Salt water corrosion of aluminum alloys in the presence of other metals

National Research Council of Canada. Radio Branch

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SALT WATER CORROSION OF ALUMINUM ALLOYS IN THE PRESENCE OF OTHER METALS

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OTTAWA

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SALT WATER CORROSION OF ALUMINIUM ALLOYS IN THE PRESENCE OF OTHER METALS

Salt spray has always been one of the chief sources of deterioration of equipment at sea. It must be noted that the following report entails only methods of reducing corrosion, not a complete cure. Further, these methods are only satisfactory in the presence of salt spray and should not be used where equipment is to be immersed in salt water.

Many aluminum alloys have been developed that have a high resistance to salt spray [1]; however, when other metals are employed in conjunction with the aluminum alloys rapid corrosion ensues with the metal highest in the electromotive series being sacrificed [2].

Mr. A.C. Halferdahl of the N.R.C. Corrosion Research Section was consulted and the following conclusions reached.

(a) The ideal solution is the use of one non-corrosive metal throughout

(b) Separate the two dissimilar metals by; a metal higher in the electromotive series than the two metals, a corrosive resistant metal such as stainless steel, or a non-hygroscopic insulator. Also, a sponge of phosphor bronze (oilite) is considered sufficient separation.

(c) Special treatment of all exposed aluminum alloys.

(d) Overall painting of the equipment.

One of the first considerations in most radio equipment installed on board small craft is weight; naturally an aluminum alloy is the first choice. Unfortunately, these alloys have some undesirable mechanical properties, especially hardness, rigidity and insistance to wear. Small parts, such as nuts, bolts, studs, etc. of aluminum alloy would be very short-lived in the company of the average sailor who is accustomed to equipment built in somewhat massive proportions. All small exposed parts must be strong and capable of withstanding considerable abuse. It remains, therefore, to prevent or deter the electrolytic corrosion to the greatest possible extent without sacrificing the mechanical properties of the equipment.

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1 refers to Appendix 1.

2 refers to Appendix 2.

Referring to sketch 1 the precautions taken can be very clearly illustrated. The main housing, part 18, is cast from SAE No.37. Intermediate aluminum alloy. First, the main casting is sand blasted, then all machining operations are performed; this is followed by anodizing the entire casting inside and out. It should be noted that the anodizing alters the dimensions so slightly that the process offers no difficulties in this respect. Finally the casting is given a chromate dip. This treatment passivates the aluminum from electrolytic corrosion.

The studs, parts 48 and 49, threaded into the casting, and the taper pin, part 73, are made of 18-8 stainless steel. The elastic stop nut, part 50, is brass to insure no action between it and part 66, which is also brass. The stop nut, part 47, is also brass but zinc plated in order to protect the aluminum alloy cover, part 45. By using a stainless steel washer, part 46, the cover is given further protection and this method is to be preferred.

The male tubing connectors, parts 52 and 54, are made of brass and aluminum alloy respectively. The dissimilar metal contacts occasioned by the use of a metallic oil line, part 53, are avoided in this case by using an oil-resistant plastic tubing such as "Saran" manufactured by the Dow Chemical Co.

Gaskets, parts 51, and 55, are 1/32" neoprene; part 51 serving the dual purpose of an oil seal and a non-hygroscopic insulator between the brass pump body and the aluminum alloy main casting. In part 55, the diameter of the holes through which the screws, part 43, pass are made to the pitch diameter of the screw to ensure against any salt water reaching the tapped hole in the aluminum alloy casting. The screws, part 43, and all other exposed screws in the assembly are zinc plated. Gasket, part 56, is 1/32" pure electrolytic zinc annealed in oil; since being used here expressly to ensure good electrical bonding between the cover and the main casting to prevent electrical noise produced by the drive motor from escaping and interfering with other radio equipment. The shims, part 68, are made from a non-hygroscopic, oil-resistant plastic.

Referring to sketch 2 another method is shown by which the unlike metals are separated by neoprene. It will be noted the brass section, part 1, is insulated from the aluminum alloy, part 3, by a gasket, part 2, Where accurate spacing of parts is required, part 2 is made of plastic, otherwise neoprene is very satisfactory. Part 4 is a neoprene-backed washer, the hole through the neoprene being the nominal diameter of the bolt and the washer of the same material as the bolt, part 5. For best results, this bolt and washer should be stainless steel but as fastenings in this metal are difficult to obtain, brass or steel may be used provided that both bolt and washer are zinc plated.

The entire outside of the assembled rotator is painted with a zinc chromate primer in a bakelite varnish vehicle. This primary coating is followed by at least two coats of the desired pigment in a bakelite varnish vehicle.

The rotator discussed has a section of circular waveguide, part 57, passing through the hollow main shaft, part 69. Condensation in the entire run of waveguide is prevented by the passage of dry air at a slight positive pressure through the guide. In order to prevent sweating and breathing in the gearbox, this supply of dry air is given access to the gearbox. Through slots cut in the oilite, part 42, and holes in the main shaft, part 69.

It will be noted that in all cases where a metallic coating is specified, plating is to be used in order to obtain better dimensional control of small parts, especially threaded parts.

Metallic contacts with other metals should be avoided. The separation of two dissimilar metals or alloys by a non-hygroscopic insulator does not prevent the electrolyte from bridging, but the addition of an insulator effectively increases the electrical resistance of the circuit thus insuring longer life of the metal with the highest solution potential. All precautions mentioned are palliative only and constant inspection and maintenance is required to detect any signs of corrosion. This is especially necessary in the case of zinc or zinc-plated parts as they will sacrifice themselves for the aluminum alloy. Any scratches in the paint must be cleaned with a wire brush and painted immediately they are detected.

APPENDIX 1

SALT WATER RESISTANT ALLOYS

British Admiralty specifies (B.S.I. Spec. 702 dated 1936) for aluminum alloy used in the presence of salt water is as follows:

Aluminum - 85.5 to 88.4

Silicon - 10.0 to 13.0

Iron - 0.6

Manganese - 0.5

Zinc - 0.2, Copper - 0.1, Titanium - 0.1

All other metals excluding Sodium - 0.1

It will be noted that the above alloy differs very slightly from SAE Standard No.37 Intermediate Alloy. Many other alloys in the SAE Standard list have low porosity and good salt-spray corrosion resistance, a few of these being No.322, type 2; No.323, type 2; No.35, type 1; and No.38, type 2.

Regardless of what type of alloy is chosen, if used with other metals in salt-spray surroundings, corrosion will ensue. The choice of the alloy, therefore, should be made mainly for its mechanical properties and foundry characteristics, bearing in mind the corrosion-resistance properties of the alloy.

APPENDIX 2

(Issue 2 - January, 1943)

CORROSION DUE TO ELECTROLYTIC ACTION BETWEEN DISSIMILAR METALS

To prevent corrosion due to the occurrence of electrolytic action between dissimilar metals in the presence of moisture, it is essential that careful consideration be given to the selection of materials in order to avoid a potential difference greater than approximately 0.25 volt normally, but see also Appendix XII, clause (2/14)).

In the following schedule are shown the typical values of the E.M.F. between various materials in sea-water and a calomel electrode. The E.M.F. between any pair of materials in contact with each other is equal to the difference between the values given for each material. The material having the more negative value will tend to corrode.

SCHEDULE
Potentials in seawater at 25 deg.C.

Material	Potential against Calomel electrode Volts
Aluminium and Aluminium alloys, heat-treated and aged	-0.75
Duralumin (4L3)	-0.60
RR Alloys	-0.73
L.33	-0.75
MG.7	-0.61
MG.5	-0.82
Aluminium	-0.76
Brass, Bronze, etc. -	
Monel Metal	-0.16
Gunmetal (2B2)	-0.24
Copper	-0.18
Cupro-Nickel (70:30)	-0.18
Phosphor Bronze	-0.22
45 per cent. Nickel Alloy (DTD 237)	-0.13
Aluminium Brass	-0.21
Aluminium Bronze	-0.23
Brass (3B5)	-0.30
Steels:-	
Stainless:-	
Austenitic, e.g., DTD 166, 171, 176, 189, 207, 211	-0.20
High Chromium, e.g., S.80, DTD 60, 146, 168, 185, 225	-0.35
12 per cent Chromium, e.g., S.61, S.62, S.85, DTD 161, 203	-0.45
46A	-0.58

:-

Material	Volts
Steels:-	
Non-Stainless:-	
3S3	-0.70
S.88	-0.62
S.65	-0.71
S.4	-0.72
DTD 138	-0.72
S.2	-0.73
S.6	-0.76
S.21	-0.76
S.84	-0.79
Magnesium Alloys (DTD 118 and 120)	
Miscellaneous:	
Cadmium (Plating)	-0.78
Nickel (plating)	-0.14
Zinc (plating	-0.10
Silver (plating)	+0.01
Tin (tinned steel)	-0.47
Tinman's Solder	-0.48
Zinc-cadmium solder	-1.04
0.000035-inch Chromium Plating, on Nickel Plated Steel	-0.42
0.0005-inch Chromium Plating on Nickel Plated Steel	-0.53
German Silver	-0.19
Silver Lead Solder	-0.50
Cast Iron, Grey	-0.70
Galvanised Iron	-1.06
Zinc Base Alloy	-1.09

(APPENDIX XII)

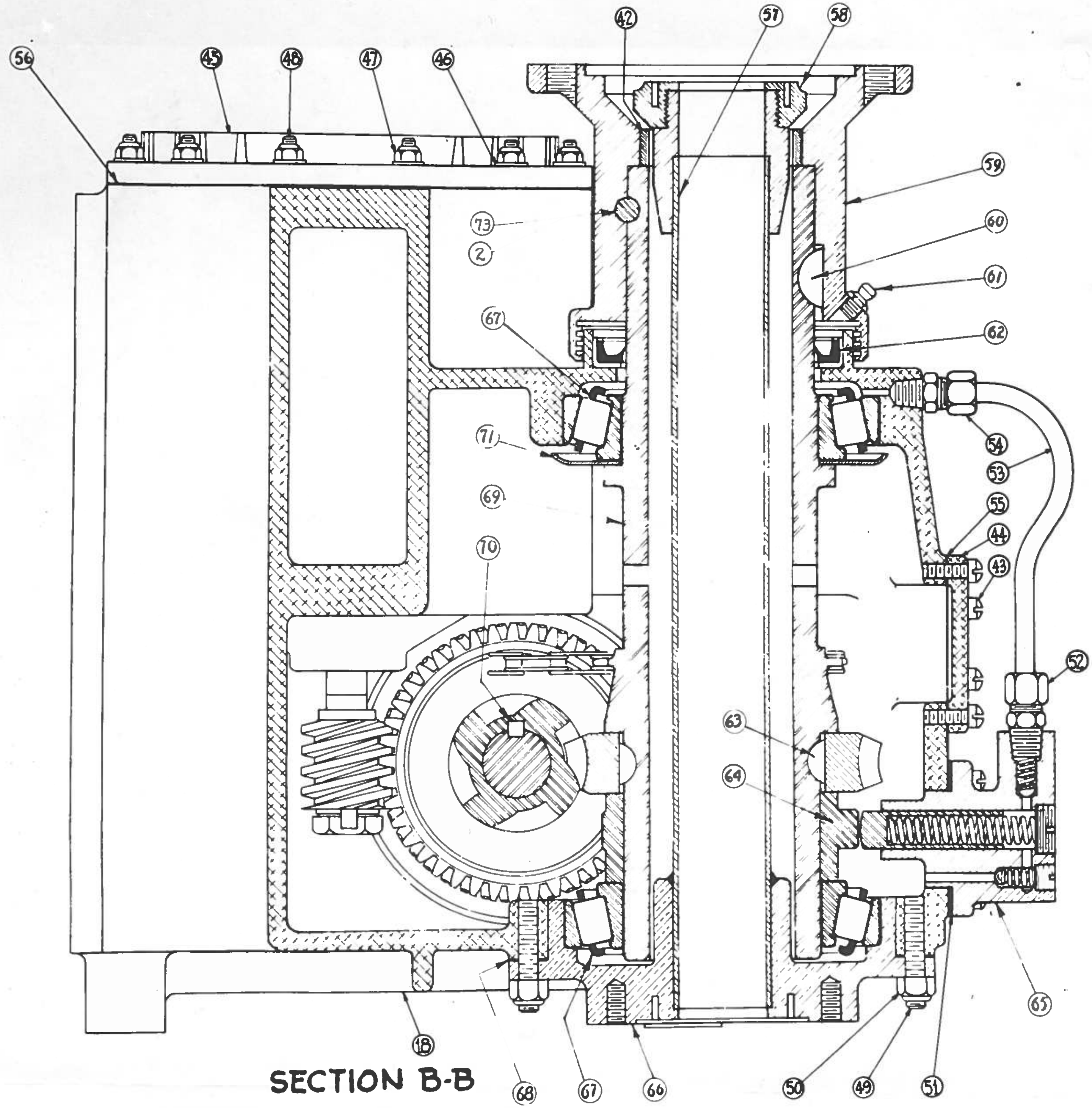
(Issue 2 - January, 1943) #

WAR TIME EMERGENCY FINISHES
AND ALTERNATIVE MATERIALS, ETC.

(2/14) Corrosion due to Electrolytic Action between Dissimilar Metals - The limiting figure of potential difference of (approximately) 0.25 volt maximum specified in Appendix IV to this specification may now be increased for general radio purposes to 0.5 volt.

Higher values will be accepted provided that the joint between the dissimilar surfaces is sealed with an air-drying varnish. Air-drying varnish as specified in Appendix VII to this specification is preferred, but a good, air-drying, hard-setting varnish other than those specified may be used, subject to approval.

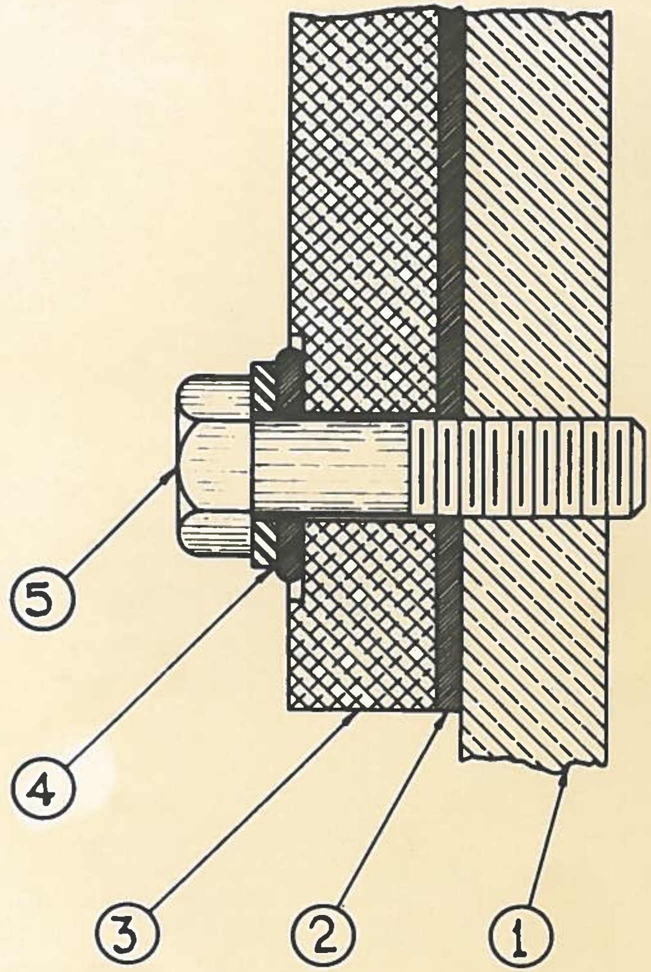
Extracts from Specification No. D.C.D., W.T.1000
General Production Requirements for
Royal Air Force Radio Apparatus.



SECTION B-B

Sketch No 1

S.E.W. Ward.



ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY A · C · S	DATE Nov. 20 · 43	SUPERSEDES
CHECKED	DATE	SCALE
ENG. APPROV.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME Sketch No. 2	DWG. NO.