9/36/70

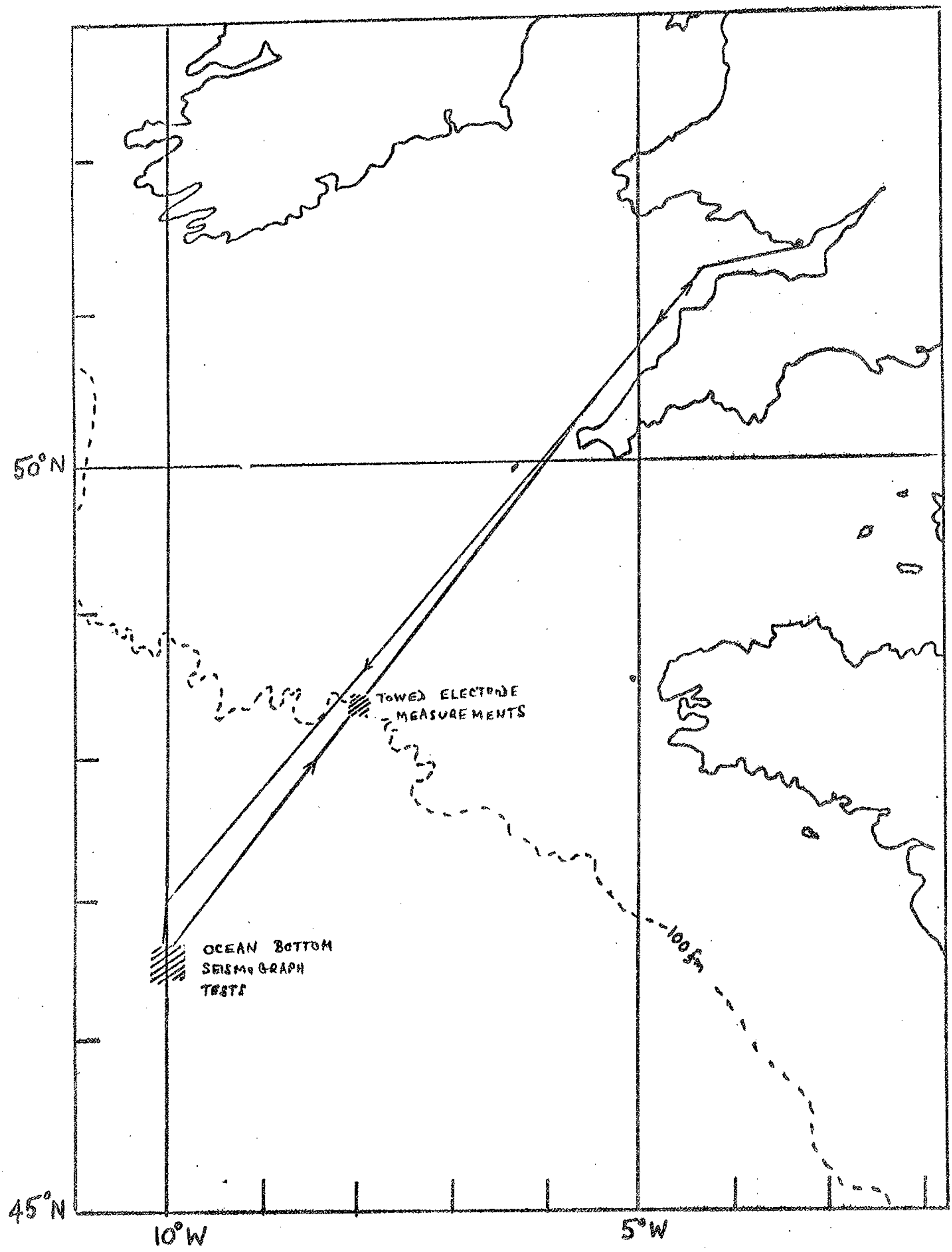
Report of Cruise 2/70

of R.R.S. John Murray

2nd-7th March 1970

N.E.Atlantic

UKAEA - Blacknest



R.R.S. JOHN MURRAY TRACK CHART 2ND - 7TH MARCH 1970

Summary

The purpose of this cruise was to test the spherical pressure vessels for the ocean bottom seismographs in deep water and to check the descent, bottom release, tracking and recovery of a twin sphere assembly which on later cruises will house the seismograph. All these tests were successfully accomplished, but a number of improvements in the construction and recovery of the equipment can be made.

A subsidiary purpose of the cruise was to gain familiarity with the use of Ag/AgCl non-polarising electrodes in measuring potential gradients in the sea.

Personnel

Dr. T. J. G. Francis	N.E.R.C.-U.K.A.E.A. Blacknest
Mr. P. J. Osborne	U.K.A.E.A.-A.W.R.E. Aldermaston
Mr. E. W. James	U.K.A.E.A. - Blacknest

Daily Log

2nd March	1200	Left lock at Barry.
3rd March		On passage.
4th March	0855	Arrived area of operations, approx. 46½°N, 10°W.
	0900-0945	Laid Dan buoy in 4700 metres of water.
	1000-1630	Pressure testing 3 empty spheres to 4500 m depth. Operation suspended temporarily due to weather.
5th March	0700-1300	Pressure testing twin-sphere assembly on main warp to 4500 m depth.
	1300-1430	Minor repairs to twin-sphere assembly.
	1430-1515	Tracking twin-sphere assembly floating on surface.
	1515-2335	Free-fall of twin-sphere assembly in 4700 m water, tracking and recovery.
	2345-0030	Recovered Dan buoy.

6th March	0030-1345	On passage to Barry.
	1345-1615	Towing non-polarising electrodes at 3 kt. Various courses over edge of shelf.
	1615-	On passage to Barry.
7th March c.2000		Arrived Barry.

Pressure Tests of Three Empty Spheres

This test consisted of lowering the three spheres to 4,500 metres depth (6,750 p.s.i.) with the main coring winch and keeping them at that depth for 3½ hours. The spheres are designed to operate down to 6,100 metres depth (9,150 p.s.i.), at which depth the safety factor is 1.27. All the spheres withstood the pressure and no leaks occurred. A steel probe indenting an Indium surface was installed in one of these spheres to measure its contraction under pressure. This showed a reduction of the internal diameter of the sphere (25½") by 1/16".

Pressure Test of Twin Sphere Assembly

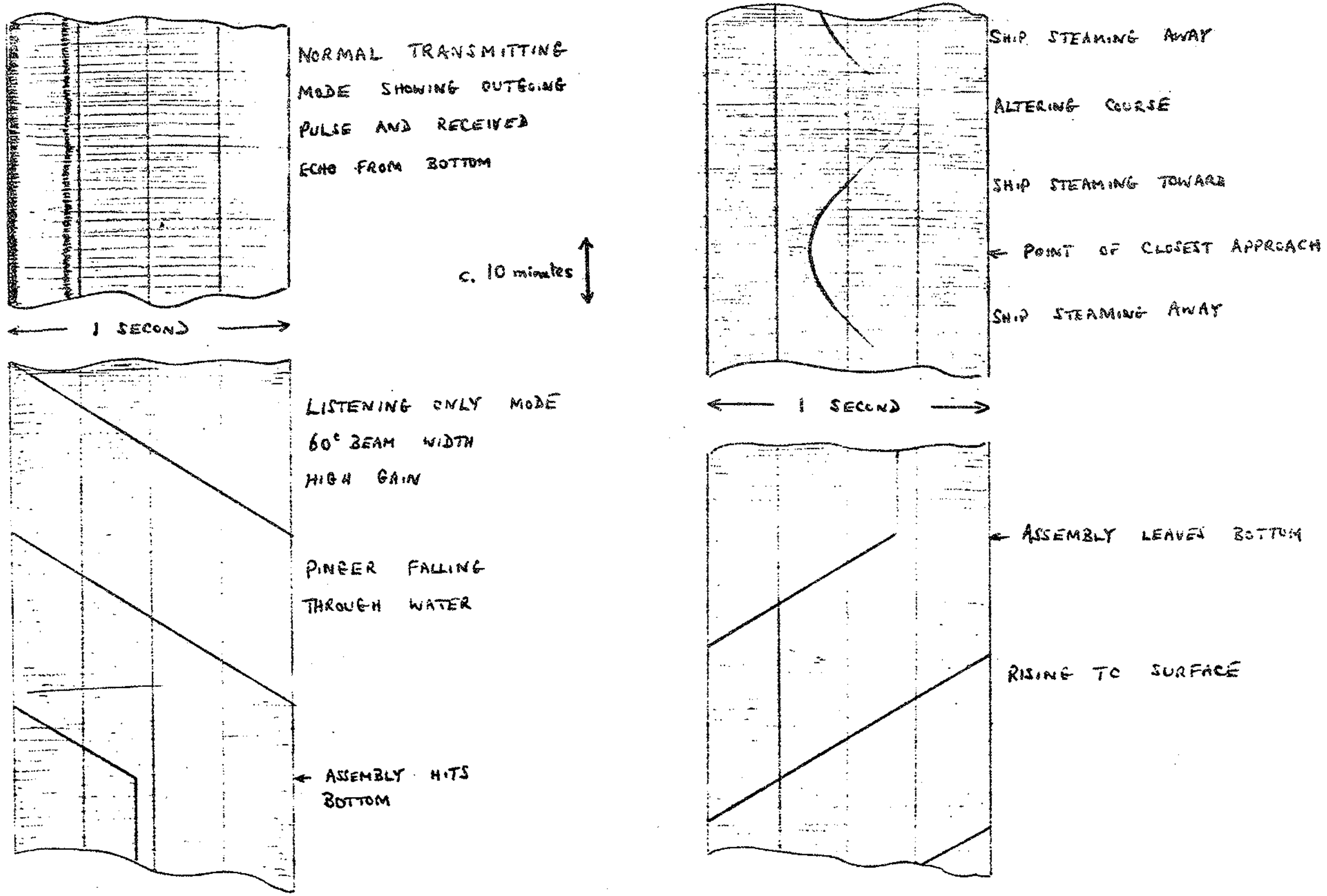
This consisted of lowering the assembly to 4,500 metres depth (6,750 p.s.i.) with the main coring winch and keeping it at that depth for 1½ hours. The pinger and flashing light were operated throughout from electronics and power supplies in the lower sphere. The explosive bolt was fired at depth by a clockwork time delay also housed in the lower sphere. The firing of the bolt was not detectable at the ship, but the pinger was recorded throughout on the PDR (Precision Depth Recorder) - indicating that the sphere containing its electronics was intact. Lead weights simulated the seismographic equipment in the lower sphere so that if flooding occurred no expensive apparatus was harmed. All the equipment under test operated satisfactorily, but damage to minor structural elements and to the glass of the flashing light was caused by rough handling on bringing the assembly inboard.

Test of Twin Sphere Assembly as Surface Buoy

In this test the assembly was placed in the water in the identical configuration in which it would surface from a free release, to test that it floated correctly and our ability to track it visually and by radar. Only the top 3-4 ft. of the structure appear above the surface when floating, so that it is too low in the water to be an effective radar target. At the time of this test sea conditions were favourable, with little sea and a moderate swell, and the assembly was detectable by radar to a range of 0.5 nautical miles. Visually, through binoculars, it could be sighted at more than twice this range. No attempt was made to try alternative radar reflectors as it was thought that their effect would only be marginal.

Free Release, Tracking and Recovery of Twin Sphere Assembly

The two preceding tests with the twin sphere assembly were necessary preliminaries to this main test in which the assembly was allowed to fall free to the sea bed at 4700 metres depth (7050 p.s.i.), remain there for 4 hours, then fire its explosive bolt and rise to the surface for recovery. During its descent, ascent and stay on the bottom the acoustic pinger fitted to the assembly was continuously recorded on the ship's P.D.R., enabling its rate of fall, rise and position on the bottom to be determined. The acoustic pinger transmitted a 10 Khz pulse precisely at 1 second intervals - the same frequency and pulse repetition frequency as the ship's echo sounder - so that any change in the relative velocity of the pinger and the ship (e.g. the assembly landing on the bottom or the ship steaming away) caused a change in slope of the pinger record on the P.D.R. Examples of the records obtained are shown in the diagram and the relevant weights, buoyancies and rates of sinking and surfacing observed are given in the table.



EXAMPLES OF P.D.R. RECORDS SHOWING TRACKING OF ACOUSTIC PINGER ON TWIN SPHERE ASSEMBLY

While the assembly was being tracked acoustically the position of the ship was observed by radar fixes on a moored dan buoy. Each course past the twin sphere assembly on the bottom produced a hyperbolic trace on the P.D.R. from which the time of closest approach could be obtained. At this time the assembly lies on a line perpendicular to the ship's track. By following a number of courses a number of position times were obtained, hence a fix of the equipment on the sea floor. The position obtained was only 0.1 nautical miles distance horizontally from the point at which the assembly was released on the surface, i.e. not significantly different from the latter.

The test was timed so that the assembly surfaced at night, since its flashing light can be seen more easily at night than the actual structure in daylight.

When a body falling freely through a viscous fluid has reached its terminal velocity (U), the drag force it experiences is given by

$$F = \tfrac{1}{2} C_D U^2 S \rho$$

where S is its cross sectional area perpendicular to the direction of motion, ρ is the density of the fluid and C_D is a dimensionless number called the drag coefficient. C_D is a function of the Reynolds number

$$R = \frac{Ud\rho}{\nu}$$

also dimensionless, where d is a relevant dimension and ν is the viscosity of the fluid. For a cylinder C_D lies between 1.3 and 0.3 for values of R ranging from 10^2 to 10^6 (Goldsmith, Modern Developments in Fluid Dynamics, 1938).

In the case of the twin-sphere assembly falling through the sea, $U \approx 100$ cm/sec, $\rho = 1.025$ gm/c.c., $\nu = 0.015$ poise and $d \approx 50$ cm. Hence the Reynolds number is rather large, $R \approx 3 \times 10^5$, near the limit of the range for which C_D is specified by Goldsmith. Nevertheless, the drag coefficients both for the descending and ascending assembly come out at the reasonable figure of 0.6 (see table).

	Weight of Assembly in Air	Weight of Assembly in Seawater	Cross Sectional Area S	Terminal Velocity U	Drag Coefficient C_D
Descent	1360 lb	+240 lb	18.35 ft^2 (sinker)	1.42 m sec^{-1}/4.65 ft sec^{-1}	0.60
Ascent	910 lb	-40 lb	5.24 ft^2 (equatorial ring)	1.11 m sec^{-1}/3.64 ft sec^{-1}	0.58

$g = 32 \text{ ft sec}^{-2}$ $\rho_{Seawater} = 64 \text{ lb ft}^{-3}$

Conclusions and Recommendations

The most critical part of the whole operation was retrieving the twin sphere assembly from the sea. This was done three times in the course of the cruise, each time more smoothly than the last as the crew grew used to the problem. Nevertheless the spheres struck the ship's side a number of resounding blows which would have subjected apparatus inside them to greater accelerations than we would wish. The following damage was caused:

(1) Gouging and scratching of the hemispheres and particularly of the equatorial rings, which could weaken the pressure vessels and by removing the protective surface allow corrosion to start.

(2) Distortion of the conical structure on top of the assembly. This is of minor importance as the structure only holds up the lifting bridle and does not take the weight of the assembly when it is lifted out of the water.

(3) Dislodgement of pinger scroll and flashing light from top sphere and consequent shattering of glass dome of the flashing light. The grub screws holding these to the boss of the top sphere were too light.

(4) Fracturing of clamp securing the bosses of the top and bottom spheres together. This can be strengthened.

To avoid a repetition of this damage rubber fenders will be fitted around both equatorial rings before the next sea trip.

The setting of the clockwork time delays used on this cruise to fire the explosive bolt required the bottom sphere to be split on the open deck of the ship. This was a tricky operation because of the crudity of the available lifting gear and the motion of the ship. With the seismographic equipment installed, the sphere will only be split in a closed compartment to avoid contamination by spray anddamp. It will also be necessary to have our own chain hoist for lifting.

The rate of fall of the twin-sphere assembly was rather higher than necessary and the weight of the sinker should be reduced.

T. J. G. Francis

UKAEA,
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20th March 1970