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DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1975/144

BMR PUBLICATIONS COMPACTUS
(NON-LENDING-SECTION)

MANUFACTURE AND TESTS OF RADAR REFLECTING BUOYS FOR MARINE SURVEYS

BY

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SUMMARY

An investigation was made into the design and construction of simple light-weight marker buoys suitable for use in marine geophysical surveys. Several types were constructed and subjected to sea trials. These showed that light-weight buoys of simple design, which could be constructed on board a survey vessel using readily obtainable material and components, would last for four weeks when moored offshore in moderate seas about 75 m deep.

1. INTRODUCTION

The investigation into the manufacture of light-weight buoys was undertaken at the request of the BMR Geophysical marine group which required simple light-weight buoys to mark traverse intersections at sea. Preference was indicated for buoys which could be constructed on board a survey vessel from prefabricated parts. The buoys were to be anchored in the open seas of the continental shelf around Australia and were required to survive for periods up to eight weeks.

Several types of buoys were considered, and a number of these were constructed and tested under conditions which could be met in the actual survey area.

The project commenced in June 1969 and lasted for exactly one year, during which time approximately 25 buoys were made. Three trips by chartered ship were undertaken to position these buoys in the open sea. The first trip, by M.V. Krait, also involved checking electronic equipment for a marine survey; the other two trips to Montague Island were purely for testing radar target buoys.

The cost of the project came to approximately $1500 and included items such as charter of vessels and purchase of materials, e.g. dustbins, plastic foam, steel, aluminium tubing, flashing lights, and assorted hardware. It excluded costs for overhead.

2. FIRST PROTOTYPES

Investigations into the feasibility of constructing the requested type of buoy commenced after a sketch was obtained of a simple marker buoy which had been used without success on a contract survey along various parts of Australia's coastline. It consisted of a cardboard box filled with polystyrene foam through which was fitted an aluminium tube 4 m long and 2½ cm in diameter. A counterweight was attached to the bottom and an eight-cornered reflector to the top of the mast, and the assembly was anchored to the bottom of the sea. The failure of this type of buoy was almost certainly due to disintegration of the box and foam plastic. None of these buoys was ever relocated, and it is indeed doubtful if such a fabrication would have survived more than a few hours even in a calm sea. The principal consideration then, in the design of a more durable buoy, was the selection of the material for the skin of the float. Galvanized iron and plastic were thought to be the most suitable, particularly as they could be obtained in a size and shape readily adaptable for a float, namely the common 38-litre household garbage can. A number of such cans were purchased together with some plastic ones. Each was filled with hard-setting polystyrene foam to provide buoyancy and fitted with a 7-m length of standard waterpipe through the centre, secured to the body with bolts and nuts. A simple reflector was attached to the top approximately 4 m above the waterline, and a counterweight, chain, and anchor were attached to the bottom of the pipe.

A number of these assemblies were tested for some three months in Canberra's Lake Burley Griffin near the Scrivener Dam. At the end of the period the floats were retrieved; some had dragged their anchor a hundred feet or more from where they were first anchored, but most importantly, none of them had failed. At the BMR workshops the floats were cut open and inspected for water penetration, corrosion, and deterioration of skin and foam, but no evidence of water leaks, brittleness, and corrosion could be found. It was therefore decided to construct a batch of second-generation buoys to the same basic designs for sea trials.

3. BARRANJOEY SEA TRIALS

Approval was obtained from the Department of Shipping and Transport NSW Region to conduct a series of tests 1000 m SSE of Barranjoey Lighthouse at latitude 33°35'15"S and longitude 151°20'10"E in approximately 12 m of water. The period allowed for the test was from 3 February 1970 till 3 March 1970 and the Volunteer Coastal Patrol, which operated the M.V. Krait from Pittwater, agreed to assist in the positioning of the buoys.

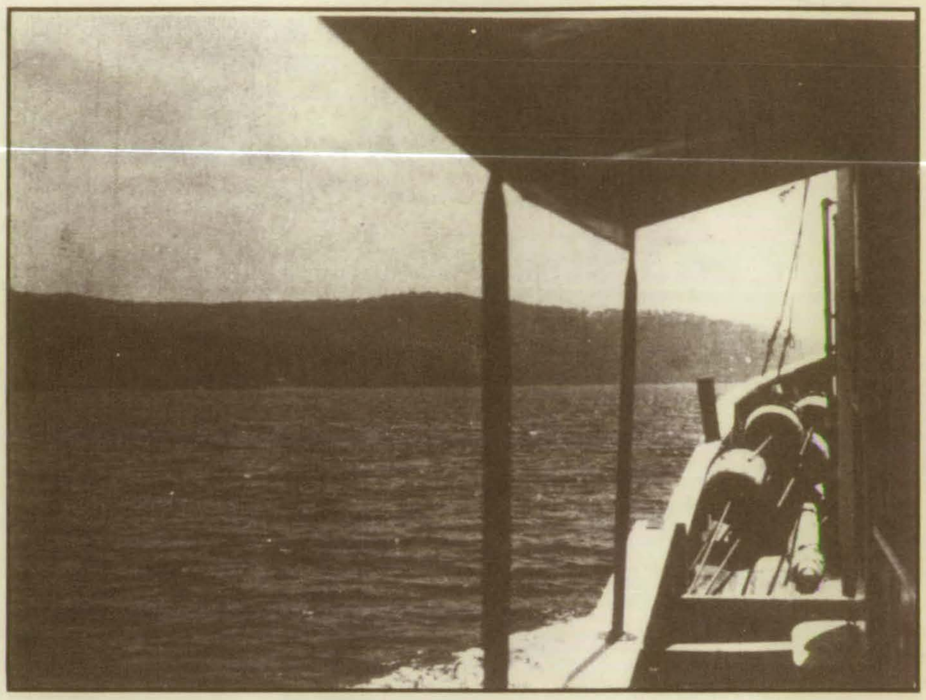


Fig.1 BUOYS ON DECK M.V.KRAIT

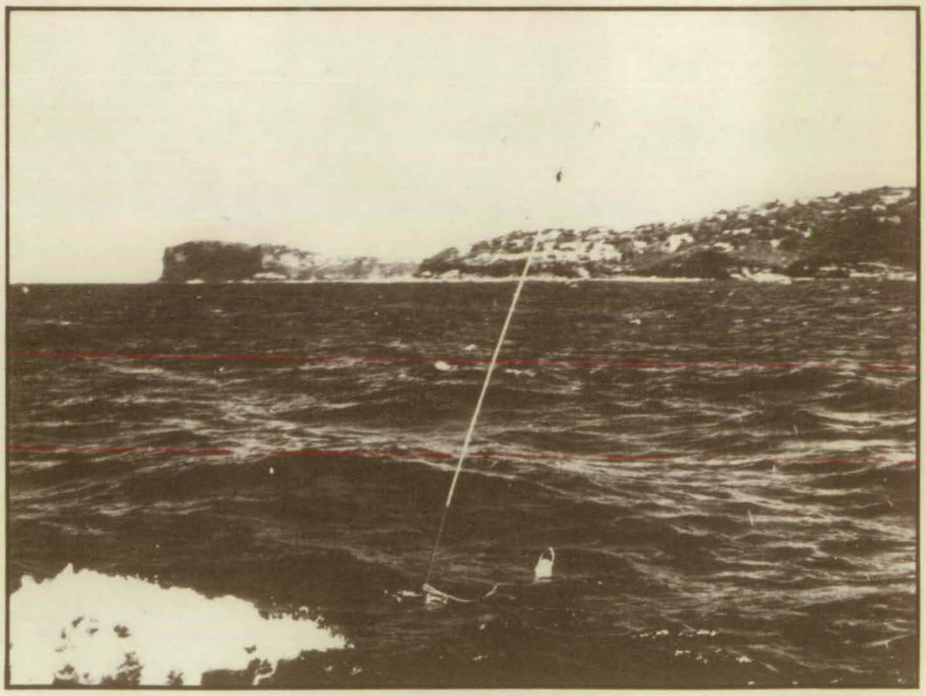


Fig.2 CLOSE-UP OF BUOYS AND NAVIGATION LIGHT

Six buoys were manufactured to designs tested in Lake Burley Griffin, transported from BMR in Canberra to Sydney, and put on board the Krait (Fig. 1). With the help of the crew under Commander Nobbs, a small party from BMR, consisting of the writer and Messrs Spence and Grace, positioned these buoys off Barranjoey Lighthouse in a moderate sea. To warn small-boat operators, who might be in the vicinity after dark, of hazards to their craft, each buoy was provided with a flashing navigation light, (see Fig. 2).

When the six buoys were riding their anchor it became obvious that they were subjected to considerably more movement due to swell and wind than their predecessors had experienced in Lake Burley Griffin. These movements introduced stresses and strain in various sections of the mast. Load factors like these had not been foreseen, and it became fairly obvious that failures could be expected. Nevertheless it was disappointing to note during observations from the beach that two buoys had broken up within about 3 hours after positioning. The remaining four could still be seen to ride their anchor later that night, but at daybreak the following day these buoys too had broken up and disappeared. The cause of the failures can only be attributed to metal fatigue at various points along the mast.

4. REDESIGN OF BUOYS

After the Barranjoey test Captain Taylor, Regional Controller, NSW advised that in his opinion the buoys were too light to be anchored in waters over 100 m deep for periods up to 8 weeks and suggested that the Hydrographer R.A.N. be approached to see if the navy had suitable buoys that were surplus to their needs. Captain Taylor suggested inquiry into the Dan buoy.

Subsequent information from the navy was obtained via Captain Osborn and Lieutenant Varley, who mentioned that the Dan buoy was completely unsuitable for our requirements because of its enormous dimensions and weight, but suggested the Marlin Buoy as an alternative. This buoy was commercially available from Nautical Service (Aust.) Pty Ltd, and was not unlike the buoys described in this record, having a mast which rose 5 m out of the water, a draft of 2 m, and a counterweight of approximately 30 kg.

On top of the mast was fitted a flashing warning light and under it an eight-cornered solid radar reflector. The price of this buoy, however, was $966.81 (10.6.70), making it an uneconomical proposition.

The Barranjoey trials had clearly shown how much greater the open sea's destructive power was than that of an inland water such as Lake Burley Griffin, even though it can be very windy and choppy there. Because there was no doubt that the spars were the weaker part of the assembly means of strengthening them or replacing them with spars of a different dimension and material had to be found. Four new buoys were made for preliminary trials in the lake, in the following manner.

(a) galvanized iron float cases were used in the construction of all floats

(b) one buoy had its steel waterpipe mast reinforced with four stays (see Fig. 3).

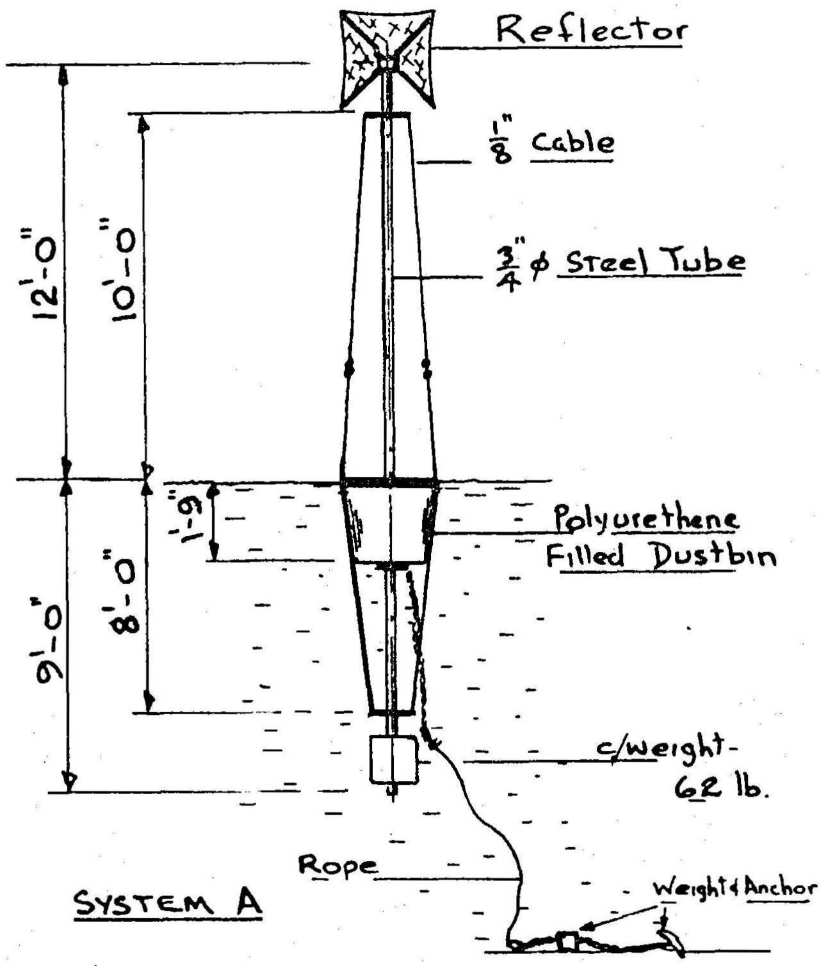
(c) the second buoy had as a mast an 18-gauge aluminium tube, 8 m long and 5 cm in diameter (see Fig. 4).

(d) the third buoy had a mast consisting of galvanized iron down pipe 6 m long and 10 cm in diameter (see Fig. 5).

(e) the fourth buoy had a galvanized iron conical float with a mast of steel waterpipe reinforced with stays as under (b) (See Fig. 6).

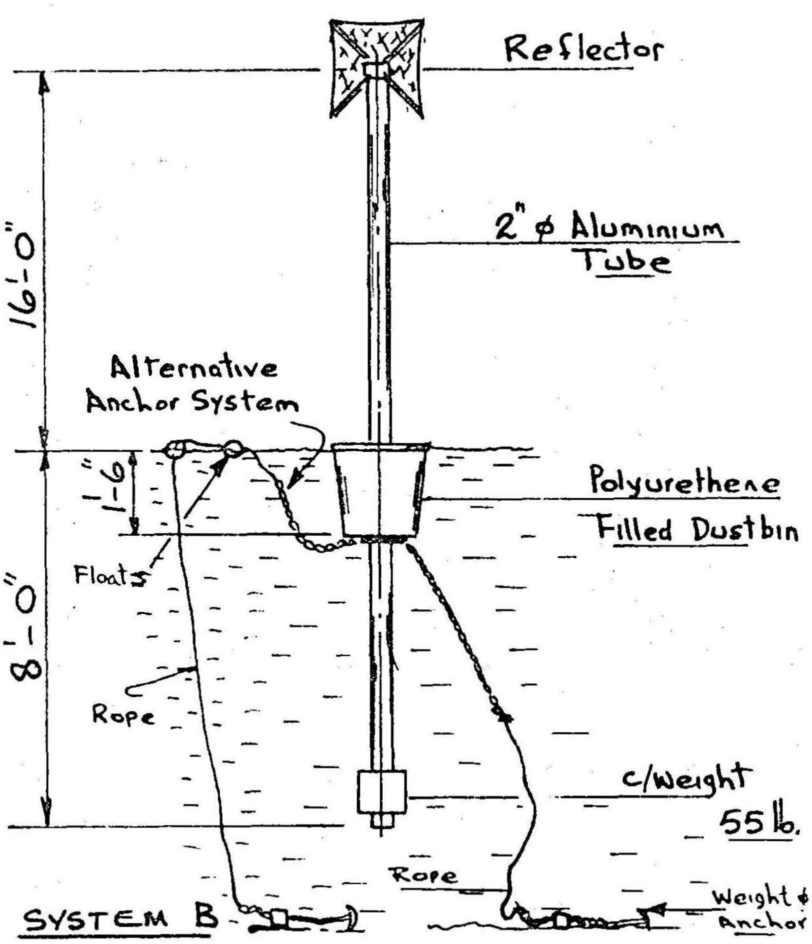
The method of attaching the floats and counter balance weights to the masts was by using bolts and nuts in two of the assemblies and with hose clamps and sleeves in the other two. The four buoys had their mooring line attachment points relocated from a point just underneath the counter balance weight to a point immediately underneath the float. This gave them a more upright position when they floated in areas of heavy sea current. As these buoys were to provide the survey crew with reflected radar signals over as long a distance as possible, it was essential that they regained their vertical attitude in rough and choppy seas as quickly as possible, and for that reason an experimental marine plywood stabilizer board was fitted to one float. The conical buoy was made to test its ability to float upright in turbulent seas, but subsequent tests proved inconclusive.

FIG. 3



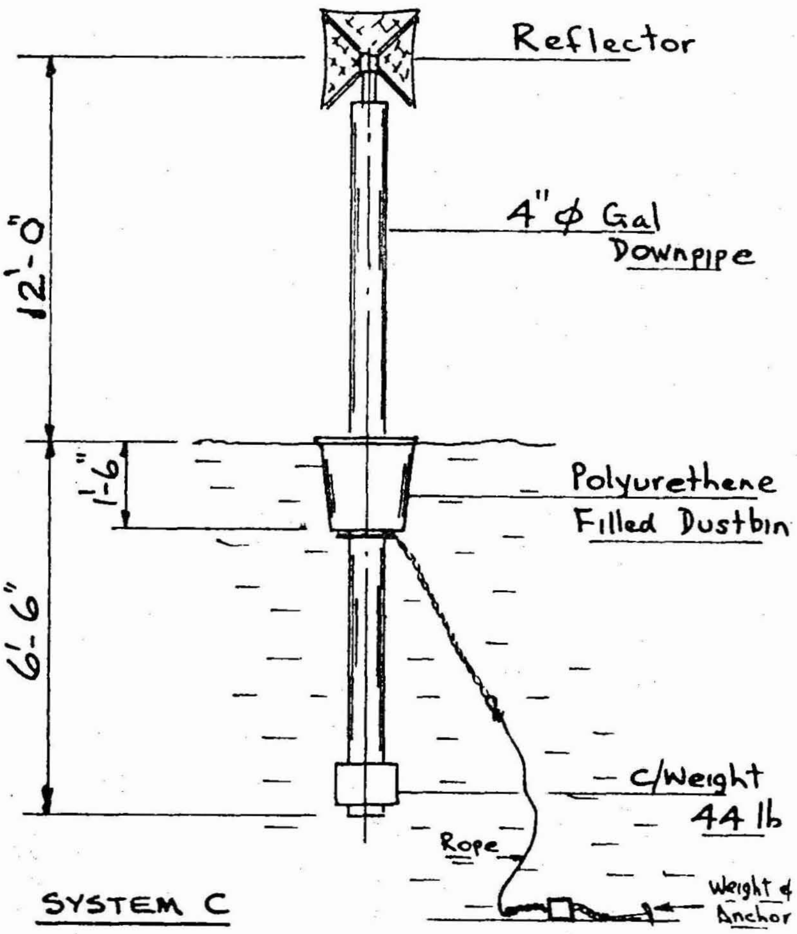
Reflector
1/8" Cable
3/4" ϕ Steel Tube
12'-0"
10'-0"
1'-6"
Polyurethene Filled Dustbin
8'-0"
9'-0"
c/weight- 62 lb.
Rope
Weight & Anchor
SYSTEM A

FIG. 4



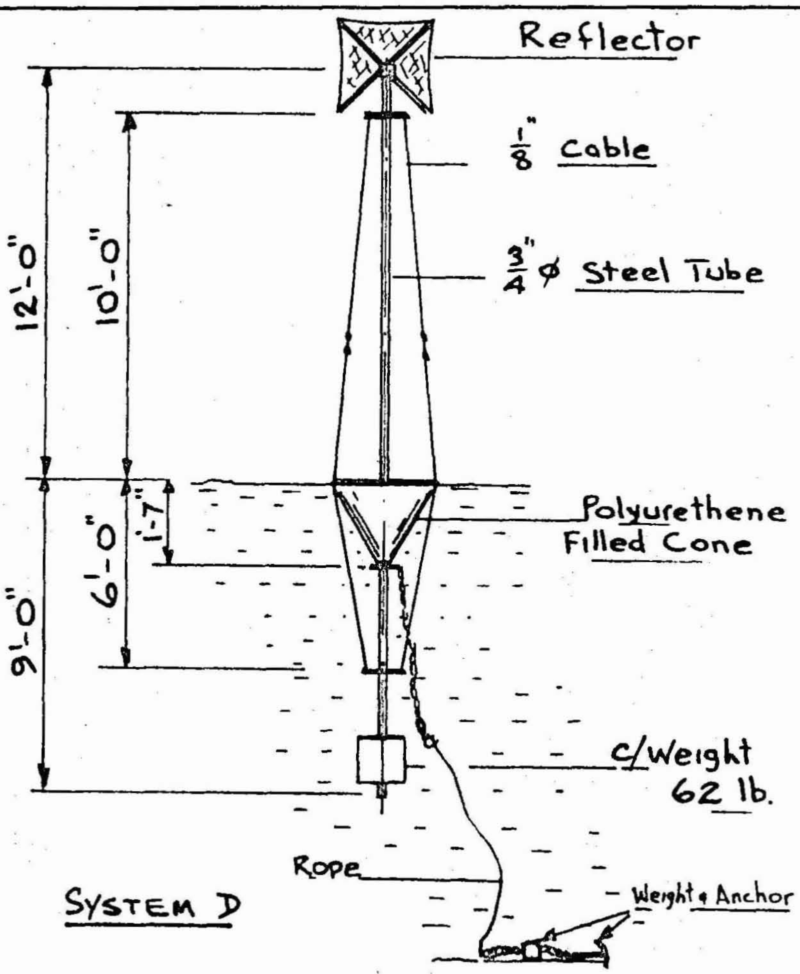
Reflector
2" ϕ Aluminium Tube
16'-0"
Alternative Anchor System
1'-6"
Polyurethene Filled Dustbin
Floats
8'-0"
Rope
c/weight 55 lb.
Rope
Weight & Anchor
SYSTEM B

FIG. 5



Reflector
12'-0"
4" ϕ Gal Downpipe
1'-6"
Polyurethene Filled Dustbin
6'-6"
C/Weight 44 lb
Rope
Weight & Anchor
SYSTEM C

FIG. 6



Reflector
1/8" Cable
12'-0"
10'-0"
3/4" ϕ Steel Tube
1'-7"
Polyurethene Filled Cone
6'-0"
9'-0"
C/Weight 62 lb.
Rope
Weight & Anchor
SYSTEM D

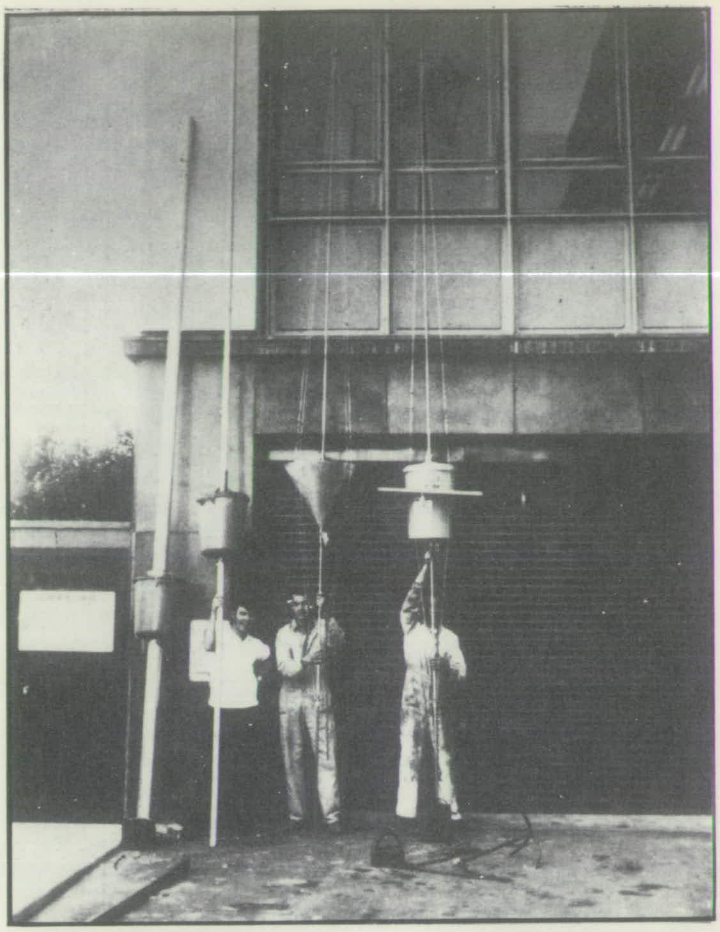


Fig.7 FOUR MANUFACTURED BUOYS
LEFT TO RIGHT C,B,D AND A

Fig.8 ASSEMBLING BUOYS ON FISHING BOAT

The four final assemblies (see Fig. 7) were tested in Lake Burley Griffin over a period of approximately 4 weeks. The lake tests were successfully concluded by mid-April 1970, when approval was obtained from the Department of Shipping and Transport for sea trials to be conducted near Montague Island over an eight-week period.

5. FIRST MONTAGUE ISLAND TEST

Six experimental buoys to designs described above were positioned in the open sea about one mile offshore from Montague Island on 22 May 1970. D. Creighton, a local fisherman who also maintained a ferry service between Narooma and Montague Lighthouse on behalf of the Department of Shipping and Transport, assisted with the positioning of the buoys.(Fig. 8). The weather at the time was good and by the end of the day the six buoys were riding their anchors satisfactorily in 20 m of water in a reasonably strong southerly current.

On 26 May, Creighton relayed a message from the lighthouse keeper, who had a clear view of the buoys, which said that the buoy of Figure 6 had disappeared and that another buoy of Figure 3 type had been dismasted. The rip was dragging the buoy of Figure 5 type just under the surface of the sea, but the three remaining buoys, one as in Figure 3 and two as in Figure 4, were upright and appeared to be firmly anchored. After that message the weather deteriorated further, Creighton was unable to leave Narooma, and the lighthouse keeper could not be contacted because his phone was out of order. The PMG advised that communications with the island would not be restored until after a maintenance crew could be ferried across.

On 5 June Creighton reported that the extremely high current and winds had dragged the buoys about 1.5 km further out to sea, that the buoy of Figure 3 type had disappeared, but that the two buoys of Figure 4 type were still standing. When he inspected the mooring of one of these, he found that the anchor was badly damaged. This buoy was taken out of the water because sooner or later it would have drifted away. The last remaining buoy appeared solid enough to be left in place; its anchor held steady but to avoid damage to the anchor rope, a number of small spherical floats were attached to keep it clear from the rocky sea bottom. This buoy lasted just under 4 weeks in the water, after which it suddenly vanished. The buoy which was retrieved from the water was inspected for signs of wear and corrosion and although it was in a remarkably good condition, there was evidence of substantial corrosion in areas where dissimilar metals had been used e.g. along steel bolt heads, nuts and clamps.

6. SECOND MONTAGUE ISLAND TEST

In view of the encouraging results from the first test at Montague Island it was decided to build another four buoys. Corrosion and hence the weakening of the structures due to electrolysis could be reduced by using plastic wrapping between the interfaces of the various metals. The new buoys each had a heavy duty galvanized iron garbage can filled with firm-setting polystyrene foam as a float. The masts were chosen as follows:

(a) two buoys had 18 gauge aluminium tube 5 cm in diameter
(b) one buoy had 12 gauge anodized aluminium tube 5 cm in diameter
(c) one buoy had galvanised iron down pipe 10 cm in diameter.

With the assistance of Creighton and his crew the four buoys were anchored off Montague Island in the same manner as in the first test. The weather was windy and the seas turbulent, but the positioning was accomplished satisfactorily. The buoys rode their anchor well and could be observed from the lighthouse. For three weeks they remained in their positions. The R.A.N., while on exercise in calm seas near Montague Island, reported sighting the flashing warning lights which were attached to each buoy in the dark hours of an early morning. They even closed in sufficiently to see the outline of one of the buoys. It is therefore a mystery that less than 12 hours later three buoys had suddenly disappeared; the fourth buoy having the galvanised iron down pipe for a mast lasted another four or five days before it too disappeared. The astonishing fact about the disappearances was that the seas were reasonably calm and Creighton, who had looked after the navigation lights, had stated at his last inspection four days earlier that each buoy was in perfect condition. It is possible of course that strong rips which do occur near the island had caused the anchor lines to weaken to such an extent that they parted under the continuous strain. The anchor line was made of a 9 mm polypropylene rope which had a breaking strain of 600 kg. A 6 mm chain or a 3 mm diameter steel rope had been considered but they would have added too much weight for the float to support it in waters deeper than 20 m. The anchor was a four-pronged steel bar device attached to a heavy drag weight and was considered sufficiently sturdy and heavy to hold the buoy in position in rough seas. A short search from the air for possible remnants of these buoys along the beaches north and south of Narooma met with negative results.

7. PRELIMINARY SUPPLY OF BUOYS TO THE SURVEY PARTY

At this time the marine seismic party was about to leave on its tour of duty and had to be supplied with radar intersection buoys. Among the designs which had been tried with a reasonable degree of success was the galvanized iron garbage can filled with foam and fitted with the 18 gauge aluminium tube 8 m long. The components were readily obtainable ex stock from hardware stores and aluminium merchants such as Alarco. Radar reflectors had been imported in bulk from the USA neatly folded and tightly packed in boxes of 25. Sufficient material, component parts, etc. for the construction of 25 buoys were delivered to the survey vessel while the counter balances and drag weights, made out of concrete, had been ordered to specifications from suppliers in Port Moresby, which was one of the ports of call in or near the survey area. Unfortunately no results are available about the suitability of these buoys as marker buoys because the survey was conducted over very deep waters in which these buoys could not be anchored.

8. FURTHER INVESTIGATIONS AND TESTS

After it became known that various navies, fishing fleets, and even European army and airforce units had successfully experimented with heavy-duty inflatable plastic buoys or even plastic outboard-motor driven dinghies and pontoons, inquiries were made with suppliers of the local market about their availability in Australia. Two trial buoys were subsequently received for experimental work. Both were spherical and constructed from a tough thick plastic; they had a buoyancy of 60 kg and 30 kg. Each float also had provision for fitting a 5 cm diameter mast through a centre opening. This mast was held in position after inflating by the air pressure which tightened the skin of the buoy around the mast. Such method of securing the mast proved to be not entirely successful as the spar tended to slip through the buoy; however, two clamps, one on either side of the float, overcame this problem.

Two trial buoys were fitted with masts, radar reflectors, counterweights, anchor chains, and anchors and tested in Lake Burley Griffin over a period of at least six weeks, where they appeared to be as successful as the earlier metal buoys. The obvious advantages of the inflatable buoy were of course the very much easier assembly to the final stage, the enormous savings to be gained in storage area on board the survey vessel, no further need for the tedious job of mixing and pouring polystyrene foam, and their reduced weight. The disadvantage of plastic buoys appears to be their vulnerability to piercing by flotsam, which would render them useless.

Sea trials have not been conducted with plastic buoys and hence no report on their behaviour under more realistic survey conditions can be presented.

9. CONCLUSIONS AND RECOMMENDATIONS

The tests so far undertaken have proved that buoys could be economically manufactured which have a life expectancy of about 4 weeks in seas around the continent. It is possible, however, that plastic buoys could outlast those made of metal garbage cans since they are lighter and therefore require slightly lighter counterweights. This in turn reduces stress and strain introduced in the mast under the continuous motion of even a reasonably calm sea, thereby lengthening the life of the spar.

It is recommended that some plastic buoys should be given sea trials similar to those conducted for the metal types. If this is impossible, then the survey party should obtain a number of plastic floats and test them alongside the other type for evaluation.

ACKNOWLEDGEMENTS

The author expresses his thanks to:

Captain J.H.S. Osborn and Lieutenant Varley, Hydrographic Service R.A.N. for information on the Naval Dan buoy and on the Marlin buoy;

Captain L.W.D. Taylor, Regional Controller N.S.W., Dept of Stores and Transport, for valuable information regarding buoys, and his approval to test BMR buoys in the open sea;

Commander Nobbs and crew, Volunteer Coastal Patrol, Pitt Water, for assisting in positioning buoys off Barranjoey Lighthouse;

Messrs A.J. Barlow, A.G. Spence, J.K.C. Grace, D. Peterson, R.J. Westmore, D.M. Foulstone and R.L. Gibbs for their suggestions and assistance with the project;

Officers of the Commonwealth Department of Works, Canberra, for their assistance with the lake tests.

APPENDIX

Suppliers of Commercial Inflatable Marker Buoys

(a) W. Kopsen & Co. Pty Ltd,
376-382 Kent Street,
Sydney, NSW 2000
Phone: 296331

(b) Seismic Supply (Aust.) Pty Ltd,
31 Kurelpa Street,
(P.O. Box 141),
West End, QLD 4101
Phone: 411221