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AN EXPERIMENTAL ANALYSIS OF THE DYNAMICS OF A SUBMERGED TETHERED CRADLE

by

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AN EXPERIMENTAL ANALYSIS OF THE DYNAMICS OF A SUBMERGED TETHERED CRADLE IN A SEAWAY

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ABSTRACT

Submerged recovery of small submersibles by means of surface tethered platforms offers the possibility of operations in sea states higher than is now possible using surface recovery means. The Woods Hole Oceanographic Institution's submersible support catamaran LULU has such a tethered system. The system consisting of cradle, chains, and hoist is designed to recover DSRV ALVIN at a depth of 100 feet, and then lift the submersible rapidly through the air-sea interface. Scientific commitments as well as possible damage to the cradle and/or ALVIN, and danger to personnel have prevented full scale recovery experiments. A 1/40 scale model of the catamaran, chain and cradle was constructed to investigate cradle heave and pitch response in regular sinusoidal waves. Model tests were conducted at the Massachusetts Institute of Technology Tow Tank Facility and data was recorded electronically and photographically. Test runs were made at various ship speeds, cradle depths, wave heights, wave lengths, and cradle suspension modifications. Results indicate that for the existing system, cradle pitch and heave is only slightly attenuated over catamaran response at speeds less then 3 knots (full scale). By decreasing the number of cradle suspension points, and varying hoist resiliency and cradle added mass characteristics, cradle motion can be substantially reduced over catamaran motion.

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H	wave height measured peak to trough
RAO	response amplitude operator
z_o	heave measured positive upward
θ_o	pitch amplitude
h_o	wave height measured peak to trough
λ	wave length measured peak to peak
ω_e	frequency of encounter
u_w	wave velocity
u_s	ship speed
α	heading direction of vehicle relative to the direction of wave propagation ($\alpha = 180°$ for head seas)
C_d	coefficient of viscous drag
ϕ	wave velocity potential
g	acceleration due to gravity
A	one half peak to trough wave height
ω	wave frequency
K	wave number
k_o	values of K which satisfy $k_o \tanh k_o h = K = \omega^2/g$
h	water depth
t	time
δ	wave phase angle
z	depth measured negative downward from the free surface
u	velocity component in x direction
w	velocity component in z direction
M	real cradle mass plus added mass ($m + m_a$)
C	damping coefficient of cradle

C_c	critical damping
k	equivalent spring constant
X_o	amplitude of ship vertical motion
y	cradle vertical motion (+ upward)
y_o	amplitude of platform vertical motion
A_c	projected area of cradle normal to flow
ρ	fluid density
ω_n	undamped natural frequency, $\omega_n = (k/M)^{\frac{1}{2}}$
X_{STAT}	at rest spring deflection due to suspended mass
$S_\zeta(\omega)$	spectral density, such that total energy in an increment $\delta\omega$ at the central frequency ω_n is $\rho g[S_\zeta(\omega_n)\delta\omega]$
L	ship length

INTRODUCTION

The Deep Submergence Research Vehicle (DSRV) ALVIN and her support catamaran LULU are perhaps the most successful deep submersible combination that regularly operates in the open ocean. Funded and owned by the U.S. Navy and operated by the Woods Hole Oceanographic Institution, ALVIN has to date completed 390 dives in six operating seasons from 1964 to 1971. The most recent operating period, lasting from 4 June 1971 to 17 December 1971, was ALVIN's most active with a total of 82 dives.

As presently configured (Figure 1), LULU has a 30 ton net capacity cradle with four-point chain hoists located between her two hulls just aft of mid-ships. During transit, the cradle is two-blocked in the raised position such that the top of the cradle is flush with the surrounding deck, providing easy access for maintainence of ALVIN. Launch of the submersible is executed by having the catamaran lie to with the sea astern, while the cradle is lowered so that it is clear of the floating submersible. Snubber lines prevent lateral relative motion between ALVIN and LULU until the pilot on board ALVIN has powered her clear of LULU's stern at which time all lines are removed, and the dive can commence. Retrieval is the reverse of the launch sequence. Upon completion of the dive, ALVIN surfaces well clear of LULU. The two vessels then close each other with the aid of visual and/or radio direction devices. The catamaran maneuvers such that the seas are astern (Figure 2), at which time ALVIN approaches LULU, receives snubber lines, drives herself between the hulls, and is positioned over the submerged cradle. When alignment is correct, the cradle