

EVALUATION REPORT OF KOPPERS COMPANY -  
MAAG GEAR - WHEEL COMPANY LIMITED  
30,000 HP AT 4000 RPM SELF-  
SYNCHRONIZING OVERRUNNING CLUTCH

NAVSECPHILADIV PROJECT T-789  
S-4622, TASK 14910

4 NOVEMBER, 1971

**NAVAL SHIP ENGINEERING CENTER,  
PHILADELPHIA DIVISION**

PHILADELPHIA, PA. 19112



Each transmittal of this document outside the agencies of the U. S. GOVERNMENT must have prior approval of the DEPARTMENT OF THE NAVY, Commander, Naval Ship Engineering Center, Code 6145, Hyattsville, Maryland 20782

## TABLE OF CONTENTS

	Page
ABSTRACT	1
SUMMARY PAGE	ii
ADMINISTRATIVE INFORMATION	iii
LIST OF ILLUSTRATIONS	iv
REPORT OF INVESTIGATION	1
Introduction	1
Object	1
Material Tested	2
Facilities	3
Procedures	4
Methods and Results	4
Discussion	8
Clutch Construction	
Manual Pawl Free Position	
Overrunning Mode of Operation	
CONCLUSIONS	11
RECOMMENTATIONS	12
APPENDICES	
A. - Test Agenda	
B. - Test Time Frame	

ABSTRACT

A Koppers Company - Maag Gear Wheel Company Limited 30,000 HP at 4,000 RPM Self-Synchronizing Overrunning Clutch was tested at NAVSECPHILADIV. Due to gas turbine temperature limitations, maximum power transmission attained was 24,920 HP at 36,200 lb-ft of torque. Since this is essentially full torque, it is felt that the 30,000 HP transmission is well within the capabilities of this unit. Clutch synchronizing and engagement capability was confirmed on the steam turbine test facility by the accomplishment of seventy-seven smooth and trouble-free engagements at various input and output speeds and speed differentials.

The clutch is mechanically suitable for Naval use. Qualification for a particular application, however, would require that the operational profile for that application be specified and that additional testing be accomplished to determine reliability.

## SUMMARY PAGE

PROBLEM

To test and evaluate the Koppers Company - Maag Gear Wheel Company Limited Self-Synchronizing Overrunning Clutch to determine its suitability for use in a combined Gas Turbine Power Plant.

FINDINGS

No apparent pawl or ratchet wheel wear was evident after seventeen hours or ratchetting operation during which 1,000,000 ratchetting revolutions were accomplished. Due to gas turbine test facility limitations, the maximum power transmitted was 24,920 HP. This was successfully transmitted for fifty-five hours. Seventy-seven no load engagements were also successfully accomplished. This particular clutch design configuration considerably simplified clutch alignment, assembly, and disassembly.

## LIST OF ILLUSTRATIONS

<u>FIGURE NO.</u>	<u>TITLE</u>
1	Clutch Engaged and Disengaged Cross Sections
2	Clutch Hydraulic System
3	Steam Turbine Test Facility Machinery Arrangement and Rotational Inertias
4	Gas Turbine Test Facility Machinery Arrangement and Rotational Inertias
5	Steam Turbine Test Facility Vibration Transducer Locations
6	Clutch Speed Versus Time Curves
7	Pawl Tip Condition Before and After Engagement Testing
8	Pawl Condition Before and After Ratchetting Operation
9	Ratchet Wheel Condition Before and After Ratchetting Operation
10	Gas Turbine Test Facility Vibration Transducer Locations
11	Clutch Input Coupling Tooth Condition Prior to Full Power Engaged Operation
12	Clutch Input Coupling Tooth Condition Following Full Power Engaged Operation



DEPARTMENT OF THE NAVY  
NAVAL SHIP ENGINEERING CENTER, PHILADELPHIA DIVISION  
PHILADELPHIA, PA. 19112

IN REPLY REFER TO  
6733:JD:lml  
9421,T-789  
Ser: 124

27 SEP 1974

From: Officer in Charge, Naval Ship Engineering Center  
Philadelphia Division  
To: Commander, Naval Ship Engineering Center, (6145)  
Subj: Evaluation of Koppers Company - Maag Gear - Wheel Company  
Limited 30,000 HP at 4000 RPM Self-Synchronizing Overrunning  
Clutch (S-4622 Task 14910) Final Report; Forwarding of  
Ref: (a) Fonecon Mr. J. Cacciola, NAVSECPHILADIV 6730/  
Mr. R. Peterson, NAVSEA 03413 of 13 Nov 1968  
Encl: (1) Evaluation of Koppers Company - Maag Gear - Wheel  
Company Limited 30,000 HP, 4000 RPM Self-Synchronizing  
Overrunning Clutch

1. Enclosure (1), final report for NAVSECPHILADIV Project T-789,  
which was authorized by reference (a), is hereby forwarded.

Copy to:  
NAVSEA 035(2),0932(4),03C  
NAVSEC 6145D(2)  
DDC (20)  
Koppers Co., Baltimore, Md. (2)  
NAVSECPHILADIV 6711F(2),6730,6733B(4)

*E. L. Lewis*  
E. L. LEWIS  
By direction

## REPORT OF INVESTIGATION

Introduction

The increasingly widespread use of combined Gas Turbine Propulsion Plants in Naval vessels has accentuated the need for a reliable clutching system. A Koppers Company - Maag Gear Wheel Company Limited Self-Synchronizing Overrunning Clutch was tested to evaluate it for use in such systems.

It should be noted that this clutch was not tested for use in a particular vessel, nor were the test stands designed to simulate a particular power train. Both the steam turbine and gas turbine test stands had been previously constructed and were modified simply to accept the test clutch. On the steam turbine test stand the clutch was mounted between two steam turbines which allowed various input and output speeds. If this testing was successful, the clutch was installed on the gas turbine test stand and tested under load.

Object

The object of this test was to determine whether the capabilities of the subject clutch were in accordance with the following specifications:

- a. Maximum Speed           4,400 rpm
- Maximum Torque       39,400 lb. ft.
- Full Power            30,000 HP

b. The clutch shall automatically engage when the input shaft speed accelerates through synchronism with the output shaft.

EVALUATION REPORT OF KOPPERS COMPANY -  
MAAG GEAR - WHEEL COMPANY LIMITED  
30,000 HP AT 4000 RPM SELF-  
SYNCHRONIZING OVERRUNNING CLUTCH

NAVSECPHILADIV PROJECT T-789  
S-4622, TASK 14910


4 NOVEMBER, 1971

By

J. J. De Baecke

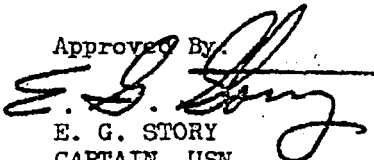
-----  
APPROVAL INFORMATION

Submitted By:

  
W. J. BOYLAN

Head, Machinery Systems Department

Approved By:

  
E. G. STORY

CAPTAIN, USN  
Officer in Charge

Each transmittal of this document outside the agencies of the U. S. GOVERNMENT must have prior approval of the DEPARTMENT OF THE NAVY, Commander, Naval Ship Engineering Center, Code 6145, Hyattsville, Maryland 20782



## PROJECT T-789 TEST TIME FRAME

November 13, 1968	Telecon Mr. J. Cacciola, NAVSECPHILADIV Code 6730/ Mr. R. Peterson, NAVSHIPS 03413 Authorizing clutch Testing
August 1, 1969	Clutch received by NAVSECPHILADIV from Koppers Co.
November 10, 1969	Installation on Steam Turbine Test Facility commenced
January 21, 1970	Test operation on Steam Turbine Test Facility commenced.
February 10, 1970	Test operation on Steam Turbine Test Facility completed
April 17, 1970	Interim Test report submitted
October 19, 1970	Installation on Gas Turbine Test Facility commenced
December 12, 1970	Test operation on Gas Turbine Test Facility commenced
January 13, 1971	Test operation on Gas Turbine Test Facility completed
October 29, 1971	Final report submitted

# CLUTCH ENGAGED AND DISENGAGED CROSS SECTIONS

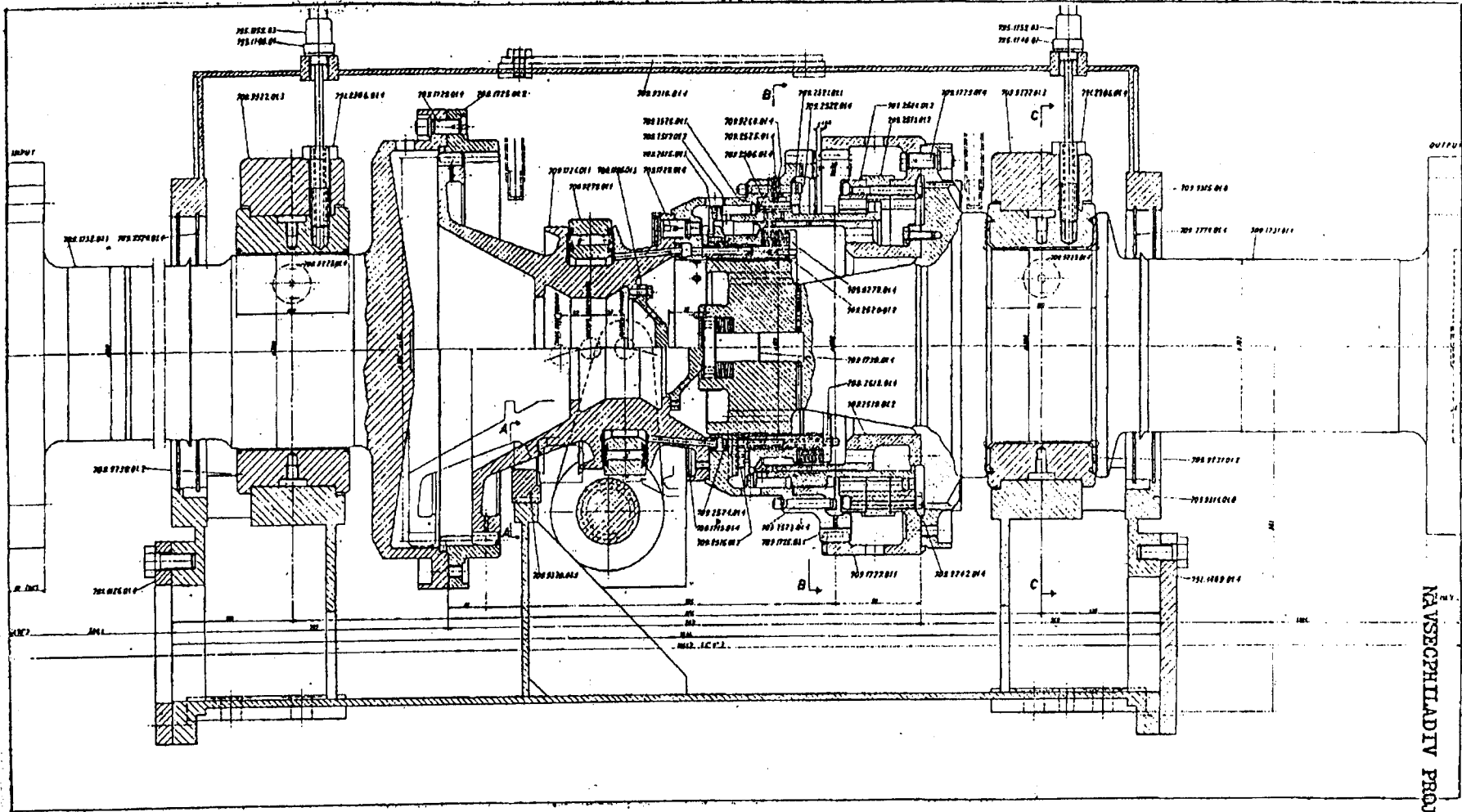
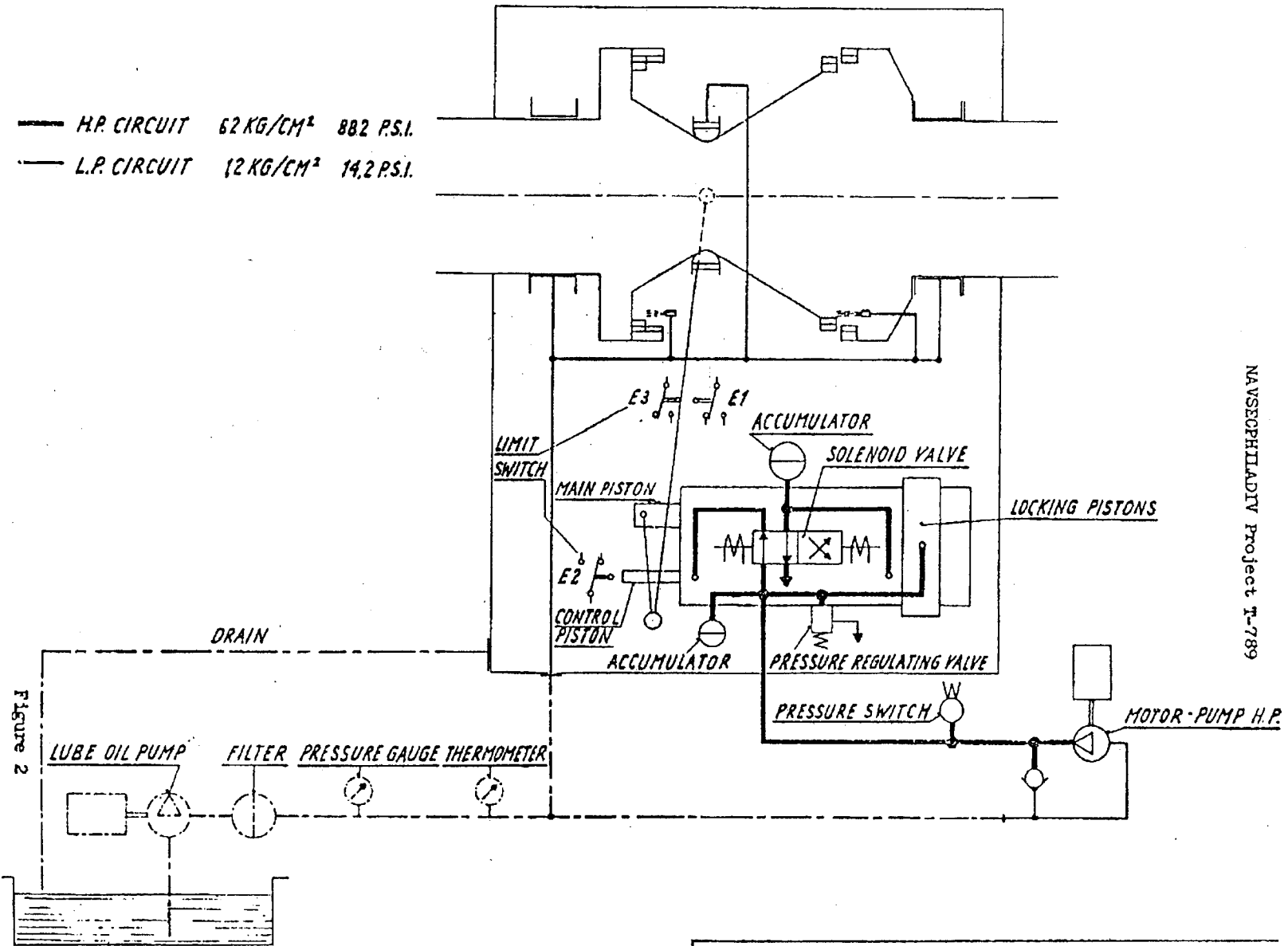


Figure 1

NAVSECHITADIV PROJECT 1-789

CLUTCH HYDRAULIC SYSTEM

— H.P. CIRCUIT 62 KG/CM<sup>2</sup> 882 P.S.I.  
 — L.P. CIRCUIT 12 KG/CM<sup>2</sup> 14.2 P.S.I.

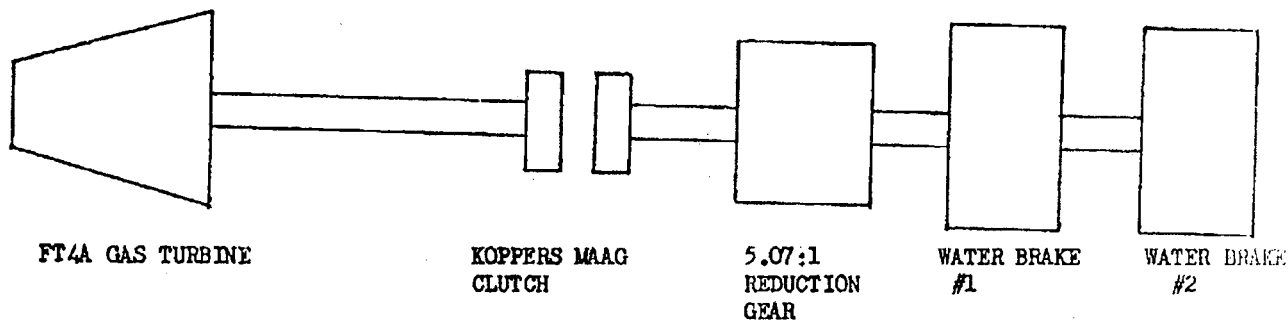


NAVSECPHILADIV Project T-789

OIL FLOW DIAGRAM

Figure 2

GAS TURBINE TEST FACILITY MACHINERY ARRANGEMENT AND ROTATIONAL INERTIAS



FT4A GAS TURBINE

KOPPERS MAAG  
CLUTCH

5.07:1  
REDUCTION  
GEAR

WATER BRAKE  
#1

WATER BRAKE  
#2

INPUT INERTIA 155.5 SLUG-FT<sup>2</sup>

OUTPUT INERTIA 95.0 SLUG-FT<sup>2</sup>  
(REFLECTED TO CLUTCH SHAFT)

Figure 4

CLUTCH SPEED VERSUS TIME CURVE  
2500 RPM DIFFERENTIAL ENGAGEMENT

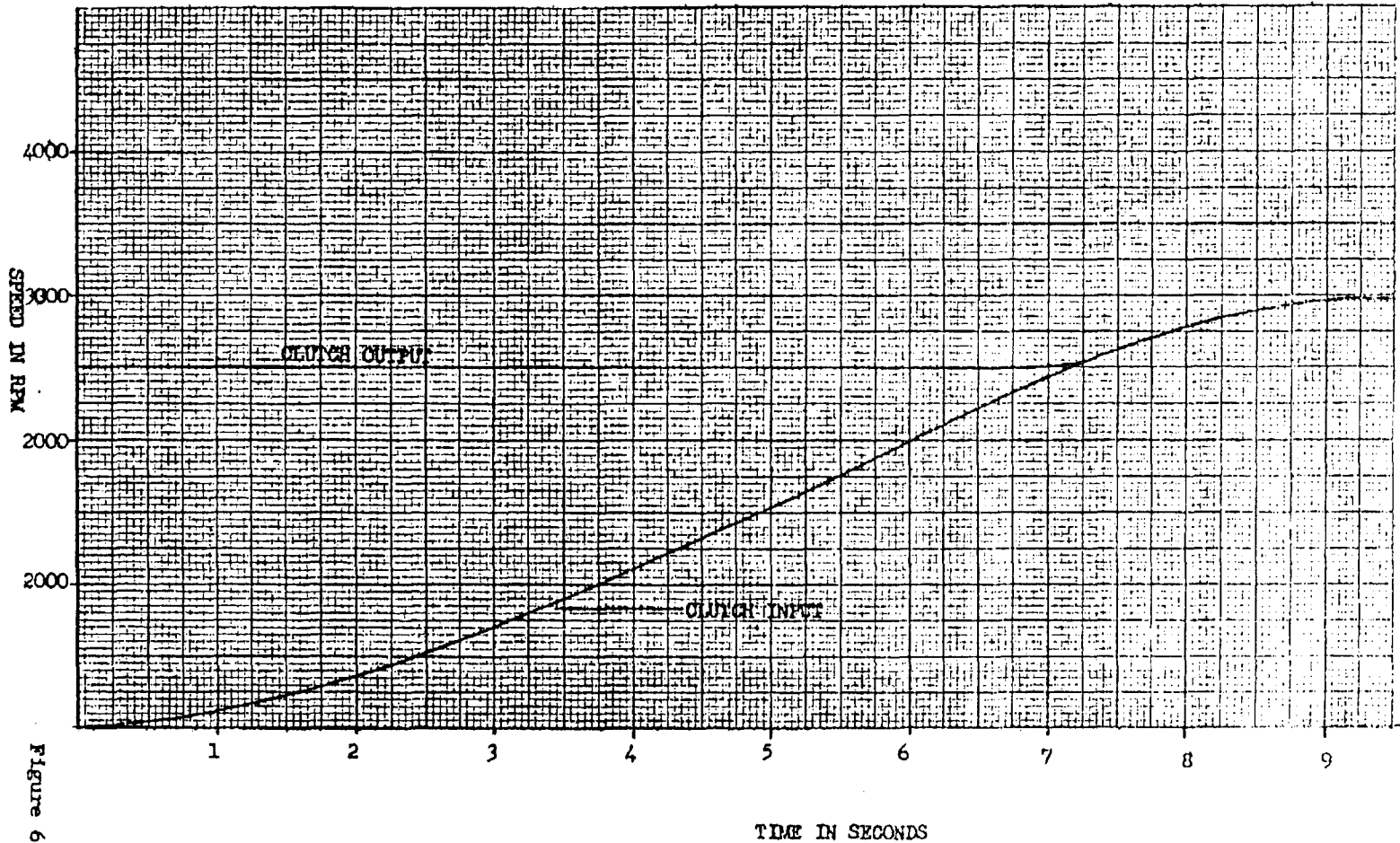


Figure 6

## DOCUMENT CONTROL DATA - R &amp; D

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

1. ORIGINATING ACTIVITY (Corporate author) Naval Ship Engineering Center, Philadelphia Division		2a. REPORT SECURITY CLASSIFICATION  UNCLASSIFIED	
3. REPORT TITLE Evaluation Report of Koppers Company - Maag Gear - Wheel Company Limited 30,000 HP at 4000 RPM Self-Synchronizing Overrunning Clutch		2b. GROUP	
4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)  Evaluation Report			
5. AUTHOR(S) (First name, middle initial, last name)  J. J. De Baecke			
6. REPORT DATE  4 November 1971		7a. TOTAL NO. OF PAGES  39	7b. NO. OF PAGES  NONE
8a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S)  NAVSECPHILADIV PROJECT T-789	
b. PROJECT NO. NAVSECPHILADIV T-789 S-4622, TASK 14910		9b. OTHER REPORT NUM(S) (Any other numbers that may be assigned this report)  NONE	
10. DISTRIBUTION STATEMENT Each transmittal of this document outside the agencies of the U. S. GOVERNMENT must have prior approval of the DEPARTMENT OF THE NAVY, Commander, Naval Ship Engineering Center, Code 6145, Hyattsville, Maryland 20782			
11. SUPPLEMENTARY NOTES  NONE		12. SPONSORING MILITARY ACTIVITY  Naval Ship Engineering Center, Philadelphia Division	
13. ABSTRACT A Koppers Company - Maag Gear Wheel Company Limited 30,000 HP at 4,000 RPM Self-Synchronizing Overrunning Clutch was tested at NAVSECPHILADIV. Due to gas turbine temperature limitations, maximum power transmission attained was 24,920 HP at 36,200 lb-ft of torque. Since this is essentially full tor- que, it is felt that the 30,000 HP transmission is well within the capabilities of this unit. Clutch synchronizing and engagement capability was confirmed, on the steam turbine test facility by the accomplishment of seventy-seven smooth and trouble-free engagements at various input and output speeds and speed differentials.  The clutch is mechanically suitable for Naval use. Qualification for a particular application, however, would require that the operational profile for that application be specified and that additional testing be accom- plished to determine reliability.			