FILE

**INSTITUTE OF OCEANOGRAPHIC SCIENCES**

WORMLEY, GODALMING, SURREY

# R. R. S. JOHN MURRAY

# Cruise 9

## 5 September - 25 September 1973

WAVE MEASUREMENTS DURING THE JOINT NORTH SEA WAVE PROJECT (JONSWAP 2)

**I.O.S. CRUISE REPORT No. 7**

(Issued June 1974)

INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY, GODALMING, SURREY

R.R.S. JOHN MURRAY

Cruise 9

5 September - 25 September 1973

# Wave measurements during the Joint North Sea Wave Project (JONSWAP 2)

I.O.S. Cruise Report No. 7

(Issued June 1974)

## Cruise Itinerary

| | |
|---|---|
| 5 September: | Left Barry |
| 9-13 September: | On station off Sylt |
| 13-16 September: | Esbjerg |
| 16-23 September: | On station off Sylt |
| 25 September: | Arrived Dover |

## Personnel

J.A. Ewing (Senior Scientist)

C.H. Clayson

E.P. Collins

A.C. Braithwaite

K.G. Birch

K. Tipping

## Objectives

The general aim of the Joint North Sea Wave Project 2 is to extend the earlier work made in the same area off Sylt during 1968 and 1969. In JONSWAP 1 the main emphasis was on the measurement and interpretation of wave spectra obtained under limited fetch conditions. The present study extends these results by including direct measurements of the energy transfer from the atmosphere to the wave field at stations 4 and 8 (see Fig. 1). In addition to these studies a number of auxiliary experiments were planned to study waves by remote sensing techniques including laser altimetry and stereo-photography from aircraft and to carry out comparisons with ground-truth data.

IOS participation in the project was mainly concerned with measurements of waves at station 10 (see Fig. 1) using the pitch-roll buoy and, during bad weather when the pitch-roll buoy cannot be used, the shipborne wave recorder. Additional wave measurements were made with two moored telemetering buoys placed along and normal to the 'profile'. It was planned to use the e.m. spar buoy (reduced to 7 m length) for comparative current measurements with the fixed current meters on the mast at station 8 but, due to the failure of the telemetry system on station 8, this work was not carried out.

## Narrative

The equipment was loaded on 4 September and the wave buoys calibrated while the ship was in Barry dock. 'John Murray' left Barry at 10.30 hrs on 5 September for the North Sea. Although the sea was calm the ship had to reduce speed due to fog in the English Channel and this delayed our arrival on station off Sylt by about one day. During the passage to Sylt moorings for the telemetering buoys were made up ready for deployment. The battery packs for these buoys were also assembled and timing clocks adjusted.

The first telemetering buoy was moored at 0700 on 9 September at a position 75 km along the profile and 23 km distant from John Murray's position at station 10. This distance was subsequently found to be too great for an adequate signal and the buoy was re-moored 13 km along the profile from station 10. The second wave buoy was moored 10 km from station 10 (normal to the profile). Final details of the telemetering buoy positions and ship position are given in the following table:-

TABLE 1

I.O.S. Ship and Buoy Positions

| | Position | Depth | Remarks |
|---|---|---|---|
| 'John Murray' | 55°04'N, 7°32'E | 24.0 m | Station 10 |
| Telemetering buoy (blue) | 55°05'N, 7°20'E | 25.5 m | 65 km along the 'profile' |
| Telemetering buoy (red) | 55°08'N, 7°35'E | 20.5 m | 10 km normal to the 'profile' at station 10 |

The general plan of the cruise was to make wave measurements with the pitch-roll buoy for 30 mins every 2 hrs during east wind conditions and every 4 hrs during west winds. The two telemetering buoys transmitted signals of 20 min duration every 2 hrs using internal clocks and a similar criterion dependent on wind direction was used to record these transmissions. During bad weather the pitch-roll buoy could not be used because of possible damage during launching or recovery and measurements were made with the shipborne wave recorder instead. The signal from the telemetering buoys was usually very weak during storm conditions due to variations in transmission path in high, steep waves and although recorded may not be suitable for analysis. In addition to the wave measurements wind speed and direction, air and sea temperatures and barometric pressure were measured routinely every 3 hrs and also during the pitch-roll buoy measurements.

During the cruise communications were carried out with the land station on Sylt via the German ship 'Planet'. On 12 September we received a message from Sylt which stated that the bad weather of the previous 5 days had delayed the installation of the wave followers at the inner stations, 4 and 8, and hampered the operation of the aircraft. As a result it was decided to call all ships into port while installation of the wave followers could be made during the next few days when the weather was expected to be moderate. 'John Murray' spent this 'break' period from 13-16 September in Esbjerg, Denmark.

After the interval we found the telemetering buoys in their original positions and transmitting correctly in spite of the presence of a fishing fleet operating from Esbjerg. Once again, like the first half of the cruise, we encountered bad weather which restricted us in the operation of the pitch-roll buoy. In fact, for 40% of the entire cruise we experienced winds of Force 7 or more and on two occasions Force 9-10.

On 17 September we sighted and recovered the upper half of the wind buoy of Oregon State University originally moored at station 10. We reported our finding and later transferred the buoy to 'Planet' on 22 September. We also reported on the status of the outer wind buoys before returning to Dover.

Intercomparison wave measurements were made between stereophotography (from 2 helicopters) and pitch-roll buoy measurements on 2 separate occasions. Additionally comparative measurements were made between all the IOS wave recorders - pitch-roll buoy, shipborne wave recorder and telemetering buoys. The ship returned to Dover on 25 September, one day earlier than expected to avoid extensive gales which were forecast.

Apart from minor difficulties with the two telemetering buoys all equipment worked very well. We were however restricted in our intended use of the pitch-roll buoy throughout the cruise although we were able to fill in these gaps with measurements from the other two systems. The analysis of the pitch-roll buoy records was completed in the Institute in January 1974 and the results have been found to be very good. The results from the analysis of the shipborne wave recorder were found from intercomparison measurements with the pitch-roll buoy to be satisfactory for wave periods longer than about 5 sec. We have experienced some difficulty in selecting good parts of the records from the telemetering buoys due to signal variations and at the time of writing (March 1974) we do not know what proportion of the records given in Table 2 will give meaningful results in the form of spectra.

We thank Captain Maw and the officers and crew of 'John Murray' for their very able help and co-operation during the cruise.

J.A.E.

Report on Equipment

1. Pitch-roll Buoy (C.H. Clayson, K. Birch, A.C. Braithwaite)

This was the first occasion on which the fully modified pitch-roll buoy, complete with digital compass, was used; the compass had previously functioned successfully on the e.m. spar buoy on two occasions and had since been modified for serial readout to economise on cables and connectors. Two complete buoys were taken, one of these being used throughout the measurements. Another minor defect which came to light was unidirectional noise spikes on the pitch and roll potentiometer outputs due to intermittent contact of the wipers with the wire windings. This was subsequently eradicated by capacitors connected between each wiper and the supply rails, resulting in a "track and hold" action. Apart from these modifications, the equipment worked well: the use of the A-frame on 'John Murray' made launching and recovery of the buoy a relatively straightforward and safe procedure which was ably carried out by the crew. Thirty $\frac{1}{2}$ hour records were made on $\frac{1}{4}$" magnetic tape and were subsequently transferred to 7-track magnetic tape using the IBM 1800 at Wormley. The computations for the directional spectra were carried out using the IBM 360/65 in London.

C.H.C.

2. Telemetering Buoys (E.P. Collins, C.H. Clayson, K. Tipping)

These buoys were based on the electronics used in the I.O.S. disposable wave buoy design but, since the measurements were to cover a two week period, it was necessary to develop a more rugged float and electronics canister as well as a suitable mooring system. The float was constructed of marine plywood filled with expanded polyurethane and protected around its circumference by sections of motor car tyre. The electronics canister consisted of a modified Mk I pitch-roll buoy housing, the lid of which was fitted with a flashing light unit and aerial base. A mooring eye was attached to the bottom of the housing by means of a tripod bolted to the caniser webs. This eye was attached to the mooring which is illustrated in figure 2.

Tank towing trials established a drag load of 3 kg on the buoys at the expected maximum $2\frac{1}{2}$ knot current in the operational area and, on the strength of this figure, a bottom weight of 50 kg was considered adequate to hold the buoy on station. To this was added 7 metres of drag chain (18 kg weight) to damp out excessive snatch loads while minor variations due to wave motion effects on the buoy were covered by employing 20 metres of 9 mm bungee rubber as the main link in the system. The latter was backed up by a 35 metre length of 4 mm wire to prevent the rubber from exceeding its elastic limit during launch and recovery condition. A short length of light chain was incorporated into the mooring 2 metres below the buoy. This weighed 4.5 kg and gave the surface unit a self righting ability in heavy weather conditions. To further this aim and to prevent unwanted snatching the cable length was adjusted to keep an approximate 4% stretch load in the rubber under all conditions.

On completion of the trials both moorings were recovered and were found to be free from any sign of excessive wear in spite of the severe weather conditions prevailing during the greater part of the cruise period.

About 24 hours after each buoy had been deployed, intermittent breaks in transmission began to occur and, on subsequent recovery of the buoy, this fault was found to be due to excessive flexing at the base of the aerial mount resulting in motion being transmitted to the aerial connector and consequent intermittent contact. This problem was overcome by eliminating the electrical plugs and as an added precaution the mounts were stiffened to reduce aerial flexing. The aerial mount has since been modified completely to prevent this fault from recurring.

Following the above modifications the buoys operated satisfactorily and the moorings were in good condition upon final recovery. The problem of weak signal strength during rough conditions has been mentioned above and was probably due as much to the low mounting of the receiving aerial as to the varying propagation from the buoys. The "line of sight" range from the receiving aerial was calculated to be 9.3 km: an increase of 5 m in aerial base height would have increased this to 12.3 km, with consequent improvement in reliability of the link, but was not practically attainable.

We thank Dr R.M. Carson for help and advice on the design of the buoy and mooring system.

E.P.C. and C.H.C.

## TABLE 2

A. PITCH-ROLL BUOY All times are CET. Record duration is 30 min. All measurement at station 10 except where stated.

| IOS run no. (P) | Day (Sept. 1973) | Record start | Wind speed (kts) and direction during measurement (kts) | (deg) |
|---|---|---|---|---|
| 1 | 9 | 1323 | 18 | 285 |
| 2 | 9 | 2023 | 33 | 330 |
| 3 | 10 | 1220 | 20 | 340 |
| 4 | 10 | 1621 | 20 | 340 |
| 5 | 11 | 0826 | 16-28 | 340 |
| 6 | 11 | 1220 | 18-28 | 340 |
| 7 | 11 | 1620 | 18-25 | 340 |
| 8 | 11 | 2027 | 17-25 | 330 |
| 9 | 12 | 0017 | 20 | 320 |
| 10 | 12 | 0423 | 28 | 310 |
| 11 | 12 | 0827 | 30 | 310 |
| 12 | | not suitable for analysis | | |
| 13 (stn 9) | 17 | 1249 | 14-16 | 130 |
| 14 | 17 | 1623 | 10 | 120 |
| 15 | 17 | 1820 | 25 | 110 |
| 16(1) | 17 | 2020 | 25-35 | 120 |
| 17 | 19 | 1419 | 15-25 | 135 |
| 18 | 19 | 1620 | 15-27 | 135 |
| 19 | 19 | 1817 | 20 | 160 |
| 20 | 19 | 2015 | 10-20 | variable |
| 21 | 20 | 0020 | 4 | variable |
| 22 | 20 | 0420 | 18 | 295 |
| 23(2) | 20 | 0954 | 15-20 | 285 |
| 24 | 20 | 2016 | 10 | 210 |
| 25 | 21 | 0021 | 15-17 | 230 |
| 26 | 21 | 0416 | 12 | 170 |
| 27 | 21 | 0815 | 10-15 | 120 |
| 28 | 21 | 1019 | 20 | 120 |
| 29 | 21 | 1220 | 20-26 | 080 |
| 30(3) | 23 | 1216 | 15 | 240 |

(1) Comparison measurement with shipborne wave recorder

(2) Comparison measurement with stereo-observations

(3) Comparison with IOS telemetering buoy (blue)

TABLE 2 (continued)

B. TELEMETERING BUOYS All times CET. Record duration is 20 mins. Red buoy at position 10 km normal to the north of station 10. Blue buoy at station 65 km along the profile.

| Day (Sept. 1973) | Record start | IOS Run no Red buoy | IOS Run no Blue buoy |
|---|---|---|---|
| 9 | 1010 | 1 | |
| 9 | 1210 | 2* | |
| 9 | 1610 | 3* | |
| 9 | 2010 | 4* | 1 |
| 10 | 0810 | 5 | 2 |
| 10 | 1210 | | 3 |
| 10 | 1610 | | 4 |
| 10 | 2010 | | 5 |
| 11 | 0010 | | 6 |
| 11 | 0410 | | 7 |
| 11 | 0810 | | 8 |
| 11 | 1210 | | 9 |
| 11 | 1610 | 6 | 10 |
| 11 | 2010 | 7* | 11* |
| 12 | 0010 | 8 | 12 |
| 12 | 0410 | 9 | 13* |
| 12 | 0812 | 10 | 14 |
| 12 | 1212 | 11 | 15 |
| 12 | 1612 | 12 | 16 |
| 12 | 2012 | 13 | 17 |
| 13 | 0012 | 14 | 18 |
| 17 | 1017 | 15 | |
| 17 | 1222 | 16* | |
| 17 | 1422 | 17* | |
| 17 | 1617 | 18 | 19 |
| 17 | 1815 | 19 | 20 |
| 17 | 2015 | 21* | 21* |
| 17 | 2225 | 22 | 22* |
| 18 | 0415 | 23 | 23 |
| 18 | 0615 | 24* | 24 |
| 18 | 0815 | 25 | 25 |
| 18 | 1415 | 26 | 26* |
| 18 | 1615 | 27* | 27 |
| 18 | 1810 | | 28 |

TABLE 2 (continued)

| Day (Sept. 1973) | Record start | IOS Run no Red buoy | Blue buoy |
|---|---|---|---|
| 18 | 2018 | | 29 |
| 18 | 2215 | 28 | 30 |
| 19 | 0015 | 29 | 31 |
| 19 | 0215 | 30* | 32* |
| 19 | 0415 | 31 | 33 |
| 19 | 0615 | 32 | 34 |
| 19 | 0815 | 33 | 35* |
| 19 | 1015 | 34 | 36* |
| 19 | 1225 | 35* | 37* |
| 19 | 1415 | 36 | 38* |
| 19 | 1615 | 37 | 39 |
| 19 | 1815 | 38 | 40 |
| 19 | 2015 | 39 | 41 |
| 20 | 0015 | 40 | 42* |
| 20 | 0415 | 41 | 43* |
| 20 | 0815 | 42 | 44 |
| 20 | 1215 | 43* | 45 |
| 20 | 1421 | 44 | |
| 20 | 1615 | 45 | 46 |
| 20 | 2015 | 46 | 47 |
| 21 | 0015 | 47 | 48 |
| 21 | 0415 | 48 | 49 |
| 21 | 0815 | 49 | 50 |
| 21 | 1015 | 50 | 51 |
| 21 | 1215 | 51 | 52 |
| 21 | 1415 | 52 | 53* |
| 21 | 1615 | 53 | |
| 21 | 1815 | 54 | |
| 21 | 2015 | 55 | |
| 22 | 0015 | 56 | |
| 22 | 0415 | 57 | |
| 22 | 0820 | 58 | 54 |
| 22 | 1220 | 59 | |
| 22 | 1615 | 60 | 55 |
| 22 | 2010 | | 56 |
| 23 | 0010 | | 57 |
| 23 | 0420 | 61 | |
| 23 | 0820 | 62 | 58* |
| 23 | 1209 | | 59 |

* Weak signal. Spectral analysis may not be possible for this record.

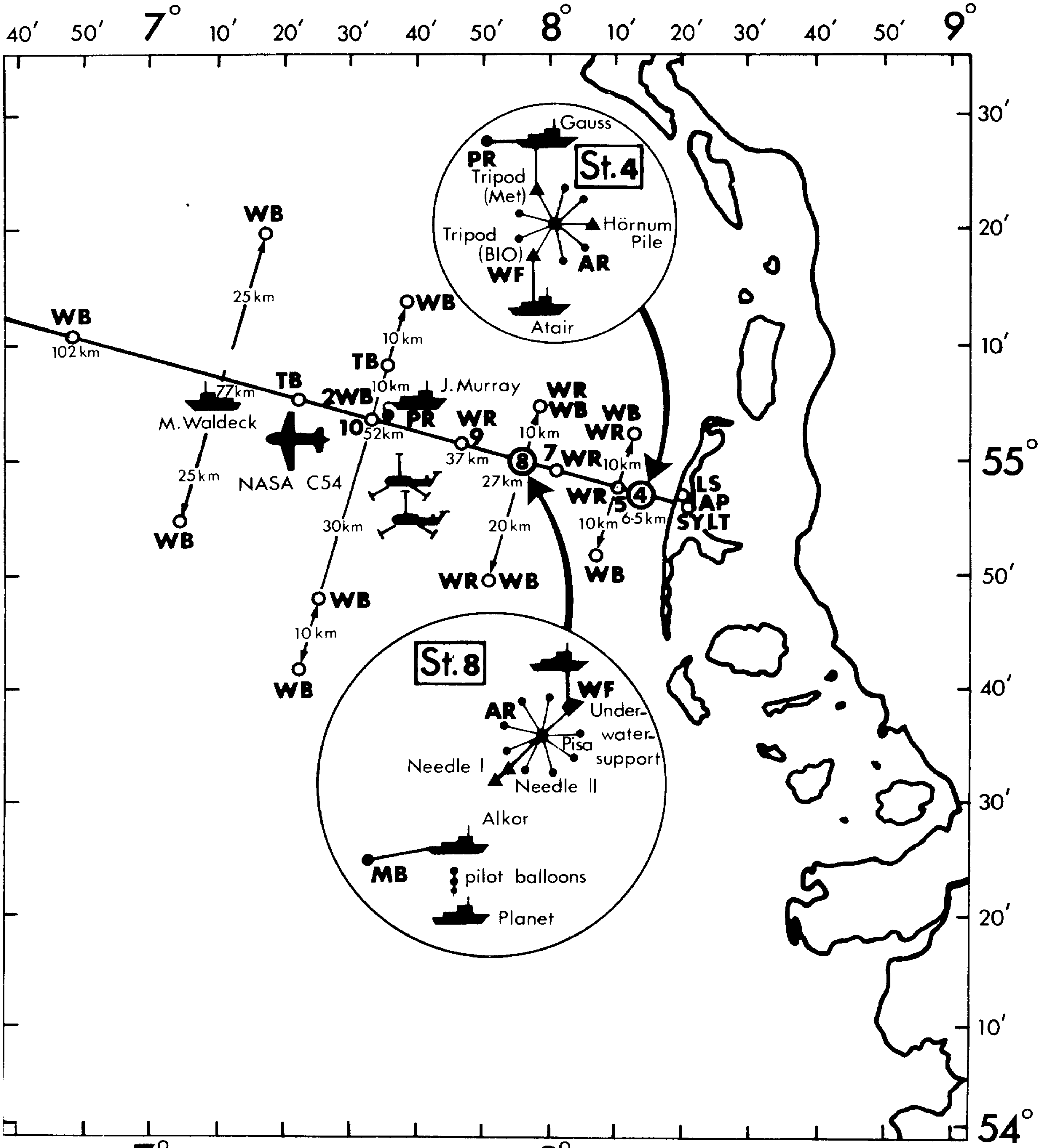
TABLE 2 (continued)

C. SHIPBORNE WAVE RECORDER All times are CET. Record duration is 30 mins. All measurements at station 10. These records were taken when it was impossible to launch the pitch-roll buoy during severe weather.

| IOS run no. (S) | Day (Sept. 1973) | Record |
|---|---|---|
| 1 | 10 | 0035 |
| 2 | 10 | 0300 |
| 3 | not suitable for analysis | |
| 4 | 10 | 0800 |
| 5 | 10 | 2020 |
| 6 | 11 | 0005 |
| 7 | 11 | 0435 |
| 8 | 12 | 1215 |
| 9 | 12 | 1640 |
| 10 | not suitable for analysis | |
| 10a | not suitable for analysis | |
| 11 | 13 | 0005 |
| 12(1) | 17 | 2016 |
| 12a | 17 | 2105 |
| 13 | 17 | 2215 |
| 14 | 18 | 0015 |
| 15 | 18 | 0240 |
| 16 | 18 | 0410 |
| 17 | 18 | 0815 |
| 18 | 18 | 0925 |
| 19 | 18 | 1220 |
| 20 | 19 | 0415 |
| 21 | 19 | 0830 |
| 22(2) | 20 | 0940 |
| 23 | 20 | 1210 |
| 24 | 22 | 0830 |
| 25 | 22 | 1610 |

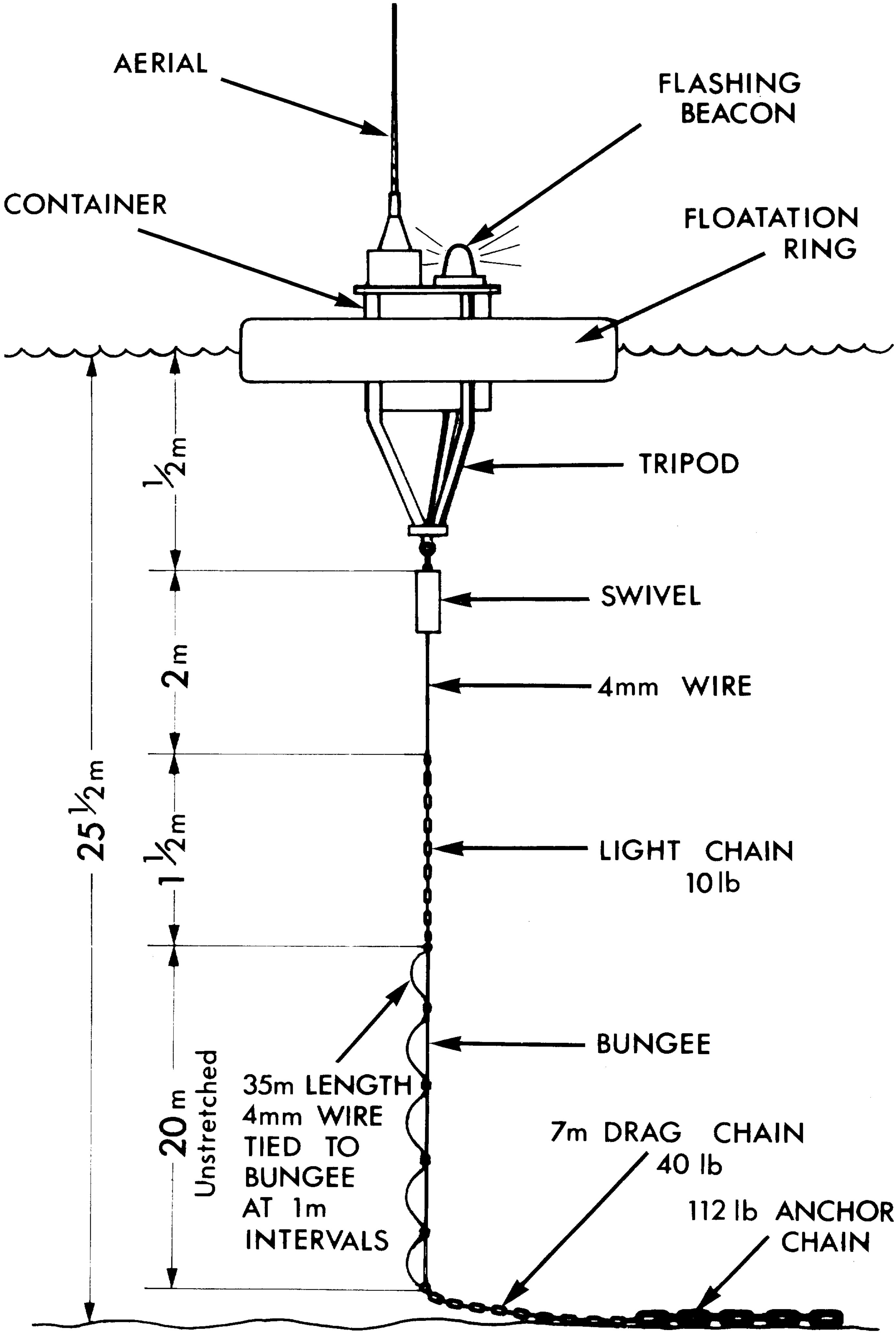
(1) Comparison measurement with pitch-roll buoy

(2) Comparison measurement with pitch-roll buoy and stereo-observations.




**WF** - WAVE FOLLOWER
**AR** - WAVE GAUGE ARRAY
**PR** - PITCH & ROLL BUOY
**WR** - WAVE RIDER BUOY
**WB** - WIND BUOY
**MB** - METEOROL. BUOY
**AP** - AIRPORT
**LS** - LANDSTATION
**TB** - TELEMETERING BUOY

FIG.1




I.O.S. TELEMETERING BUOY (not to scale) FIG. 2