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Report No. 316/33
Watertown Arsenal

October 5, 1936

Comparison of Some Stainless Steels and Chrome-Plated Steel for Roller Bearings for Under Water Use

by

P. R. Kosting and M. B. Gruzdis

Object:

To compare 12% chromium .3% carbon stainless steel (C.R.S.5H) 17% chromium 1.% carbon (BHH) and chrome plated steel for corrosion resistance to synthetic sea water spray and in synthetic sea water when coupled with Monel metal, 18/8 (C.R.S. #1) and bronze.

References: Ex. O. 624 A1
" " 613

Conclusions:

Roller and ball bearings made of stainless steel (C.R.S. 5H) and of high chromium stainless (17% Cr 1%C) and of chrome-plated steel, rust quickly in synthetic sea salt spray, but the latter tends to be very much more susceptible to progressive corrosion than C.R.S. 5H or 17% chromium 1% carbon.

C.R.S. 5H and 17% chromium 1% carbon and chrome-plated steel are dangerously anodic (corroded) when coupled with Monel metal and C.R.S. #1 and bronze in synthetic sea water, chrome-plated steel more so than C.R.S. 5H.

C.R.S. 5H and 17% chromium 1% carbon are very susceptible to types of corrosion other than galvanic such as concentration cells.

17% chromium 1% carbon is anodic (corroded) when coupled with C.R.S. 5H in synthetic sea salt solution.

From the viewpoint of susceptibility to corrosion when in contact with non-ferrous metals C.R.S. 5H and 17% chromium 1% carbon are not very efficient

Two fresh coats of red lead paint are sufficient to insulate dissimilar metals against galvanic corrosion when submerged in synthetic sea water. Should it be necessary to use such materials in wet mounts they are listed in the order of decreasing preference:

C.R.S.5 H; 17% chromium 1% carbon; chrome-plated steel.

Introduction:

There are available, in commerce, corrosion resistant ball and roller bearings made of C.R.S.5 H, (12% Cr.0.3%C) 17% chromium 1% carbon (BHH) and chrome-plated steel. Information concerning the relative behaviour of these in possible special ordnance applications was desired.

Material:

Material used was:

C.R.S. 5H Navy inspected,	12% Cr; 0.3%C;	150 R_c	54
BHH (Firth Sterling)	17% Cr; 1% C;	150 R_c	9
		"	48
		"	56

Strip 18% Cr, 8% Ni: .07% carbon

Monel metal

Bronze Casting: 4% Sn; 2% Ni; 94% Cu

Ball Bearings - Timken Roller Bearing #27 (chrome-plated)

Federal Bearing Co., Bearing #1205
(BHH, 17% Cr., 1% C)

Method:

Specimens were polished with 00 emery cloth, cleaned and weighed. They were then coated with paraffin except for 1 sq. inch and connected to form couples through a junction box by means of which a milliammeter could be placed instantaneously in the circuit. Periodic measurements were then made for one hundred hours of current generated by the different metallic combinations, separated 1/2" in quiescent synthetic sea water. At the end of one hundred hours all specimens were cleaned and weighed.

The commercial bearings were taken apart and subjected to salt spray exposure and to contact with Monel Metal in synthetic sea water.

One electrode of a galvanic couple subject to bad corrosion was painted with red lead and attempts were made to detect any galvanic current that flowed.

Results:

On Figures 1 and 2 some data is given showing the behavior of galvanic currents with time for different combinations as follows:

Fig.	Curve	Anode	Cathode	I at 100 hours m.a./sq.in.
1	1	CRS 5H	CRS #1 (18/8)	.009
	2	"	Bronze	.001
	3	"	Monel	.047
	4	Soft 17% Cr 1% C	CRS #1 (18/8)	.025
	5	" " "	Monel	.050
	6	Med. hard 17% Cr 1% C	CRS #1 (18/8)	.020
	7	" "	Monel	.051
2	1	Hard 17% Cr 1% C	Monel	.020
	2	" " "	Bronze	.026
	3	" " "	CRS 5H	.016

The following tables give the behavior of the two bearings under test.

TABLE I

17% Cr, 1% C (BHH) Bearing
(Federal Bearing Co. #1205)

Synthetic Sea Salt Spray	Condition
2 hours	Ball slightly stained; racer slightly stained.
16 hours	Balls and racer badly stained; separator stained.
24 hours	Continued corrosion.
48 hours	Shallow pits on racer; separator and balls stained.

Each specimen of the racer was anodic (corroded) to Monel metal and to 18/8. Coupled with Monel metal the current increased from 0.022 milliamperes to 0.060 milliamperes in 48 hours. With 18/8, the current increased from 0.011 milliamperes to 0.040 milliamperes during the same period. Weight losses of the bearing specimens were respectively 5.9 and 5.7 milligrams at the end of 100 hours.

TABLE II

Chrome-Plated Bearing
Timken Roller Bearing #27

Synthetic Sea Salt Spray	Rollers Examined in Duplicate
1 hour	No rust
2 "	Rust on ends of one roller, but not on other
4 "	Rust on end of both rollers
8 "	Rust on ends and on faces
16 "	Rusting more pronounced
24 "	" " "
48 "	" " "

Race: Rusting occurred within 2 hours and within 48 hours over 50% of available area was rusted and stained. Rusting on chrome plated areas was more pronounced than on areas free from chrome plate. Chrome plate flaked in areas, especially on edges which appeared to be severely pitted with shallow black sharp vertically walled depressions and porous areas.

Race in contact with Monel was rusted badly, deeply pitted in spots, even on polished race-surface, and lost less than 20 mg. The current increases from 0.05 milliamps during the first hour to .165 milliamps within 24 hours, and varied between .14 and .19 milliamps during the next 76 hours.

In the salt spray both C.R.S. 5H and 17% chromium 1% carbon rate C and occasionally B when plumb bob specimens are tested.

One coat of red lead on one electrode was not sufficient to prevent flow of galvanic current in a couple but two coats were.

Discussion:

In all cases C.R.S. 5H and 17% chromium 1% carbon were anodic (corroded) to Monel, 18/8 and bronze.

As the hardness of the 17% chromium 1% carbon samples increase its corrosion resistance increased. Assuming the composition of the carbide of chromium and iron to be 5.3% Carbon, 63% chromium as reported, then in the annealed condition 17% chromium 1% carbon would have only 5.1% chromium available to impart corrosion resistance, whereas, C.R.S. 5H would have 8.4% chromium. If 50% of the carbon is in the form of carbides then 17% chromium 1% carbon would have 11% chromium available for corrosion resistance and C.R.S. 5H would have 10.2% chromium. The 17% chromium 1% carbon steel in the quenched and low drawn condition has more chromium tied up as carbide than anticipated.

It is apparent that 17% chromium 1% carbon will not be an improvement over C.R.S. 5H for galvanic behavior though there are conditions when it might be superior for straight corrosion.

On the basis of composition, since approximately 16% chromium is necessary for imparting galvanic corrosion resistance against copper alloys and 1% carbon is necessary for hardness then a 28% chromium 1% carbon steel might be galvanically neutral to copper.

Nickel may have to be added to affect hardening ability. Whether steels of this composition are forgeable or not is questionable; probably they are not.

Comparison of weight losses, current, and appearance of specimens indicate that 17% chromium 1% carbon and C.R.S. 5H are susceptible to corrosion of the differential concentration type.

The chrome-plated rollers showed rust on ends within two (2) hours in synthetic sea salt spray and on roller face within eight (8) hours. Rusting progressed and became more pronounced the longer the parts were exposed to the spray.

The races were only partially plated and in the salt spray flaking occurred. Rusting and bad staining occurred. The chromium plate was on a poorly prepared surface which appeared to be porous in areas. Wide black shallow pits developed. The staining and pitting on a polished piece of steel which was placed in the spray at the same time were not so pronounced.

In contact with Monel, rusting and deep pitting occurred within 100 hours, a current of 0.165 m.a./sq.inch of cathode area of 8 sq. inch anode area flowing. The weight loss was less than 20 mg. The protection offered by the chrome plate was slight and not as great as that observed for chrome-plated steel tested previously.

The use of chromium plated roller bearings will not solve the anticipated corrosion problem met with in wet mounts. Stainless steels of the high chromium high carbon (17:1) variety are believed to resist corrosion under the test conditions used to a better degree; C.R.S. 5H is evidently best.

The use of chromium-plated roller bearings for general purposes need not be condemned.

Respectfully submitted

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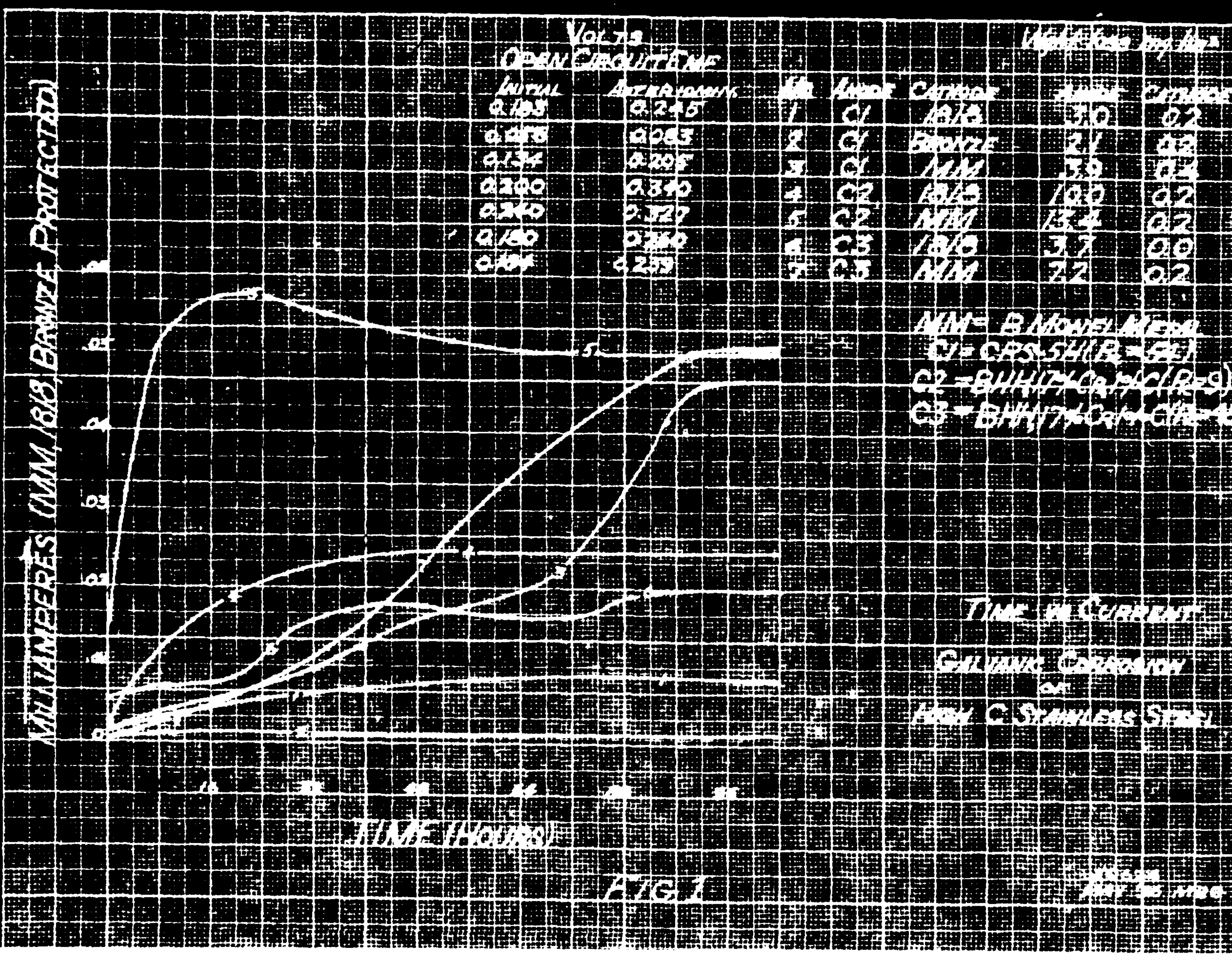

VOLTS
OPEN CIRCUIT EMF
INITIAL
AFTER
ANODE
CATHODE
0.245
0.063
0.205
0.340
0.260
0.259
0.134
0.200
1
2
3
4
5
C1
C1
C1
C2
C2
C3
C3
18/8
BRONZE
M.M
18/8
M.M
18/8
M.M
CATHODE
2.1
10.0
3.7
7.2
0.2
0.2
0.2
0.2
0.0
0.2
M.M = B MONEL METAL
C1 = CRS-5H
C2 = BHH
C3 = BHH
TIME vs CURRENT
GALVANIC CORROSION
C STAINLESS STEEL
MILLIAMPERES (M.M, 18/8, BRONZE PROTECTED)
.05
.04
.03
.02
0
TIME (HOURS)

FIG. 1

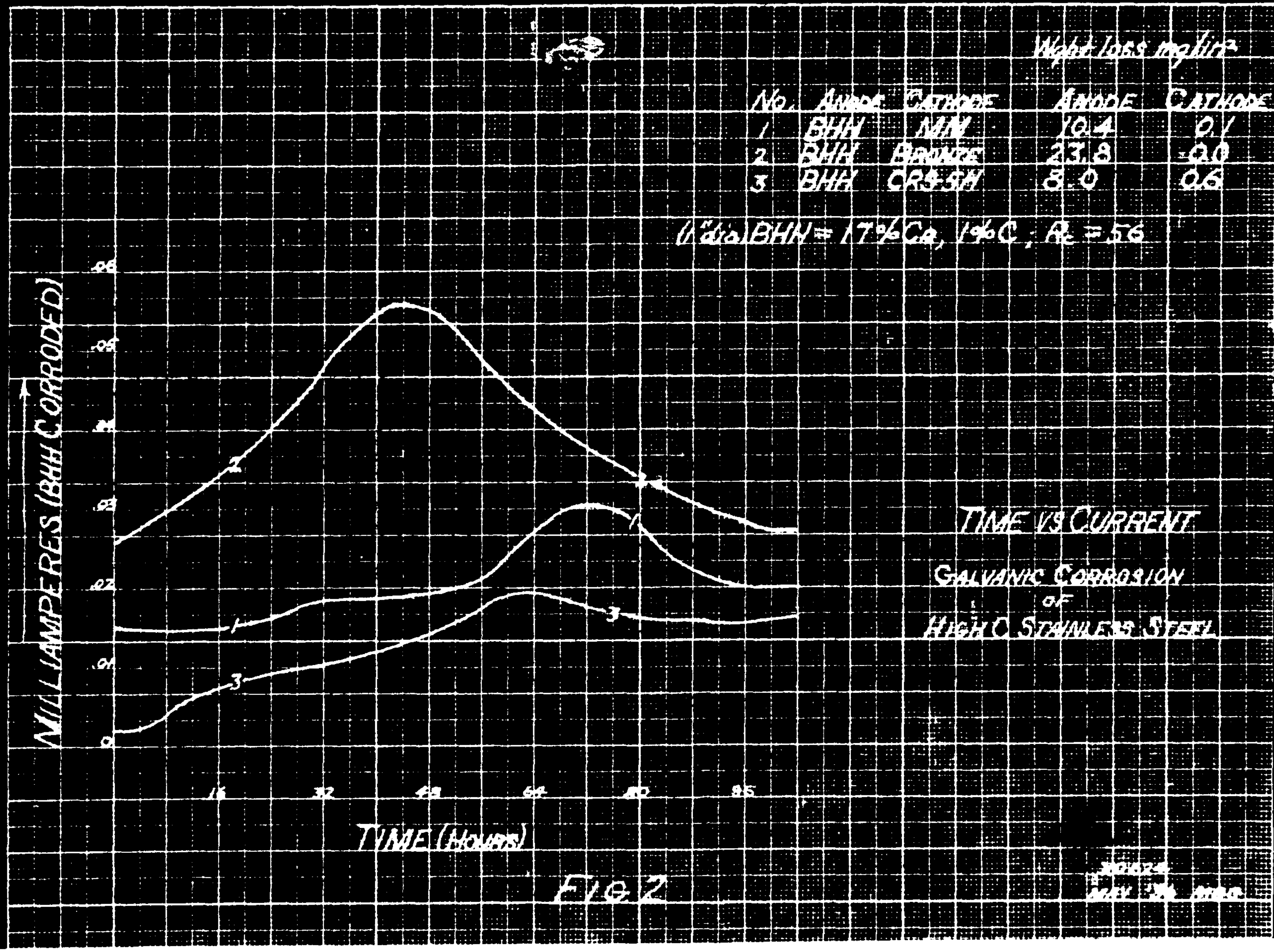
Wght loss mg/in²
No. Anode Cathode Anode Cathode
1 BHH MN 10.4 0.1
2 BHH Bronze 23.8 0.0
3 BHH CR55H 8.0 0.6
(1" dia) BHH = 17% Cr, 1% C; Rc = 56
MILLIAMPERES (BHH CORRODED)
.06
.05
.04
.03
.02
.01
0
16
32
48
64
80
96
TIME (Hours)
TIME VS CURRENT
GALVANIC CORROSION
OF
HIGH C STAINLESS STEEL

FIG 2