

3685

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1003-20-4838

July 1 to Sept. 30, 1954

NBS REPORT
3685

PROGRESS REPORT ON ENGINE AIR CLEANING

by
Carl W. Coblenz
Heating and Air Conditioning Section
Building Technology Division

to

Office of the Chief of Transportation
Department of the Army

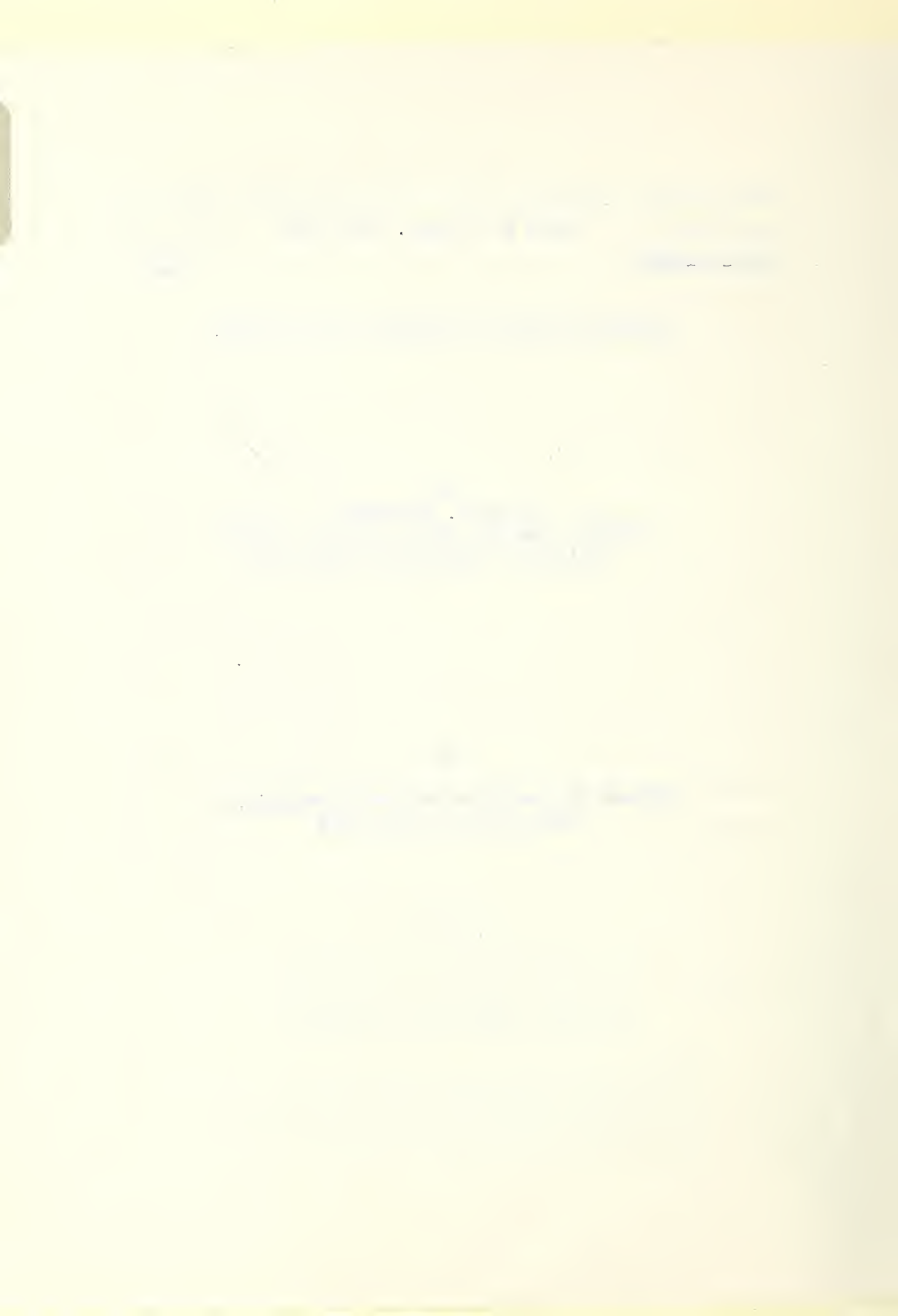
NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

The publication, re
unless permission is
25, D.C. Such per
cially prepared if t

Approved for public release by the
Director of the National Institute of
Standards and Technology (NIST)
on October 9, 2015.

In part, is prohibited
standards, Washington
report has been specifi-
report for its own use.



FEDERAL BUREAU OF INVESTIGATION

A visit was made to the Cadillac Motor Car Division, GM at Detroit, Michigan, to discuss and abstract the report on their investigation of engine wear using two dusts of 0 to 2-1/2 micron and 0 to 40 micron size respectively. This report had not been published and no copies were available but the company consented to having it examined and abstracted.

The tests were conducted on an 8-cylinder tank engine with a standard W-5 oil-bath air cleaner, with and without using a precleaner. It was found that only dust particles of less than 2-1/2 micron size would pass the oil-bath air cleaner. It was found that the efficiency of the standard oil-bath air cleaner alone averaged 97.5% but with the addition of a 67% efficient precleaner the overall efficiency dropped to 98.8% while lengthening the service period of the oil-bath cleaner about three times. The theory was advanced that the precleaner breaks up the larger dust particles giving the oil-bath cleaner more fine dust to handle. It is the fine dust particles that pass the oil-bath cleaner, thus decreasing the overall efficiency.

In order to obtain a supply of dust similar to that found in the absolute filter cloth used during the air cleaner tests a 0 to 2-1/2 micron dust from the Phoenix, Arizona area was specially prepared by the A. G. Spark Plug Division,

REPORT ON THE PROGRESS OF THE WORK

The first part of the report deals with the progress of the work done during the year. It is divided into two main sections, the first of which deals with the work done in the laboratory and the second with the work done in the field. The first section is divided into three parts, the first of which deals with the work done in the laboratory during the year, the second with the work done in the laboratory during the year, and the third with the work done in the laboratory during the year. The second section is divided into two parts, the first of which deals with the work done in the field during the year, and the second with the work done in the field during the year.

The first part of the report deals with the progress of the work done during the year. It is divided into two main sections, the first of which deals with the work done in the laboratory and the second with the work done in the field. The first section is divided into three parts, the first of which deals with the work done in the laboratory during the year, the second with the work done in the laboratory during the year, and the third with the work done in the laboratory during the year. The second section is divided into two parts, the first of which deals with the work done in the field during the year, and the second with the work done in the field during the year.

The second part of the report deals with the progress of the work done during the year. It is divided into two main sections, the first of which deals with the work done in the laboratory and the second with the work done in the field. The first section is divided into three parts, the first of which deals with the work done in the laboratory during the year, the second with the work done in the laboratory during the year, and the third with the work done in the laboratory during the year. The second section is divided into two parts, the first of which deals with the work done in the field during the year, and the second with the work done in the field during the year.

OWC. For equal masses and concentrations of dust in the inlet air this very fine dust was found to cause 32% less top cylinder wear and 63% less top piston ring wear than 0 to 40 micron dust of the same origin.

It was also found that dust entering the crankcase affected the bearings, piston skirts and oil rings more than the dust entering the induction system. The latter is responsible for more wear at the top of the cylinders and pistons above the compression rings.

A chrome-plated compression ring in the upper groove decreased the wear at the top of the cylinder sufficiently to eliminate the taper ordinarily encountered in the top inch of piston travel. The wear with the chrome-plated compression ring ranged from 10 to 22 percent of that observed with conventional rings. The wear of the second compression ring and the oil ring was not affected by chrome-plating the top ring. A chrome-plated oil ring resulted in increased wear by this ring. Manufacturing difficulties make it too difficult to control the accuracy of the chrome-plated oil ring, resulting in high oil consumption. The higher oil consumption results in a heavier oil film on the cylinder walls which carries more abrasive and results in greater wear.

When dust was fed directly into the crankcase the cylinder wear was much more uniform from top to bottom; there was

The first thing I noticed when I stepped out of the car was the cold, crisp air. It felt like a fresh blanket after a long, hot summer. I took a deep breath, savoring the scent of pine trees and the distant sound of water. The sun was just beginning to rise, painting the sky in soft, pastel hues of pink and orange. I walked towards the lake, my feet crunching on the path of fallen leaves. The water was still, reflecting the colors of the dawn. I saw a small boat in the distance, its oars dipping into the water. The world felt so peaceful, so quiet. I had found a little piece of heaven on earth.

less wear at the top of the ring travel and more at the bottom. The piston wear was much greater, particularly at the bottom of the skirt end, while the piston ring wear was better, the oil ring had worn much more than the top compression ring. The bearing wear was extremely high. Whereas the blow-by was excessive when the dust was fed into the induction system because of the top ring and cylinder wear, it remained reasonable when the dust was fed into the crankcase. The oil consumption was higher in latter case, probably because of the piston and bearing clearances. The difference in wearing characteristics resulting from dust entering the crankcase and the intake manifold should provide a very useful basis for analyzing the causes of wear in a badly worn engine.

While in Detroit, it was considered advantageous to visit the A. E. Spark Plug Division, GEC in Flint, Michigan, since this Division builds and tests all air cleaners for the General Motors Corporation. The Division has recently concluded a contract with the Continental Motor Corporation to develop an air cleaner for helicopters. They were, therefore, reluctant to discuss this problem.

However, they showed the National Bureau of Standards representative an air filter presently used for helicopters consisting of a wire mesh panel one inch thick which they had received from Continental Motor Corporation. They considered it is

The first part of the report deals with the general situation of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The second part of the report deals with the financial position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The third part of the report deals with the administrative position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The fourth part of the report deals with the social position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The fifth part of the report deals with the economic position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The sixth part of the report deals with the educational position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The seventh part of the report deals with the health position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The eighth part of the report deals with the agricultural position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The ninth part of the report deals with the industrial position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

The tenth part of the report deals with the transport position of the country and the progress of the work done during the year. It then goes on to discuss the various projects which have been undertaken and the results which have been achieved. The report concludes with a summary of the work done and a statement of the conclusions which have been reached.

filter inadequate in efficiency as well as dust holding capacity.

Tests of the standard automotive oil-bath air cleaners at the A. C. Spark Plug Division, GPO were said to show 100% efficiency on dust particles greater than 100 microns in diameter. However, they were trying to improve the filtering efficiency for very small particles.

The air cleaner test apparatus used by this Division generally conformed to that described in Army Specification 93-21. Inquiries regarding the effectiveness of a flannel cloth as an absolute filter for air cleaner tests were answered with the information that this cloth did retain about 95% of all dust that passed through the test filter and that they did not know of any better material for the purpose. The engineer who operated this test apparatus recommended that at least three tests under each condition should be made to obtain a good average value. The Division was setting up a test to determine the features of a Farr-Rotomatic cyclonic type filter as a preclearer with a flannel cloth after filter.

Findings of Other Investigations on Engine Wear

The test results of the only two other investigations made on the subject of engine wear are summarized in the following pages.

These findings are being reported to the Board of Directors.

It is noted that the Board of Directors has not yet received a copy of the report of the Committee on the subject of the proposed merger with the American Telephone and Telegraph Company.

The Board of Directors has not yet received a copy of the report of the Committee on the subject of the proposed merger with the American Telephone and Telegraph Company. It is noted that the Board of Directors has not yet received a copy of the report of the Committee on the subject of the proposed merger with the American Telephone and Telegraph Company.

The Board of Directors has not yet received a copy of the report of the Committee on the subject of the proposed merger with the American Telephone and Telegraph Company.

Mr. G. T. O'Harrow of the Allis-Chalmers Mfg. Co. investigated the wear of an engine with wet cylinder sleeves due to dusts of three size classifications and from three different sources. Although the chemical analysis of the dusts collected from the Allis-Chalmers' Test Field, from Phoenix, Arizona, and from St. Anthony, Idaho, varied widely as to their content of silica, alumina and ferric oxide and also in loss on ignition, Mr. O'Harrow was unable to detect any correlation between the chemical composition of the dusts and the rate at which they caused wear to the engine.

There was some difference in wear produced by dusts of the same size classification, but of different origins. The dust collected at Test Allis and at St. Anthony, Idaho, produced generally higher rates of wear than dust originating in the Phoenix, Arizona area, in spite of the fact that higher rates of engine wear are often encountered in the Phoenix area during actual use of engines. These tests indicated that this is not because the Phoenix dust is more abrasive, but apparently because the air around Phoenix contains more of the fine dust particles that are not effectively caught by the air cleaners.

Mr. E. A. Davis of the Australian Aeronautical Research Laboratories drew the following conclusions from his tests;

THE U. S. DEPARTMENT OF THE INTERIOR

Geological Survey

Washington, D. C.

Report of the Director

for the year 1900

Part I

General Report

by the Director

and

by the Chief of the Division of Geology

and

by the Chief of the Division of Water

and

by the Chief of the Division of Oil and Gas

and

by the Chief of the Division of Lumber

and

by the Chief of the Division of Reclamation

and

by the Chief of the Division of Biological Resources

and

by the Chief of the Division of Conservation

and

by the Chief of the Division of Education

a. When dust is fed to an engine constantly at a moderate rate the wear at the top of the cylinder and the average cylinder wear are proportional to the amount of dust fed. The wear of the top compression rings is also proportional to the dust fed, but with alloy pistons, a preliminary growth takes place so that the final change in dimensions is not indicative of the wear. The total weight of metal worn from the cylinder walls, piston and rings is proportional to the weight of dust fed for a wide range of wear.

b. The higher the dust feed rate the less wear is produced per unit weight of dust. Under the conditions of the tests the ratio of the total metal wear to the amount of dust fed decreased from 1.6 to 1.0 when the dust concentration was increased from 1 mg per cu.ft. to 6 mg per cu.ft.

c. Other factors being equal, the wear produced by a given weight of dust depends on the size of the dust. The maximum wear occurs with a dust size of about 15 microns, the wear with 100 micron dust being about half that of 15 micron dust.

Course dust particles larger than 100 microns are easily removed aerodynamically. The less easily retained fine particles, down to less than one micron size, should be prevented from entering the engine if wear is to be kept to a minimum.

The first part of the report is devoted to a description of the
 experimental apparatus and the method of observation. The
 apparatus consists of a glass vessel containing a liquid,
 in which a small amount of a substance is dissolved. The
 vessel is placed in a bath of water, and the temperature
 of the bath is kept constant. The substance is
 introduced into the vessel in the form of a solid, and
 its weight is measured. The weight of the substance
 is found to be constant, and this is taken as evidence
 that the substance is not dissolved in the liquid.
 The second part of the report is devoted to a description
 of the results of the experiment. It is shown that the
 weight of the substance is constant, and that the
 temperature of the bath is constant. This is taken as
 evidence that the substance is not dissolved in the
 liquid. The third part of the report is devoted to a
 discussion of the results of the experiment. It is
 shown that the results of the experiment are in
 agreement with the theory of the dissolution of
 solids in liquids.

Conclusions

The three investigations on engine wear, due to dust, which have been summarized above and which are the only ones known to have been made on this subject, to date, cover only a few of the possible variables. Therefore, the total knowledge of the effect of dust particle sizes and concentration on the engine wear is rather limited. It might seem obvious that the larger the particles and the greater the concentration the heavier the wear. On the other hand, it is quite likely that large particles in excess of 100 micron size will not force their way into the interstices between piston and cylinder and are ejected through the exhaust without causing much wear; and particles below 1 micron size, or so, do not bridge the oil film and thus produce a lapping effect rather than an abrasive one, but even so it has been shown that the presence of small particles weakens the oil film.

The removal of the large dust particles from the induction air can be accomplished with practically 100% efficiency with moderate difficulty whereas the fine particles which still cause considerable wear are hard to collect in a simple filter.

State of Laboratory Work

The assembly of the test apparatus was completed about Sept. 1st. Tests are now being conducted to determine the

Introduction

The first consideration in making any plan is that of the nature of the work to be done. It is necessary to have a clear idea of the scope and extent of the project, and of the resources available for its execution. This involves a study of the organization, its personnel, and its financial position. It is also necessary to have a clear idea of the objectives of the project, and of the methods to be used to achieve them. This involves a study of the nature of the work, and of the methods to be used to perform it. It is also necessary to have a clear idea of the time available for the project, and of the time to be spent on each part of it. This involves a study of the calendar, and of the time to be spent on each part of the project. It is also necessary to have a clear idea of the risks involved in the project, and of the measures to be taken to avoid them. This involves a study of the nature of the work, and of the methods to be used to perform it. It is also necessary to have a clear idea of the responsibilities of each person involved in the project, and of the measures to be taken to ensure that they are fulfilled. This involves a study of the organization, its personnel, and its financial position. It is also necessary to have a clear idea of the progress of the project, and of the measures to be taken to ensure that it is completed on time. This involves a study of the calendar, and of the time to be spent on each part of the project. It is also necessary to have a clear idea of the results of the project, and of the measures to be taken to ensure that they are achieved. This involves a study of the nature of the work, and of the methods to be used to perform it.

Method of Investigation

The method of investigation used in this report was a combination of the following methods: a study of the organization, its personnel, and its financial position; a study of the nature of the work, and of the methods to be used to perform it; a study of the calendar, and of the time to be spent on each part of the project; a study of the risks involved in the project, and of the measures to be taken to avoid them; a study of the responsibilities of each person involved in the project, and of the measures to be taken to ensure that they are fulfilled; a study of the progress of the project, and of the measures to be taken to ensure that it is completed on time; a study of the results of the project, and of the measures to be taken to ensure that they are achieved.

operational characteristics of a standard 300 cfm squirrel cage blower that has been modified to work as a rotating filter or precleaner in accordance with the experience obtained with a small pilot model. Besides the possible desirability for some additional structural changes, the present tests will furnish information as to the efficiency of the filter at different rotor speeds, blow-down ratios, air flow rates, dust concentrations and the effect of dusts of different fineness. The observations made to date are incomplete, but the efficiency of the rotating filter appears to be somewhat better than that reported in the literature for other precleaners and the pressure drop is considerably less than for the cyclonic type filter. The results will be presented in the next progress report.

After the tests with the rotating filter are completed the helicopter engine, which just arrived here from Ft. Hill, Oklahoma, will be analyzed for causes of excess wear.

The procurement of a good commercial air cleaner available to helicopter use has been postponed until information is obtained regarding the specifications contemplated for such equipment. It is considered desirable that a commercial air cleaner be tested here to compare its performance with the present concepts of the duty expected of helicopter air cleaners.

