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Fabrication of Stainless Steel Spherical Anodes for Use with Boat-Mounted Boom Electroshockers

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Abstract.—A frugal method of fabricating spherical anodes from stainless steel mixing bowls is presented. We believe that the purported mechanical disadvantages of using spherical electrodes are largely unfounded.

Spherical electrodes are generally believed to have superior electrical properties (Novotny and Priegel 1974; Novotny 1990). A 1982 questionnaire of U.S. fishery workers (Lazauski and Malvestuto 1990), however, revealed that the most commonly used anode closely followed the "Wisconsin ring" design described by Novotny and Priegel (1974). The Wisconsin ring anode consists of large numbers of "dropper" electrodes suspended from a 1-m-diameter ring, and it is considered to be the most practical means of approximating the electrical field of a sphere while avoiding the mechanical disadvantages of spherical electrodes (Novotny and Priegel 1974; Novotny 1990). The purported disadvantages of spheres include lack of availability, difficulty in assembly, and impeded boat maneuverability.

Lack of availability has probably limited the familiarity of many fishery workers with spherical electrodes. Advertisements for commercially available spheres did not appear in *Fisheries* magazine (the American Fisheries Society bulletin) until 1989. Labor and materials often result in high costs for custom-made or commercially sold stainless steel spherical anodes. Our method of fabricating spherical electrodes boasts considerable savings over currently available commercial products.

Stainless steel is widely considered to be the most desirable material for electrodes (Reynolds 1983) because of its corrosion resistance and durability (Novotny 1990). We found satisfactory spherical anodes could be fabricated from readily available and inexpensive stainless steel mixing bowls and other stainless steel components. We worked with mixing bowls from department stores and restaurant supply houses and found the dif-

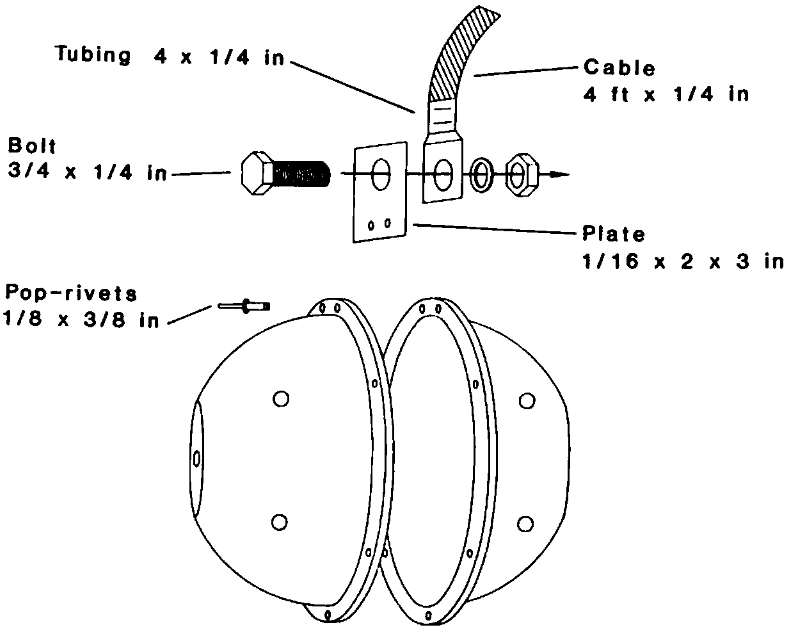

FIGURE 1.—Schematic diagram depicting fabrication of a spherical anode made from mixing bowls. All materials are stainless steel.

ferences in bowl quality to have inconsequential effects on anode performance.

Sphere assembly begins by facing two bowls of identical diameter toward each other (Figure 1) and clamping their aligned rims together with two Vise-grips. A 3/16-in drill bit is used to make one or two holes for rivets in three quadrants of the bowls' rims (use two holes per quadrant in bowls 11 in or more in diameter). The unriveted quadrant becomes the top of the electrode. Stainless steel pop-rivets (1/8 in × 3/8 in) are passed through these holes and set.

A 2-in × 3-in × 1/16-in tab is cut from stainless steel plate to serve as an attachment point to a cable dropper. This tab is drilled 1/2 in from an end with a 3/8-in drill bit. The undrilled end is then slipped between the rims of the two bowls at the top of the electrode, leaving 2.5 in of the tab extending beyond the sphere's equator. Two 3/16-in holes are then drilled through the rims and tab 1/2 in from the edges of the tab. Rivets are set in these holes to secure the tab to the sphere. It may be necessary, especially with smaller bowls whose rims are less flexible, to attach the tab before the rivets are set in the other three quadrants.

At least one hole per hemisphere (placed at the bottom of each bowl) is drilled in each sphere to facilitate rapid sinking and draining. Additional holes can be drilled if desired (Figure 1).

A fitting for attaching the sphere to a 1/4-in stainless steel cable is made by flattening 2 in of one end of a 4-in × 1/4-in (inside diameter) segment of stainless steel tubing. One end of the cable is then inserted into the tube until it contacts the restriction, and the tube is then crimped onto the cable. Next, a 3/8-in hole is drilled through the flattened portion of the tubing, 1/2 in from the end. A 1/4-in × 3/4-in stainless steel bolt is used to attach the cable to the sphere's tab (Figure 1).

The tag end of the cable is attached to the boom of the electrofishing boat. Cable length adjustments are made so the entire sphere rides just under the water's surface. Then the portion of the cable in contact with the water and the tab of the sphere are insulated to preserve the characteristics of the spherically produced electrical field.

Novotny (1990) listed six requirements for effective electrofishing electrode systems. A spherical electrode produces the largest zone of effective electric current distribution in the water without generating locally large current densities that waste available power and potentially harm fish (Novotny and Priegel 1974; Novotny 1990). Novotny (1990) also recommended that electrodes be adjustable to accommodate changes in water conductivity. Conductivities less than 100 μS/cm are considered low (Reynolds 1983; Nelson and Little 1988; Zalewski and Cowx 1990). Measurements

TABLE 1.—Comparison of electrofishing catches per unit effort between 1987 (when cylindrical and cable anodes were used) and 1988(spherical anodes) at reservoirs sampled in northwestern Colorado. Electrofishing was conducted with two anodes, one from each boom, and two netters collecting fish, unless otherwise specified. In 1987, all fish species electroshocked were collected. In 1988, primarily sportfish were targeted for collection.

Reservoir	Surface area (hectares)	Conductivity (μS/cm)	Sampling date	Anode style[a]	Fish species captured[b]	Number of fish per hour
Elkhead	178	290	Jul 1987	CD, 18, 2	FH, RT, WS, FM, GS, SM, LM	222
		180	Jul 1988	SP, 11, 2	NP, RT, RS, WS, CC, BG, SM	245
Hollenbeck	24	205	Aug 1987	CD, 18, 2	GS, BG, LM	338
		250	Jul 1988	SP, 13, 1[c]	GS, BG, LM	425
Harvey Gap	79	510	Aug 1987	CD, 18, 2	RB, WS, BG, SM, LM, BC	288
		500	Jul 1988	SP, 13, 1[c]	RB, WS, BG, SM, LM	240[d]
Rifle Gap	162	770	Aug 1987	CB, 24, 2	RB, GS, SM, WY	132
		750	Jul 1988	SP, 9, 2	RB, GS, SM, WY	156
Mack Mesa	12	550	Jul 1987	CD, 18, 2	RB, CP, SM, GS, BG, LM	250
		1,000	Jul 1988	SP, 13, 1[c]	CP, GS, BG, SM, LM	288
Kenney	249	800	Jul 1987	CB, 12, 2	RB, BT, CP, RT, RN, FH, SD, FM, BB	28
		610	Oct 1988	SP, 9, 2	RB, CP, RT, WF, BH, FM, BB, LM	400
Rio Blanco	47	2,390	Aug 1987	CB, 6, 2	CP, GS, BG, LM, BC	98
		2,790	Jul 1988	SP, 7, 1[e]	NP, CP, GS, BG, LM, BC, YP	141[d]

[a] Entries are anode type, anode size, number of anodes. Anode type: CD = 3-in-diameter aluminum conduit; CB = ¼-in-diameter stainless steel cable; SP = sphere. Anode size is given in inches submerged in water (length for conduit and cable, diameter for spheres).

[b] RB = rainbow trout *Oncorhynchus mykiss*; MW = mountain whitefish *Prosopium williamsoni*; BT = brown trout *Salmo trutta*; NP = northern pike *Esox lucius*; CP = common carp *Cyprinus carpio*; RT = roundtail chub *Gila robusta*; RN = red shiner *Cyprinella lutrensis*; FH = fathead minnow *Pimephales promelas*; SD = speckled dace *Rhinichthys osculus*; RS = redside shiner *Richardsonius balteatus*; WS = western white sucker *Catotomus commersoni*; BS = bluehead sucker *C. discobolus*; FS = flannelmouth sucker *C. latipinnis*; BB = black bullhead *Ameiurus melas*; CC = channel catfish *Ictalurus punctatus*; GS = green sunfish *Lepomis cyanellus*; BG = bluegill *L. macrochirus*; SM = smallmouth bass *Micropterus dolomieu*; LM = largemouth bass *M. salmoides*; BC = black crappie *Pomoxis nigromaculatus*; YP = yellow perch *Perca flavescens*; WY = walleye *Stizostedion vitreum*.

[c] A single spherical anode was fastened centrally on a length of aluminum angle spanning the booms.

[d] Electrofishing was conducted with a single netter collecting fish.

[e] A spherical anode was mounted on one boom and another sphere of equal size, serving as the cathode, was mounted on the other boom.

ranging from 100 to 500 μS/cm are considered to encompass normal (Reynolds 1983) to extremely high water conductivities (Serns 1982). However, we concur with Zalewski and Cowx (1990) that conductivities over 1,000 μS/cm fall in the high range. We routinely encounter conductivities ranging from 50 to 3,000 μS/cm in northwestern Colorado, and many waters exceed 500 μS/cm.

Lennon (1959) suggested electrodes of various sizes were needed to successfully electrofish over the wide range of conductivities encountered in fresh waters. Reynolds (1983) advised adjusting electrodes to accommodate varying conductivities, emphasizing that this meant changing electrode diameter, not merely raising or lowering the electrode in the water.

The wide size range of stainless steel mixing bowls easily accommodates this requirement. Smaller spheres for higher water conductivities and larger spheres for less conductive waters are easily fabricated and switched as needed. Because of the incremental range of mixing bowl sizes available, the advantages of always using the largest electrode possible within physical constraints and limitations of the generator and electrical control system can be maximized (Novotny and Priegel 1974; Novotny 1990). We successfully electrofished with spherical anodes over a wide range of water conductivities, increasing our catches per unit effort over those obtained by the use of dropper anodes in nearly all cases (Table 1).

The ability to fabricate spheres of various sizes addresses both the assembly and adjustability requirements. Concerns about avoiding unnecessary water disturbances, which could impair observation of fish and maneuverability of the boat (Novotny and Priegel 1974; Novotny 1990), were answered during our extensive use of spherical anodes.

We operated boat-mounted boom shockers in both lentic and lotic habitats and never experienced an impaired ability to see or net fish that had succumbed to the electrical current. Our ability to operate in weedy habitats, a specific consideration of Novotny (1990), was not hampered by our use of spherical anodes. Our electrofishing success in weedy areas was affected more by an inability to net stunned fish entangled in vegetation or by choking of the boat motor's propulsion or cooling system with weeds. Even in swiftly flowing rivers, we successfully negotiated obstructions that could have proven hazardous if ring electrodes had been used.

Perhaps the most legitimate criticism of spherical anodes is their impairment of boat maneuverability. However, this can be largely overcome with good boatmanship. In standing water, it was difficult to suggest any notable disadvantages of spherical anodes. We strongly advise that boat operation in flowing waters not be relegated to inexperienced crew members. Other than this caution, we believe the purported mechanical disadvantages of spherical anodes are largely unfounded.

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