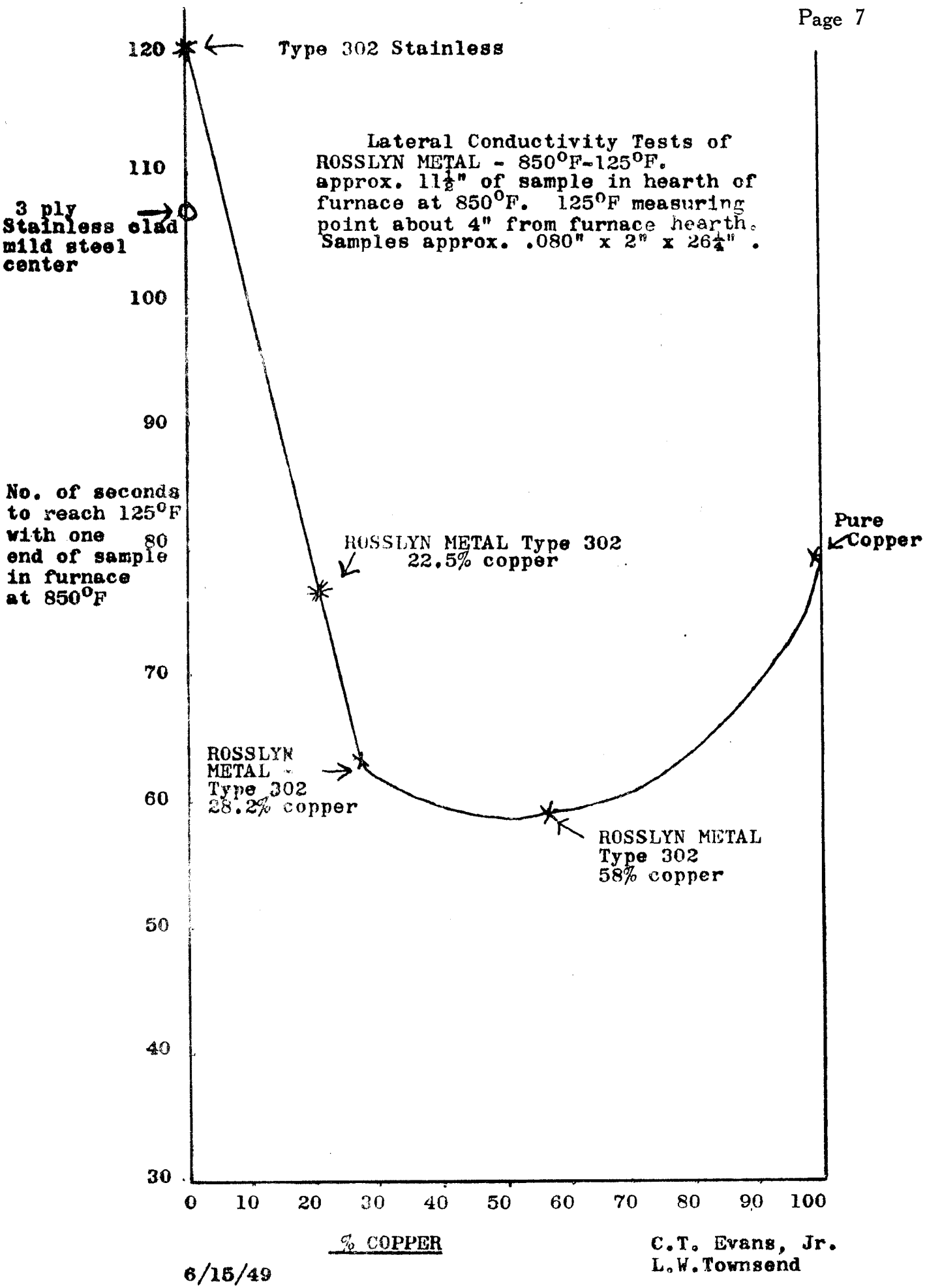
Arrangement of Samples IN FURNACE

(Approx. Scale: ¼" =1")



6/15/49

C. T. Evans, Jr.
L. W. Townsend



6/15/49

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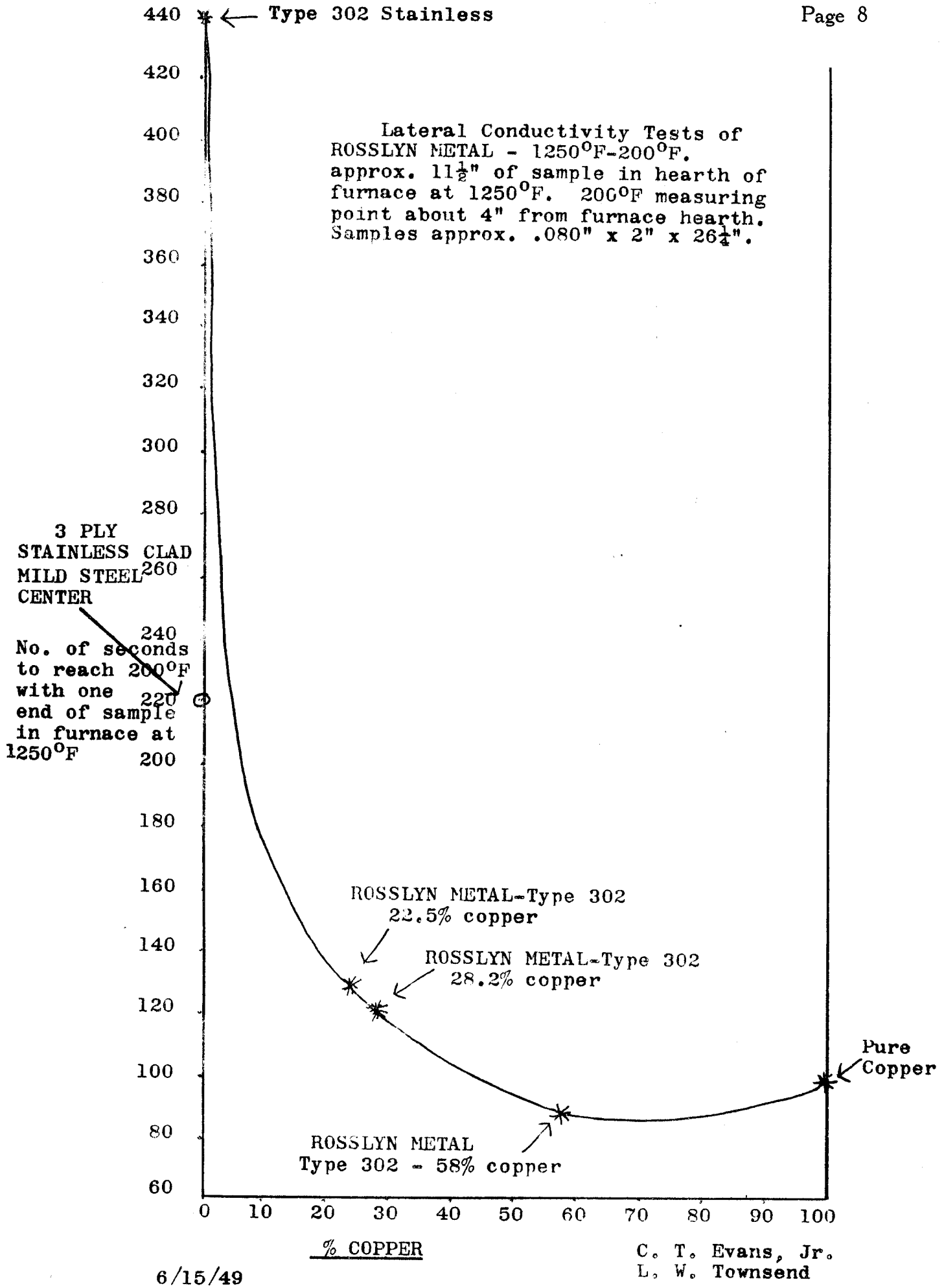

6/15/49

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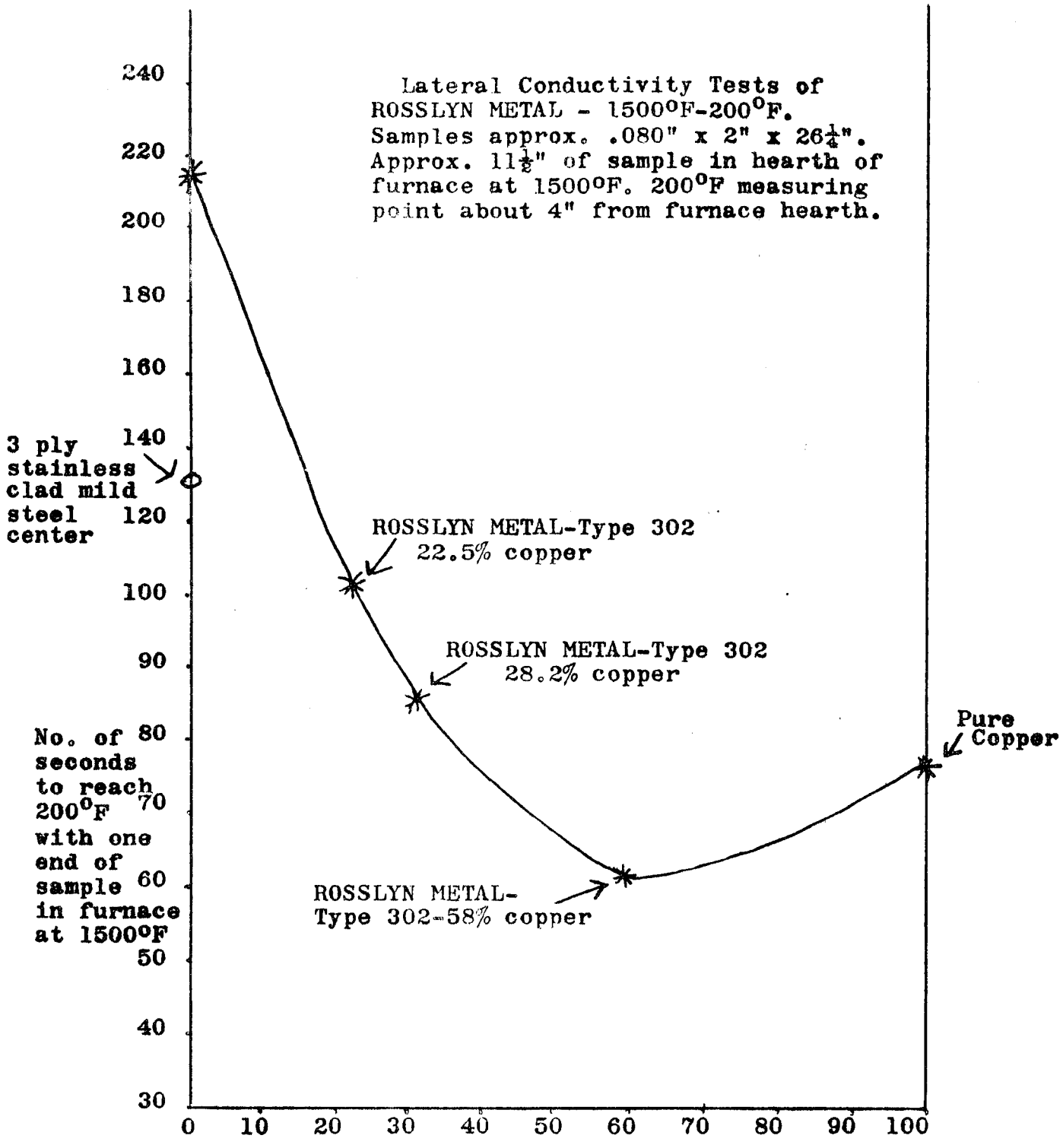

C. T. Evans, Jr.
L. W. Townsend

6/15/49

LATERAL CONDUCTIVITY TESTS

Furnace Temp. 850°F Tempilstik Temp. 125°F

No. of Seconds to Reach Temp.

Run #	A (22.5% cu.)	B (28.2% cu.)	C (58% cu.)	D (0% cu.)	E (3 ply stainless clad mild steel center)	F (100% cu.)
		All samples polished before test.				
1	104(5-6)	87(4-5)	82(4-5)	158(6-7.5)		
2	67.5(3-4)	67.5(3-4)	60(4-5)	137(7.5-8)		
3	77.0	67.5	56(3-4)	127(7.5-8)		
4	65.0(3-4)	55.0(3-4)	55(3-4)	116(6-7.5)		
5	85.0(4-5)	60.5(3-4)	55(3-4)	114(6-7.5)		
6	80.0(4-5)		226.0	118(6-7.5)		
7	90.0(4-5)		Av. 56.5			
8	55.0(3-4)					
9	80.0(4-5)					
10	64.5(3-4)					
	664.0					
	Av. 73.6					
		B & D Oxidized - E & F New Samples				
1		68.0		119.5	160.5(5-6)	84.6(2-3)
2		318.5		594.5	115.4(4-5)	78.3(2-3)
3		Av. 63.7		Av. 118.9	103.0(4-5)	84.4(2-3)
4					108.9(4-5)	77.2(2-3)
5					102.5	82.8
		E & F Oxidized - Previously exposed at 1250° and 1500°				
1					105.8	75.9
2					108.2	79.6
3					107.0	80.0
					750.80	558.20
					Av. 107.26	79.74

6/15/49

C. T. Evans, Jr.
L. W. Townsend

LATERAL CONDUCTIVITY TESTS - Continued

Furnace Temp. 1250°F Tempilstik Temp. 200°F

No. of Seconds to Reach Temp.

Run #	A (22.5% cu.)	B (28.2% cu.)	C (58% cu.)	D (0% cu.)	E (3 ply stainless clad mild steel center)	F (100% cu.)
		All samples new before test				
1	265	200	100	437.0		
2	175	162	92.5	425.0		
3	150	133	94.5	450.0		
4	155.5	134	88.5			
5	149	145	275.50			
	454.5		Av. 91.83			
	Av. 151.5					
		All Samples previously exposed at 850°F				
1						92.9
2		132.5		448.6	218.9(29.5)	95.7(6-7.5)
3		146.4		442.2	230.0(29.5)	105.6(6-7.5)
4		149		442.2	217.5	107.0
		839.9		2645.0	666.4	401.2
		Av. 139.9		Av. 442.5	Av. 222.1	Av. 100.3

Furnace Temp. 1500°F Tempilstik Temp. 200°F

All Samples previously exposed at 1250°F

1	105	80.0	63	230		
2	105	80.0	60	200		
3	135	87.0	60	210		
4	210		57	640		
	Av. 105		240	Av. 213		
			Av. 60			
		All Samples previously exposed at 1250°F				
1		89.8				60.6(9.5-13)
2		93.5			116.1(5-13)	69.4
3		91.9			132.7	70.2
4		522.2			120.3	76.6
		Av. 87.03			369.1	276.8
					Av. 123.03	Av. 69.2

6/15/49

C. T. Evans, Jr.
L. W. Townsend

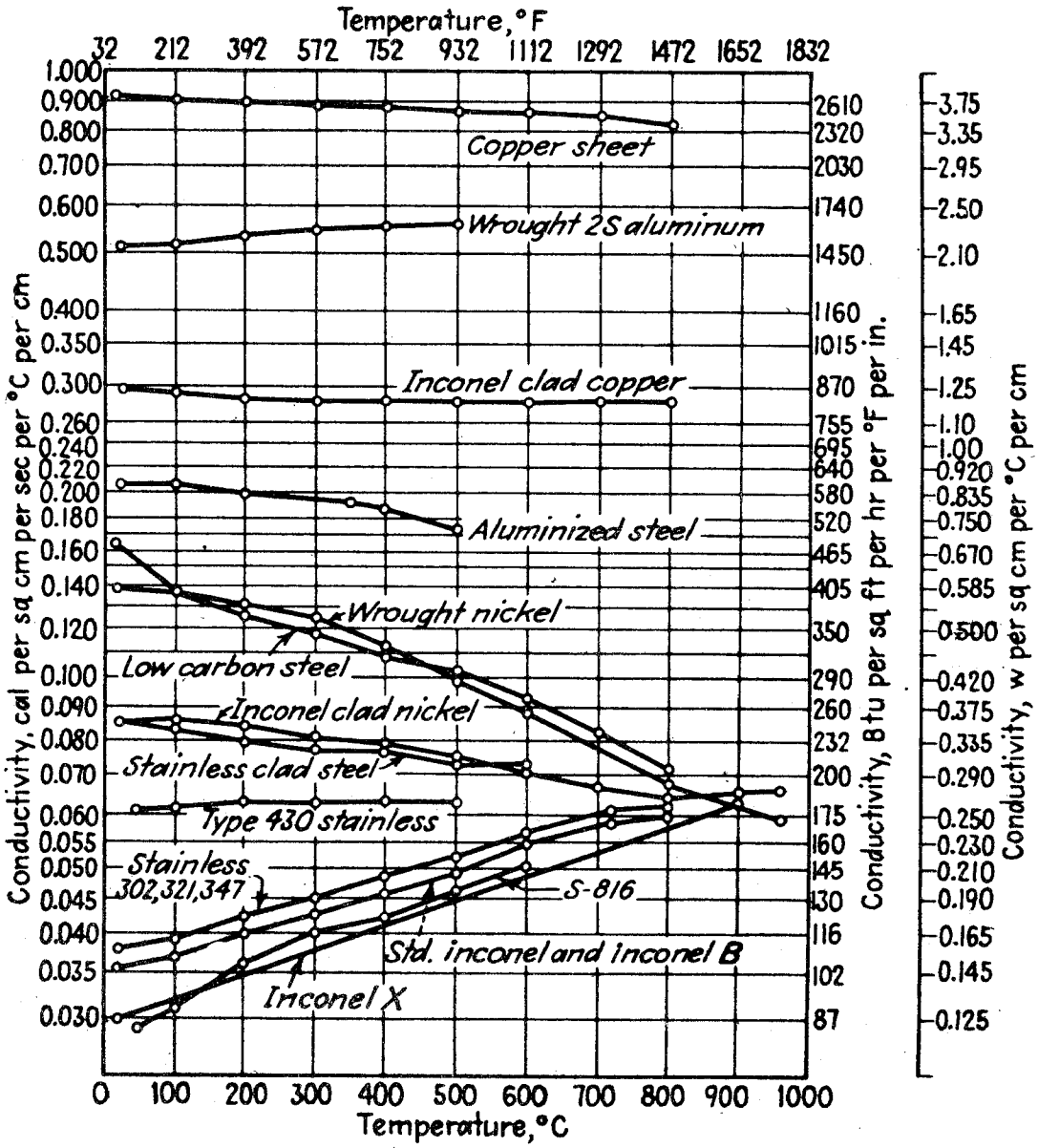

FIG. 5 - Thermal conductivity of sheet materials.

Oxidation Resistance

In structures where the copper core is not exposed, the oxidation resistance of ROSSLYN METAL is determined by the oxidation resistance of the stainless, or Inconel, itself. However, due to the relatively low melting point of the copper, (1981°) a maximum metal temperature of 1800°F. in service should be specified for ROSSLYN METAL even with cladding of Inconel or Type 310 (25-20) stainless, which are themselves capable of withstanding surface temperatures up to 2000°F. The probable maximum service temperatures for various grades of ROSSLYN METAL in continuous exposure to air atmosphere are:

AISI Types 302, 304, 316 and 347 - 1600°F.
AISI Types 309, 310, and Inconel - 1800°F.

The presence of atmospheres other than air may modify these maximum temperatures. For example, Inconel is not recommended for use above 1500°F. in the presence of oxidizing sulphurous gases, and is restricted to 1000°F. or below in reducing sulphurous atmosphere.

Although the copper core when exposed begins to oxidize at about 750°F the scale formed is semi-protective and that the rate of oxidation decreases with time. At 1500°F., in relatively, still air (Hayes preheat furnace, "peephole" open), testing shows approximately only .045" oxide penetration from the edge into the copper core in 744 hours. Thus, in most cases, it appears unnecessary to protect the copper from oxidation.

If protection against oxidation of the copper is required, then there are relatively simple methods which can be employed. As illustrated in the attached photomicrographs, the edges may be "seal" welded, or for almost equally effective results the copper edge may be "Calorized".

"Calorizing diffuses aluminum into copper to form an alloy of high oxidation and corrosion resistance. The attached photomicrographs illustrate the effective protection obtained by this procedure in over 700 hours exposure at 1500°F. Additional photomicrographs show that this procedure also provides partial protection even at 1700°F.

There are several possible methods of calorizing including: powder, cold dip and spray metal. The "powder" method is employed by the Calorizing Company, Wilkinsburg, Pennsylvania, and this firm is in a position so to treat ROSSLYN METAL sheets and articles made therefrom.

The "cold dip" calorizing process was developed largely by the General Electric Company and they should be contacted through their Schenectady office for details if it is desired to use this process.

The "spray metal" method can be applied with a standard Schoop metallizing spray gun, using regular aluminum metallizing wire. The edge surfaces should first be roughened somewhat as with a file, then 1/16" thick coating sprayed with the gun. This coating will be a mixture of aluminum diffused into the copper edge by heating for 1 1/2 hours at

Oxidation Resistance (Cont'd)

1400°F. Before heating, the sprayed aluminum coating should be coated with a solution of approximately 20% water glass in water.

The choice of protective methods will depend on the size and shape of the article. The "seal welding" method provides the most "foolproof" protection. The "spray metal" calorizing method should only be used when it offers exceptional advantages in convenience and economy, since it is somewhat less certain than the other calorizing processes.

September 12, 1940

FORM 1114
1M1247

ELLIOTT COMPANY

METALLURGICAL LABORATORY

Date: April 7, 1949
Reference:
Metallographer: E.J.V.-C.T.E., Jr.

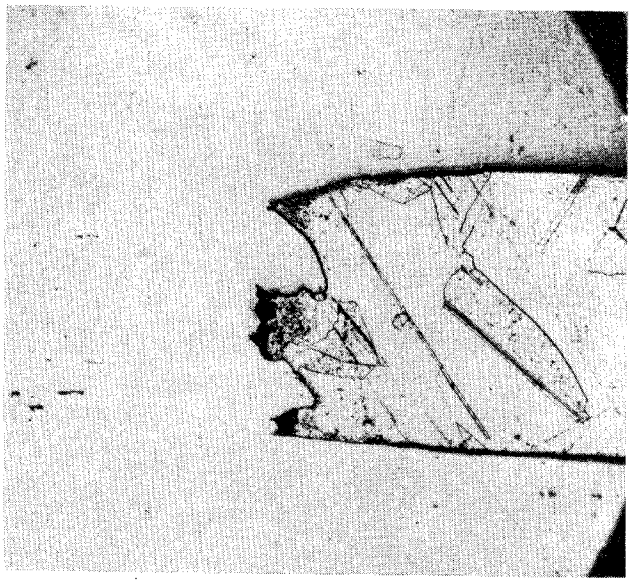

Plate 458A Magnification X40 Etchant $NH_4OH + H_2O_2$
Material Stainless Clad Copper (1/3 cu) From American Cladmetals Co., Carnegie, Pa.
Remarks Type 309S Cladding. Edge "seal welded" with heliarc. No filler metal. Copper first pickled back about .030". Stainless edges pinched together before welding. 2-1/2 inches welded using 5 liters Argon, 65 amps, 22-25 volts, standard heliarc head (1/16" tungsten). No evidence of copper pickup.

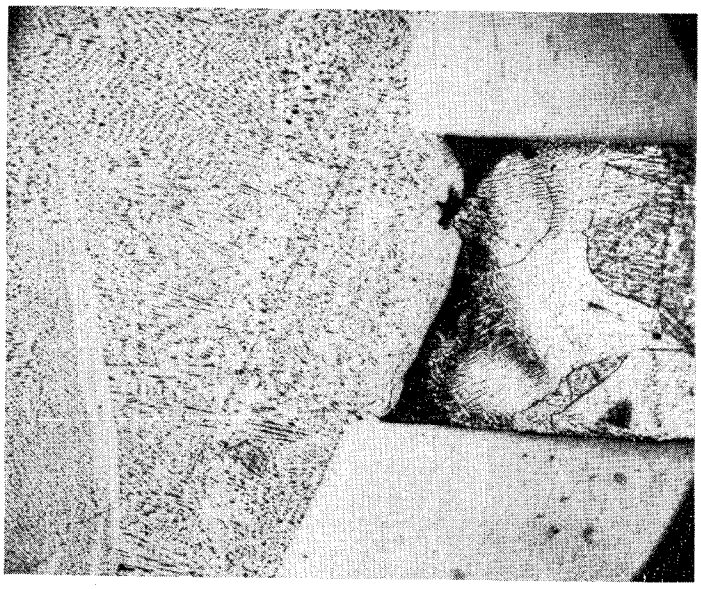

Plate 458 Magnification X40 Etchant $NH_4OH + H_2O_2$
Material Stainless Clad Copper (1/3 cu) From American Cladmetals Co., Carnegie, Pa.
Remarks Other edge of sample shown in Plate 458A. No pickling. 1/16" diameter Type 347 filler rod used. All other welding conditions the same. No evidence of copper pickup.

FORM 1114
1M1247

ELLIOTT COMPANY

METALLURGICAL LABORATORY

Date: September 8, 1949
Reference: Met. Project #106
Metallographer: C.L.C.

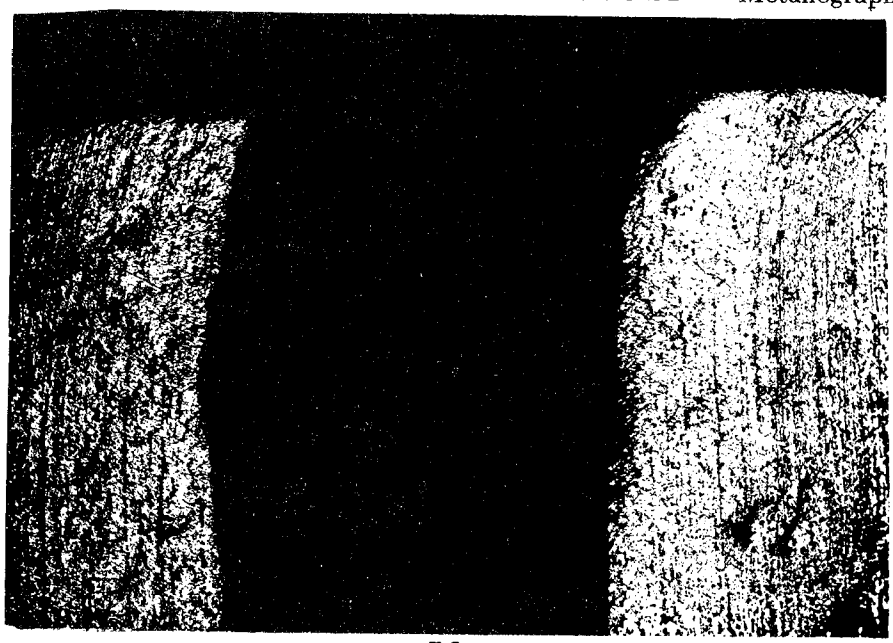

Plate 607 Magnification 50 Etchant None
Material Stainless Clad Copper From American Cladmetals Company
Remarks Type 309 Rosslyn Metal. Exposed for 118 hours at 1700°F. in electric furnace. Copper oxidized to a depth of approximately .042".

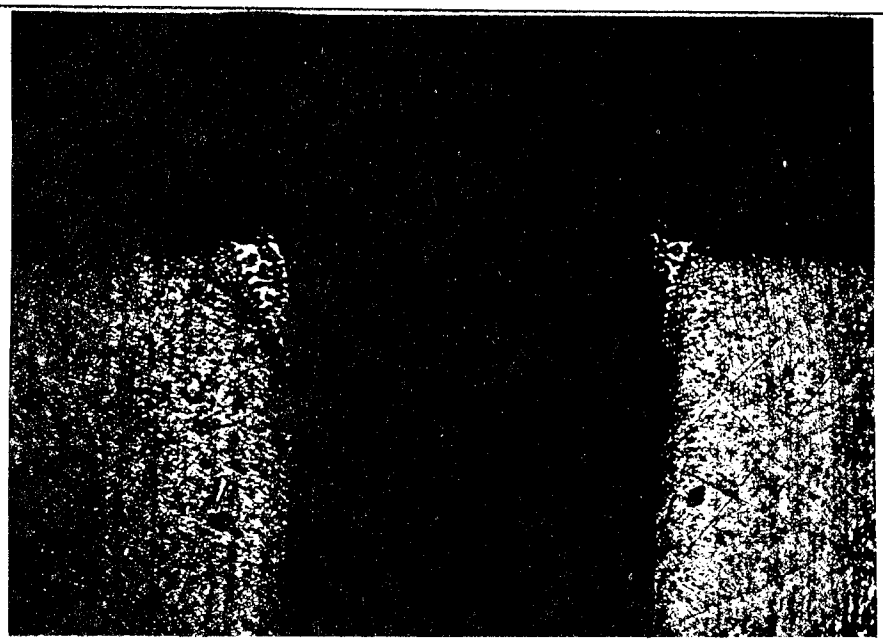

Plate 607A Magnification 50 Etchant None
Material Stainless Clad Copper From American Cladmetals Company
Remarks Type 309 Rosslyn Metal calorized by powder method by Calorizing Company of Wilkinsburg, Pennsylvania. Exposed for 118 hours at 1700°F. in electric furnace. Note absence of oxidation.

ELLIOTT COMPANY

METALLURGICAL LABORATORY

Date: August 12, 1949
Reference: Met. Proj. #106
Metallographer: C.L.C.

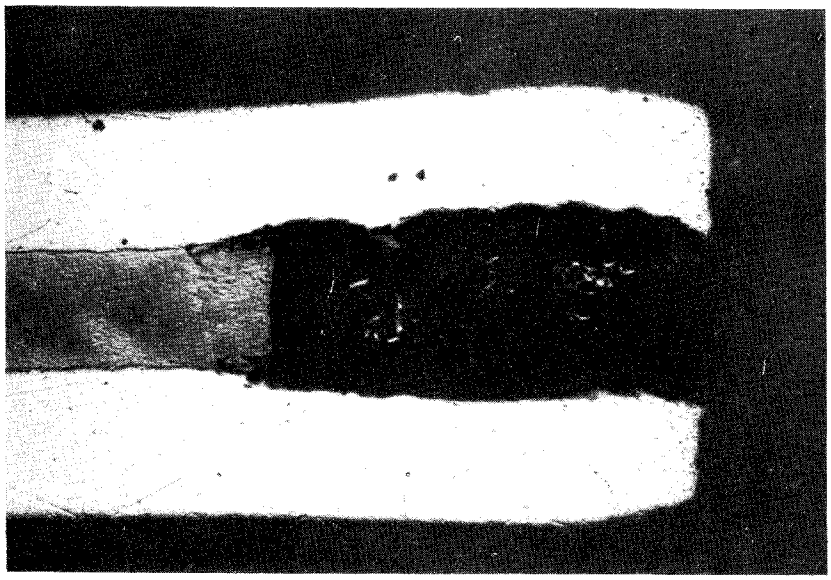

Plate 584 Magnification 50 Etchant None
Material Stainless Clad Copper From American Cladmetals Company
Remarks Type 302 Rosslyn Metal. Exposed for 744 hours at 1500°F. in electric furnace. Copper oxidized to a depth of approximately .044".

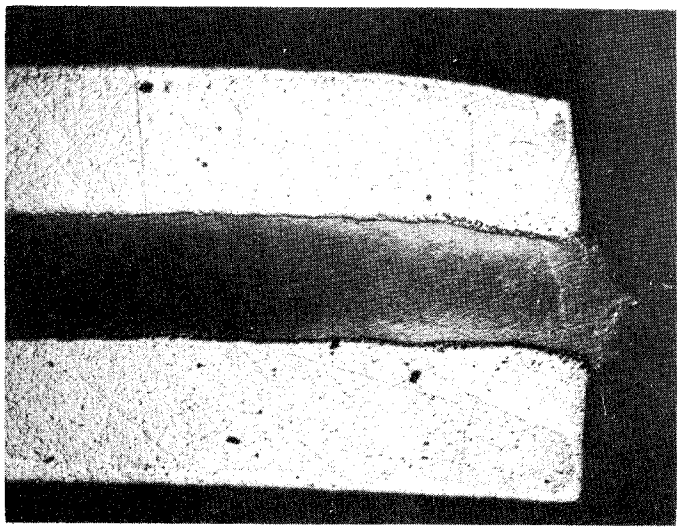

Plate 583 Magnification 50 Etchant None
Material Stainless Clad Copper From American Cladmetals Company
Remarks Type 302 Rosslyn Metal calorized by powder method by Calorizing Company of Wilkinsburg, Pennsylvania. Exposed for 744 hours at 1500°F. in electric furnaces. Note absence of oxidation.

Copper Embrittlement Tests

It is well known that metals of relatively low melting point, such as zinc, lead and tin, can cause cracking troubles when molten and in contact with steel, nickel, or other more refractory materials. Ordinarily, cracking will not occur unless the surface has been "wet" by the low melting metal or alloy, and unless a state of tension stress exists at the contact surface.

Cases of "copper embrittlement" of mild steel and stainless steel have also been reported, and the question has been raised as to whether or not ROSSLYN METAL is subject to this attack. The Elliott Company, Jeannette, Pennsylvania, has made tests from 1200° F. through 2200° F. which indicate that "copper embrittlement" is not a problem in ROSSLYN METAL.

These tests were conducted with specimens of gauge length approximately 1/2" x 1/2" x .060" of Types 302, 347 and 310 and Inconel ROSSLYN METAL and a Type 302 single-sided butt weld 1/2" x 1/2" x .072" made by arc welding with 80% nickel - 20% chromium electrode. This specimen is shown in the attached drawing. As shown in the attached photograph, the specimens were held at cantilevers in a heat resisting alloy fixture and were stressed in bending by the application of levers, pins and weights at the ends. In the case of the welded specimens, the machining was conducted so that the weld would be in the plane of maximum tension stress.

Before starting the tests, SR-4 strain gauge measurements demonstrated that at high stress levels, creeping of the copper does not invalidate the bending stress formula. The maximum stress is essentially pure tension. Also, the fact that the tests were made in bending rather than a direct pull insures a maximum opportunity for "copper embrittlement", since there is continuous "pressure" of the copper against the heat resisting alloy.

The attached table lists the stresses, temperature and times for these tests. In most cases, pronounced sagging of the specimens occurred but the design of the specimens is such that stress would remain essentially constant throughout the tests. The set-up was planned so that at least 3% elongation could take place before the weights rested on the fixture, limiting further deformation.

No failures occured. After testing, each sample was bent back on itself through 180° around the region of maximum stress, with the results noted in the table. No indications of "copper embrittlement" were evident in these tests.

ROSSLYN METAL FOR HIGH TEMPERATURE APPLICATIONS

Copper Embrittlement Tests

Table of Bending Tests Run by Elliott Company

Test Temp. °F.	Duration, Hours	Specimen Number	Grade of ROSSLYN METAL[1]	Maximum Stress, Psi	Approx. Hours Before Weights Rested on Fixture	Degree of Bend After Test Without Cracking[2]
1200	168	CM5-1	Type 302	15,600	---	180
1200	168	CM5-2	Type 302	19,300	---	180
1200	168	CM5-3	Type 302	25,900	---	180
1200	140	Inc-6	Inconel	27,600	110	180
1200	140	310-6	Type 310	27,300	125	180
1200	140	347-6	Type 347	28,100	---	180
1200	140	RMW1E	Type 302 Welded	24,400	---	150
1350	90	Inc-5	Inconel	16,750	72	180
1350	90	310-5	Type 310	16,500	78	180
1350	90	347-5	Type 347	17,200	60	180
1350	90	RMW-1B	Type 302 Welded	10,500	---	170
1500	100	Inc-1	Inconel	3,870	---	180
1500	100	310-1	Type 310	4,000	---	180
1500	100	347-1	Type 347	3,950	---	180
1500	120	Inc-2	Inconel	7,130	---	180
1500	120	310-2	Type 310	7,350	---	180
1500	120	347-2	Type 347	7,300	---	180
1500	144	RMW-1C	Type 302 Welded	10,100	118	Specimens destroyed for microstudy.
1500	144	RMW-1D	Type 302 Welded	5,450	---	
1700	96	Inc-3	Inconel	700	75	180
1700	96	310-3	Type 310	675	85	180
1700	96	347-3	Type 347	710	60	180
1700	70	Inc-4	Inconel	3,960	46	150 (cracked on corners)
1700	70	310-4	Type 310	3,900	---	180
1700	70	347-4	Type 347	4,000	24	180
1700-2200	48 hrs. at 1700°F. - raised to 2200°F. in 45 minutes[3]	Inc-7	Inconel	710	--3	180
		310-7	Type 310	725	--3	180
		RMW-1F	Type 302	3,870	15	Oxidized

NOTES

[1] In each case the percentage of copper was about 30%.

[2] Each specimen bent flat against itself around the region of maximum stress.

[3] At the conclusion of the 48 hour period at constant temperature of 1700°F., both the Inconel and Type 347 specimens were still nearly horizontal. As the temperature was raised to 2200°F., both specimens gradually sagged until the weights were resting on the fixture shortly after reaching 2200°F. In all cases, the copper melted and oxidized to such an extent that after cooling to room temperature only a few particles of metallic copper could be observed, in the center of the specimen. However, the Type 310 and Inconel strips were still completely ductile.