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SEA TRIALS OF THE DAMPED VIBRATION ABSORBER FITTED TO H.M.A.S. --ETC(U)

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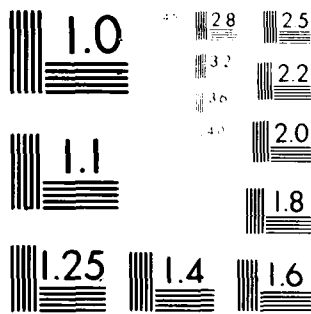
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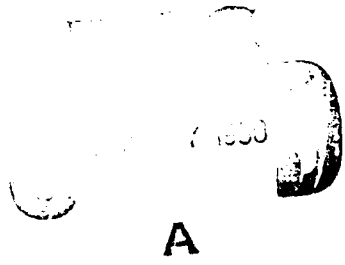
Structures Technical Memorandum 315

SEA TRIALS OF THE DAMPED VIBRATION ABSORBER  
FITTED TO H.M.A.S. TARAKAN

A. GOLDMAN

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Structures Technical Memorandum 315

SEA TRIALS OF THE DAMPED VIBRATION ABSORBER  
FITTED TO H.M.A.S. TARAKAN

A. GOLDMAN

5 May 89

Technical drawing (13/25)

SUMMARY

A damped vibration absorber, similar to those previously installed on H.M.A.S. Balikpapan and H.M.A.S. Brunei, has been fitted to H.M.A.S. Tarakan. Some changes to the installation have been made, and tests carried out to prove the effectiveness of these changes. The reasons for the changes, and details of the tests, are described.

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POSTAL ADDRESS: Chief Superintendent, Aeronautical Research Laboratories,  
P.O. Box 4331, Melbourne, Victoria, 3001, Australia.

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DOCUMENT CONTROL DATA SHEET

Security classification of this page: UNCLASSIFIED

1. DOCUMENT NUMBERS	2. SECURITY CLASSIFICATION
a. AR Number: AR-002-201	a. Complete document: UNCLASSIFIED
b. Document Series and Number: Structures Technical Memorandum 315	b. Title in isolation: UNCLASSIFIED
c. Report Number: ARL-STRUC-TECH-MEMO-315	c. Summary in isolation: UNCLASSIFIED

3. TITLE:  
SEA TRIALS OF THE DAMPED VIBRATION ABSORBER  
FITTED TO H.M.A.S. TARAKAN

4. PERSONAL AUTHOR(S):  A. GOLDMAN	5. DOCUMENT DATE: MAY, 1980
	6. TYPE OF REPORT AND PERIOD COVERED:

7. CORPORATE AUTHOR(S): Aeronautical Research Laboratories	8. REFERENCE NUMBERS
	a. Task: NAV 76/18
9. COST CODE: 23 2610	b. Sponsoring Agency:

10. IMPRINT: Aeronautical Research Laboratories, Melbourne	11. COMPUTER PROGRAM(S) (Title(s) and language(s)):
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12. RELEASE LIMITATIONS (of the document):  
  
Approved for Public Release.

12.0. OVERSEAS:	N.O.		P.R.	1	A		B		C		D		E	
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13. ANNOUNCEMENT LIMITATIONS (of the information on this page):  
  
No Limitation.

14. DESCRIPTORS: Vibration.                      Vibration tests. Ships. Landing craft. Vibration damping. Damping tests.	15. COSATI CODES: 2011 1310
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16. ABSTRACT:  
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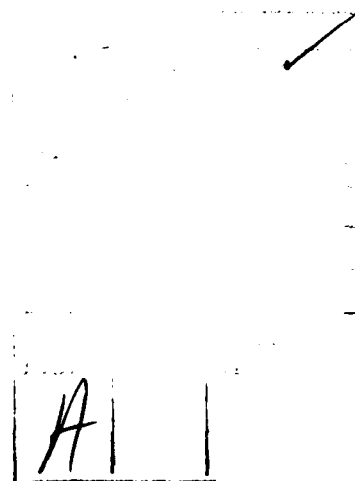
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## 1. INTRODUCTION

The design, and operation, of the tuned vibration absorber installed in the Landing Craft Heavy (LCH) operated by the R.A.N., have been adequately described in earlier reports. (Refs. 1 and 2).

Following installation of the first absorber in H.M.A.S. Balikpapan, and the subsequent sea trials reported in Ref. 2, it was considered that improvements could be made to the absorber by increasing the damping applied to the absorber.

This consideration was brought about by the way the absorber, in heavy seas, reduced the initial vibrations quite rapidly, but retained enough energy to re-introduce vibrations to the ship. This can be seen on Fig. 9 which is a curve produced from data recorded on sea trials on H.M.A.S. Balikpapan and shows the response of the ship, in the vertical plane, sensed by an accelerometer at the bow of the ship. On this curve it can be seen that the initial vibration decayed significantly after 3 cycles of vibration, and then increased in amplitude as energy from the absorber was transferred back to the ship. This response should be compared with Fig. 12 which was produced from data recorded on a sister ship, H.M.A.S. Tarakan, with the absorber in a correctly tuned operative condition. On this curve, the vibrations are seen to decay rapidly with no subsequent increase.

The initial design of vibration absorber as fitted on H.M.A.S. Balikpapan had dampers fitted along each side at distances from the pivot as indicated on Fig. 2. Unfortunately, the lower dampers were incorrectly installed in the inverted position which reduced their effectiveness considerably. The overall effect of this inversion was to lower the damping of the absorber from 10% to 7%. This reduced damping was measured on the sea trials but the inversion of dampers causing the problem was not discovered until some time later when the absorber was removed for inspection.

By this time, steps had been taken to modify the design by increasing the number of dampers and placing them at greater distances from the pivot of the absorber. Fig. 3 shows this new arrangement and in Tables 1 and 2 the effects, of the incorrect installation and subsequent modifications, on the damping of the absorber, are set out. The effectiveness of a damper is proportional to the square of the distance it is placed from the pivot point of the absorber.

The effect of inverting a damper is to make it ineffective in one direction of operation. An absorber with dampers as shown in Fig. 3 was installed in H.M.A.S. Brunei and H.M.A.S. Tarakan. Sea

trials carried out on H.M.A.S. Brunei in October 1978 recorded absorber damping far in excess of that expected. (Ref. 3). This was subsequently found to be due to incorrect installation of the absorber giving rise to excessive friction in the region of the pivot. Recommendations were made to reduce this, and in October 1979 the absorber was tested and found to be operative but highly damped. At this time, tests were carried out on H.M.A.S. Tarakan and the same conditions of high absorber damping were recorded. This condition is demonstrated in Fig. 10 which is a decay curve produced from data recorded on sea trials on board H.M.A.S. Tarakan in October 1979. The curve shows the response of the ship in the vertical plane as sensed by an accelerometer at the bow of the ship. The absorber was as close to correct tuning as could be ascertained from information available at that time. It can be seen that with the dampers fitted to the absorber in the arrangement shown in Fig. 3 the ship vibrations decay more rapidly than in the ship without an absorber (Fig. 8) but not as rapidly as would be expected if the correct value of absorber damping was used (see Fig. 12).

Following these trials, the recommendation was made to reduce the number of dampers to the configuration shown in Fig. 4. This, as shown in Table 2, would bring the damping down to approximately the 10% which would have been provided by the original design if the installation had been correct.

The following sections describe the trials on H.M.A.S. Tarakan in October 1979 prior to this last modification, and those in December 1979 after the modification.

## 2. CALM WATER TESTS - OCTOBER 1979

Tests were carried out to determine the characteristics of the absorber and ship. In these tests, the A.R.L. mechanical vibrator was used to excite the ship and absorber, in separate tests, to obtain the natural frequency of the absorber as a function of absorber spring pressure, and the natural frequency of the ship as a function of loading.

The results of these tests are presented in Fig. 5 showing the variation of absorber natural frequency with top spring air pressure, and Fig. 6 showing the variation of ship natural frequency with ship loading. As with previous tests, described in earlier reports (Refs. 2 and 3) the amplitudes obtained by use of the mechanical vibrator were relatively small compared with wave induced vibrations. On Fig. 6, three points are shown for tests in calm water. The point obtained from the test at the heaviest loading has not been used in the plotting of the curve. The frequency for this loading is very much less than has been obtained on similar tests on H.M.A.S. Balikpapan and H.M.A.S. Brunei, and it is considered that there is an error in this value. The most likely cause of error is in the determination of

ship loading. Also on Fig. 6 a second curve is plotted using results obtained from recordings made during transient tests described in Section 3 of this report.

The difference between the two curves is caused by the non-linearity of the ship's structure in that larger amplitude forces excite the structure at lower frequencies. This demonstrates the need to tune the absorber for operation at the correct conditions.

From Figs. 5 and 6, a third chart, Fig. 7, was produced giving recommended absorber top spring pressures versus ship loading. The pressure in the absorber bottom spring is not noted, this pressure being adjusted to position the absorber at the mean position. This positional location is carried out by means of a periscope and markers on the absorber and ship structure.

### 3. TRANSIENT TESTS - OCTOBER 1979

These tests were carried out on completion of the calm water tests described above, with the absorber and dampers as shown in Fig. 3. Accelerometers were fitted to measure vertical motion of the absorber, vertical motion of the ship in the same transverse plane as the measurement of the absorber motion, and fore-and-aft motion of the ship at a location on the bridge.

The ship was sailed into heavy seas and the vibration response of the ship to the impact of waves was recorded on a magnetic tape recorder.

This was carried out with the absorber locked, so as to be inoperative, and at various top spring pressures, and two ship loadings.

The data were later analysed in the laboratory, the results indicating that the damping of the absorber was excessive.

The decision was made to reduce the number of dampers to that shown in Fig. 4 and carry out further tests.

### 4. TRANSIENT TESTS - DECEMBER 1979

These tests were carried out during a scheduled journey by H.M.A.S. Tarakan from Brisbane to Tin Can Bay during which heavy seas were encountered.

The loading of the ship was fixed at 590 tonnes, and variation was not possible during the journey. The vibrations of absorber and ship were monitored at the same three locations as in the previous tests and records taken, at various absorber spring pressures, using a 4 channel tape recorder.

At the same time that recording was in progress, an analysis was carried out using the A.R.L.-developed Random Decrement Analyser. This machine works on principles described in some detail in Ref. 4.

The decay curves shown in Figs. 8-14 were produced in this way and show the response of the structure of the ship to wave impacts. The signal into the analyser was passed through a filter to eliminate frequencies below 1 hertz, caused by the pitching and rolling of the ship, and above 5 hertz caused by vibrations outside the area of interest. The length of time history taken in each sample was 5 seconds and the final curve was produced after approximately 1000 averages.

The set of curves shown in Figs. 8-14 was produced in this way from the tape recordings obtained during these tests and the previous tests in October 1979.

The following points should be observed from these:

Fig. 8 was produced from data recorded in October 1979 on board H.M.A.S. Tarakan with the absorber locked to prevent any movement relative to the ship. From this curve, which shows the response of the ship to wave impact, it will be seen that the vibration requires 8 cycles before reaching half the initial amplitude.

Fig. 9 was produced from data recorded in October 1977 on board H.M.A.S. Balikpapan when the absorber was fitted with dampers as shown in Fig. 2, half of the dampers being inverted. It can be seen here that the ship vibration decays rapidly but rises again as energy is transferred from the absorber back into the ship.

Fig. 10 was produced from data recorded in October 1979 on board H.M.A.S. Tarakan when the absorber was fitted with dampers as shown in Fig. 3. The absorber had been correctly tuned in accordance with the data obtained in the calm water tests. It can be seen that the vibrations have reduced to half the initial peak amplitude in 6 cycles, which is an improvement over the undamped ship shown in Fig. 8; however, the damping is still higher than the optimum.

Figs. 11-14 were produced from data obtained in December 1979 on board H.M.A.S. Tarakan when the absorber was fitted with 9 dampers. The intention had been to have 10 dampers fitted in the configuration shown in Fig. 4 but trouble with one of the mountings prevented the tenth damper being fitted in the time available. These decay curves show that the vibrations induced in the ship by wave impact decay far more rapidly with the absorber in use than when it is locked. They also show that while pressure in the top spring may

be varied by  $\pm 25$  kilopascals from the optimum tuned pressure without seriously affecting the performance, the optimum performance is obtained when the absorber is tuned in accordance with the graph given in Fig. 7.

## 5. CONCLUSIONS

The tuned absorber is shown to be effective in reducing vibrations quickly to an acceptable level, if the damping is correct. The satisfactory operation of the absorber in any particular sea state will depend upon the amount of damping applied to the absorber. Because it is not practicable, with the present design, to vary the damping to suit different sea states in service, the absorber has been left with 10 dampers fitted, in the positions shown in Fig. 4.

This will provide the optimum level of damping in sea states 3 and 4. In heavier seas, there will be a tendency for the vibrations to decay and then rise as shown in Fig. 9.

Following the tests now carried out on three ships with various configurations of dampers, it appears that all ships are sufficiently similar for a single tuning chart to be used.

It is recommended that each installation, on the remainder of the ships in the squadron, be tested to ensure that the absorber performs in a similar manner to the previous installations. Continuous monitoring of all ships at sea is not essential if the ships and installations remain similar.

Inspection of the absorber and dampers must be carried out at regular intervals to ensure continuous satisfactory performance over the life of the ship. An interval of not more than 1 year is recommended for inspection of all dampers, and two years for complete removal and inspection of the whole absorber. Replacement of corroded components should take place at these times.

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Random Decrement signatures.  
NASA CR-2205, 1973.

TABLE 1

EFFECT OF DAMPER INVERSION ON DAMPING COEFFICIENT

Distance of damper from pivot (x metres)	Initial Design		Initial Installation	
	No. of dampers ( $\eta$ )	effectiveness (f)	No. of dampers ( $\eta$ )	effectiveness (f)
1.003	2	1.0	2	0.5
1.118	2	1.0	2	1.0
1.232	2	1.0	2	0.5
1.346	2	1.0	2	1.0
1.461	2	1.0	2	0.5
1.575	2	1.0	2	1.0
	$\Sigma \eta x^2 f = 20.40 \equiv 10\%$ damping		$\Sigma \eta x^2 f = 15.74 \equiv 7.7\%$ damping	

N.B. damping effect of dampers is proportional to the square of the distance of the unit from the pivot.

TABLE 2

EFFECT OF FINAL MODIFICATION ON DAMPING COEFFICIENT

Distance of damper from pivot (x metres)	Revised design (FIG. 2)		Final Modification (FIG. 3)	
	No. of dampers( $\eta$ )	effectiveness(f)	No. of dampers( $\eta$ )	effectiveness(f)
1.232	2	1.0	2	1.0
1.346	2	1.0	2	1.0
1.461	2	1.0	2	1.0
1.575	2	1.0	2	1.0
1.689	4	1.0	2	1.0
1.803	2	1.0		
	$\Sigma \eta x^2 f = 33.8 \equiv 16.6\%$ damping		$\Sigma \eta x^2 f = 21.6 \equiv 10.6\%$ damping	

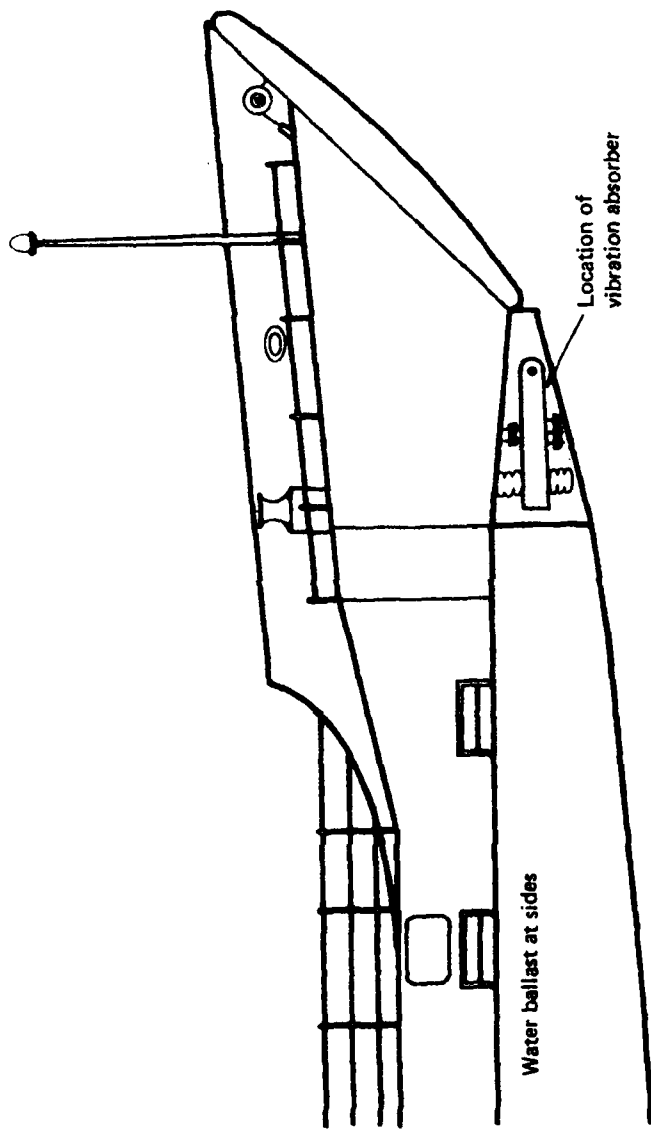


FIG. 1: LOCATION OF VIBRATION ABSORBER IN THE FORWARD WATER-BALLAST TANKS.

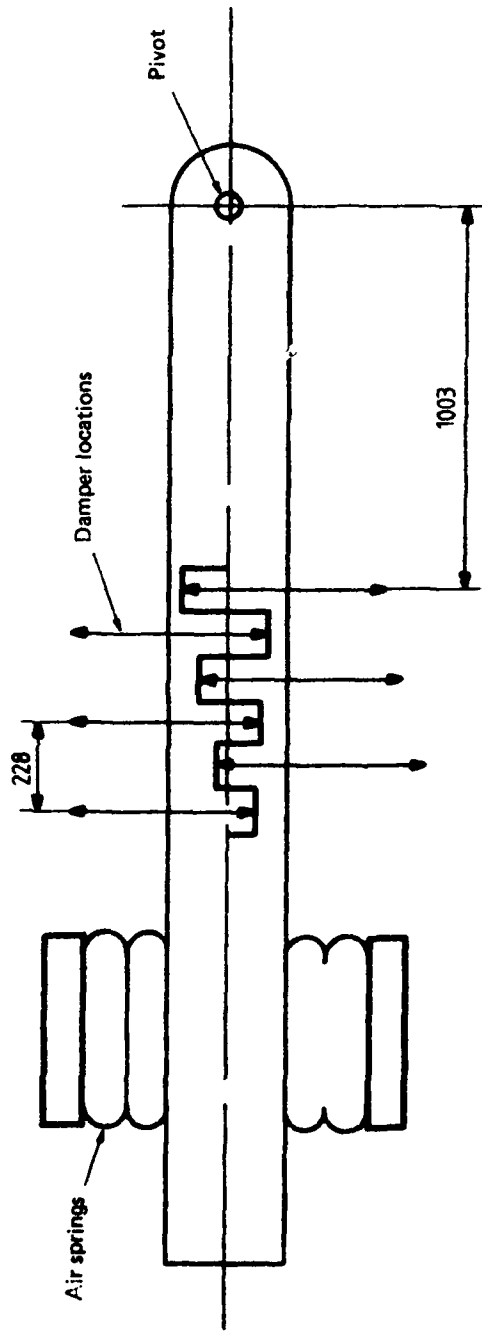


FIG. 2: ORIGINAL INSTALLATION ON H.M.A.S. BALIKPAPAN (INSTALLED WITH LOWER THREE DAMPERS ON EACH SIDE INVERTED)

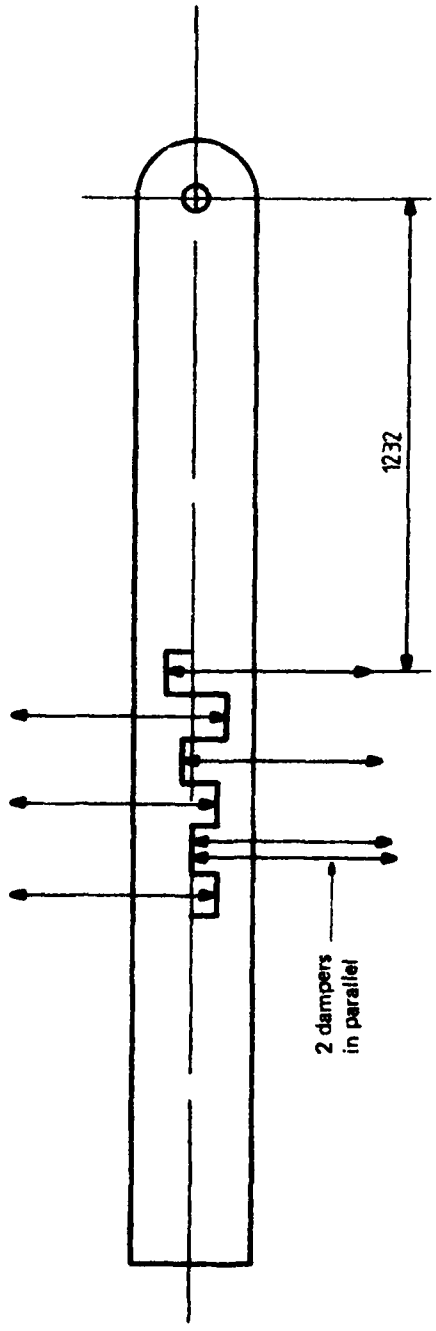


FIG. 3: MODIFIED INSTALLATION OF H.M.A.S. BRUNEI AND H.M.A.S. TARA KAN TO INCREASE DAMPING (OCT 1978)

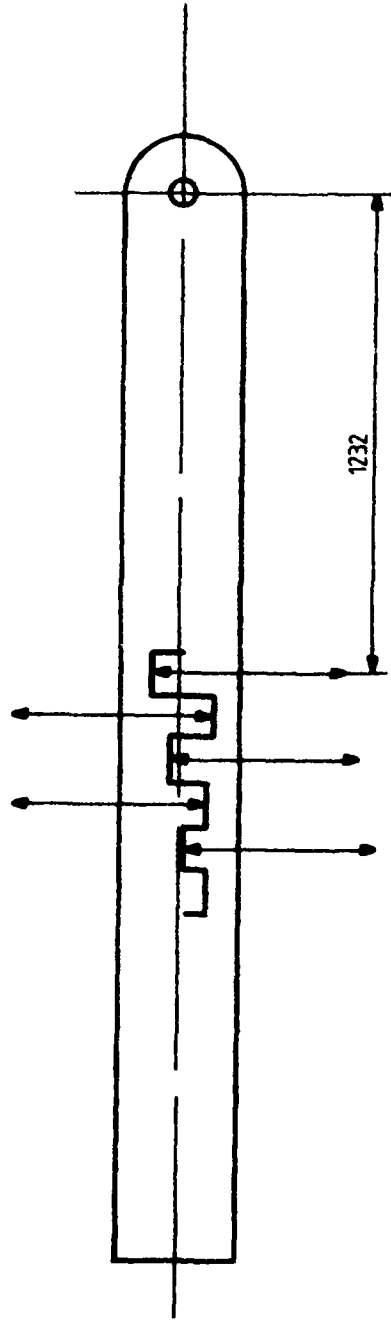


FIG. 4: MODIFICATION TO ALL SHIPS TO REDUCE DAMPING (NOV. 1979)

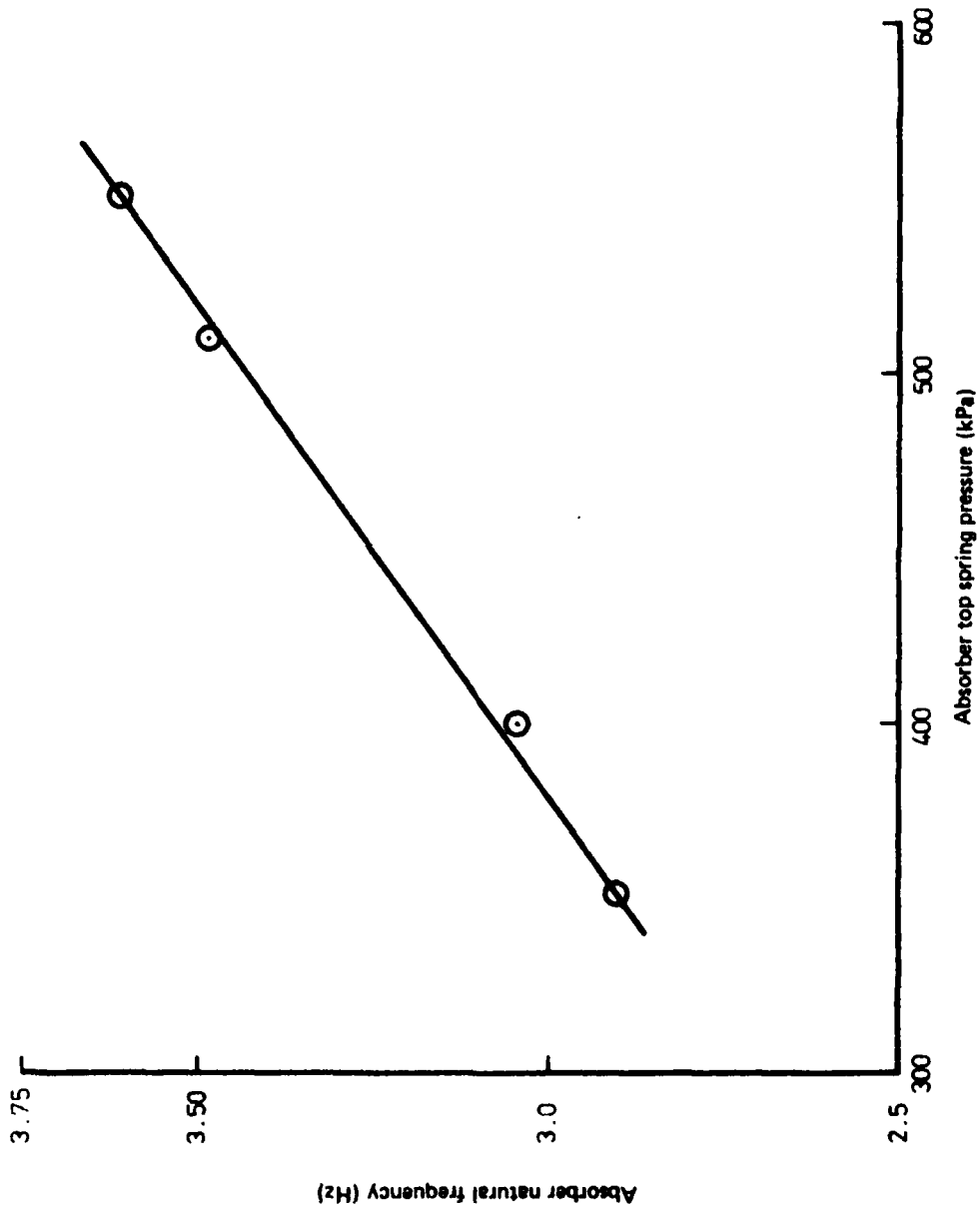


FIG. 5: H.M.A.S. TARA KAN, ABSORBER NATURAL FREQUENCY VS AIR SPRING PRESSURE

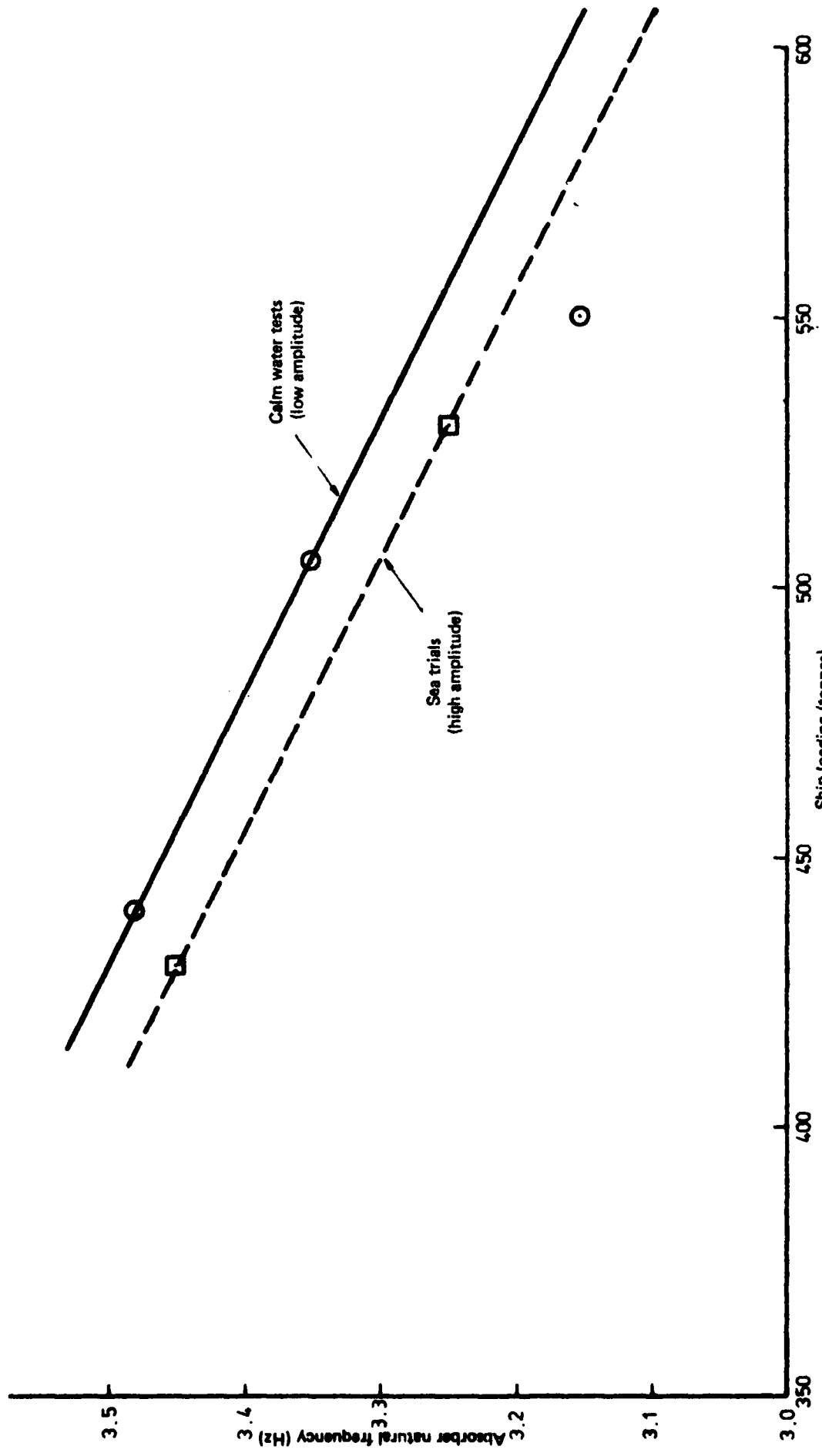


FIG 6: H.M.A.S. TARAKAN, SHIP NATURAL FREQUENCY VS LOADING

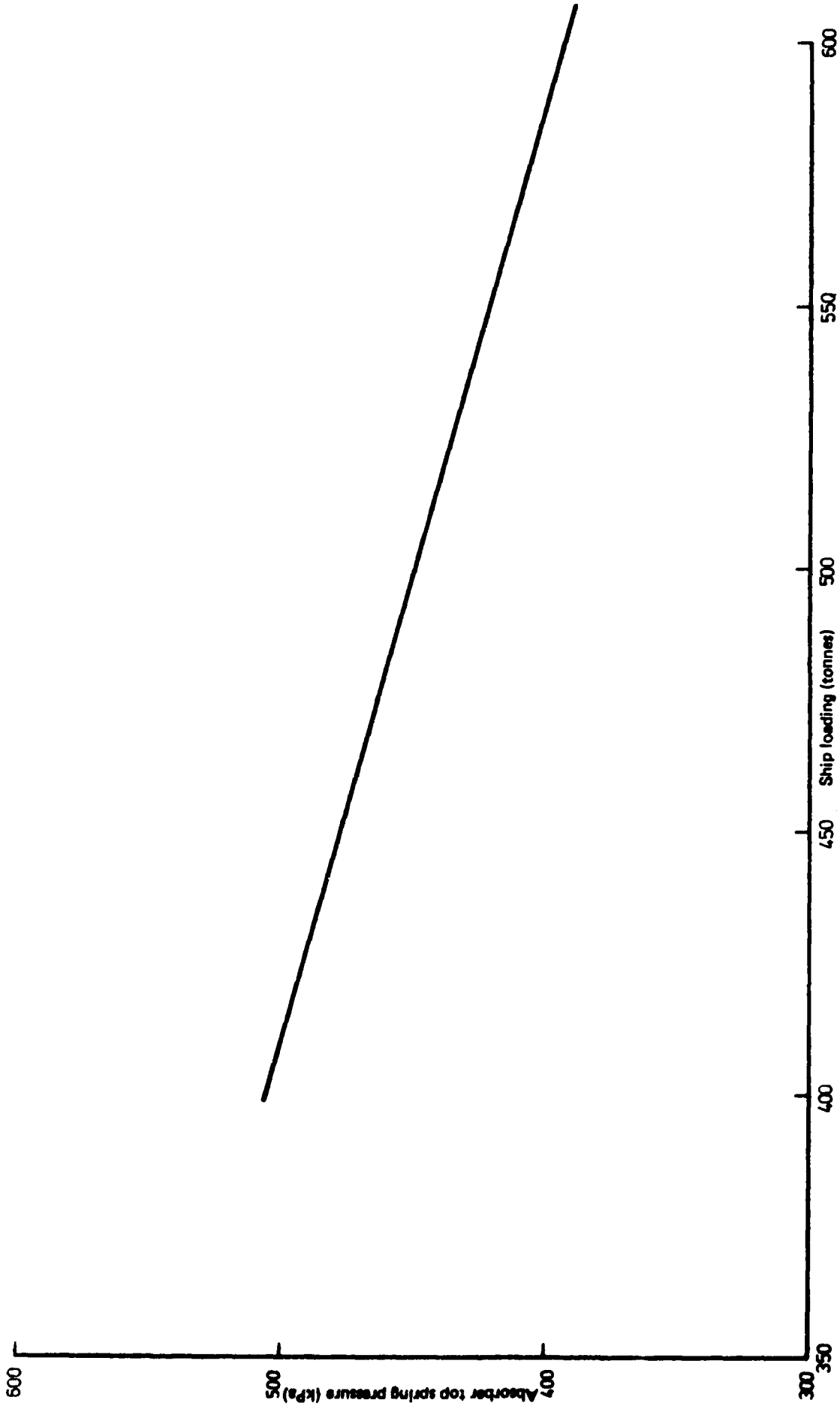
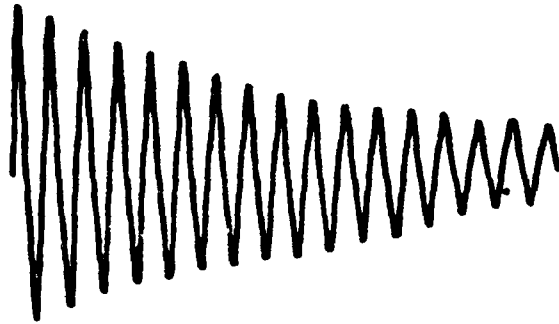
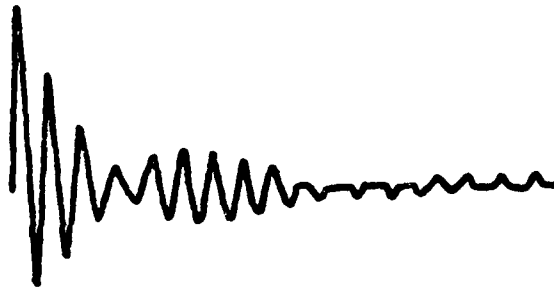


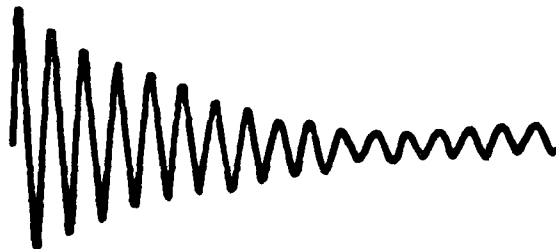
FIG. 7: H.M.A.S. TARAKAN, RECOMMENDED ABSORBER TOP SPRING PRESSURE VS SHIP LOADING



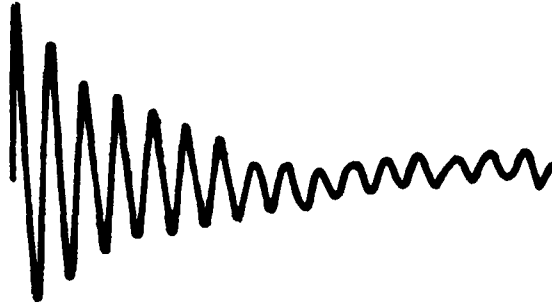
**FIG. 8: SHIP RESPONSE WITH ABSORBER LOCKED (HMAS TARAKAN OCT 1979)**



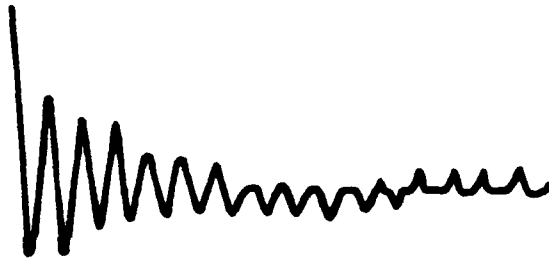
**FIG. 9: SHIP RESPONSE WITH ABSORBER CORRECTLY TUNED BUT WITH INSUFFICIENT DAMPING (HMAS BALIKPAPAN OCT 1977)**



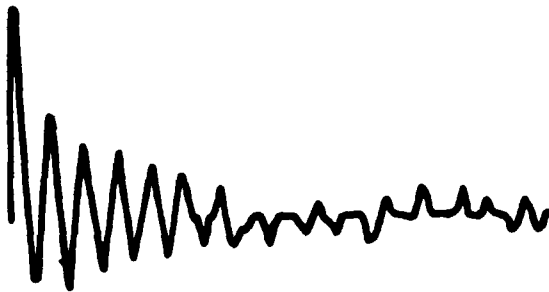
**FIG. 10: SHIP RESPONSE WITH ABSORBER CORRECTLY TUNED BUT WITH TOO MUCH DAMPING (HMAS TARAKAN OCT 1979)**



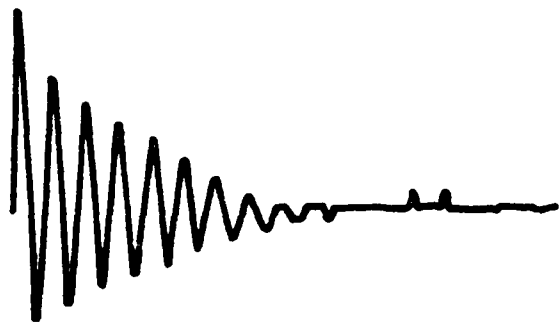
**FIG. 11: SHIP RESPONSE WITH 9 DAMPERS. SPRING PRESSURE 475 kPa. SHIP LOADING 590 TONNES (HMAS TARAKAN DEC 1979)**



**FIG. 12: SHIP RESPONSE WITH 9 DAMPERS. SPRING PRESSURE 425 kPa. SHIP LOADING 590 TONNES (HMAS TARAKAN DEC 1979)**



**FIG. 13: SHIP RESPONSE WITH 9 DAMPERS. SPRING PRESSURE 400 kPa. SHIP LOADING 590 TONNES (HMAS TARAKAN DEC 1979)**



**FIG. 14: SHIP RESPONSE WITH 9 DAMPERS. SPRING PRESSURE 375 kPa. SHIP LOADING 590 TONNES (HMAS TARAKAN DEC 1979)**

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