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NAVY DEPARTMENT

THE DAVID W. TAYLOR MODEL BASIN

WASHINGTON 7, D.C.

MEASUREMENT OF MOTION AND THRUST VARIATION OF MAIN PROPULSION SYSTEM OF USS FRED T. BERRY (DDE858)

by

Quentin R. Robinson

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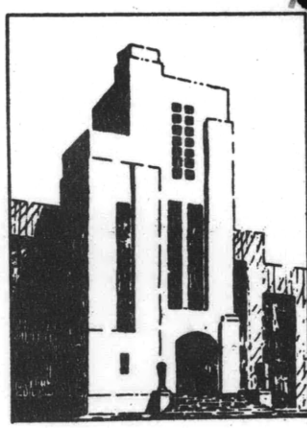

January 1954

Report 887
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ENCLOSURE (1)

MEASUREMENT OF MOTION AND THRUST VARIATION OF MAIN PROPULSION SYSTEM OF USS FRED T. BERRY (DDE858)

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ABSTRACT

Measurements of steady thrust, alternating thrust, and vibratory motions of both reduction gear cases of the USS FRED T. BERRY (DDE858) were obtained with the ship operating at various shaft speeds. The data show correlation between thrust and vibration of the starboard reduction gear and fix the first two longitudinal critical frequencies at 560 and 940 cpm, respectively. On the port propulsion system the amplitude peaks were indistinct and a similar correlation could not be established. Amplitudes of vibration on ships of this class are too small to permit determination of the spring constants of machinery foundations and thrust bearings.

INTRODUCTION

Information for design purposes was desired by the Bureau of Ships relating alternating thrust to steady thrust and relating the longitudinal vibration of the main propulsion systems to the alternating thrust. The David Taylor Model Basin was requested to make the thrust measurements, and the New York Naval Shipyard was designated to measure vibratory motions of the main propulsion systems.[1*]

The first test was conducted on 12 January 1953 enroute from Newport, Rhode Island, to Rockland, Maine. Vibrations of both reduction gear casings and of both low-pressure turbines were measured by the New York Naval Shipyard, and an attempt was made by the Taylor Model Basin to measure both the alternating and steady thrust. Some data on the motions of the reduction gear casings and the low-pressure turbine casings were obtained. However, rough seas prevented the operation of the ship above 230 shaft rpm.[2] The pressure data obtained during this test were considered unreliable, and little information could be extracted from them.

On 4 May 1953, after better instrumentation had been developed, a successful test was conducted by the Taylor Model Basin during which both static and alternating thrust measurements were made. No vibratory motions were measured during this test.

* All references are listed at the end of this report.

In order to determine whether or not the pressure capsules, used as sensing devices in the thrust meters, caused any change in the resonance frequencies of the propulsion systems due to additional flexibility introduced in the thrust bearing still another test was authorized.[3] This test involved measuring the vibratory motions of both reduction gear cases after removal of the thrust meters. It was conducted enroute from Philadelphia, Pennsylvania, to Earle, New Jersey, and from Earle to Newport, Rhode Island, on 27 and 28 August 1953.

INSTRUMENTATION

On the vibration test conducted by the New York Naval Shipyard motions of the reduction gear cases were measured with Geiger vibrographs mounted on the top of the after end of each main reduction gear case. Askania vibrographs were used to measure vibrations of the low-pressure turbines. The measurements were made in the fore-and-aft direction. The thrust measurements during this test were made with thrust meters utilizing elastic-tube gages[4] as sensing devices. The signal from the elastic-tube gage was fed into a TMB strain indicator and recorded on a General Electric oscillograph. As was previously pointed out the pressure measurements were not very successful due to instrumentation difficulties and rough seas.

For the second test the instrumentation used to measure alternating and steady thrust utilized a diaphragm pressure gage with a magnetic micrometer as the sensing element. The output of the gage was fed through a TMB magnetic micrometer indicator, Mark II, to a Sanborn d-c amplifier and recorded on a Sanborn 2-channel recorder. The value of steady thrust was obtained by balancing the indicator and reading the meter while the alternating component was recorded on the Sanborn recorder. This test was conducted in a calm sea off Rockland, Maine.

TMB pallographs were used to measure motions of the reduction gear cases on the third test. A Type H pallograph, oriented to measure longitudinal vibrations, was mounted on the top of the after end of the reduction gear case in the forward engine room. A Type V pallograph converted to measure horizontal motions was mounted at a similar location in the after engine room. General Radio vibration meters and pickups feeding through Brush amplifiers to Brush recorders were used in addition to the pallographs. No measurements were made of the turbine motions.

TEST PROCEDURE

All three tests were conducted in the same manner, that is, measurements were made with the ship operating on a straight course and maintaining a constant speed. The shaft rpm was changed in 5-rpm increments. Test 1 covered shaft speeds from 60 rpm to 230 rpm, Test 2 from 55 rpm to 330 rpm, and Test 3 from 35 rpm to 340 rpm. The ship's displacements for the three tests were 3235 tons, 3250 tons, and 3085 tons, respectively. Test 1 was conducted in rough seas, and Tests 2 and 3 were conducted in calm seas.

TEST RESULTS

The results of measurements made at the reduction gear in the forward engine room (starboard propulsion unit) are plotted in Figure 1. The motions and alternating pressures plotted are of the fourth order (frequency 4 times shaft rpm). The curves indicate that a resonance frequency occurs at about 140 shaft rpm (560 cpm). The curves for Tests 2 and 3 also indicate a possible resonance frequency at about 235 shaft rpm (940 cpm).

Figure 2 shows a plot of the data obtained from the reduction gear in the after engine room (port propulsion unit). These curves also indicate fourth order motions and thrust variations. The motion curve (Test 1) indicates the possibility of a resonance in the range 175 to 195 shaft rpm. The thrust curve (Test 2) indicates a resonance at 75 rpm and possible resonances at 140 and 290 shaft rpm. The motion curve for Test 3 shows a maximum amplitude of vibration occurring at 130 rpm and at 275 rpm.

In addition to the fourth-order vibrations plotted in Figure 1 (Test 3) vibrations having a frequency of about 68 cpm were recorded by the electrical pickup at shaft speeds of 80, 85, and 90 shaft rpm. Single amplitudes of motions at these speeds were 3, 2.5, and 0.5 mils respectively. Although not plotted, vibrations of the second and twelfth order were also recorded at shaft speeds of 285 rpm and above. The maximum amplitude recorded was about 4 mils single amplitude at a frequency of 600 cpm (second order) which occurred at 300 shaft rpm. The twelfth order vibrations were in the neighborhood of 2 mils single amplitude.

On the port reduction gear small motions having a frequency of about 60 cpm were recorded on the electrical pickup at shaft speeds from 35 rpm to 100 rpm. The maximum amplitude of these vibrations was about 1 mil.

The motions of the low-pressure turbines measured during Test 2 are not plotted in this report. The curves are similar to those indicating the motions of the reduction gear and are contained in reference (2).

DISCUSSION

The data plotted in Figure 1 indicate that the resonance frequencies of the starboard propulsion system occur at about 140 and 235 shaft rpm corresponding to frequencies of 560 cpm and 940 cpm respectively. The correlation between Tests 2 and 3 indicates that there is no appreciable change in the resonance frequency of the system due to the presence of the pressure capsules in the thrust meter.

Similar conclusions cannot be reached from the data obtained on the port propulsion system (see Figure 2). Test 1 indicates an amplitude build-up at about 180 shaft rpm. However, the fact that the amplitudes are small and were measured with a seismic instrument in rough seas renders this curve somewhat unreliable for determining the actual resonance. Test 2 indicates maximum alternating thrust ratios occurring at 75, 140, and 290 shaft rpm. Test 3 shows maximum motion occurring at 130 and at 275 shaft rpm. There is some agreement between Tests 2 and 3 in that the maximum amplitudes of motion were recorded at nearly the same shaft speed at which the maximum thrust variation was recorded with the exception of the thrust recorded at 75 rpm. It cannot be determined whether the difference in frequency is due to the presence of the thrust meter or whether it is due to the fact that the tests were not run simultaneously. Attention is called to the fact that at 75 shaft rpm the maximum thrust variation (Test 3) was not accompanied by a maximum amplitude of motion of the reduction gear (Test 2). The thrust values plotted indicate the ratio of alternating thrust to steady thrust. For comparison the actual alternating thrust measur at 75 rpm was about 1125 lb while the alternating thrust at 250 rpm was about 5400 lb. Using the amplitude of motion measured at 250 rpm (0.5 mils) and the ratios of alternating thrust at 75 and 250 rpm (1125/5400), it is reasonable to assume that the amplitude of motion of the reduction gear at 75 rpm would be about 0.1 mil and would not be detected.

SUMMARY

The data obtained on the starboard shaft show consistency and appear to establish the first two longitudinal critical frequencies. Of these the first is appreciably lower than that found for the corresponding system on DD692.[5] The second critical frequency checks fairly well.

In the case of the port system no such consistency exists, and the amplitude peaks are not sufficiently pronounced to establish definite values of the critical frequencies.

It does not appear that longitudinal vibration of the propulsion machinery on this class is of sufficient magnitude to serve as a basis for establishing experimental values of k_f (machinery foundation spring constant) and of k_{tb} (thrust bearing spring constant) for use in future designs. No further investigations of this type are recommended for vessels of this class unless for the purpose of establishing thrust variation only.

PERSONNEL

Vibration measurements were conducted on Test 1 and the results were analyzed and forwarded to the Taylor Model Basin by personnel of New York Naval Shipyard. The thrust measurements were made by James A. Higgins and Wayne H. Connell of the Taylor Model Basin. Test 3 was conducted by Quentin R. Robinson and Carrol H. Kinsey of the Taylor Model Basin.

REFERENCES

1. BuShips ltr All/Noise (371) Ser 379-709 to NYNSY and DTMB dated 30 Dec 1952.

2. NYNSY ltr 941:WHK:PW S41/L5 to BuShips and DTMB dated 26 March 1953.

3. BuShips ltr DDE858(371) Ser 371-282 to DTMB dated 16 June 1953.

4. Wenk, E., Jr., "An Elastic-Tube Gage for Measuring Static and Dynamic Pressures," TMB Report 627, May 1948.

5. "USS SUMNER (DD692) Vibration Survey of 12 June 1944" Report No. V-117, Navy Yard, New York, 17 June 1944.

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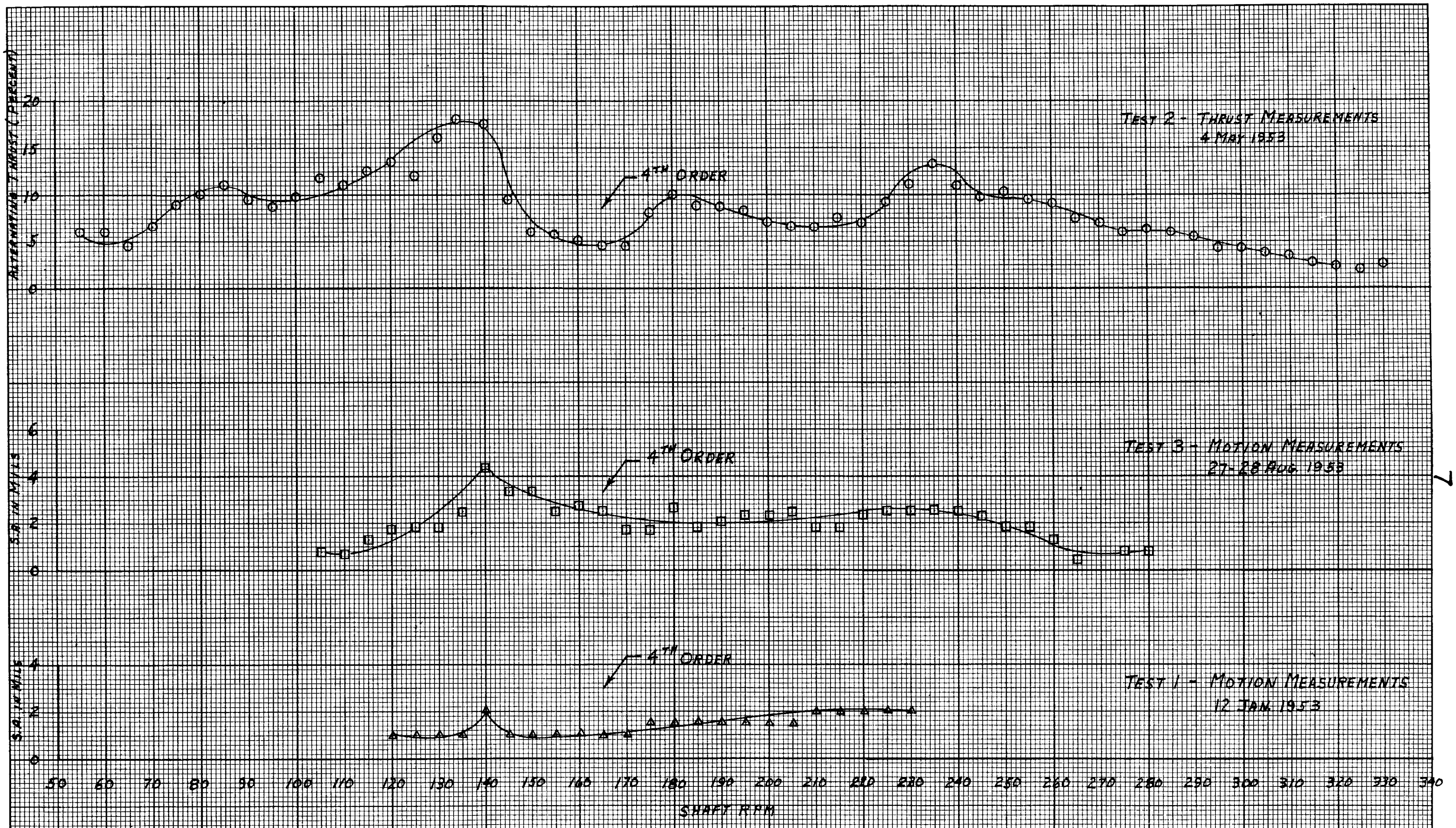

Figure 1 - Motion and Thrust Variation of Starboard Main Propulsion System

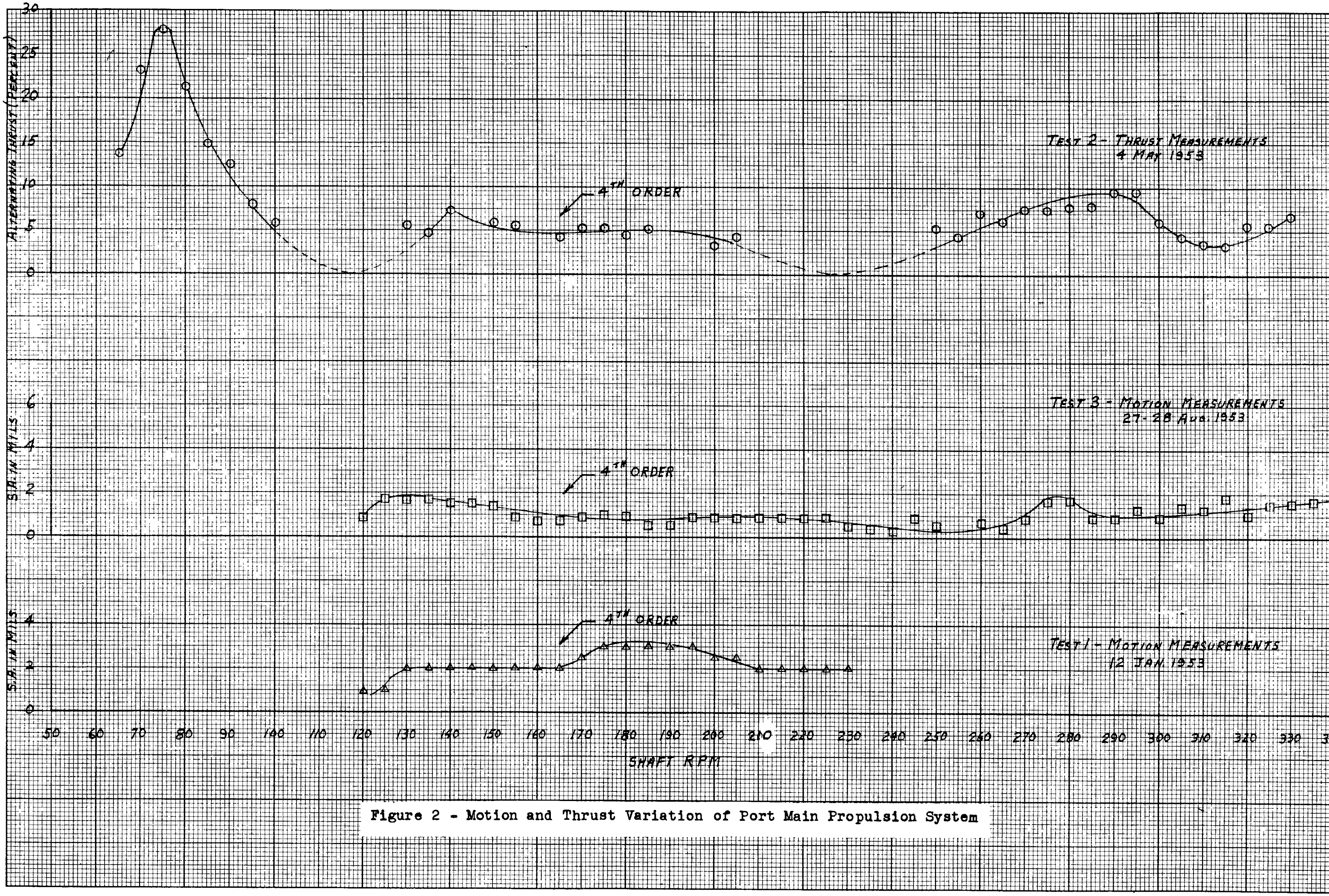

Figure 2 - Motion and Thrust Variation of Port Main Propulsion System

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MEASUREMENTS OF MOTION AND THRUST VARIATION OF MAIN PROPULSION SYSTEM OF USS FRED T. BERRY (DDE 858), by Quentin R. Robinson. January 1954. 8 p. incl. figs., refs. UNCLASSIFIED

Measurements of steady thrust, alternating thrust, and vibratory motions of both reduction gear cases of the USS FRED T. BERRY (DDE 858) were obtained with the ship operating at various shaft speeds. The data show correlation between thrust and vibration of the starboard reduction gear and fix the first two longitudinal critical frequencies at 560 and 940 cpm, respectively. On the port propulsion system the amplitude peaks were indistinct and a similar correlation could not be established. Amplitudes of vibration on ships of this class are too small to permit determination of the spring constants of machinery foundations and thrust bearings.

1. Ships - Propulsion
2. Vibration - Measurement
3. FRED T. BERRY (U.S. destroyer escort DDE 858)
I. Robinson, Quentin R.
II. Bureau of Ships. NS 712-100

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