Nicholas
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Powerplant Section
CAA Technical Development Service

CLADMETALS

ROSSLYN METAL

A Stainless Metal with good heat conductivity

AMERICAN CLADMETALS CO.

P. O. Box 544 CARNEGIE, PA.

--MAKERS OF--

"Rosslyn Metal"

INDEX

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.

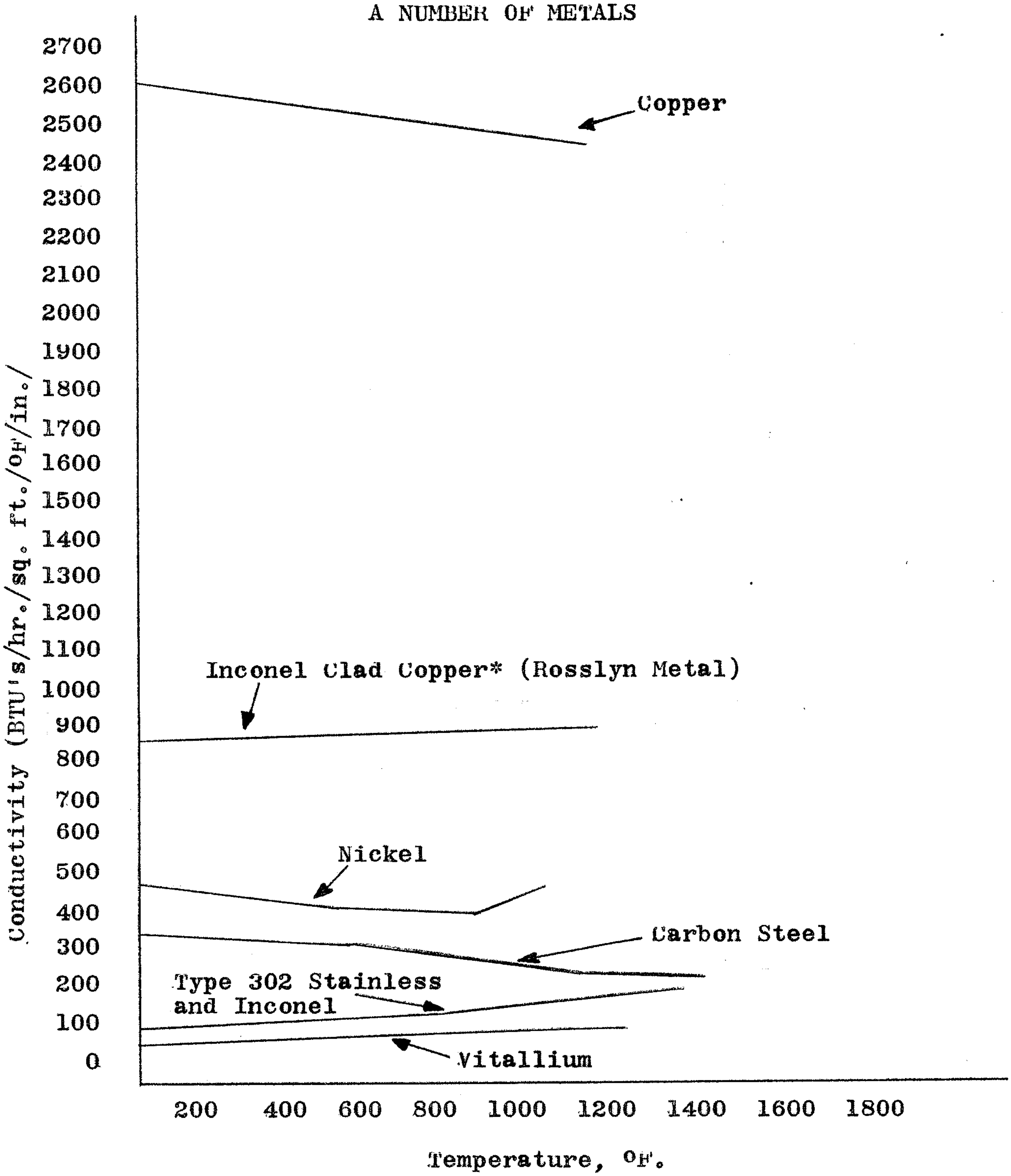
Subsequent sections cover the room temperature and high temperature physical properties of this material, forming and welding information, oxidation tests and embrittlement tests.

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

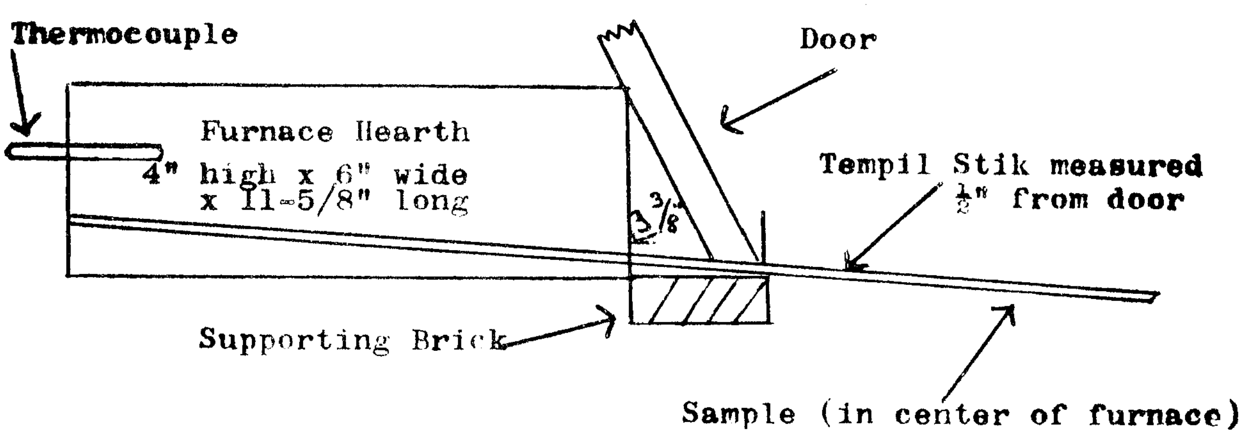
F= Pure Copper; .082" x 2" x 26¼"

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.

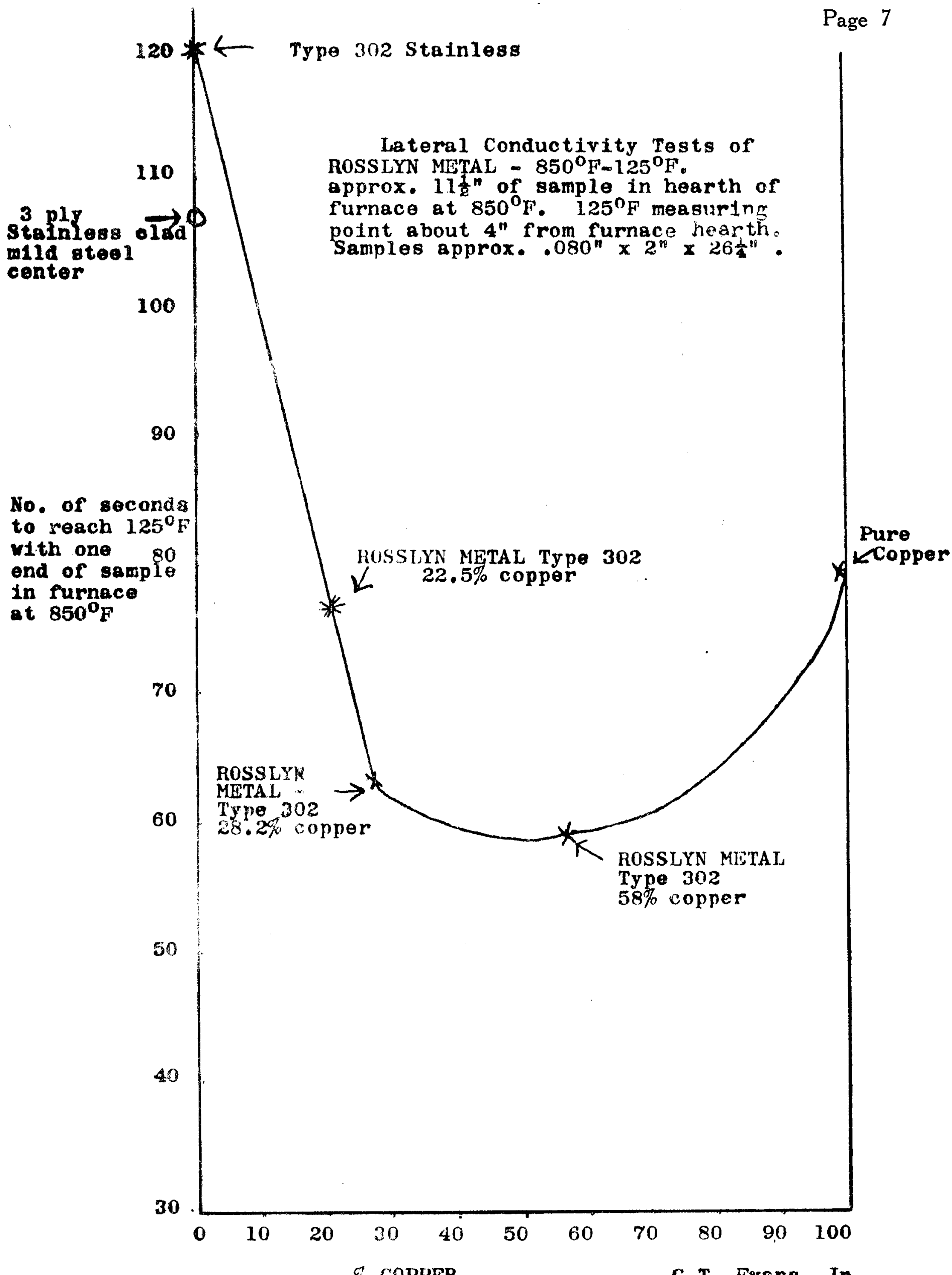
Arrangement of Samples IN FURNACE

(Approx. Scale: ¼" =1")



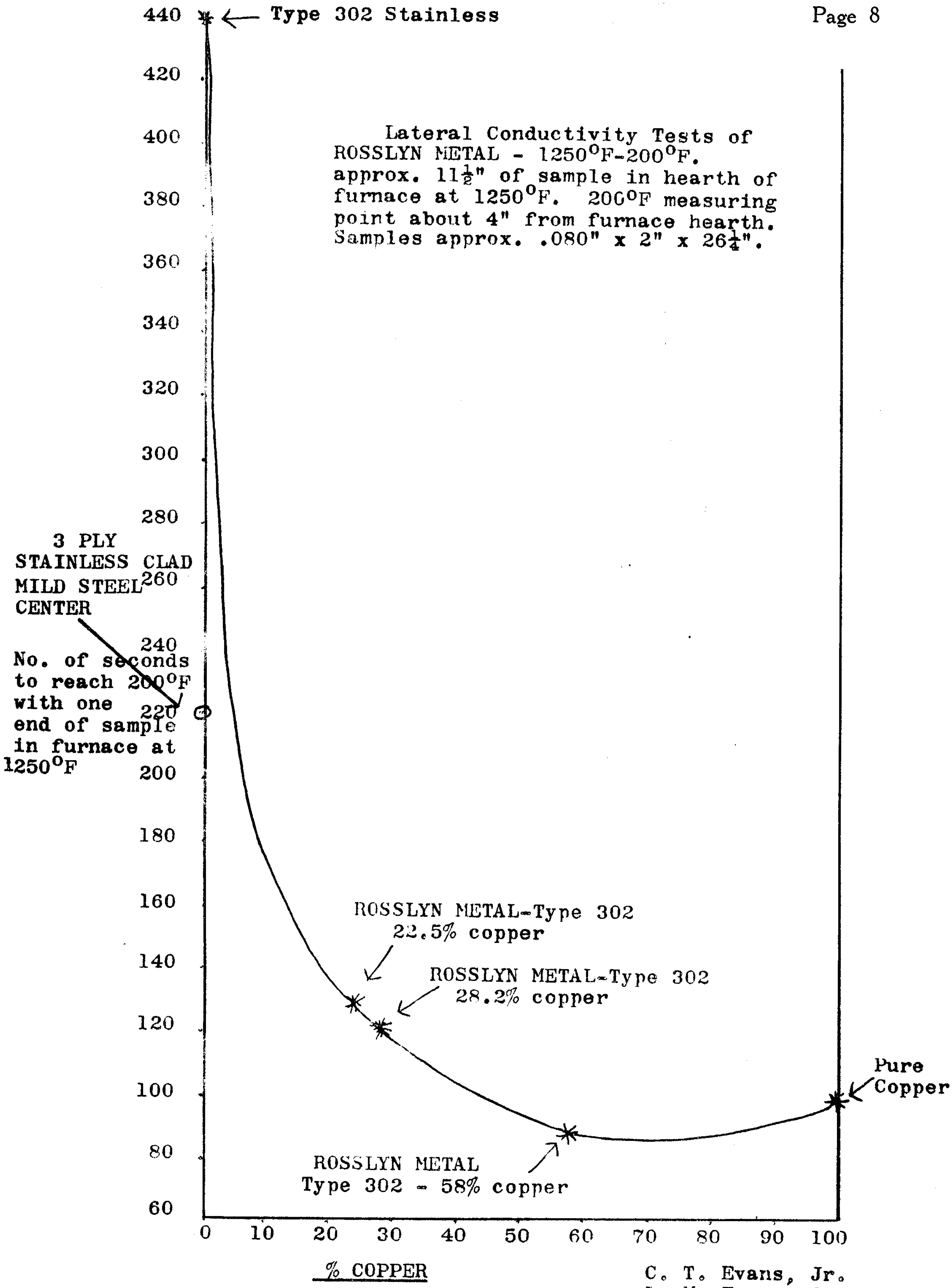
6/15/49

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



6/15/49

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



6/15/49

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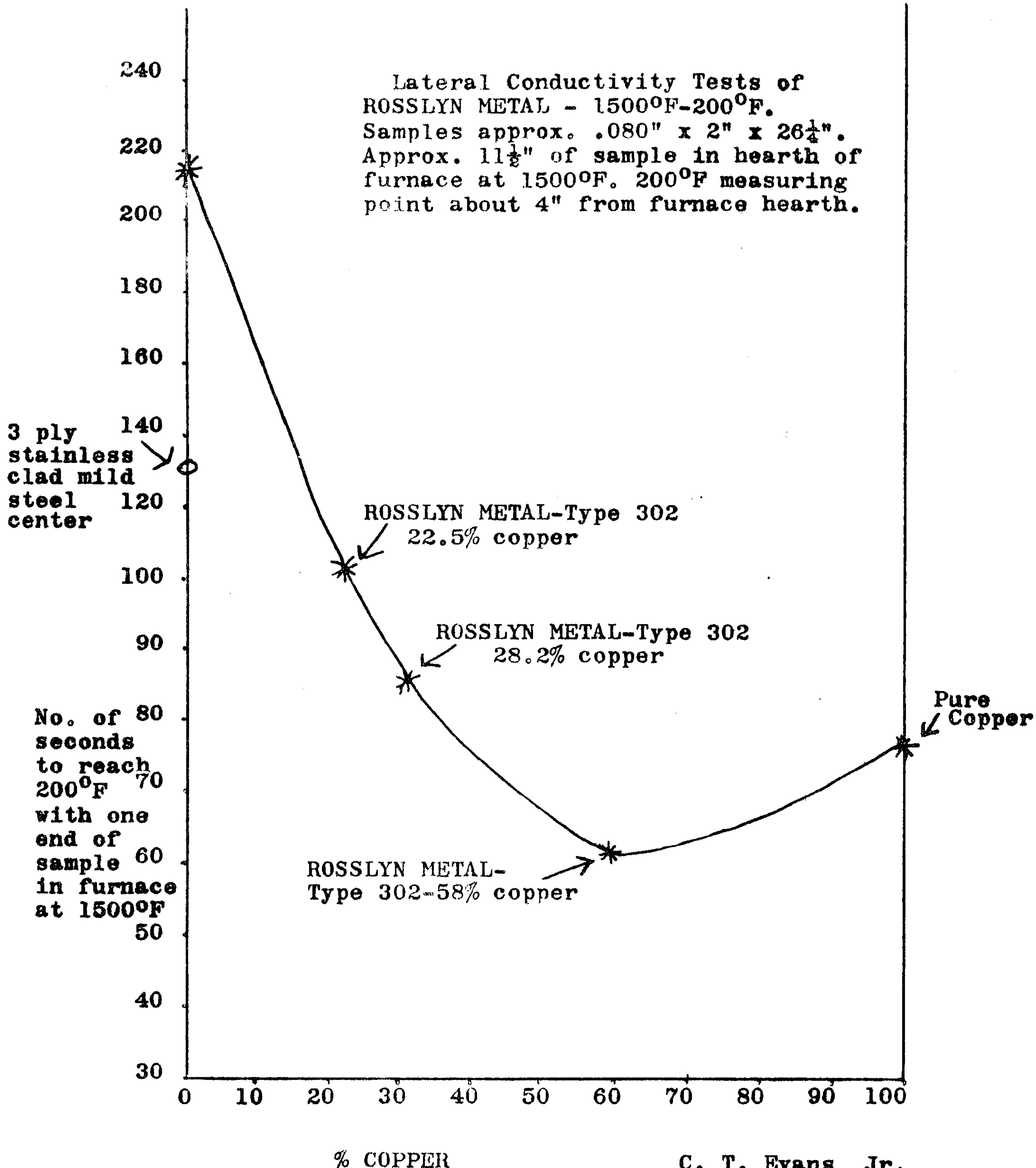

C. T. Evans, Jr.
L. W. Townsend

6/15/49

LATERAL CONDUCTIVITY TESTS

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

No. of Seconds to Reach Temp.

All samples polished before test.

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.)
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

Run #	A	B	C	D	E	F
1		68.0		119.5	160.5(5-6)	[illegible]4.6(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°

Run #	E	F
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.

All samples new before test

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.)
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

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.)
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

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.)
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

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.)
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

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L. W. Townsend

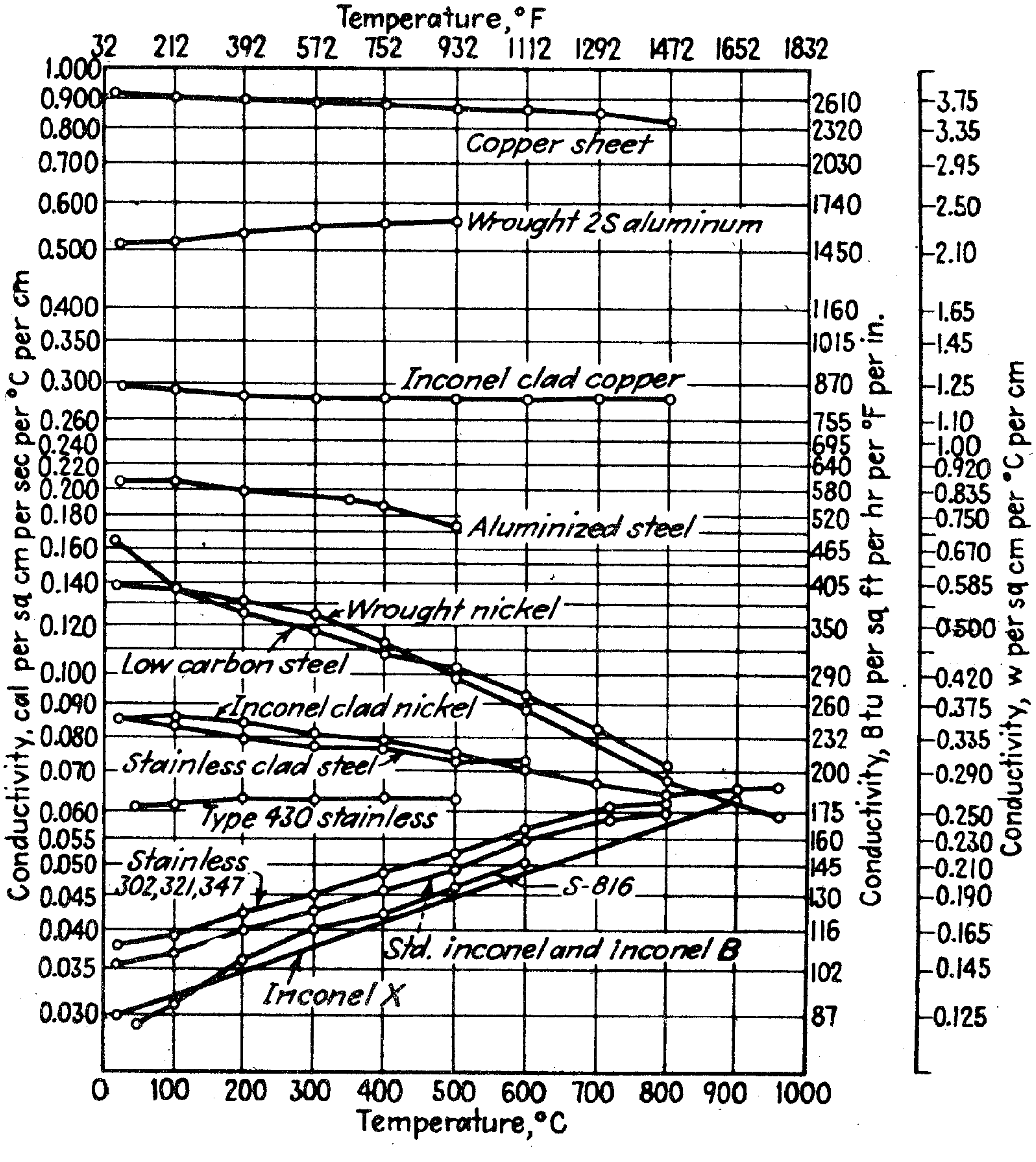


FIG. 5 - Thermal conductivity of sheet materials.

FIGURES FROM "SHEET METALS FOR HIGH TEMPERATURE SERVICE"

by

P. A. Haythorne

September 23, 1948

IRON AGE

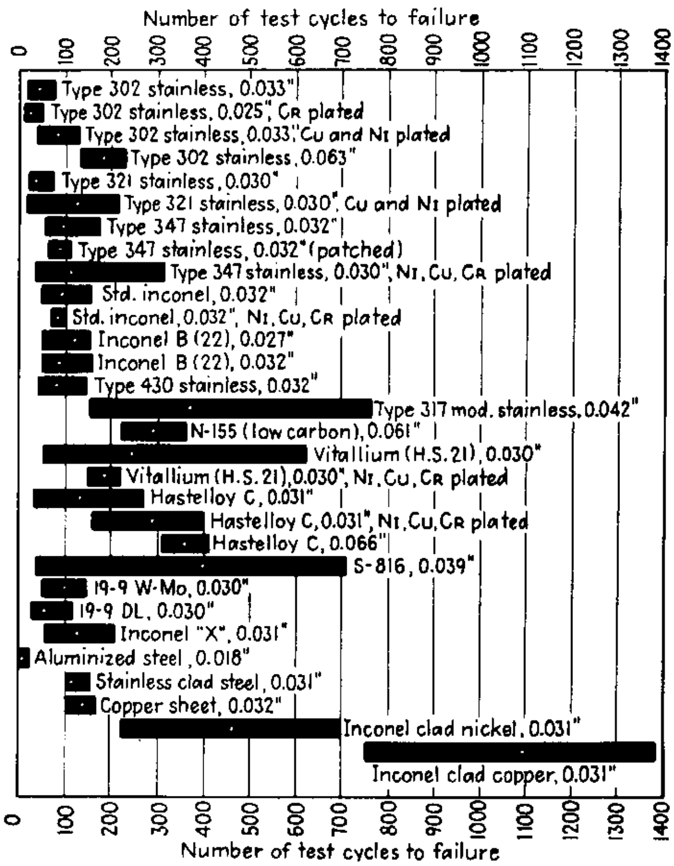
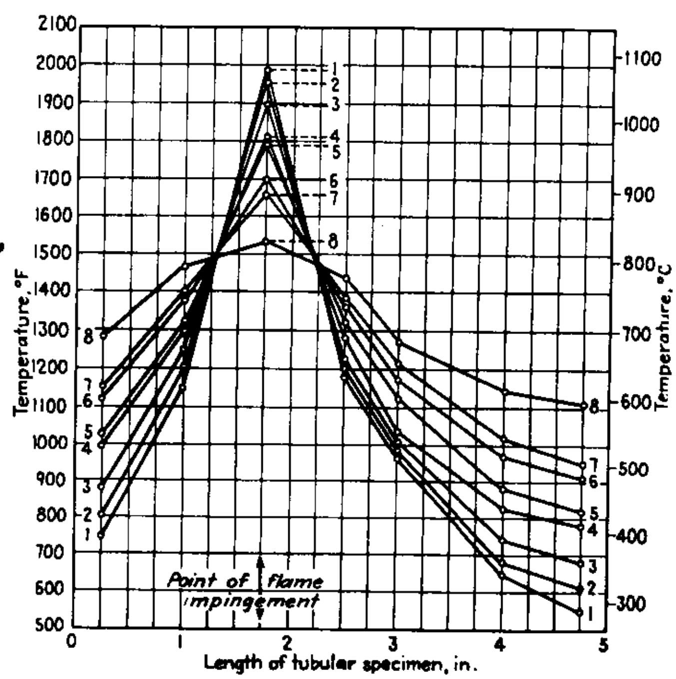


Fig. 4 - Summarized results of flame impingement. Failure taken as first visible indication of circumferential cracking. Cylinders shown in previous illustrations were heated to 1500 - 2000 F. in each cycle.

Fig. 7 - Typical temperature distribution curves - impingement test. The curves are identified as follows: (1) Inconel X, S-816, vitallium, Hastelloy C, N-155; (2) stainless types 302, 317 mod, 321, 347, standard Inconel, Inconel B (22), 19-9 W-Mo, 19-9 DL; (3) type 430 stainless; (4) Inconel clad nickel, stainless clad steel; (5) electroplated stainless types 302, 321, 347 and standard Inconel; (6) aluminum coated steel; (7) Inconel clad copper; (8) commercial copper sheet.



ROSSLYN METAL FOR HEAT RESISTING APPLICATIONS

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

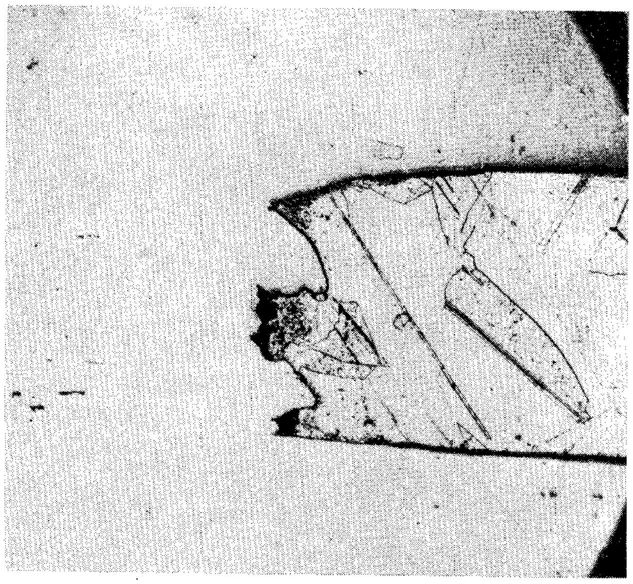


Plate 458A **Magnification** X40 **Etchant** $NH_4OH + H_2O_2$
Material Stainless Clad Copper (1/3 cu) **From** American Cladmetals Co., Carnegie, Pa.
Remarks Type 309S Cladding. Edge "seal welded" with heliarc. No filler metal. Copper first pickled back about .030". Stainless edges pinched together 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.

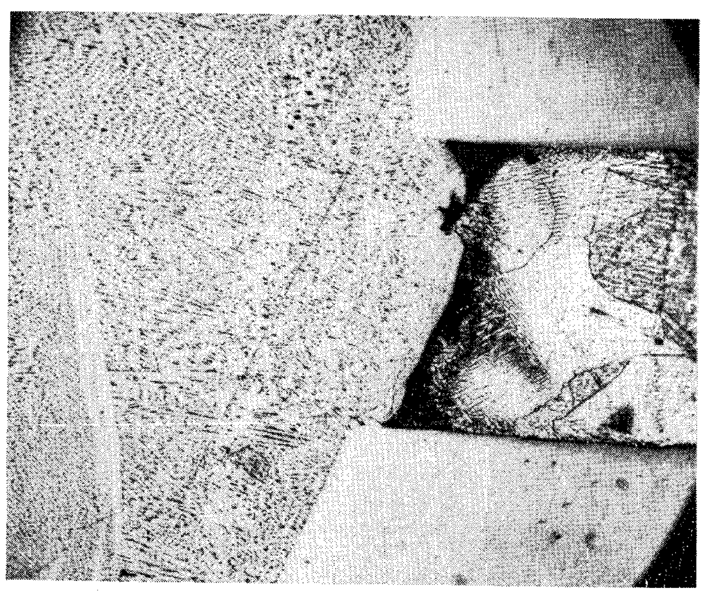


Plate 458 **Magnification** X40 **Etchant** $NH_4OH + H_2O_2$
Material Stainless Clad Copper (1/3 cu **From** American Cladmetals Co., Carnegie, Pa.
Remarks Other edge of sample shown in Plate 458A. No pickling. 1/16" diameter Type 347 filler rod used. All other welding conditions the same. No evidence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

FORM 1114
1M1247

ELLIOTT COMPANY

METALLURGICAL LABORATORY

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

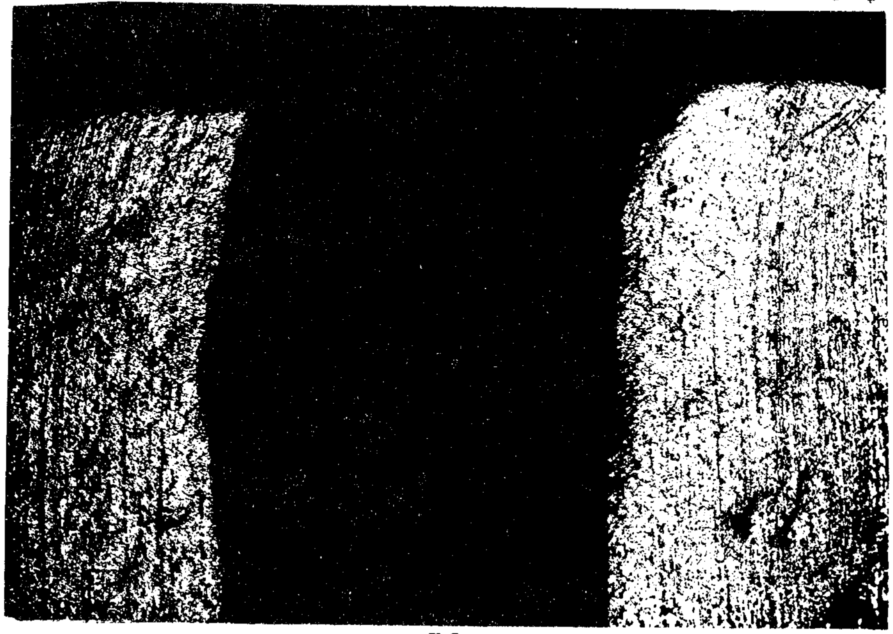


Plate 607 **Magnification** 50 **Etchant** None
Material Stainless Clad Copper **From** American Cladmetals Company
Remarks Type 309 Rosslyn Metal. Exposed for 118 hours at 1700°F. in electric furnace. Copper oxidized to a depth of approximately .042".

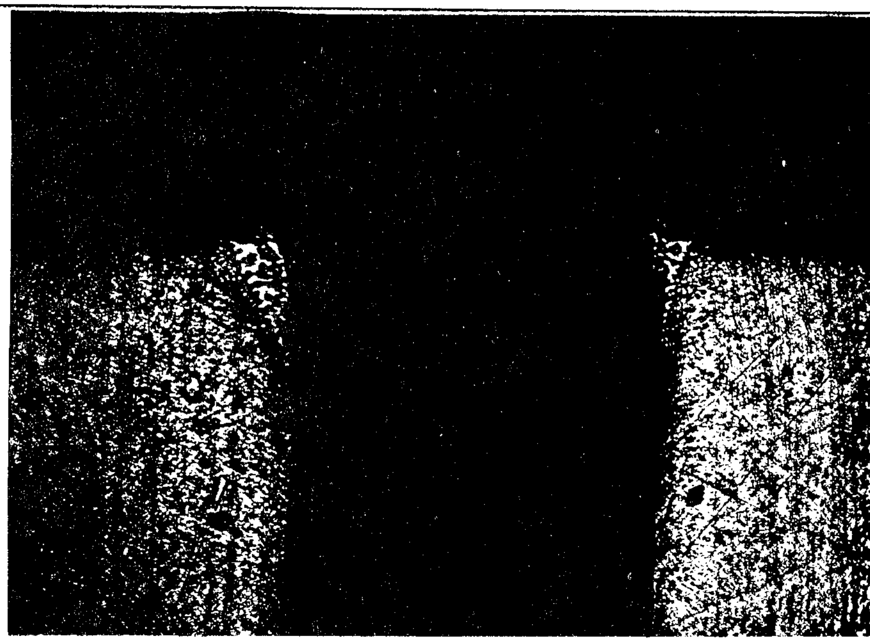


Plate 607A **Magnification** 50 **Etchant** None
Material Stainless Clad Copper **From** American Cladmetals Company
Remarks Type 309 Rosslyn Metal calorized by powder method by Calorizing Company of Wilkinsburg, Pennsylvania. Exposed for 118 hours at 1700°F. in electric furnace. Note absence of oxidation.

ELLIOTT COMPANY

METALLURGICAL LABORATORY

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

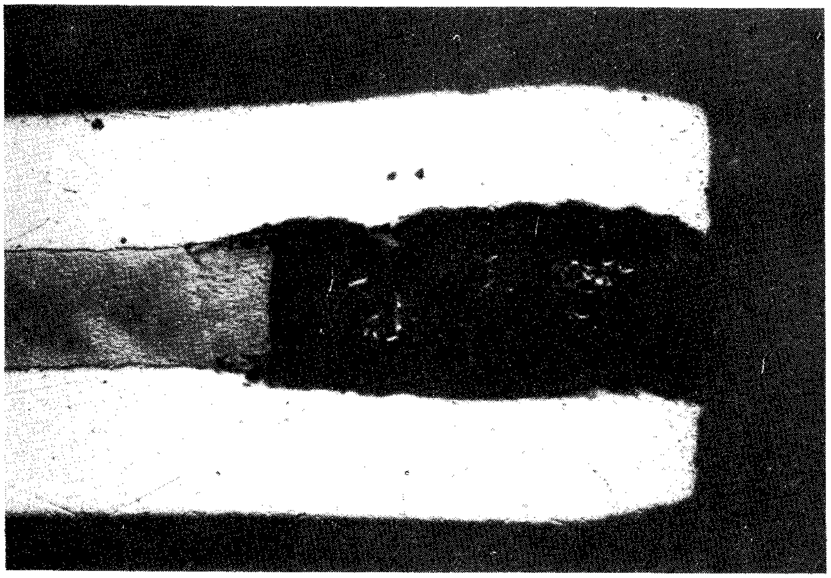


Plate 584 **Magnification** 50 **Etchant** None
Material Stainless Clad Copper **From** American Cladmetals Company
Remarks Type 302 Rosslyn Metal. Exposed for 744 hours at 1500°F. in electric furnace. Copper oxidized to a depth of approximately .044".

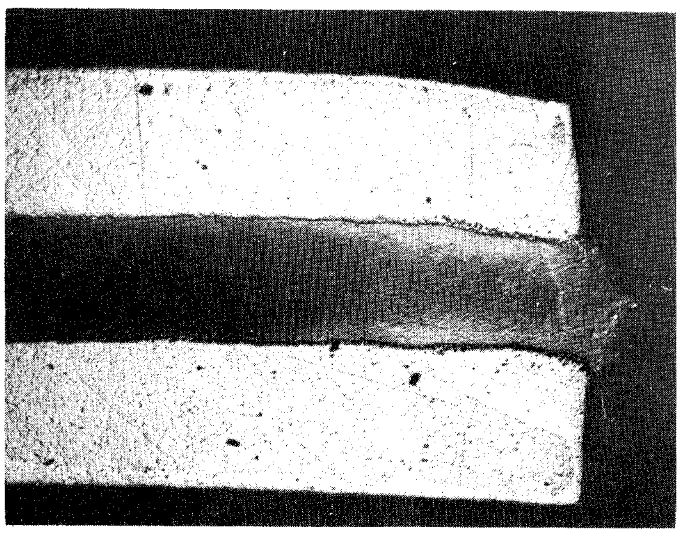


Plate 583 **Magnification** 50 **Etchant** None
Material Stainless Clad Copper **From** American Cladmetals Company
Remarks Type 302 Rosslyn Metal calorized by powder method by Calorizing Company of Wilkinsburg, Pennsylvania. Exposed for 744 hours at 1500°F. in electric furnaces. Note absence of oxidation.

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.

FORM 1114
1M1247

ELLIOTT COMPANY

METALLURGICAL LABORATORY

Date: September 12, 1949
Reference: D. Spec. 203.5
Metallographer: E.J.V.

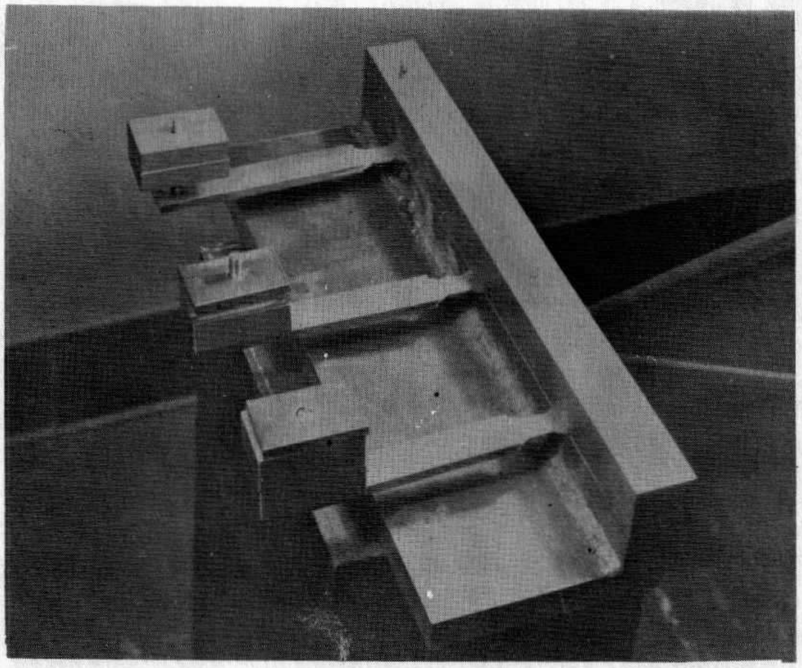


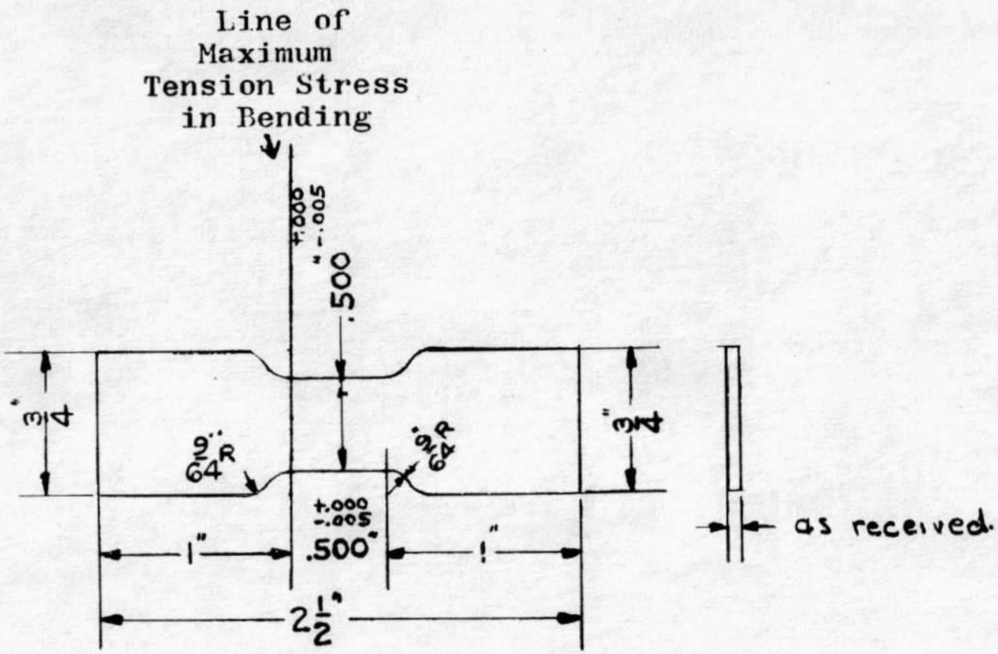
Plate 549-61 **Magnification** Approx. 1/4 **Etchant** None
Material Stainless & Inconel Clad Cu. **From** American Cladmetals Company
Remarks Photograph of set-up for copper embrittlement tests at elevated temperature.

FORM NO. 1126

S-240375

TOOL LIST

PROCESS SPECIFICATION



	PATT-FORG.	CAT. NO.	NO.	NAME OF PART & DESCRIPTION BAR STOCK SIZE DOES NOT INCLUDE STOCK ALLOWANCE	MAT'L.	SPEC.	FIRST ORDER

ENGR. CHANGES

Δ

WORKING TOLERANCES UNLESS OTHERWISE SPECIFIED

MACHINING	FABRICATING
±.010" TO 2"	±1/8" TO 24"
±.015" 2" TO 10"	±1/4" OVER 24"
±.030 OVER 10"	
ANGLES ±1/2°	

ALL THREADS CLASS 2 FIT

SURFACE ROUGHNESS

= 16, = 32, = 63, = 130, = 250, = 500, = 1000 MICRO INCHES

STAINLESS CLAD COPPER TEST SPECIMEN

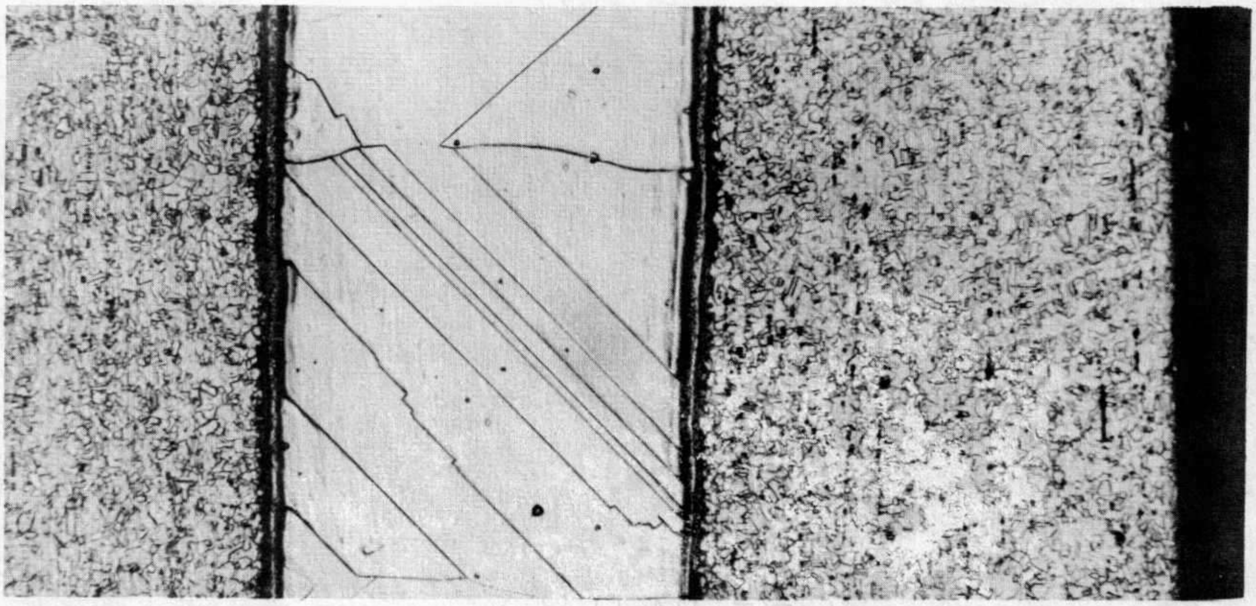
DR. [signature]	ENG. AP. [signature]	SCALE: FULL SIZE
CK. S.C.S	MFG. AP.	DATE 6-10-49
DES. AP.	MET. AP.	S. O.

ELLIOTT CO,
JEANNETTE, PA.

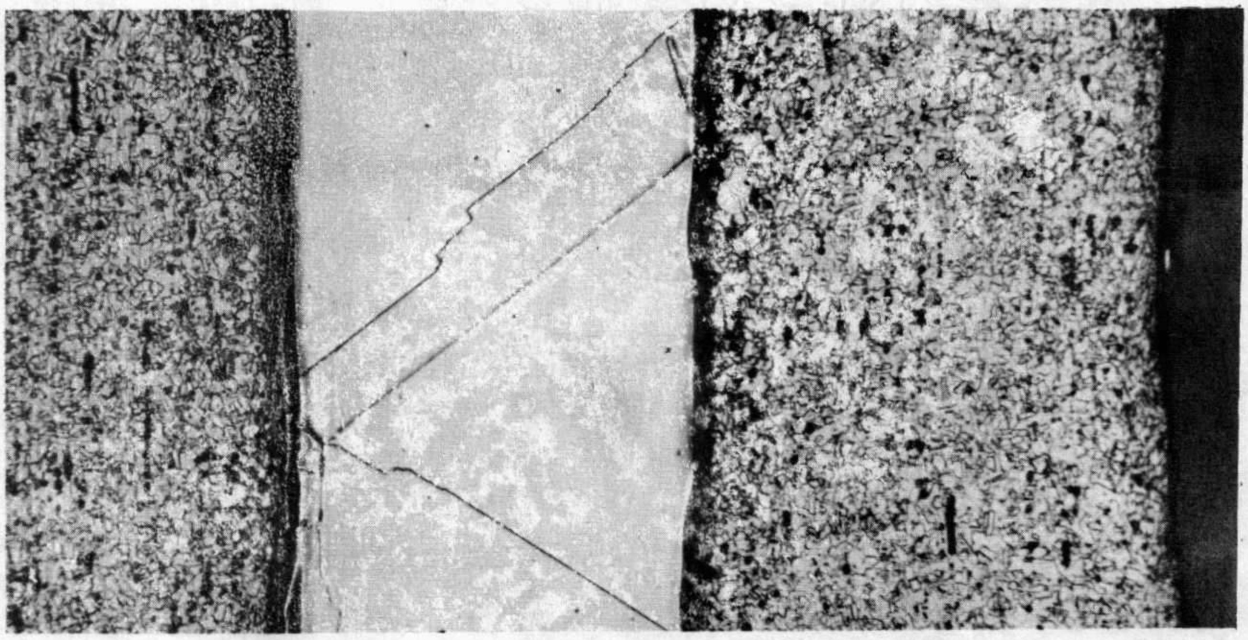
S-240375

Zenith A. ... SMITH CO. PGH., PA.

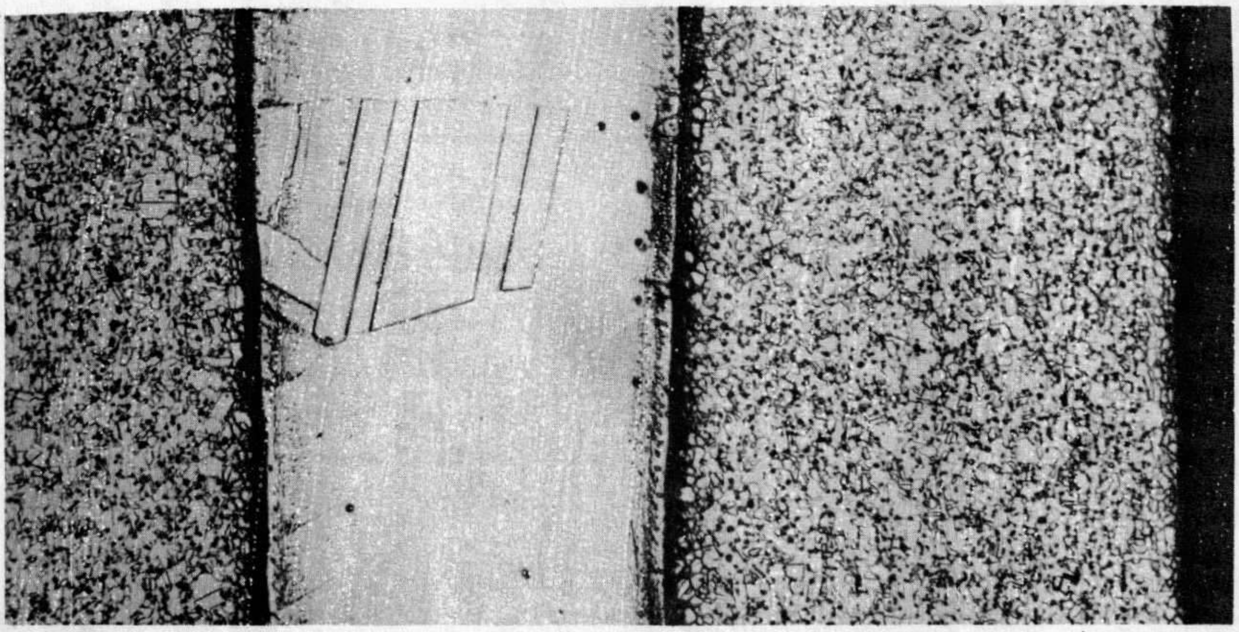
ASSEMBLY DWG. ______ SUPERSEDES ______ SUPERSEDED BY ______



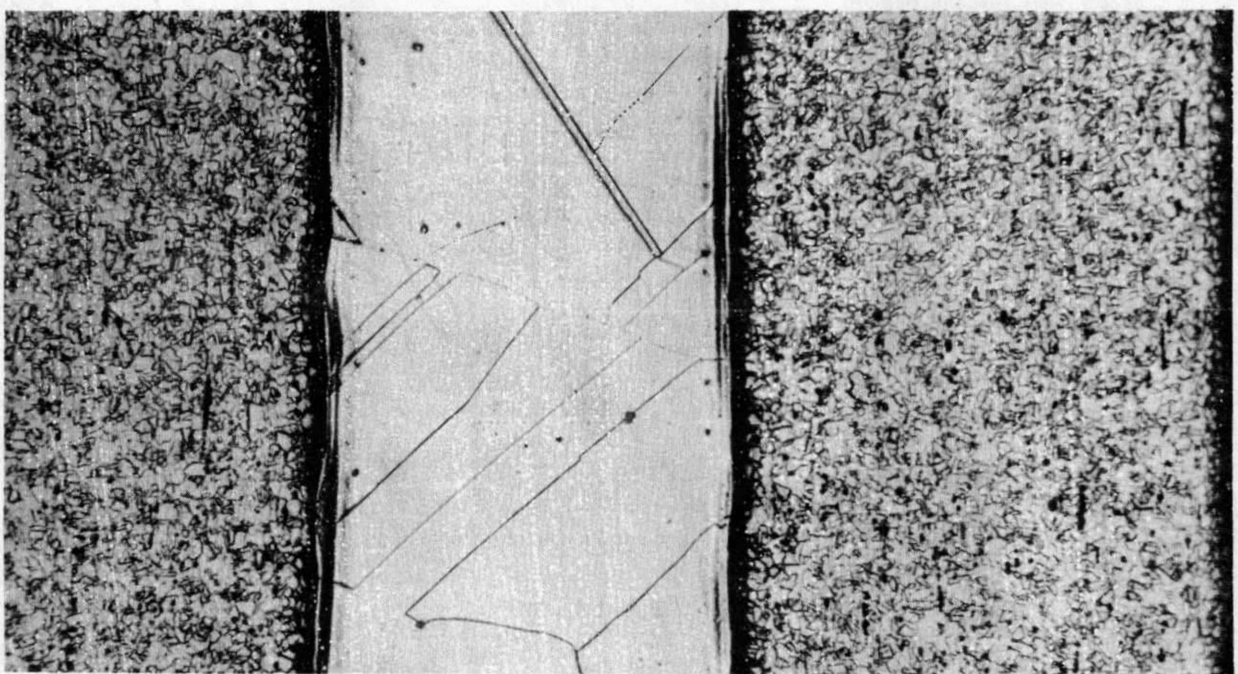
ROSSLYN METAL, TYPE 347 CLAD, AS RECEIVED. 200X



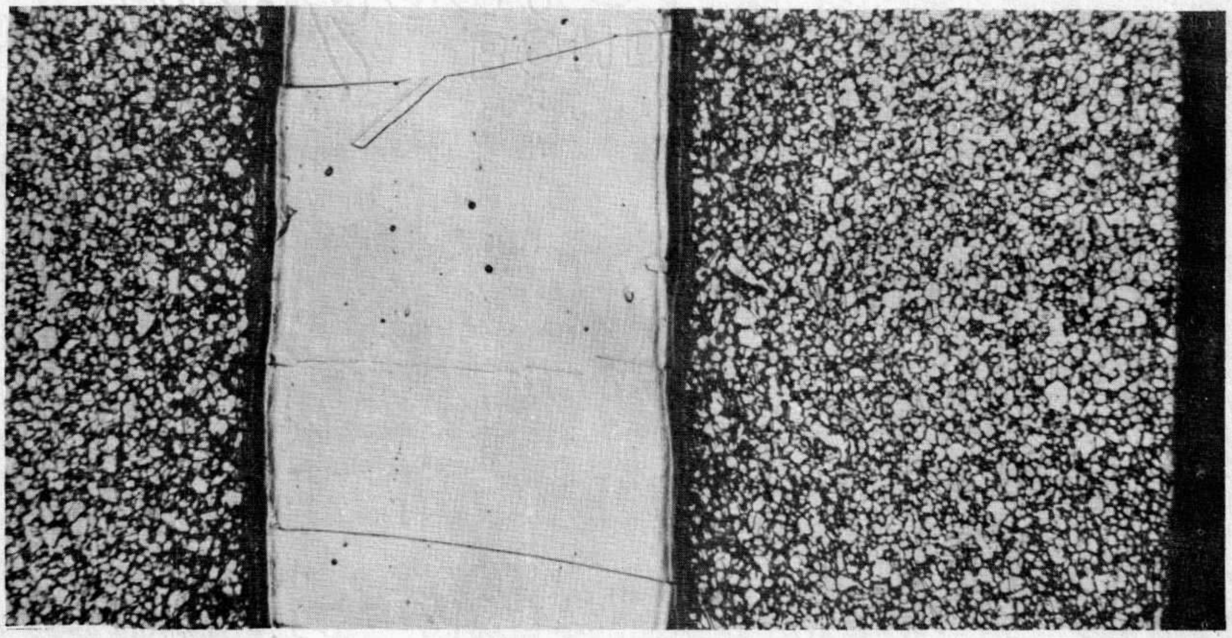
ROSSLYN METAL, TYPE 347 CLAD, DIFFUSION TREATED AT 900°F.
FOR 65 HOURS 200X.



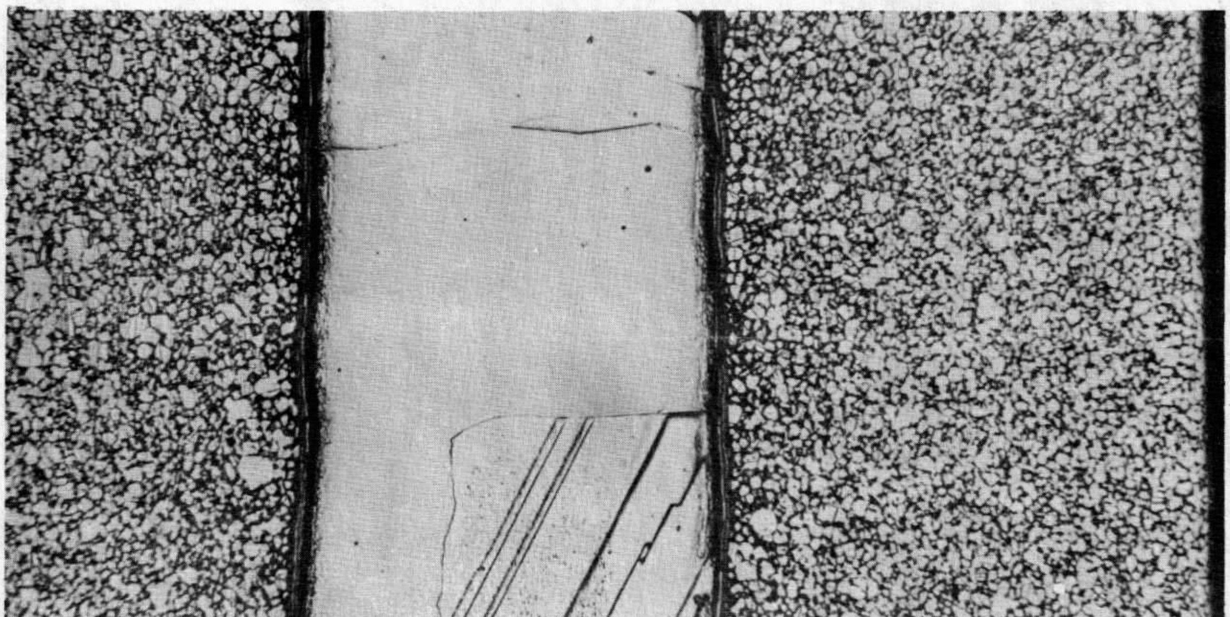
ROSSLYN METAL, TYPE 347 CLAD, DIFFUSION TREATED AT 1400°F. FOR 40 HOURS. 200X.



ROSSLYN METAL, TYPE 347 CLAD, DIFFUSION TREATED AT 1600°F. FOR 2 HOURS. 200X.



ROSSLYN METAL, TYPE 347 CLAD, DIFFUSION TREATED AT 1100°F.
FOR 24 HOURS. 200X.



ROSSLYN METAL, TYPE 347 CLAD, IFFUSION TREATED AT 1200°F.
FOR 30 HOURS. 200X.

ROSSLYN METAL FOR HEAT RESISTING APPLICATIONS

High Temperature Design

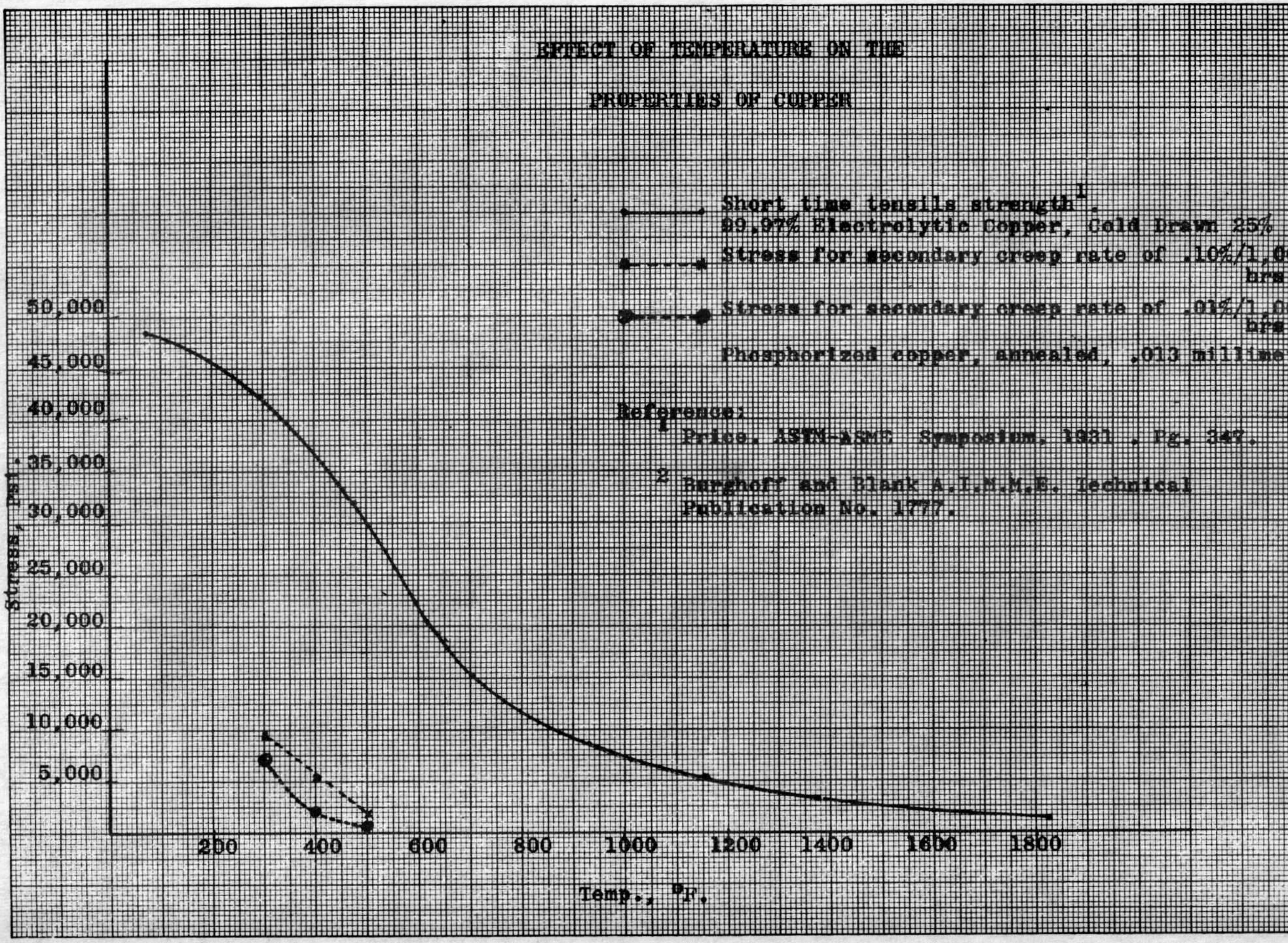
The most popular grades of ROSSLYN METAL for heat resisting applications have thus far been Inconel, Type 310 (25-20) stainless and Type 347 (18-8 columbium) stainless. The question naturally arises as to what factors should be used in design to allow for the copper core.

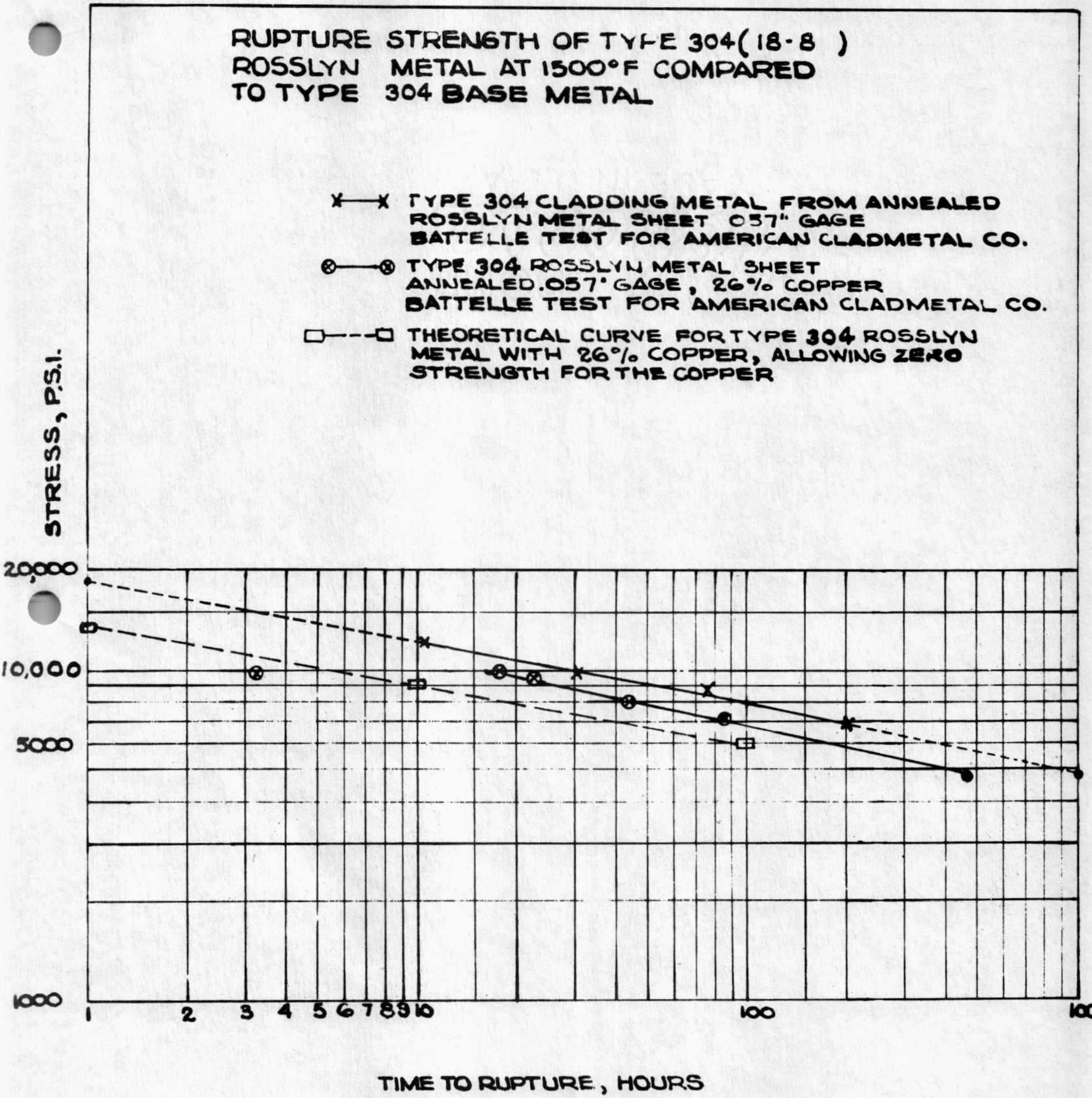
Copper has relatively low high temperature strength, as shown in the attached figure. Some exploratory work has been done to see how much reduction in the overall strength of the assembly should be allowed for the copper. The attached curve "Rupture Strength of Type 304 (18-8) ROSSLYN METAL at 1500° F. compared to Type 304 Base Metal" indicates that the following "rule of thumb" can be applied as an approximation: The percentage reduction in rupture strength at 1500° F. will be about 50% of the percentage of copper in the assembly. Thus if 30% of copper is present, the overall strength reduction at 1500° F. is about 15%. This is not quite as much reduction as the reduction in room temperature tensile strength, which is approximately 65% of the percentage of copper in the assembly.

High temperature design data for the various grades of cladding has been published widely in recent years. However, for ready reference we are attaching design curves giving rupture and creep strength for the three clad materials mentioned above.

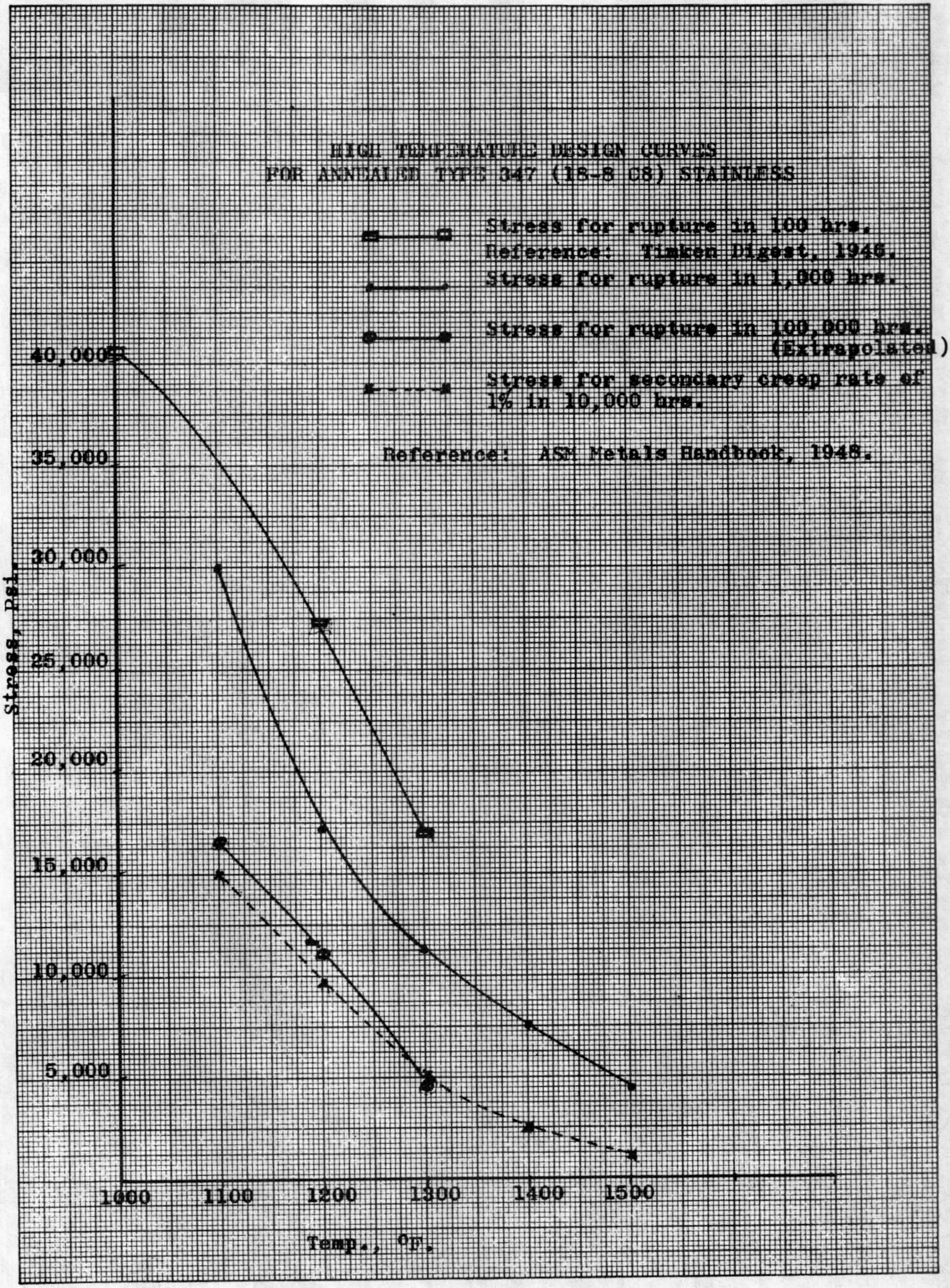
Thermal expansion curves are attached for copper, Types 347 and 310 stainless and Inconel. For most purposes of design it should be satisfactory to work with the values for the cladding material.

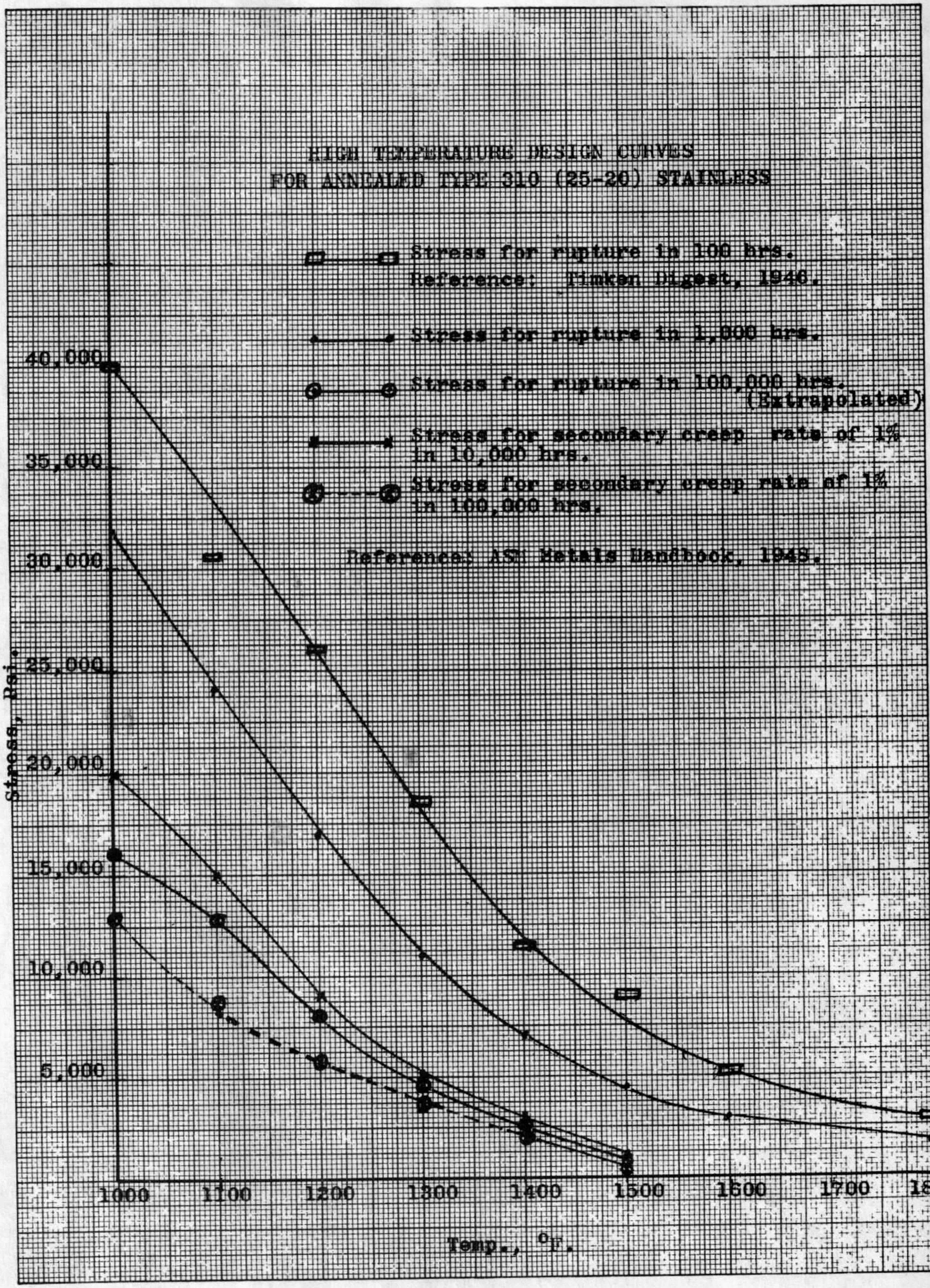
For estimating purposes, based on confirmed laboratory data the strength of a given ROSSLYN METAL sheet at room temperature to 500°F. should be taken to be at least the strength of a sheet of the solid stainless metal component having a thickness equal to the given ROSSLYN METAL sheet less 2/3 the thickness of its copper core; the 2/3 factor becomes 1/2 in the temperature range from 500° - 1500°F. where ROSSLYN METAL appears relatively stronger than at lower temperatures. Thus on standard 30% copper core ROSSLYN METAL, 80% of the total gage may be used in design at the rated strength of the cladding from room temperature to 500°F., 85% of the total gage may be used from 500°F. to 1500°F.

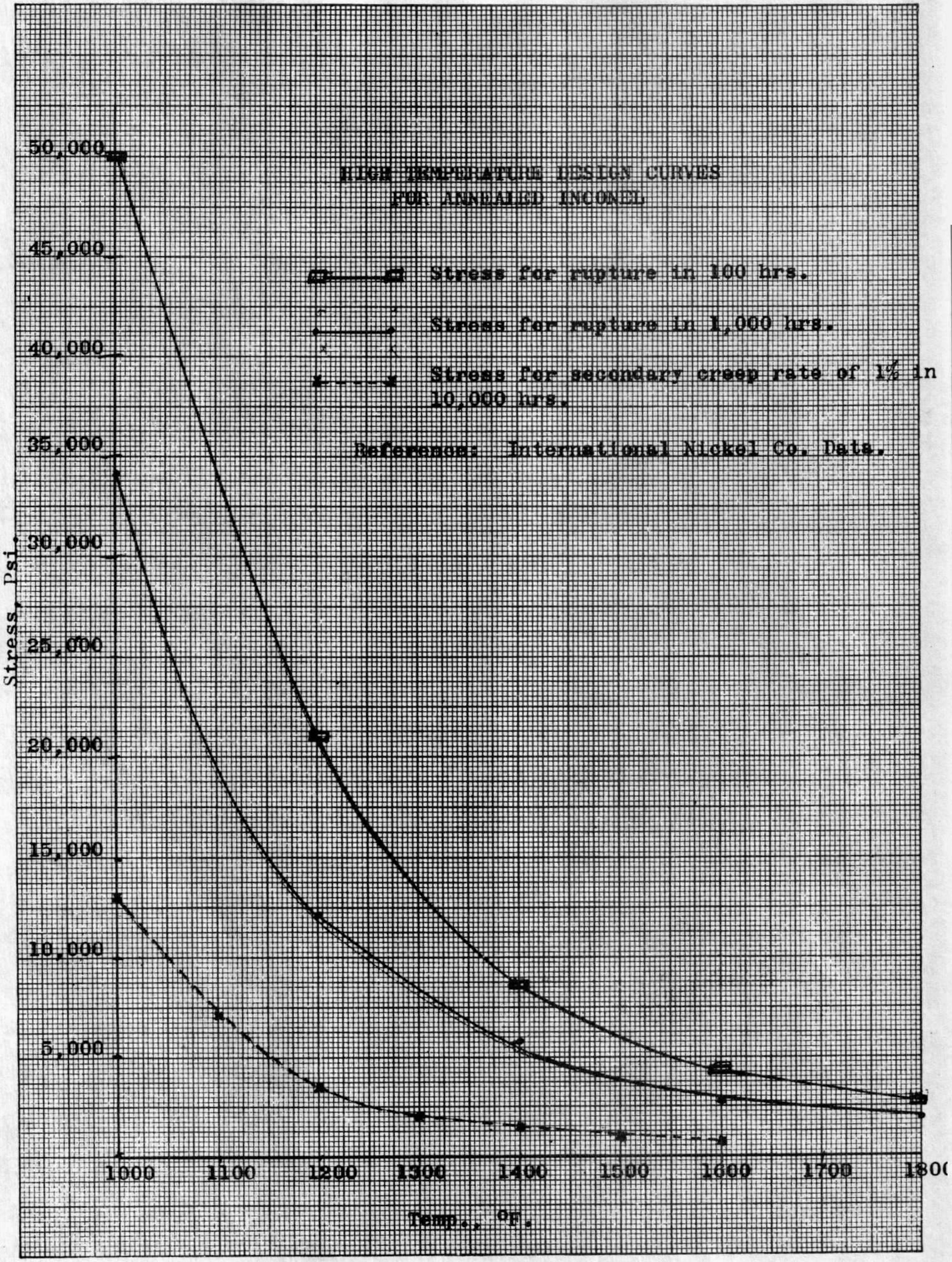

EFFECT OF TEMPERATURE ON THE
PROPERTIES OF COPPER
Short time tensile strength[1].
99.97% Electrolytic Copper, Cold Drawn 25%
Stress for secondary creep rate of .10%/1,000 hrs.[2]
Stress for secondary creep rate of .01%/1,000 hrs.[2]
Phosphorized copper, annealed, .013 millimeter.
Reference:
1 Price. ASTM-ASME Symposium, 1931 , Pg. 347.
2 Burghoff and Blank A.I.M.M.E. Technical Publication No. 1777.
Stress, Psi.
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
200
400
600
800
1000
1200
1400
1600
1800
Temp., °F.

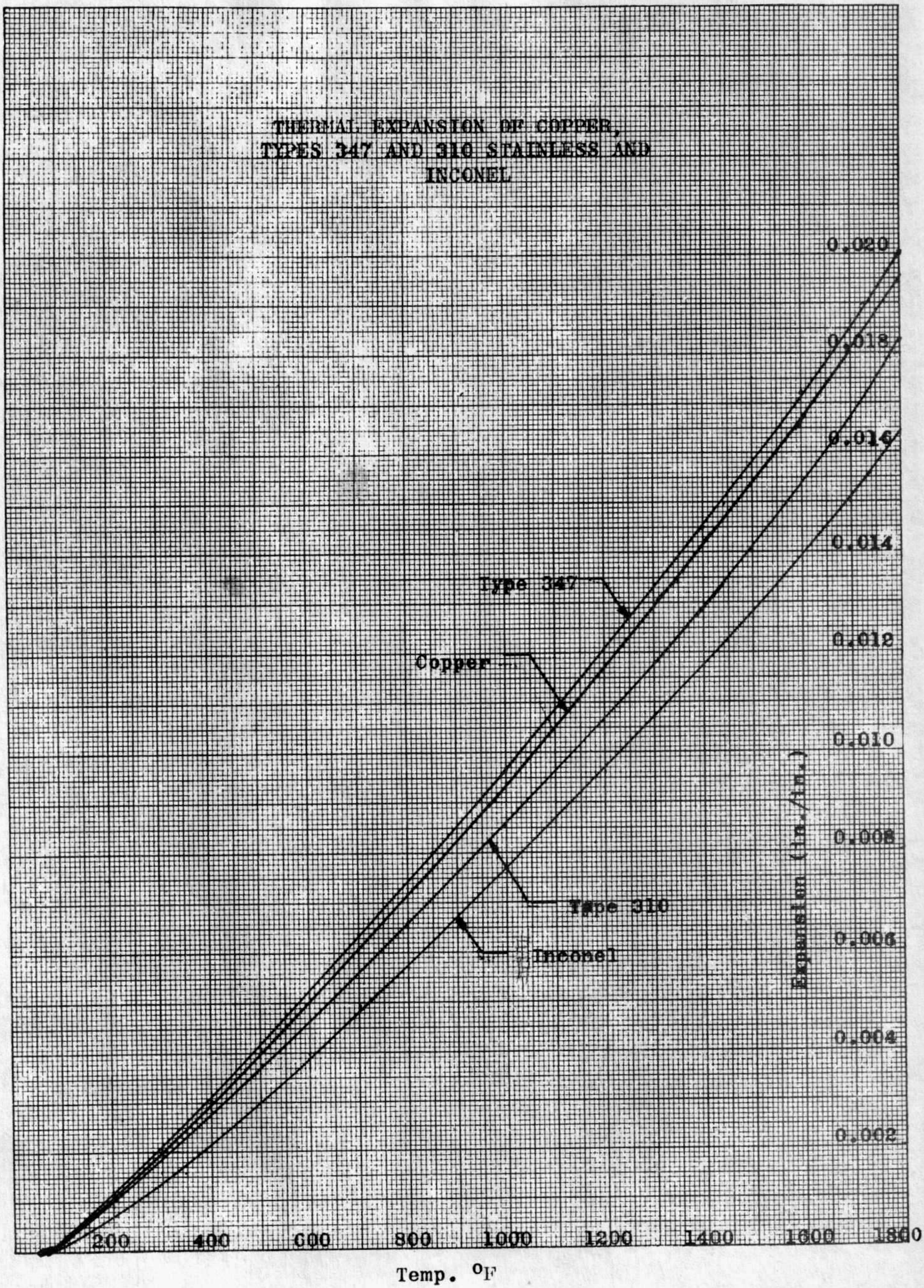


C.T. EVANS, JR. 10-8-49


HIGH TEMPERATURE DESIGN CURVES
FOR ANNEALED TYPE 347 (18-8 CB) STAINLESS
Stress for rupture in 100 hrs.
Reference: Timken Digest, 1946.
Stress for rupture in 1,000 hrs.
Stress for rupture in 100,000 hrs. (Extrapolated)
Stress for secondary creep rate of 1% in 10,000 hrs.
Reference: ASM Metals Handbook, 1948.
Stress, Psi.
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
1000
1100
1200
1300
1400
1500
Temp., °F.


HIGH TEMPERATURE DESIGN CURVES
FOR ANNEALED TYPE 310 (25-20) STAINLESS
Stress for rupture in 100 hrs.
Reference: Timken Digest, 1946.
Stress for rupture in 1,000 hrs.
Stress for rupture in 100,000 hrs. (Extrapolated)
Stress for secondary creep rate of 1% in 10,000 hrs.
Stress for secondary creep rate of 1% in 100,000 hrs.
Reference: ASM Metals Handbook, 1948.
Stress, psi.
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
1000
1100
1200
1300
1400
1500
1600
1700
1800
Temp., °F.


HIGH TEMPERATURE DESIGN CURVES
FOR ANNEALED INCONEL
Stress for rupture in 100 hrs.
Stress for rupture in 1,000 hrs.
Stress for secondary creep rate of 1% in 10,000 hrs.
Reference: International Nickel Co. Data.
Stress, Psi.
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
1000
1100
1200
1300
1400
1500
1600
1700
1800
Temp., °F.


THERMAL EXPANSION OF COPPER, TYPES 347 AND 310 STAINLESS AND INCONEL
Type 347
Copper
Type 310
Inconel
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
Expansion (in./in.)
200
400
600
800
1000
1200
1400
1600
1800
Temp. °F

ROOM TEMPERATURE LONGITUDINAL PHYSICAL PROPERTIES OF ANNEALED ROSSLYN METAL

Grades of Cladding	Thickness	Modulus of Elasticity Psi.	Proportional Limit Psi.	Yield Strengths, Psi.		Ultimate Tensile Strength Psi.	% Elong.
				0.1% Offset	0.2% Offset		
Type 302 Stainless	.0753	22,200,000	30,900	47,600	49,100	85,100	56.0
Type 310 Stainless	.0575	22,200,000	18,400	33,800	37,300	86,300	60.5
Type 347 Stainless	.0318	21,400,000	22,300	30,500	31,600	64,200	48.0
Inconel	.0501	23,600,000	23,900	44,300	48,100	81,900	31.0

All tests were made by Pittsburgh Testing Laboratory, Pittsburgh, Pa.

All samples contained approximately 30% copper in the core.

Longitudinal and transverse bend tests 180° around pins with diameters approximately 3X sheet thickness were made with no cracks or fractures.

PHYSICAL CONSTANTS OF VARIOUS CLADDING METALS AND COPPER

	Type 347 Stainless[1]	Type 310 Stainless[1]	INCONEL[2]	COPPER[3]
Modulus of Elasticity, Psi.	28,000,000	29,000,000	31,000,000	17,300,000
Density, lb. per cu. in.	0.29	0.29	0.307	0.322
Specific Resistance, 70° F. microhms per cu. cm.	73	78		1.27
Specific Heat (32-212° F.) BTU/lb./°F.	0.12	0.12	0.109	0.0917 (at 77° F.)
Melting Range, °F. Solidus	2550	2550		
Liquidus	2600	2650	2540	1981

References:

1. ASM Metals Handbook. 1948
2. International Nickel Co. Data
3. Kent's Handbook. 11th Edition

ROSSLYN METAL FOR HEAT RESISTING APPLICATIONS

Physicals Constants, Room Temperature Properties, Forming, Annealing, Pickling

Physical Constants and Room Temperature Physical Properties

To aid in designing and forming equipment from ROSSLYN METAL tables of physical constants of various cladding material and copper and a table of room temperature physical properties for ROSSLYN METAL are given on following pages. Other fundamental properties, such as thermal conductivity and thermal expansion, are covered in separate sections.

Blanking

ROSSLYN METAL blanks without difficulty. Care should be used to prevent clad metal and copper drag over on the blanked edges, by using a neat, close, clearance between the punch and the die.

Forming

The core of copper lends exceptional ductility and formality to ROSSLYN METAL.

It will be easier and consequently less expensive to form a given part from ROSSLYN METAL than from the same gauge of solid cladding metal. Unusually deep draws are possible and intermediate annealing steps can be less frequent.

When deep drawing ROSSLYN METAL, it is important that the shop practice be adapted to the physical properties of ROSSLYN METAL. ROSSLYN METAL appears to be the same as a solid section except upon close examination of the sheared edge.

Hold down pressures should be considerably reduced where ROSSLYN METAL is being cold drawn so as to prevent excessive stretching of the metal. ROSSLYN METAL should be drawn so as to form the part with a minimum of stretching. Die lubricants recommended for the cladding metal should be used.

The initial finish (#1, #2, etc.) ordered in the sheet from the mill may correspond with the usual purchasing practices for the cladding material, with the expectation that the final finish on the ROSSLYN METAL part will be at least equivalent to the same part made from solid cladding metal.

Figure 65 illustrates the forming sequence used in making a Type 302 ROSSLYN METAL, stock pot 12" dia. x 12" deep x .078" gauge. The Olson cup test values listed below are further evidence of excellent deep drawing qualities.

Figure No. 65

An illustration of various steps in drawing a deep stock pot from blank through three draws to finished article.

DUCTILITY INDEX

OLSEN CUP TEST VALUES

Grade of "ROSSLYN METAL"	Depth of Button, In.	Thickness of Specimen, In.	Gauge
Type 302	.460-.515	.078	14
	.435-.465	.050	18
	.425-.475	.037	20
	.435-.480	.025	24
Type 304	.480-.550	.078	14
	.445-.495	.050	18
	.435-.495	.037	20
	.470-.490	.025	24
Type 305	.460-.550	.078	14
	.455-.490	.050	18
	.435-.485	.037	20
	.430-.470	.025	24
Type 347	.450-.490	.078	14
	.430-.480	.050	20

Spinning

Spinning may be accomplished on ROSSLYN METAL at somewhat higher speeds than would be used on stainless steel. Free-spinning type 305 ROSSLYN METAL has been spun at about two-thirds the speed used on copper.

We quote below from a letter received from one of our customers who is spinning ROSSLYN METAL, as we feel that this information may be helpful.

> "In the spinning process, we find that the height of spinning should be kept to 1/2 of the diameter (providing the diameter is not over 8", if greater diameter is used, this ratio decreases gradually). We found that the best tool to use was one having a formula of: Carbon - 3.00%, Nickel - 2.50% - 3.00%, Chromium - .75% - 1.00%, Silicon - 1.20% - 1.50%.
>
> As a lubricant, we use tallow base laundry soap. We run our machinery at one-half the speed we use on aluminum. We use as may breakdowns as on stainless steel, although it spins easier than spinning quality stainless."

Tallow-base laundry soap has proven to be a good lubricant.

Mechanical Finishing

Grinding and buffing operations, if required, should correspond to the same procedures which have been effective with the cladding metal.

Annealing

When intermediate anneals are required between forming operations, an annealing temperature of 1650°F. is recommended if "pebbling" or "orange peel" is to be avoided on the final surface. Where this effect is unimportant (as in most heat resisting applications) an annealing temperature of 1750°F. should be used.

Where service conditions will involve long-time exposure above 1200°F., a finish anneal at 1750°F. is recommended for maximum strength.

Time at temperature will vary according to the furnace used, size and gauge of part, and whether or not the annealing process is batch type or continuous. A rough general rule which is suggested is five minutes at temperature up to .020" plus one minute for each .010" thickness of Rosslyn Metal or part thereof.

It should be remembered that the high heat transfer of the copper core in the ROSSLYN METAL will shorten the required total time considerably from that required for the same gauge of solid cladding metal.

Induction annealing is not effective with ROSSLYN METAL, due to high conductivity of the copper core.

Pickling

Here again, identical procedures may be used to those applicable to the cladding metal. A suggested chemical solution for removing scale resulting from annealing is:

Nitric Acid (42° Baumé)	13%
Hydrofluoric Acid (60%)	6%
Water	81%
Temperature	150°F
Time	5 Minutes

Metallic Arc Welding of "ROSSLYN METAL"

When considering the welding of "ROSSLYN METAL" in a butt joint, the conditions in the weld must be studied from various viewpoints. The type of rod used should be designed to give weld metal analysis which will give strength, ductility and corrosion resistance, equal to the parent metal. It is well known that ordinary 18-8 can absorb 4% of copper in solution without deleterious effect on its corrosion resistance or its ductility, in fact, a small copper addition up to 4% enhances the corrosion resistance to sulphuric acid of the 18-8 stainless steels, as well as making these metals less subject to work hardening.

We, therefore, can proceed in the development of a welding procedure which will minimize the copper pickup so as to hold it within safe limits. In order to accomplish this purpose, therefore, it is obvious that the current used must be the minimum current which can be used and at the same time achieve proper fusion. The copper in "ROSSLYN METAL", due to its high heat conductivity, has little tendency to melt down in the weld puddle. The heat is carried away from the weld puddle at such a rapid rate that the stainless molten metal casts itself against the copper with a minimum of fusion.

Assuming that this condition represents the factual limitations, it is logical, therefore, to develop a fitup which will permit the stainless weld to be made on the bottom layer of stainless with a minimum of copper being melted. When a joint is made with the two sections of "ROSSLYN METAL" very close together, the only way in which the bottom layer of stainless can be fused is to melt the copper which, on a close fitup, lies between the arc and the bottom layer. It is necessary that a wider gap be used between the sections to be welded, so as to permit the arc to fuse the bottom layer of stainless without having to melt through copper. Beveling the edges to be welded for a 90° included angle will also help prevent excessive copper pickup. When the proper gap between the pieces which are to be welded is prepared, the bottom layer of stainless can be fused, and the metal frozen with a chill bar beneath the joint. The molten metal then will fill up the gap in the copper layer and a minimum copper pickup will be encountered because of the chilling effect which the copper has on the molten metal in the welding puddle. The top layer of stainless will then be fused because of the relatively poor conductivity of the stainless and the tendency of the stainless to fuse into the weld puddle rather than disperse the heat of the weld puddle laterally away from the welded seam. See Figure 1.

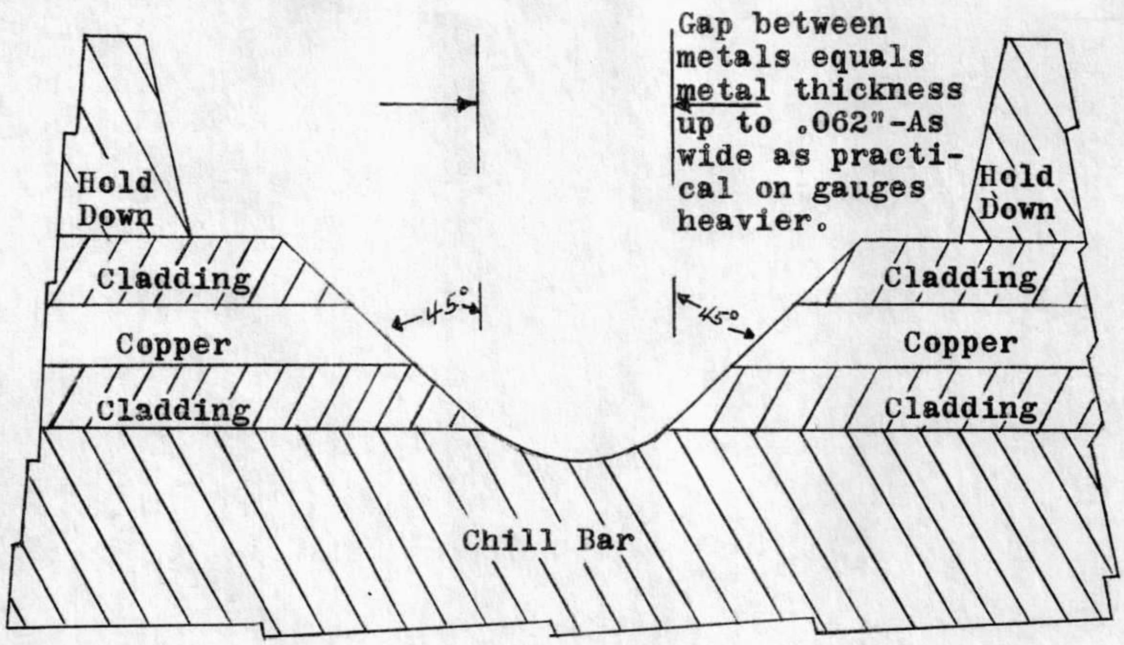


Figure #1

The current to be used should be accurately controlled and the voltage-amp characteristics should be the minumum which will give proper fusion. The use of 3/32" or smaller electrodes coated for direct current is recommended. When welding ROSSLYN METAL, a very short arc should be used and the current should be reversed as in solid stainless welding.

It is well known that nickel and copper will go into solution in all proportions, so a high nickel bearing rod should be used. It is suggested that either Inconel or 80 nickel, 20 chrome analysis rod be used regardless of the type of ROSSLYN METAL being welded. With a high nickel content, the copper pickup has less effect than in the case of the lower nickel stainless alloys. The welding rod best suited to a particular job must be developed in connection with the gauge of the material and the design of the joint. A combination of these factors along with shop practice will determine the proper rod to be used in any particular case.

It is highly recommended that ROSSLYN METAL be welded in a jig incorporating a chill bar. This chill bar in the heavier sections may be copper with a groove below the seam, machined about 1/4 as deep as it is wide. This copper chill bar will simplify the fusing of the bottom layer without losing the puddle.

In all gauges, it is desirable to bevel the edge to be welded so as to simplify the welding of the bottom stainless. When welding ROSSLYN METAL of a heavier gauge, it is desirable to make a multiple pass weld. The first bead is designed to fuse the bottom layer of stainless. After depositing the first bead, the weld is cleaned thoroughly and subsequent layers of weld are fused to the previous bead. In this way, the weld groove may be filled with filler metal with a minimum of copper pickup.

Following the welding suggestions mentioned, welds have been made and a typical test result is as follows:

Ultimate Tensile Lbs.	Psi.	Gauge Lengths Before	After	% Elong.	Cross Section Before	After	Red. in Area
2635	69600	2.00	2.50	25	.505 x .075	.410 x .068	26.4
		1.00	1.28	28			

Specimens fractured in parent metal.

This weld was made on .078" thick Type 302 ROSSLYN METAL with a 3/32" 80% nickel, 20% chrome coated electrode. The weld was a single-sided butt weld made with a copper backup plate using a .078" gap and a 90° included angle bevel.

A photomicrograph of the weld is shown in Figure 2.

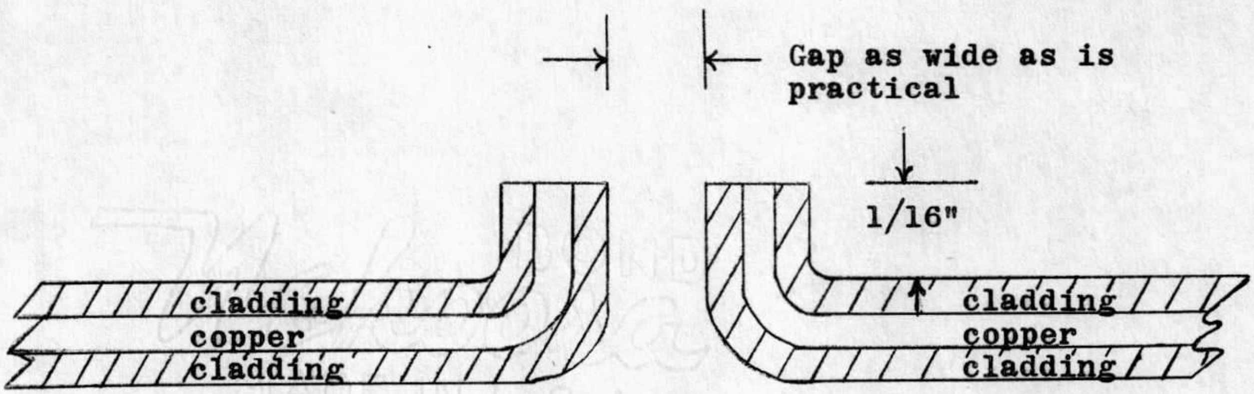


Figure #2

FORM 1114
1M1247

ELLIOTT COMPANY

METALLURGICAL LABORATORY

Date: August 4, 1949
Reference: CTE
Metallographer: CLC

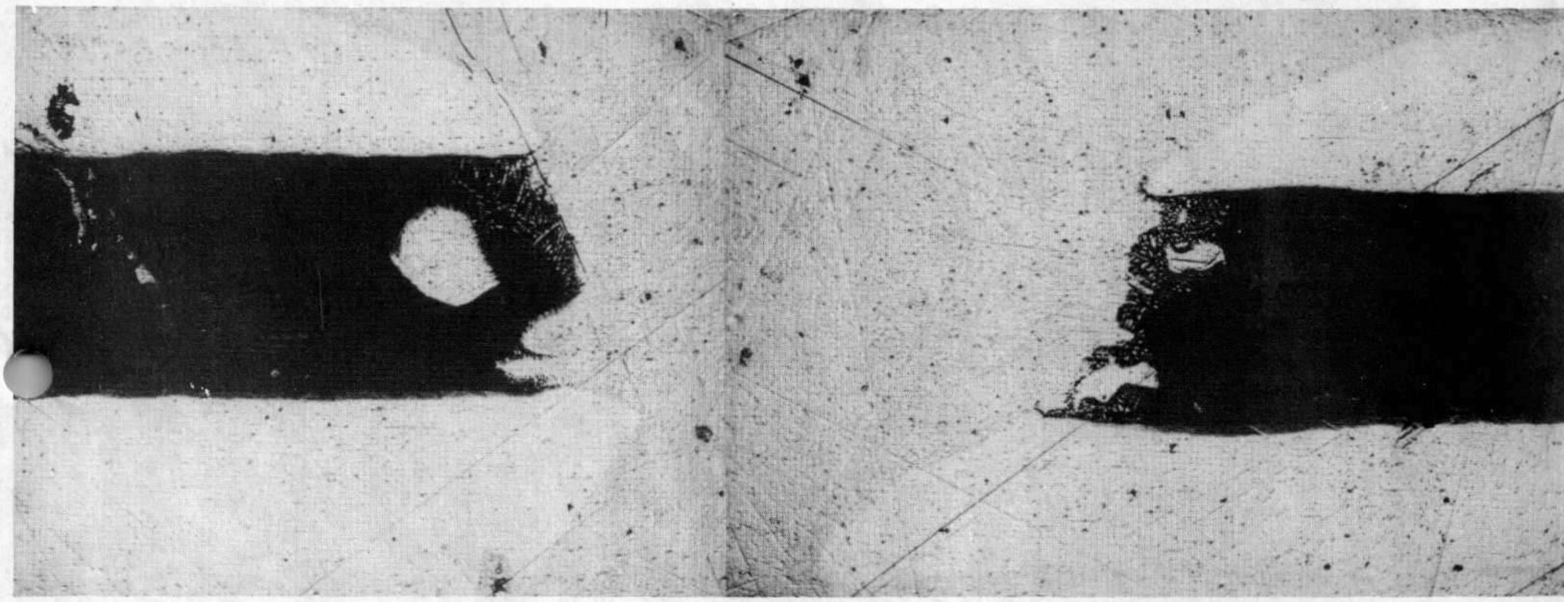


Plate 512 A and C Magnification 50X Etchant Amm. Persulfate

Material From

Remarks Weld of stainless clad copper - RMW-1. .078" thick Type 302 Rosslyn Metal welded with 80% Ni - 20% Cr electrode. Single-sided butt weld into copper backup. .078" gap, 90° included angle, 3/32" diameter electrodes. Transverse section about 1" from end of weld.

Inert Arc Welding of "ROSSLYN METAL"

ROSSLYN METAL is readily weldable by the inert arc method. The fitup and welding bevel are the same as described under the discussion of metallic arc welding. This fitup and chill bar arrangement allows for the deposition of 80-20 filler metal to fill the welding groove. By filling the 90 degree welding groove with 80-20 filler, using the minimum current commensurate with proper fusion, the copper pickup is kept very low.

When welding ROSSLYN METAL from both sides where a 100% joint is not required, a satisfactory weld may be made with a close unbevelled fitup, as in metallic arc welding, using very little filler of the same type as the cladding, or none at all.

In inert arc welding, as in metallic arc welding, a multiple pass weld with small filler rod and low heat is preferable to a one pass weld on heavier material using a larger filler rod with correspondingly higher current.

Spot and Seam Welding

ROSSLYN METAL may be spot and seam welded satisfactorily following procedures suitable to the material. The pressure and/or current used must be adjusted to meet the electrical and metallurgical properties of ROSSLYN METAL. Generally speaking, either the pressure or the current must be increased over the settings used for a solid section similar to the cladding. The findings of several customers in developing successful resistance welding techniques for ROSSLYN METAL are described below.

Customer No. 263

This customer makes combustion chamber inner liner of Inconel type ROSSLYN METAL and reports satisfactory roll welds.

The metal total thickness is .035", including .012" Inconel cladding on each surface of the sheet.

Some of the welds were entirely within the Inconel while some of the welds were alloyed with the copper, but both were sound and had adequate penetration.

Procedure: Resistance roll welds on the copper clad with Inconel on Machine No. 3095 using the following settings were made:

Pressure, PSI	1000
Heat	82%
Cycles	3 on, 24 off
Speed, IPM	18
Transformer Tap	4 - 4
Electrode width, inches	3/8
Electrode contour radius, inches	6

Cross sections of the weld at 30x were photographed.

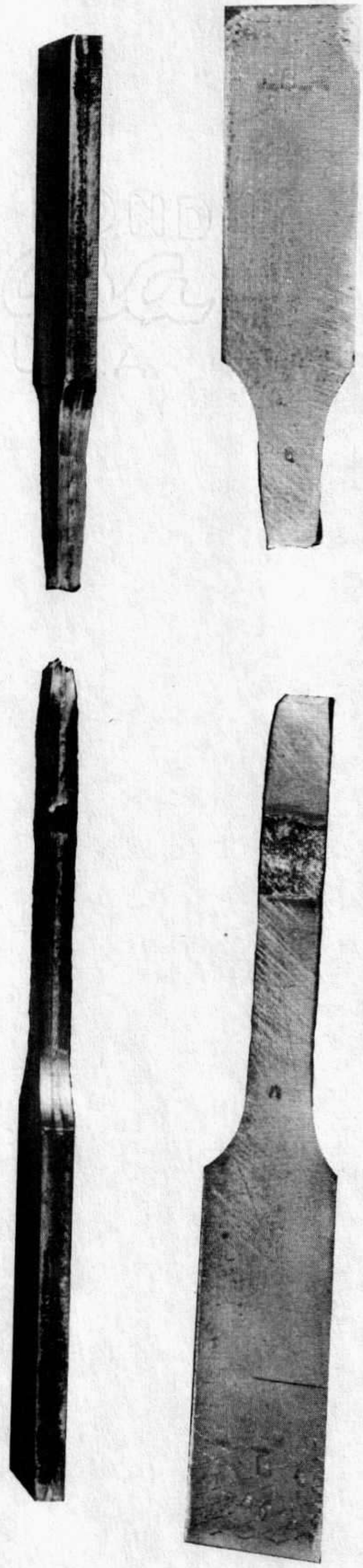
Customer No. 263-A

This customer reports that Type 302 ROSSLYN METAL .040" thick and Inconel type ROSSLYN METAL .046" thick were spot welded, thus joining two pieces of ROSSLYN METAL.

Procedure: Resistance spotwelds of apparently good quality were made on Machine No. 3676 using the following settings:

Pressure, PSI	1200
Heat	55%
Cycles	9
Electrode diameter, inches	1/4
Electrode contour radius, inches	3

Samples of each spotweld test were tension tested.



Structure of the welded materials after 24 hours at 1400° F. show no evidence of copper contamination of the Inconel or stainless steel; although a high percentage of the carbides in the grain boundaries of the Inconel dissolved while the stainless steel became severely sensitized, i. e., carbide precipitated into the grain boundaries.

Microsections were prepared to show copper and Inconel alloyed to form a good nugget at the faying surfaces of the Inconel sheets; weld is free of voids and there are no unmelted Inconel inclusions in the weld; welds tensile tested had strengths from 1170 lbs. to 940 lbs. minimum.

Customer No. 230

Customer spot welded ROSSLYN METAL Type 347 .030" thick to solid Type 302-1A stainless steel .060" thick in manufacturing an engine mount flame shield.

Minimum single spot shear strengths established by Specification AN-W-32 for materials with ultimate tensile strengths of 90,000 PSI were easily obtained.

A 3/16" diameter, 10" R upper electrode, and a flat 5/8" diameter lower electrode were used. The radii used, i.e., the top, electrode contacted the stainless-clad copper.

Volts	4	4
% Heat	90	93
Cycles	6	6
Load (Lbs.)	770	770

50% penetration into ROSSLYN METAL and 80% penetration into the solid stainless was shown with nugget .150" diameter.

Customer No. 165

This customer shows a typical procedure for ROSSLYN METAL seam welding Type 347, joining together two similar sheets as follows:

Sample	Type	Gauge	Pressure PSI	Heat	Cycles	Speed IPM	Trans-former Tap	Electrode Width in Inches	Electrode Contour Radius Inches
#1	302	.040	1380#	2	on 3	1.5 RPM	Same	5/8"	9/16"
#2	302	.040	1380#	2	off 5	or	as	thick-	flat
#3	302	.030	1380#	1½	"	47"/min.	heat	water	working
#4	302	.030	1380#	1½	"	"	"	cooled	face
#5	302	.025	1380#	1	"	"	"	wheel	"
#6	302	.025	1380#	1	"	"	"	"	"
#7	302	.020	1380#	1	"	"	"	"	"
#8	302	.020	1380#	1	"	"	"	"	"

Remarks - Heat approximately 13,000 amps. 180 KVA Sciaky machine
Heat percentage - 1 = 22½%

Sample	Type	Gauge	Pressure PSI	Heat	Cycles	Speed IPM	Trans-former Tap	Electrode Width in Inches	Electrode Contour Radius Inches
#1	347	.040	1380#	1 3/4	on 3	1.5 RPM	Same	5/8"	9/16"
#2	347	.040	1380#	2	off 5	or	as	thick-	flat
#3	347	.030	1380#	1 1/2	"	47"/min.	heat	water	working
#4	347	.030	1380#	1 1/2	"	"	"	cooled	face
#5	347	.025	1380#	1	"	"	"	wheel	"
#6	347	.025	1380#	1	"	"	"	"	"
#7	347	.020	1380#	1	"	"	"	"	"
#8	347	.020	1380#	1	"	"	"	"	"

This customer says that he employs the same practice in seam welding ROSSLYN METAL sheets as in seam welding solid stainless steel sheets of the same gauge, excepting he increases pressure and decreases heat, and he remarks that good wheel alignment and shape is important.

Test pillows made with ROSSLYN METAL at one of the large aircraft plants tested considerably better than tests on solid section of the same analysis as the cladding.

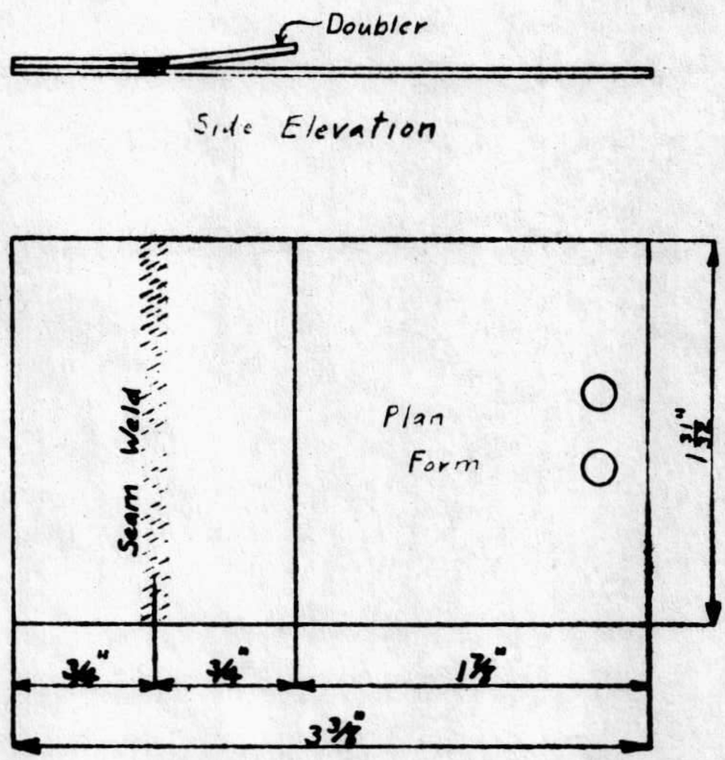
Figure No. ____ shows comparative fatigue values between ROSSLYN METAL and two solid seam welded alloy tests. It will be noticed that ROSSLYN METAL has fatigue values comperable to 19-9DL, which is a high temperature metal containing much more strategic alloy than ROSSLYN METAL.

Conclusion

The backlog of welding information is constantly increasing as ROSSLYN METAL gains acceptance in various applications. Engineers may proceed with confidence in designing a fabricated and welded article of ROSSLYN METAL. Our engineers will gladly make available all the welding information on a particular application and stand ready to help work out best practice on any proposed weldment.

We list below the welding technique used in making good inert arc welds on ROSSLYN METAL.

Type	Gauge	% Copper	Bend	Tensile	Yield	Elongation
321	.052	30	OK	74,000	38,900	35%
321	.052	30	OK	71,250	38,800	37.5%
321	.052	30	OK	74,500	37,500	48%
321	.052	30	OK	74,500	38,750	52%
321	.052	30	OK	72,250	38,400	47.5%



Sheet Specimens for Fatigue Bending Tests in a Krouse Machine

Fig. 1

DRAWN				PART NUMBER
APPROVED				
APPROVED				

REVISED

ISSUED

FORM 404

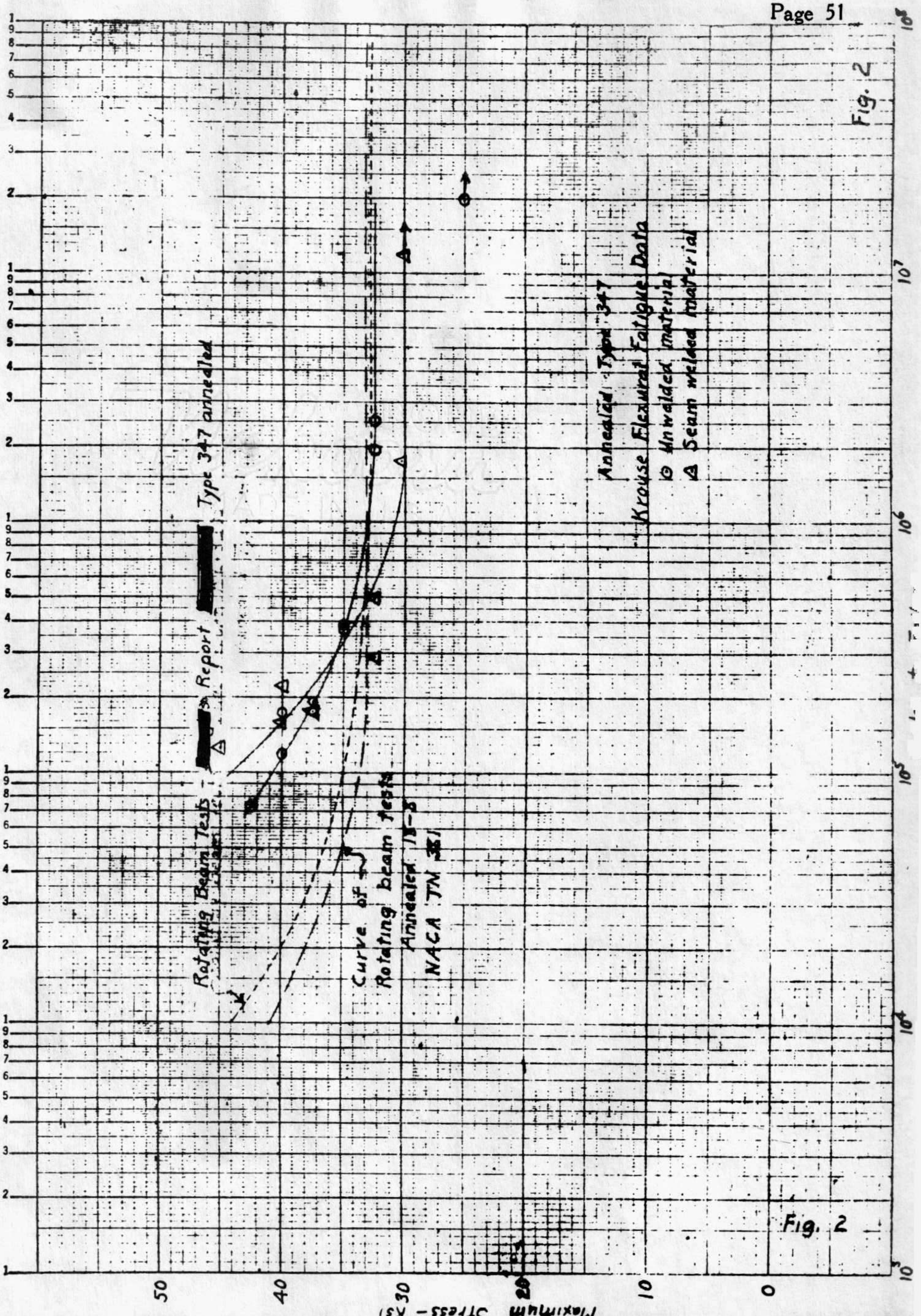
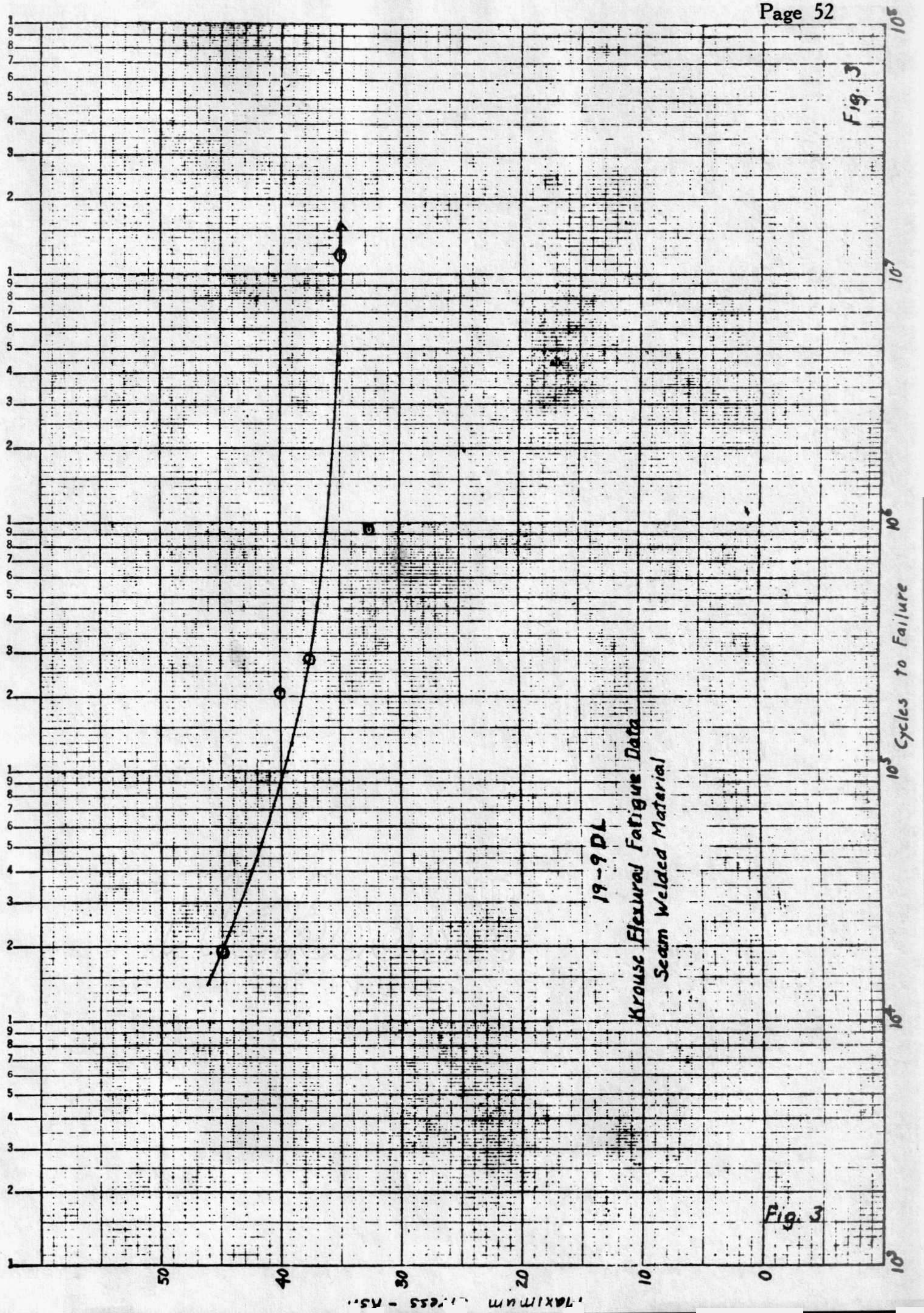

Rotating Beam Tests - [redacted] Report [redacted] Type 347 annealed
Curve of Rotating beam tests
Annealed
Annealed Type 347
Krouse Flexural Fatigue Data
⊙ Unwelded material
△ Seam welded material
Maximum Stress - ksi
50
40
30
20
10
0
10^3
10^4
10^5
10^6
10^7
10^8

Fig. 2


19-9 DL
Krouse Flexural Fatigue Data
Seam Welded Material
Cycles to Failure
50
40
30
20
10
0
Fig. 3

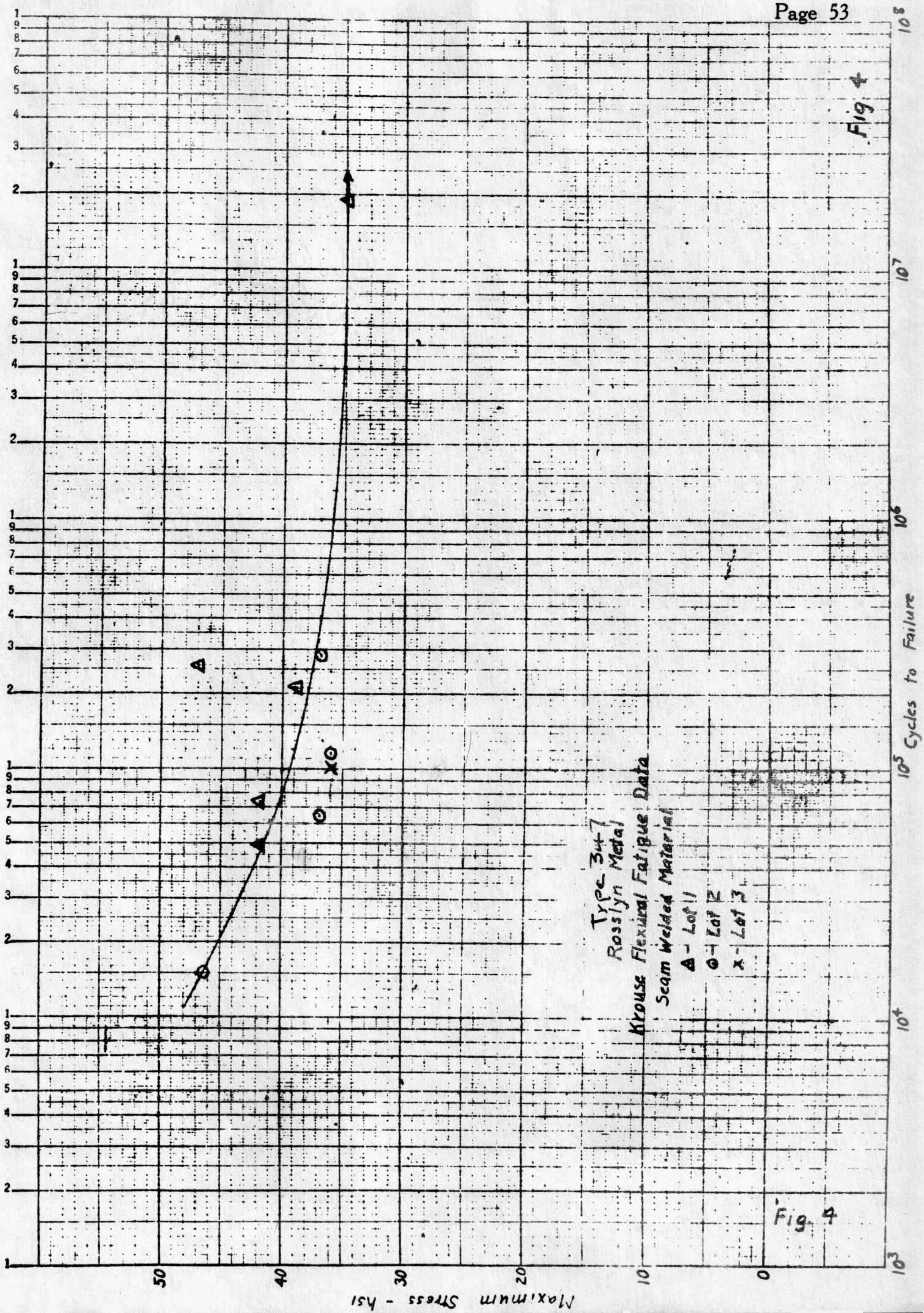


Fig. 4
Type 347
Rosslyn Metal
Krouse Flexural Fatigue Data
Seam Welded Material
Δ - Lot 1
⊙ - Lot 2
x - Lot 3
Cycles to Failure
Maximum Stress - ksi
50
40
30
20
10
0
10^3
10^4
10^5
10^6
10^7
10^8
Fig. 4

BATTELLE MEMORIAL INSTITUTE

Columbus 1, Ohio

February 10, 1950

Mr. C. T. Evans, Jr.
Chief Metallurgist
Elliott Company
Jeannette, Pennsylvania

Dear Mr. Evans:

I am enclosing a copy of Mr. Muehlenkamp's memorandum to me giving the results of his damping-capacity measurements of Rosslyn Metal. As you would expect, the values for Rosslyn Metal fall between those for the Type 302 stainless steel and pure copper.

The values obtained for Type 302 stainless steel and for pure copper were found to be consistent with values in the literature. While these tests were being made, the modulus of elasticity was calculated as an additional check on the data being obtained, and it is felt that the enclosed data are quite reliable.

Sincerely,

/s/ Ward F. Simmons

Ward F. Simmons

WFS:EH
Enc.

cc: Mr. L. W. Townsend

BATTELLE MEMORIAL INSTITUTE

Memorandum

To	Ward F. Simmons	Date	February 6, 1950
From	G. T. Muehlenkamp	Subject	Damping Capacity of Rosslyn Metal

The damping capacities of the samples of Rosslyn Metal have been completed.

Specimen	Damping Capacity (Q-1)
"B 0.082 302 RM 28.2 CU" Type 302 Rosslyn Metal with 28.2% copper	3.6×10^{-3}
"C 0.082 302 RM 58 CU" Type 302 Rosslyn Metal with 58% copper	3.3×10^{-3}
"D 0.078 302" Type 302 stainless steel	1.8×10^{-3}
"E 0.078 304 RM 61.5 ST" Type 304 Pluramelt with 61.5% steel.	2.9×10^{-3}
"F" 100% pure copper	7.4×10^{-3}

These values are relative, not quantitative, as the condition of the specimens did not permit true values to be obtained. The percentage of copper indicated for each specimen was no longer a true value since the samples were ground and much of the steel plate removed. Also, the quality of the bond would be a determining factor in the value of damping capacity. In order to obtain any conclusive data, it would be necessary to determine the consistency of the damping capacity for any one type of Rosslyn Metal. At least five specimens of each type would be required to determine a representative value.

The method of expressing damping capacity as Q^{-1} can be converted to the logarithmic decrement by multiplying by pi (π). The damping capacity was determined by measuring the resonant frequency (f_0) of the sample, as submitted, during transverse vibrations. The frequency was then varied either side of resonance until the amplitude of vibration decreased to half maximum. This band width is then a measure of damping of the specimen and Q^{-1} is defined by

$$Q^{-1} = \frac{4f}{3\ f_0}$$

This type of test involves very low stresses (200 psi) and is relatively free from errors. The frequency in these tests was approximately 900 cycles per second, except for the pure copper which was 466.

GTM:mlm

ENGINEERING NEWS LETTER NO. 7

WESIX "Dust-Free" Fin Element

The new Wesix "Dust-Free" Element is an improved strip type electric heating element for use in air. It combines the latest advancements in metallurgy with the simplicity of electric heat to give a highly efficient and flexible unit free from the many limitations of other type units.

The secret of this new Wesix achievement is in the metal sheath. It is well known that copper is by far the best metal conductor of heat--better than aluminum, steel or most any other metal. But, unfortunately, copper oxidizes at relatively low temperatures and in time is destroyed. The solution to this problem has been achieved in the development of clad metals wherein stainless steel or inconel is coated over the copper to protect it.

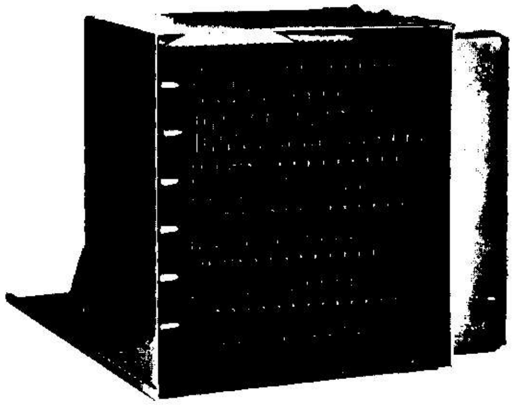
This laminated material is rolled from the ingot stage, forming a permanent bond between the stainless steel and copper. Both sides of the copper are covered with stainless steel. The copper conducts the heat and the stainless steel protects the copper--these two metals working as a team outperformed any single material.

Next, this clad metal is formed into a sheath completely enclosing the heating element and constructed with an excess of metal three times as great as that covering the element itself. This forms the fins or additional surface area necessary to more rapidly transfer heat to air. These fins are longitudinal to the element, possible only with copper core material capable of moving heat rapidly.

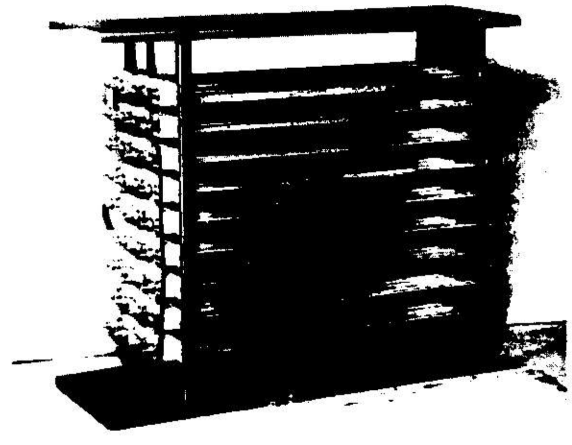
Heretofore, transverse fins have been favored because of the large additional area available to dissipate the heat into air. Transverse fins are expensive. To be successful they must be permanently welded or brazed to the element sheath. This is difficult to do and requires tedious labor to accomplish. The longitudinal fin requires no welding. The transverse fin has the larger surface area but this is very inefficiently utilized due to the low conductivity of the metal and the tendency for rapid accumulation of dust on the transverse fins.

The longitudinal fin as used by Wesix is "Dust-Free." The elements are mounted with the fin parallel to the airflow and spaced at intervals of 1 1/2 inches or more. Dust cannot accumulate on this assembly as plainly shown in the photograph. This means that the Wesix "Dust-Free" fin element remains as efficient throughout its life as the day it was installed. The old style transverse fin looks good when new but rapidly loses much of its fin area as it becomes clogged with dust. This accumulation of dirt and trash not only cuts the efficiency of the transverse fins but also reduces the airflow and results in an appreciable drop in direct air pressure at the outlet of the heater.

This new Wesix "Dust-Free" fin element is the result of two years' research for a better enclosed electric heating element. It will be used in the new Wesix industrial type unit heaters requiring closed elements and many of our duct heaters. We will continue to make the transverse fin elements for special applications and when specifically called for by specification, but we recommend the new element over the old for all-around performance and low cost.



TRANSVERSE FINS



LONGITUDINAL FINS

Mr. J. J. Hubbert
B. H. Hubbert & Son
1300 Block S. Ponca Street
Baltimore, Maryland

June 16, 1949

Dear Mr. Hubbert:

We have put into operation the 60 gallon copper clad stainless steel steam jacketed kettle and have been using same for cooking creams any where up to 260 degrees at 85 pound pressure.

We have compared this kettle with an all copper kettle, of the same size, as well as an all stainless steel kettle, of the same size, and we find that we are able to cook with a clad metal kettle as fast as the all copper kettle, which, in our estimation, is the fastest cooking steam jacketed kettle. We feel that this new kettle has a terrific advantage over the all copper kettle. Because of the stainless steel inside and outside it is more durable and can be kept in a much better looking condition and it does not have to have any rivets on the inside as is required on the copper kettle.

All in all we think you have a good thing and am sure all our future kettles will be of this type material.

With best regards, I remain

Very truly yours,

BARRICINI INC.

H. Domnitz

HD/s

Supt.

B. H. HUBBERT & SON, INC.

Coppersmiths & Machinists

Telephone Wolfe 1479

1300 Block S. Ponca St.
Baltimore 24, Maryland
November 22, 1949

American Cladmetals Co.
Carnegie, Pennsylvania

Attention: Mr. Anthony

Dear Mr. Anthony:

I know you are going to be pleased with this bit of information. The first industrial kettle put into actual production, is one of 250 gal. capacity, installed at the Quaker City Chocolate & Confectionery Co., Philadelphia, Pa. This kettle in competition with 5 - similar kettles built of copper of the same capacity, has out-performed copper far beyond our fondest dream. With a 600 lbs. batch of licorice product, the copper kettles cooked in 23 to 25 minutes. The same batch in our Rosslyn Metal kettle cooked in 9 minutes by the clock.

I witnessed this test myself and believe me, it is fantastic and nobody is going to believe this. The people who have this kettle are so highly pleased with it, that not only will we get a letter from them stating these facts along with the picture of the installation, but they have opened their doors to any manufacturer of candy who can witness this same operation.

At least there can be no doubt in anybody's mind that we have in this kettle, the answer to a cooking problem. With proper advertisement, it is going to be the answer to replacing copper in the candy industry. We are already arranging with Candy Industry Magazine, to line up the story for an early release. We will advertise that the design of this kettle and a few little wrinkles that we know has developed this kettle into what it is.

You may also be interested to know that within half an hour after I witnessed this test in Philadelphia last week, I was over at the Campbell Soup Company, and the entire purchasing and engineering department, down to a man knows about this test and they are anxiously awaiting their kettle.

I predict a great volume will follow just as soon as we educate the people to actually understand the truth about the cooking ability of our kettle. Our hardest job is going to be getting people to accept the truth and we are lining up our ammunition for a great expedition.

We can soon announce the coming of "R" DAY!

Best regards, we are

Very truly yours,

B. H. HUBBERT & SON, INC.

JJH:MH

signed/ J. J. Hubbert

AMERICAN CLADMETALS COMPANY

P. O. Box 544 Carnegie, Pa.

Base Prices and Extras - Effective October 10, 1950

ROSSLYN METAL

Copper Base* - Both Sides Clad**

BASE PRICES AND ANALYSIS

Type of CLADDING	TYPICAL ANALYSIS					BASE PRICE
	CARBON	CHROMIUM	NICKEL	COPPER	ALSO INCLUDES	
Stainless						
302	Over .08-.20	17.00-19.00	8.00-10.00			
or						
304	Max. .08	18.00-20.00	8.00-11.00			$ .77
321	Max. .08	17.00-19.00	8.00-11.00		Ti-Min. 5xC	1.11
347	Max. .08	17.00-19.00	9.00-12.00		Cb-Min. 10xC	1.30
310	Max. .25	24.00-26.00	19.00-22.00		Si-Max. 1.50	1.44
INCONEL	.08	14.00	78.50	.20	Fe 7.00	1.65
19/9 DL	.28-.35	18.00-21.00	8.00-11.00	.50 max.	Mo 1.00-1.60 W 1.00-1.75 Ti .20- .50	1.65

* Copper base of ROSSLYN METAL will be 25 to 35% of the total thickness of the ROSSLYN METAL sheet unless otherwise specified.

** For material clad on one side only, 15% will be added to invoiced prices.

EFFECTIVE OCTOBER 10, 1950 OTHER PRICES ON APPLICATION

AMERICAN CLADMETALS COMPANY

ROSSLYN METAL

FINISH EXTRAS

#1 Finish (hot rolled, descaled or sand blasted, annealed and levelled)	BASE
#2 Finish	$.12

#4 Finish (one side or both) Prices on request.

QUANTITY EXTRAS

	To and Incl.	Extra
10 lbs. and under	--	$.30
10 lbs.	25 lbs.	.20
26 lbs.	50 lbs.	.17
51 lbs.	100 lbs.	.14
101 lbs.	200 lbs.	.12
201 lbs.	300 lbs.	.11
301 lbs.	500 lbs.	.09
501 lbs.	1000 lbs.	.05
1001 lbs.	2000 lbs.	.04
2001 lbs.	5000 lbs.	.03
5001 lbs.	8000 lbs.	.02
8001 lbs.	10,000 lbs.	.01
10,001 lbs.	25,000 lbs.	Base
25,001 lbs.	99,999 lbs.	Discount .03

EFFECTIVE OCTOBER 10, 1950 OTHER PRICES ON APPLICATION

AMERICAN CLADMETALS COMPANY

SIZE EXTRAS IN CENTS PER POUND

ROSSLYN METAL

WIDTHS		6" TO 24" INCL			OVER 24" TO 36" INCL			OVER 36" TO 48" INCL		
LENGTHS		6" TO 60"	60" TO 96"	96" TO 120"	6" TO 60"	60" TO 96"	96" TO 120"	6" TO 60"	60" TO 96"	96" TO 120"
USS GA.	DECI-MAL									
7	.187"	2	2	3	2	2	3	3	3	4
8	.171"	2	2	3	2	2	3	3	3	5
9	.156"	2	1	3	1	1	2	3	2	4
10	.140"	2	1	3	1	1	2	3	2	4
11	.125"	1	BASE	2	BASE	BASE	1	3	1	3
12	.109"	1	BASE	2	BASE	BASE	1	2	1	3
13	.093"	3	2	4	2	1	3	4	3	5
14	.078"	3	2	4	2	1	3	4	3	5
15	.070"	4	3	5	3	2	4	5	4	6
16	.062"	4	3	5	3	2	4	6	5	7
17	.056"	6	5	7	5	4	6	7	7	9
18	.050"	7	6	8	6	5	7	8	9	11
19	.043"	7	6	8	6	6	8	10	11	13
20	.037"	8	7	10	7	7	9	11	13	15
21	.034"	8	7	11	7	8	10	12	14	16
22	.031"	9	8	11	7	9	11	13	15	17
23	.028"	9	9	12	8	10	12	14	17	19
24	.025"	9	9	12	9	12	15	17	19	20
	.020"	12	12	15	13	16	20	22	24	25
	.018"	15	15	18	21	24	27	30	33	36
	.015"	19	19	21	24	27	30	33	36	39

#1 Finish available in widths over 48" to 56" incl. extra 10¢ per lb.
" 56" to 63" incl. extra 20¢ per lb.

Longer lengths quoted on request.

EFFECTIVE OCTOBER 10, 1950 OTHER PRICES ON APPLICATION

AMERICAN CLADMETALS COMPANY

PACKING EXTRAS

Boxing		2 1/2¢
Paper wrapping, skid, or platform packing		
5,000 lbs. or more per skid or platform		3/4¢
Under 5,000 lbs. per skid or platform		1 1/4¢
Minimum charge per package	$7.50	

All shipments of Number 4 Polish sheets must be boxed and are subject to packing extras.

EXPORT PACKING WILL CARRY AN EXTRA 1-1/2 TIMES THOSE LISTED

STANDARD PERMISSIBLE VARIATIONS IN THICKNESS ALL FINISHES

SPECIFIED THICKNESS INCHES	TOLERANCE PLUS OR MINUS INCHES
0.145 to 0.188	0.014
0.130 to 0.145	0.012
0.114 to 0.130	0.010
0.098 to 0.114	0.009
0.083 to 0.098	0.008
0.072 to 0.083	0.007
0.058 to 0.072	0.006
0.040 to 0.058	0.005
0.026 to 0.040	0.004
0.016 to 0.026	0.003

WIDTHS AND LENGTHS

WIDTHS UP TO 48" INC.	1/8" OVER 0 UNDER
WIDTHS OVER 48"	1/4" OVER 0 UNDER
LENGTHS UP TO 120" INC.	1/16" OVER 0 UNDER
LENGTHS OVER 120"	1/8" OVER 0 UNDER
Thickness 0.131 and heavier all widths and lengths	1/4" OVER 0 UNDER

TESTING

If the value, exclusive of packing and transportation charges, of an item or items in a single testing group is less than $200.00, a charge of $5.00 will be made for each sample prepared and/or test made for mechanical properties or for each sample prepared and/or test made under the salt spray method. A similar charge will be made if any other test is required.

COMMERCIAL LABORATORY TEST

COMPLETE CHEMICAL ANALYSIS BY COMMERCIAL LABORATORY $25.00

EFFECTIVE OCTOBER 10, 1950 OTHER PRICES ON APPLICATION

EXTRAS, unless otherwise note, are in cents per pound and are to be added to the price base. Each extra is a separate and distinct extra and does not, unless specifically stated, include or absorb any other extra. The full extra applying over price base is the total of all extras applicable to specified requirements of the order.

INTERMEDIATE SIZES - In all cases, the higher extra shall be charged for any size falling between two published extras.

QUANTITY EXTRAS - When quoting, the theoretical weight of the given size will be used without regard to the maximum overweight tolerance.

For example, if the theoretical weight of an item is 1,870 pounds and the maximum rolling tolerance is 7½%, the quantity extra applying to 1,870 pounds is used and not the quantity extra applying to 2,000 pounds. If, however, 2,000 pounds of material is later actually shipped, the necessary adjustment will be made.

PRICES ARE FOB MILL AND COVER
MATERIAL FOR SHIPMENT WITHIN
THE UNITED STATES AND CANADA.
EXPORT PRICES FURNISHED ON
APPLICATION.

ALL ORDERS SUBJECT TO WRITTEN ACCEPTANCE BY COMPANY AT MILL.

In the event of rejection of sheets for any cause whatsoever, supplier's liability is limited to replacement.

"ROSSLYN METAL"

Weight per Square Foot

	20%		30%		40%		50%	
Gauge	Nickel Alloys	Stain-less	Nickel Alloys	Stain-less	Nickel Alloys	Stain-less	Nickel Alloys	Stain-less
1"	45.78	42.86	45.85	43.29	45.91	43.72	45.98	44.15
.187"	8.561	8.015	8.574	8.095	8.585	8.176	8.598	8.256
.171"	7.828	7.329	7.840	7.403	7.851	7.476	7.863	7.550
.156"	7.142	6.686	7.153	6.753	7.162	6.820	7.173	6.887
.140"	6.409	6.000	6.419	6.061	6.427	6.121	6.437	6.181
.125"	5.723	5.358	5.731	5.411	5.739	5.465	5.748	5.519
.109"	4.990	4.672	4.998	4.719	5.004	4.765	5.012	4.812
.093"	4.258	3.986	4.264	4.026	4.270	4.066	4.276	4.106
.078"	3.571	3.343	3.576	3.377	3.581	3.410	3.586	3.444
.070"	3.205	3.000	3.210	3.030	3.214	3.060	3.219	3.091
.062"	2.838	2.657	2.843	2.684	2.846	2.711	2.851	2.737
.056"	2.564	2.400	2.568	2.424	2.571	2.448	2.575	2.472
.050"	2.289	2.143	2.293	2.165	2.296	2.186	2.299	2.208
.043"	1.969	1.843	1.972	1.861	1.974	1.880	1.978	1.898
.037"	1.694	1.586	1.696	1.602	1.699	1.618	1.701	1.634
.034"	1.557	1.457	1.559	1.472	1.561	1.486	1.563	1.501
.031"	1.419	1.329	1.421	1.342	1.423	1.355	1.425	1.369
.028"	1.282	1.200	1.284	1.212	1.285	1.224	1.287	1.236
.025"	1.145	1.072	1.146	1.082	1.148	1.093	1.150	1.104