

The first set of valves failed in a short time under cycling conditions and the second set was constructed of a thicker material with resulting longer life. The valve section is being redesigned to incorporate an improved valve design based on the results of valve tests by other groups.

Mr. Rothrock stated that it appeared desirable to get very rapid combustion or possibly detonation. The Chairman suggested the addition of an explosive to hydrocarbon fuels. Mr. Rothrock stated that this type of fuel was scheduled for investigation.

Mr. Rothrock stated that Mr. North at Wright Field is working on a fuel program including factor of ram jets to be submitted by the Army to the NACA. Mr. Rothrock stated that consideration was being given to the burning in the shock wave in a steady-flow ram jet.

Mr. Pinkel stated that the second burner design for the steady-flow ram jet unit would consist of two annuli with annular shielded zones and dual nozzles injecting into the shielded zones. The burner had 40% reaction in free flow at the burner section area and holes in the shields for the introduction of primary air for the burning process. When operating with twenty-one pounds of air per second at an air-fuel ratio of 30, a combustion efficiency of 62% with a pressure drop of 1.9 was obtained. The flame length was 3 feet. The 1.9 pressure drop is equal to approximately four inches water at the conditions.

The Chairman stated that it would be desirable to install the burner in the steady-flow ram jet unit if it was in shape to run. Mr. Pinkel stated that the burner could be installed but that he would like to obtain additional test results on the burner. It was agreed that the burner would be installed immediately and that Mr. Pinkel's group would cooperate in obtaining additional burner information as the tests progressed. It was further agreed that reports on the steady-flow ram jet performance would be prepared by the Engine Installation Research Division and reports on burner performance would be prepared by the Thermodynamics Division.

Mr. Pinkel stated that there was a favorable interference between the pressure drop due to area reduction at the burner and the pressure drop caused by combustion. It was noted that the pressure drop under operating conditions was less than the cold pressure drop plus the calculated momentum pressure drop from burning.

The Chairman stated that it would be very desirable for the laboratory to get out results on the steady-flow ram jet ahead of Professor Bottell at the Massachusetts Institute of Technology who is working on a ram jet project for the Army. Mr. Silverstein stated that with the first burner installation two of the burners didn't work but the pilot alone worked on all burners. Mr. Pinkel stated that with this type of burner if the burner was not working it was almost certain that the pilot flame was out.

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Mr. Silverstein stated that it was planned to run individual lines into each burner unit and then by adding sheltered zones at the burner entrance. Mr. Pinkel noted that the sheltered zones resulting from the fuel lines had been streamlined out when the installation was made. Mr. Pinkel stated that the burner developed for the NACA jet-propulsion unit appeared to be a good design for use in the steady-flow ram jet. Mr. Silverstein described the burner developed by Professor Hottell with fuel injection normal to the stream in a flame stabilizer downstream from the fuel injection.

The data from the Ford-built unit was shown to the group by Mr. Pinkel at this time. The data showed that maximum thrust of 647 pounds was obtained with 20° water ram, 50,000 pounds of air per hour, and 2400 pounds of fuel resulting in a fuel/air of .048. The unit operated at forty cycles per second. Mr. Pinkel stated that the unit operated satisfactorily except for shaking the instruments.

Mr. Schey reviewed the work that had been carried out on valves. A valve had been developed that was twice the height of the German valve and operated successfully for three hours at 40 cycles. The design to incorporate this valve into the Ford-built unit was completed and is ready to go into the shop. The committee approved the construction and tests of this grill design in the Ford unit.

Mr. Schey reported that the hinged-type valve had very short life in the reciprocating piston apparatus. Mr. Silverstein pointed out that the changes made in the spring details may have resulted in the short life.

Mr. Schey showed a new valve design made up with a curved and straight piece riveted together that had been constructed. He stated that other valve developments are also in progress.

Mr. Rothrock stated that two groups were working on the general combustion problem. One group, under Mr. J. C. Sanders, was working on a problem of fuel properties required for jet-propulsion units. A second group, under Mr. I. Irving Pinkel, was working on the fundamentals of combustion, turbulence and pressure effect at altitude. Doctors Hicks and Simon are working on the problem of mixing fuel and air and Mr. C. D. Miller was working on the problem of mixing utilizing photographic methods.

Mr. Rothrock stated that Colonel Wessel and Mr. Worth discussed a project request for basic research on combustion in which Mr. Worth stated that emphasis should be placed on ram jets.

The following list of questions to be answered as results of this work were proposed by Colonel Wessel and Mr. Worth:

1. What is Max. heat release / cu ft / unit time.
What increase possible for hydro carbon fuels - other fuels.
2. What is the max. mix velocity or flame speed for hydro carbon fuels.

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3. What is the limit of mixture ratio for H.C. fuels.
4. What is velocity head loss for burning.
5. What is velocity head loss for mixing fuel and air.
Comments on liquid spray, air aspirated mixing, pre carb. mix.
6. What is meaning or correlation of flame color to rate of heat release.
7. Available energy of heat release as affected by condition of burning of the fuel (detonation wave pressures, etc.)
8. What is the relation between flame, visibility, and heat release.
9. What is the difference of flame travel in stationary fuel mixture as compared to stationary flame in moving fuel mixture assuming turbulence of same degree in both cases.
10. Is there a radiant energy transfer from the burning front to the yet unburned fuel.
11. Are there catalysts or additions for hydro carbon fuels which will cause higher burning rates.
12. What are the condition parameters to promote detonation.
13. What is a good yardstick for measuring the desirability of a jet fuel.
14. How can the B.T.U./unit volume be increased.
15. What basic parameters should the fuel characteristics be described with for a jet fuel.

Mr. Rothrock stated that one group of chemists in the Fuels and Lubricants Division have started an investigation on the use of catalysts in combustion.

The meeting adjourned at 4:00 p.m.

Jesse H. Hall
Jesse H. Hall,
Secretary, Ram Jet Committee.

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TECHNICAL CONFERENCE

April 13, 1945

The Committee met in the Executive Conference Room at Cleveland on April 13, 1945, at 7:00 p.m. Present:

Abe Silverstein, Chairman

B. Pinkel (TACRL)

J. M. Rothrock (LMAIL)

O. W. Schey

J. H. Hall, Secretary

The reading of the minutes of the last meeting on February 13, 1945 was dispensed with. The chairman reviewed the discussion that had taken place with Doctors Goss, Miller, and Tatum during a recent visit to the laboratory concerning the "Bumblebee" project. The project is under the direction of Dr. Tuve's group at the Johns Hopkins Applied Physics Laboratory in Silver Spring, Maryland. It is being carried out for the Navy Department, Bureau of Ordnance. The project is for the development of a ship-to-air missile using a steady flow ram-jet as the power plant. The chairman stated that the drag as obtained on the "Bumblebee" Project gave results similar to those obtained at Langley Field. It was pointed out that cold models had already been tested using telemetering instrumentation and rocket launching. Two problems expected to give some difficulty on the project are the starting problem and the fuel system. It was pointed out that the fuel system utilizing the pressure rise across the diffuser might work in a opposite direction when the missile goes slightly off the design conditions to bring the unit back to the design conditions. Mr. Schey suggested the possibility of adjusting the fuel flow to the rich range so that leaning out would increase the thrust. Mr. Pinkel stated that compensated fuel controls appeared necessary.

The Chairman made a strong recommendation for more emphasis on the missile program at this laboratory because of the intense interest evidenced by both the Army and Navy. The question was raised as to whether the laboratory could drop other projects to allow the increased work on missiles. Mr. Rothrock stated that the laboratory projects would be reviewed with this thought in mind.

The chairman stated that the design of supersonic compressors offered considerable promise if an efficient design could be worked out. He stated that Mr. Kantrowitz at LMAIL had done some work along this line. Mr. Pinkel suggested that the laboratory should carry the steady-flow ram-jet project through flight tests. The chairman pointed out that LMAIL was working on setting up a fuel station for such flight tests.

The chairman stated that the NACA Special Committee on Self-Propelled Guided Missiles was scheduled to meet on April 18 and that he would like to present a progress report covering TACRL work to date and the program of the work to be carried out. It was requested that each member of the team write up the work under his direction by Monday, April 15, 1945.

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Mr. Rothrock stated that the Army has been given a directive to develop the rocket prime mover for aircraft. The Fuels and Lubricants Division is carrying out work on fuel and combustion for rockets, but there are other problems that should be carried out at the same time, such as development of turbulence; pumps for liquid fuels; nozzles and heat resisting materials for cooling systems.

Mr. Schey stated that he could investigate the use of ceramics for rocket motor nozzles.

The chairman asked for a progress report on the work accomplished since the last meeting.

Mr. Rothrock stated that tests were underway on X-16 combustion chamber units. He stated that a setup had been made of a combustion chamber of the transparent number and small nozzle for an exit to study the effect of turbulence on combustion. An apparatus is being set up to study the mixing process for fuel in air and effective turbulence. Another apparatus is being set up for studying the steady combustion process by means of high-speed photography. A program is being carried out to prepare or synthesize new fuels considered to be of interest in the ram jet and rocket programs. A small-scale intermittent combustion chamber is being set up to study the combustion problem. The chairman suggested that the Fuels and Lubricants group look into the possibility of using the intermittent-combustion-chamber test apparatus of the Thermodynamics Division for their tests and to get the two groups together to coordinate fuels and combustion work. The chairman also suggested that the Fuels and Lubricants group consider the use of tracers for ignition in ram jets. It was also suggested that the use of sensitizers for reducing fuel autoignition temperatures be looked into.

The chairman stated that a visit by Army and Navy groups interested in ram-jet work had been discussed in a telephone conversation between Mr. Kemper and Dr. Lewis and asked for comments as to a suggested date. After some discussion it was decided that April 26, 1945 would be the most advantageous date. The chairman requested that proposed items to be included in the agenda for the meeting should be turned in by Monday, April 16, in order to discuss the program with Dr. Lewis who is expected on Tuesday, April 17.

Mr. Pinkel reported on progress on the buzz bomb work since the last meeting. He stated that tests using the first grid had been completed and the second grid was being installed. Mr. Pinkel stated that the second grid was different in that it had venturis downstream from the nozzle. After the meeting, Mr. Pinkel informed the Secretary that actually both grids had the venturis. The third grill to be tested will be the grill designed and built by the Supercharger group. Mr. Pinkel stated that with ram increased from 40° to 60° water the increase in thrust by increasing ram was tapering off in this range. He stated that it was observed that at 40° water ram the effective jet velocity was indicated to be a little higher than at 60° water. A thrust of 760 pounds net was obtained at a simulated speed of 350 miles per hour and with a fuel consumption of 3200#/hr.

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It was stated that the pressure time record from a quartz crystal pick-up had not been very satisfactory because of severe vibration. The maximum and minimum pressure instrumentation was also found to be not too satisfactory.

The high-speed motion pictures obtained with the intermittent-combustion apparatus showed uneven cycles. A surge tank has been installed in the entrance which it is believed, has improved the uniformity of the combustion cycles. More evidence will be available when the high-speed motion pictures have been developed and can be observed. Mr. Pinkel stated that the apparatus was very hard on valves since the surge chamber had been put in which indicated higher maximum pressures and a higher rate of pressure rise resulting from combustion. Indicator records are being taken on the apparatus but the Piezo electric crystal and trap pressure instruments have not been working too well. Mr. Pinkel stated that the resopulse drawings had been completed.

Mr. Pinkel stated that Mr. Parker at Annapolis has shown him captured German documents of the Smidding Company reporting on all sorts of aeropulse ideas.

Mr. Schey reported that all grill castings for the buzz bomb will be developed within a week and machining of the castings will start immediately.

Mr. Schey stated that the group working on valves had obtained designs with a life of three hours with considerable improvement, from a pressure-drop standpoint, over the German valves. Mr. Schey stated that the Ford-built grill equipped with an NACA two-piece valve will be completed in about a week at the best. He stated that little testing was being carried out at the present and the work would increase pending the outcome of tests on the full-scale unit.

The chairman asked that a list of all reports on ram jets being worked on by the group be sent to the secretary and that the list be circulated for the information of the members.

The meeting adjourned at 4:30 p.m.

Jesse H. Hall,
Secretary, Ram-Jet Committee.

JHH:jmk

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Address reply to: WFOB

Commanding General ARMY AIR FORCES
Air Materiel Command Materiel Commander Captain J. P. Amerman
Engineering Division Office of the Commanding General Major G. C. Hopper
Reference: Dept. 150
Wright Field, Dayton, Ohio

National Advisory Committee for Aeronautics
1500 New Hampshire Avenue, N.W.
Washington, D.C.

Attention: Dr. T. M. Lewis, Director
National Bureau of Aeronautical Research.

Dear Dr. Lewis:

The Materiel Command is at present making a thorough review of the development of long range, ground-launched, pilotless, controlled missiles. Of immediate importance is the design of a preset guided missile of 100 to 150 miles range.

The Army Air Forces desires, however, to develop in the minimum period of time a pilotless guided missile, ground-launched, which would have a range of 100 miles with the application of remote control for the accurate hitting of military objectives. The requirements for this new type missile have been prescribed, and are as follows:

- (1) Range - 100 miles
- (2) Pay Load - 1000 lb. demolition bomb
- (3) Speed - 550 mph.
- (4) Control - Remote or target seeking

The general requirements dictate that this missile be of the simplest construction and minimum size. It will further desired to propel this missile by means of jet propulsion. However, due to the urgency of the program, the type of motor to be used must be limited to one of the existing types or a new design which would be readily available.

In order to accomplish the development of such a missile it is felt that the program should be divided into three parts, namely (a) the vehicle itself, (b) the jet power supply, and (c) the remote control devices and launching mechanisms.

It is requested that the NACA undertake a program in cooperation with the Materiel Command to develop parts (a) and (b). If such a proposal is agreeable to the NACA, it is requested that the following action be taken:

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1. The Laboratories of the NACA immediately begin a preliminary design study of the possible vehicles and propulsion systems to accomplish the General experiments as stated above.

2. That at the earliest possible date a conference between representatives of the NACA and the Materiel Command be held at which time the design studies would be evaluated.

The comments of the NACA in regard to such a development program are requested.

Very truly yours,

(Signed) R. Z. Boger

O. CARROLL
Brig. General U.S.A.
Chief, Engineering Division

cc: Materiel Division, Asst. C/AS, US
Washington, D. C.
Materiel Command Liaison Office,
NACA Lab., Langley Field, Va.
Materiel Command Liaison Office
AAL, Moffett Field, Calif.
Materiel Command Liaison Office
NACA AERL, Cleveland, Ohio

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AM-JET CONFERENCE

July 24, 1944

The Committee met in the Executive Conference Room at AERL on July 24, 1944 at 1:30 p.m. Present:

L. N. Jacobs, Chairman
Benjamin Pinkel
L. Richard Turner,
Abe Silverstein
Robert E. English
A. D. Johnson
W. Mutterperl
Carlton Kemper
Jesse H. Hall, Secretary

1. Mr. Jacobs discussed the robot bomb currently being used by the Germans. A detailed description was given of the ram-jet installation, as well as a general description of the robot bomb and its effectiveness as a military article. Mr. Jacobs pointed out that the basic construction of the robot bomb was extremely simple but that the controls were very complicated. He stated that the robot bomb was equipped with electrical-, pneumatic-, and hydraulic-type controls. The design and construction of the controls are excellent indicating considerable effort by the Germans on this phase in contrast with the extremely simple basic construction of the robot bomb. A general discussion followed on the detail of construction used in the ram-jet robot bomb by the Germans.

2. Mr. Turner and Mr. Mutterperl presented curves on performance and efficiency based on theoretical calculations for the intermittent and steady-flow types of ram jets. The analysis from the theoretical studies indicates that the intermittent-flow ram jet is capable of higher efficiencies than the steady-flow type up to a range of 900 miles per hour.

3. Mr. Jacobs brought up the question of possible uses for ram-jet units and what line of attack could be followed in the laboratory's research on the ram-jet unit as a power plant. Suggested uses of the ram-jet units were for assisted take-off, long range projectiles, and for use as a primary power plant. It was agreed that ram-jet units should be considered as power plants for aircraft and, as such, should be thoroughly explored by the laboratory.

4. Mr. Johnson and Mr. English exhibited several valve designs that had occurred to them for possible use in ram-jet units. In discussing these valve designs, Mr. Jacobs pointed out that if complicated valves and drives were used, the fundamental advantage of simplicity of the ram-jet units would be lost to some extent. It was agreed that the first theoretical-flow ram-jet unit to be considered should have automatic inlet valves and no exit valves. Exit valves and inlet valves involving valve-drive systems would be considered later. It was decided that the laboratory should go ahead with the design and

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construction of an intermittent-flow ram-jet unit utilizing the information available on the German unit and improving on the German design wherever possible. Work on steady-flow ram-jet designs will follow later. None of the units to be built by the Ford Motor Car Company for the Army Air Forces will be requested for test as soon as these units become available.

15. Work of the group for the coming week was discussed. It was agreed that the first problem to be attacked is the design of the automatic inlet valve. Members of the group were requested to work on this problem during the following week and bring their designs to the next meeting in appropriate form for including in the minutes of the meeting. Considerations are to be given to the design of automatic valves that will allow filling the combustion chamber at full ram pressure and clearing the combustion chamber of burnt gases between cycles.

16. The next meeting was scheduled for 9:00 a.m., Tuesday, August 1, 1944, and subsequent meetings will be held each Tuesday at 9:00 a.m.

17. The meeting adjourned at 3:30 p.m.

Jesse H. Hall
Jesse H. Hall,
Secretary, Ram-Jet Committee.

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injection, the fuel pump, the fuel system, the combustion problem and the engine cooling system. The nozzle should be considered at the next stage of development. The remaining stages to be considered are the propellant system, the motor assembly, the nozzle and the nozzle exit.

The first stage of development will be concerned with the propellant system. The second stage will be concerned with the motor assembly. The third stage will be concerned with the nozzle and the nozzle exit.

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to the amount of gas entering the chamber per second. This is given by the ratio of the total volume of the chamber to the time taken for the gas to pass through the valve. The time taken for the gas to pass through the valve is given by the formula:

$$t = \frac{V}{Q}$$

where V is the volume of the chamber and Q is the flow rate of the gas. Substituting the values given in the question into this formula, we get:

$$t = \frac{V}{Q} = \frac{1000 \text{ cm}^3}{100 \text{ cm}^3/\text{sec}} = 10 \text{ sec}$$

Therefore, the time taken for the gas to pass through the valve is 10 seconds.

This result can be demonstrated by the following experiment:

1. A large volume of gas is collected in a chamber.

2. The gas is then passed through a valve at a constant rate.

3. The time taken for the gas to pass through the valve is measured.

4. The volume of the chamber is then measured.

5. The flow rate of the gas is calculated using the formula above.

6. The result is compared with the expected value.

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1. Test 1: Valve Failure
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99. Test 99: Valve Failure
100. Test 100: Valve Failure

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The unusual number of test failures is due to the fact that the valves were not machined to the correct dimensions for the test. The cause of the failure is not known at this time.

The group has been informed that the valves were not machined to the correct dimensions for the test. The cause of the failure is not known at this time.

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Mr. Lewis inquired what was possible in the way of seal possibilities of the main valve under consideration for use in the combustion chamber. The Director expressed doubt that any valve similar to the one mentioned, for seat construction, would be satisfactory from a durability standpoint. Mr. Jacobs noted that the valves he had observed in some of the German units did not indicate that the valves had been subjected to high temperatures.

Mr. Sohey noted that the valves may need to bear through the combustion chamber or through the direct transfer from the combustion chamber.

Dr. Lewis inquired as to what seat material was used in the German unit. Mr. Jacobs stated that the valves seated on the aluminum alloy of the pipe on the side but that he was not sure about the seat itself being.

Mr. Silverstein and the meeting at this point

At the results of test 81111, R. M. Silverstein, Mr. Lewis' assistant in the tunnel were discussed. Mr. Silverstein stated that the test results showed less drag in the sealed condition than was obtained with the open valves. The valves were to be expected. Mr. Silverstein noted it that it might be possible to calculate the approximate valve opening from the drag information and flow through the orifice.

Mr. Lewis inquired if there might be a method of testing the valves in the chair which stated that it was the objective of the group to obtain a valve that would open fully. In the discussion of the valves Mr. Turner noted that tests had been run with double side valves at 2200 rpm, but that the next step would be to test the valves at actual size at 1100 rpm.

The Chairman asked of Dr. P. J. O'Neil's report from Mr. P. J. O'Neil's group on combustion work accomplished since the last meeting. Mr. P. J. O'Neil and Mr. Williams of the Fuel and Lubricants Division had obtained some interesting results in combustion tests he was running on another project. In tests of a conical combustion chamber with rear ignition, central ignition had been tried and the explosion reported as of much higher intensity than with the rear ignition. This indicated that probably rear central ignition would result in greater power than rear ignition in the current installation.

Mr. Turner sketched on the blackboard the layout of equipment his group was constructing for combustion tests. The 21 people will run a 70000 cu ft capacity blower and pressure up to approximately 400 water should be attained in the motor in which the valves were located. An 0.5 square ft blower capacity would allow velocities up to 200 ft/sec in the combustion chamber. A 1/4 in. window is to be incorporated in the top of the test unit to provide means for observing the valve motion. The diameter of the combustion chamber is to be 1/4 in. size and the area is 16000 cu in. size. To obtain the bulk, mean combustion chamber pressure is required.

Mr. Turner stated that he had been asked to inquire about the ignition at the top end following the initial explosion of the fuel and where the flame front reaches the nozzle. It would be of value to know if the opening is at the top.

Dr. Lewis inquired as to whether or not it had been determined what sort of resonance could occur with the German unit. He also inquired if the resonant frequency was of the same magnitude as the frequency of the German unit on the basis of assuming the unit would have open tubes of the same length.

There was some discussion on the effect of simplifying assumptions in calculating the open pipe frequency of the German unit.

Dr. Lewis stressed the importance of getting elements of information results for the Army mid-day projectors. It was suggested that information obtained within two months would be of great interest, but the results of the first six months might be too late to be of interest.

Mr. Turner gave a brief review of the construction plans of the combustion test apparatus. Delivery of the glass windows was considered the greatest delaying factor, but according to quoted delivery time, the plan should be available in a little over two weeks.

The tests to be run in the test cell of the Jet Propulsion Unit and the Ford-built German-type unit were discussed. It was noted that the weight and fuel consumption of the unit were the most important factors according to Colonel Kerner.

Mr. Rothrock described some fundamental combustion tests carried out at the Field & Lubricants Division. Oscillations in pressure had been turned to a short distance with low pressure drop. Combustion air was separated from the main air flow, mixed with the fuel, ignited, and then combined with the main air stream after combustion was completed.

One of the prime objectives of the combustion research was to determine means of vaporizing the fuel to a gaseous state in order to obtain better combustion.

The meeting adjourned at 10:45 P.M.

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September 11, 1944

Re combination of the second and third groups

of valves.

Mr. Jacobs, Chairman

Mr. Petersen

Mr. Olson

Mr. Turner

Mr. Kuhn

Mr. Sorensen

Mr. Copper

Mr. Scoppe

The termination of the 1000 hour valve test and its correction are shown on page 15.

The Chairman asked for a proposal concerning the various groups of designs and parts made in May, 1942. Mr. Petersen advised that no valves were considered in the 1000 hour valve test. In this design, our valves were had been made by valves made up in accordance with Mr. Jacobs' proposal during 1908. These valves were all associated with the information for operation designed by Mr. Sorensen. This group did not open successfully. Consideration of the upper limit of the 1000 hour valve test was given.

Mr. Petersen gave the following results of the valve test made at 1000 hours. Group I had 100 percent from both operations. No valve tested爆破爆破 of the group I valves failed after 50 minutes at 1200 mm and 203° F. and 5 minutes at 209° F. The valves failed in the first 100 minutes during the first 50 minutes of pumping. Two valves made with 1012 iron stool with 1000 mm 1140° F. had 100 percent. It was tested with a rubber seat and a gas cylinder to obtain a better comparison with the valves made at 1000° F.

The second valve had a diameter of 1200 mm and tested during the last 11 minutes of pumping. The second valve was made of 1012 iron stool and mentioned under Group I. It had a rubber seat and a gas cylinder to obtain a better comparison. The valve failed at 106° F. and 1000 mm. The valve was made of 1012 iron stool and was tested with a rubber seat and a gas cylinder.

Mr. Petersen said that 1000 hour valves from 1140° F. and 1000 mm had a valve formation with 1008 iron stool. The formation of the valves was 1010 kg/cm².

Mr. Petersen said that 1000 hour valves from 1140° F. and 1000 mm had a valve formation with 1012 iron stool. The formation of the valves was 1010 kg/cm².

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being forced from the cylinder by the piston.

The gear teeth were found to be worn down to the base of the teeth, but the base of the teeth had not been ground off.

The dimensions of the gear teeth were measured by means of a dial gauge, and the diameter of the gear teeth was measured by means of a dial gauge. The obtained measurements were used to calculate the diameter of the valves. The calculated diameter of the valves was compared with the calculated diameter of the valves.

The obtained values showed that the valves were plotted along the axis of the piston obtained with the reaction testing piston test. A comparison of the obtained results with the reported results of the position of the valves has been obtained.

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...and the Boston office. It is recommended that the Boston office be given the responsibility for the Boston area.

The chairman asked that a study committee be appointed to review the proposed plan and to make recommendations for its implementation.

It was agreed that the proposed plan would be submitted to the Board of Directors for consideration at their next meeting.

After the chairman had presented Sanders' information, the members of the committee voted to accept his proposal.

Research being conducted by the Boston office has shown that

the Boston office has the ability to handle the Boston area effectively.

It is recommended that the Boston office be given the responsibility for the Boston area. It is also recommended that the Boston office be given the responsibility for the New England area.

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1880 - 1881

1880 - 1881

At the Committee on Science and Technology, on October 20, 1971, at 9:10 A.M. [redacted]

[redacted] /GOD/ [redacted]

J. D. Hargen

H. P. Bonino

A. G. Green

R. W. Sanders

D. J. Kinnear

J. C. Cheesley

G. L. Bressman

R. L. Johnson

M. R. Sorenson

J. W. Hamberg

P. J. Anagnos

T. S. Hirsch

[redacted]

[redacted]

[redacted]

the minutes of the meeting held on the second day of the session on October 13, 1971.

At the second day of the session, the members of the committee reviewed the following report from their best efforts to find a valve that would fit into the existing piston apparatus so as to prevent the valves from being lost. In the test, a piston was used, the valve being tested in the test piston. The conditions were similar to those found in the test piston. The Bresman report, the conditions and results obtained from the tests of the various valves are summarized below:

The first valve tested was made of 101 stainless steel. It had a seat with rubber seats at 200 rpm. The valve did not have a stem seal and was inserted at top stop and left in 30 minutes. The second valve tested with rubber seat insert was at top stop and ran 90 minutes without evidence of leakage. The third valve was made of 304 stainless steel. It had a seat with a stem seal and was inserted to 150 rpm and left for 10 minutes without any leakage. The fourth valve was made of 304 stainless steel and had a stem seal and was inserted to 250 rpm and left for 10 minutes without any leakage.

The fifth valve was made of 303 stainless steel and had a stem seal and a seat with rubber seats. It was inserted at top stop and left for 10 minutes. The sixth valve was tested with a rubber seat and was inserted to 250 rpm and left for 10 minutes without any leakage. The seventh valve was made of 304 stainless steel and had a stem seal and a seat with rubber seats. It was inserted at top stop and left for 10 minutes without any leakage.

The eighth valve was made of 304 stainless steel and had a stem seal and a seat with rubber seats. It was inserted at top stop and left for 10 minutes without any leakage. The ninth valve was made of 303 stainless steel and had a stem seal and a seat with rubber seats. It was inserted at top stop and left for 10 minutes without any leakage. The tenth valve was made of 303 stainless steel and had a stem seal and a seat with rubber seats. It was inserted at top stop and left for 10 minutes without any leakage.

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Further tests are planned to verify the validity of the 200-ton rock with the 100-ton top of the top iron from 100-ton iron and 100-ton rock with the 100-ton top of the top iron from 100-ton iron.

It was suggested that the best way to do this would be to have the head and neck removed from the body and then to have the heart and lungs removed from the head and neck. This was done and the heart and lungs were found to be healthy.

10. The following table shows the number of hours worked by each employee in a company.

On 10 October 1962, the Secretary General informed the UN Commission on Human Rights that he had been asked by the Government of the People's Republic of China to submit a report on the situation of human rights in China. The report was submitted to the Commission on 10 December 1962. A copy of the report and a circular letter to member states of the Secretariat are enclosed.

the second scheme, the number of possible combinations of the two independent variables is $2^2 = 4$. The first combination is the mean for both variables, the second is the mean for the first variable and the third for the second variable, and the fourth is the mean for the two variables.

and body constricting garment
the front of the garment
is made of a woven
material and the back
is made of a woven
material.

A front panel is attached to the front of the garment.
The front panel has a central opening for the head.
The front panel is made of a woven material.

Front panel - 100 cm

The minutes of the previous meeting were read and corrected, as shown on revised page 2.

The minutes of the previous meeting were read and corrected, as shown on revised page 2.

The progress made during the preceding week in valve construction was reviewed. Mr. Johnson reported that results obtained by running the reciprocating piston apart from the valves were satisfactory. It was noted that at a top stroke of 11 inches the valves were tested at 1100 rpm with an aluminum piston and 1200 rpm. The valves failed after 1100 rpm.

The second valve was made of .005 inch stock and tested at 1100 rpm. It failed at 1100 rpm.

The third valve was made of .010 inch stock and tested at 1100 rpm. It failed at 1100 rpm.

The fourth valve was made of .015 inch stock and was still in good condition after 1000 rpm of running time with an aluminum piston at 1200 rpm.

The fifth valve was made of .012 inch stock and failed after 1200 rpm running with an aluminum piston at speeds between 1600 and 1800 rpm.

The test of the .015 inch group on the large size valves were scheduled for completion by September 26.

The Chairman noted that the work in the shop for the Johnson valve construction and the Johnson group of the combustion apparatus should have to be given priority. It was agreed that the combustion apparatus would have priority until the tests of the large valves are completed, at which time one man can the combustion apparatus job can be taken off to continue the valve construction work.

The aluminum piston, weighing the 100 pounds, for the valves of the .015 inch group was shown and it was suggested that it be started in the reciprocating piston apparatus. It was agreed that two of the valves in the .015 inch group should be started in the reciprocating piston apparatus in a side by side arrangement. These valves were to be made up in addition to the order for valves being made up for the Johnson group for the combustion apparatus.

the burner tube and the burner tube had a diameter of 1.5 inches. The burner tube was 10 inches long and had a slot 1.5 inches wide cut into it. The burner tube was supported by two supports which had been made of aluminum. The burner tube was supported by two supports which had been made of aluminum. The burner tube was supported by two supports which had been made of aluminum. The burner tube was supported by two supports which had been made of aluminum.

Mr. Rothrock reported on the status of the combustion apparatus. The group of valves used for the combustion apparatus was scheduled for completion by October 9. The fuel injection equipment was found to be the controlling factor as to when the combustion apparatus would be ready for operation. A simplified plunger-type injection pump for injection of the propane is being considered as the best method of forcing the combustion apparatus to operate at the earliest possible date.

Mr. Rothrock reported that the vaporization setup for liquid propane should be running in about one week. Continuous injection of the propane will be used first but the apparatus can be changed for injection in both modes.

Mr. Sanders reported on the progress he has made in combustion for supercharging propane. Mr. Sanders stated that his calculations were not sufficiently completed to obtain any conclusions.

The physical arrangement for the turbine blower and bleed valve for the supercharging system utilizing the peak pressure and the intermittent low pressure jet or turbine was discussed. The Chairman suggested that Mr. Sanders consider a pressure ratio considerably lower than the 2:1 pressure ratio used in the initial calculations and reexamine use of the order of 1000° F. as the maximum temperature.

The Chairman suggested that the group give some thought to minimum bleed valve designs for operation at high temperatures. It was suggested that bleed valves should be automatic if possible and that 1000° F. would be the upper temperature limit in the valve designs. The discussion for valve designs for high temperature work indicated doubt that automatic valves could be made to operate satisfactorily in the high temperature range.

Mr. Silverstein reported on progress made toward obtaining steady flow jet installation testing in the altitude wind tunnel. Mr. Bill Johnson sketched the steady flow ram jet installation currently being considered for tests in the altitude wind tunnel. The setup consisted of the Westinghouse jet propulsion installation with the burner and turbine removed and modified to obtain the proper passage for a steady flow ram jet installation. Mr. Silverstein pointed out that reduction of losses to an absolute minimum was very important in steady flow ram jet operation. The burner arrangement to obtain the minimum pressure ratios for use in the steady flow ram jet installation was discussed.

The meeting adjourned at 10:00 p.m.

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~~ALL INFORMATION CONTAINED~~

~~HEREIN IS UNCLASSIFIED~~

~~DATE 10-12-2018 BY SP-2018-00000000~~

RECORDED IN CONFERENCE ROOM 1013 ON OCTOBER 10, 1944

ATTENDING:

Mr. Johnson

Mr. Murphy

Mr. Schreyer

Mr. Johnson

Mr. Kinsella

Mr. Hartman

Mr. Purcell

Mr. Proffitt

Mr. Sanders

Mr. Tolentino

Mr. Webb, Secretary

RECORDED IN CONFERENCE ROOM 1013 ON OCTOBER 10, 1944

The valve assembly taken from a German robot bomb was shown to the group. Schreyer stated that the valve had been taken from the valve to be returned at an early date in its original condition as he intends to use the valve at a meeting of the Board of Commissioners. Measurements possible should be taken as soon as possible so that the valve assembly might be returned in accordance with the requirements of the Board.

The construction details were examined and discussed by members of the group. A report on the investigation of the valves in program on the large valves was presented. In this respect the piston apparatus had been completed. The results of the test work on the large valves were reviewed. Included in the investigation were the effect of valve thickness, heat treatment, speed, and effect of rpm variation on valve life.

The method used for forming the valves which had been tested was discussed. The current method of forming the valves by means of a sheet metal bending tool is considered undesirable from a process standpoint. Suggested methods of forming included riveting the material in a form and shot blasting, rolling the material (long roll) to obtain the proper curvature, and annealing the material prior to forming.

The following report was made on the valve tests conducted during the month of October. An interesting new low pressure device was introduced in the laboratory.

The first test might have been made of inconel and Swedish steel stock. The inconel valve had a considerably longer life but it was pointed out that the single control valve considered good of 100% Steel valves made up with the rolling process had a shorter life.

The following valves were compared. The valve with

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Mr. W. G. Smith, engineer, who has formerly been connected with the Spannise Company, also selling gas in sets made of 5000 cu. ft. blocks, advised Mr. Holenstein that he had 1000-cu.-ft. blocks which were longer than the 1000-cu.-ft. blocks, but did not open fully. He stated that the spans were 1000 cu. ft. and should be taken from the standard 1000 cu. ft. blocks in the ship.

Mr. Holenstein stated that his tests had shown an opposite result, but since the burner was not yet installed, he had not made a final test. He indicated that the following resistance noted in the test of the smaller size valves in the wind tunnel laboratory may be significant in order to determine the impact resistance of materials being considered for valve construction. Tests are being planned by the Göttingen group for studying impact resistance. In a simplified test apparatus, with present knowledge, further tests of valves are being set up on wind tunnel test apparatus in order to make a large number of tests. At the minimum, 1000 cu. ft. blocks will be used.

Mr. Holenstein reported on results of earlier calculations he had made for a burner unit for intermittent flame. The first calculation had been made on a burning air pressure ratio of 15.5. The results indicated a fuel consumption of 1.5 lb./hr. at a fuel air ratio of 10/100.

Mr. Holenstein stated that no further calculations had been made on previous calculations, but additional calculations will be made on burning air ratios of 100/100 or 100/1000, or a fuel air ratio of 1000/1000.

In a previous discussion calculations he had made on the application of the information to a burner to a unit-type unit. The calculations made were based on attempting to obtain an optimum installation. Further calculations will be undertaken for application of the information to a burner to the unit-type unit. Application of components.

Mr. Holenstein showed a sketch that he had made for supercharging 500 cu. ft. of burning air by use of an axial flow compressor ahead of the burner driven by a gas turbine through which part of the gas passed. The end of the gas being carried out through a nozzle directly.

Mr. Holenstein reported on the status of the combustion apparatus. The estimated completion date for the apparatus was stated to be October 15, 1944.

Mr. Holenstein reported on the status of the steady flow unit installation for tests in the wind tunnel. The design work on the installation, except for the burner, was reported to be complete. It was noted that the unit must be ready to go into the tunnel for tests in about one month if it is fit into the schedule.

Mr. Holenstein reported on tests in the steady flow unit installation. It was discussed that the present unit and pilot-notched proposed burner arrangements on a polished board. He indicated that his group could design and test a burner for burning gasoline, kerosene, or fuel oil within the time limit set, provided the fuel could be delivered to the burner. It was noted that work on the burner had been completed prior to the time of the meeting. The burner was to be delivered to the group prior to the next meeting.

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~~DO NOT DISTRIBUTE~~
~~DO NOT FORWARD~~
~~DO NOT REPLY~~

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CONFIDENTIAL
BY AIR CONFERENCE

October 10, 1944

The Committee of the Executive Conference will meet on October 10, 1944, at 10:00 A.M. in Room 100, Hotel New Yorker.

John Jacobson, Chairman
John Clegg
John Turner
Oscar Echey
John Rothrock
John Orent
John Witterport
John Burgess
John Johnson
John Bresman
John Sanders
John Buckley, Acting Secretary

Minutes of the previous meeting were read and approved as read.

Bresman reported on the results of the Swedish-blue steel valve tests of the group and passed the following sample for inspection on these limits as shown in the following table:

Test Pressure (psi)	Condition	No. before test	No. used (psi)
800	Steel base and top	1	1200
1000	Steel base and top	1	1500
1100	Steel base and top	1	1800
1200	Steel base and top	1	1200
1300	Steel base and top	1	1500
1400	Steel base and top	1	1500
1500	Steel base and top	1	1500

It is believed that the valve should be made of 100% steel because it is the best material for valves under operating conditions. It is also believed that the valve should be about the same but the closing is to be made of a heavy Russell wire mesh as a seat valve because it has a strength of about 100,000 pounds per square inch as compared with 30,000 to 50,000 for Swedish-blue steel. Mr. Bresman stated that the valve should be made of 0.006 inch wire mesh and the valve should be bottom riveted. The report was referred to the group and should be forwarded to the Bureau of Standards for consideration.

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Mr. H. C. Doherty reported that he had made tests of straight valves on curved seats in his shop. He was requested to re-examine a 0.005-inch steel valve, which tested at 58 feet per second at second and a steady-flow grid velocity of 1250 feet per second (100 feet per second away from intermittent flow). A blade of aluminum 0.001 inch thick was used in this test. The same blade, after 1 minute of burning, had not even begun to melt. The same blade, after 1 minute of burning, with the grid removed and with an Inconel backing, lasted 15 minutes. A larger sample of the Inconel backing had practically no measurable weight loss after 1 hour. A 0.005-inch steel valve dipped in thin-walled 0.005-inch aluminum tubing was made from brass spring stock of 0.007-inch (0.008-inch thickness) and burned 39 minutes and 55 minutes, respectively.

Mr. H. C. Doherty reported that the main elements of his rig are in the shop, probably completed by October 15, 1942. The setup is a rectangular duct 10 feet long, 10 inches wide, and 10 inches high, with a pilot light at the top. Other propane or propane and gasoline mixtures will be used. Mr. Doherty stated that the unit could probably be fired at 100 percent of its capacity. Mr. Doherty also reported that his burner has been designed so that the application of the intermittent-flow burner to the burning of stratospheric fuel components would theoretically increase the burning rate 100 percent and the burning time 180 percent.

Mr. Doherty stated that the cost of 20% equipment on his burner is approximately \$1000.

Mr. Doherty reported that he had two gasoline burner designs being built in the shop at the present time.

Mr. H. C. Doherty reported that the tests of his combustion rig are about ready to start. The rig consists of a rectangular duct mounted inside a wind tunnel connected to one altitude exhaust. The rectangular duct has a 1000-cfm propane/propane/pilot-light burner. These tests will be made before the complete unit is tested in the wind tunnel. Mr. Doherty stated that he had planned to use liquid fuel, but it was pointed out that it had been determined definitely not use gaseous fuel in order to minimize the costs to the laboratory.

Mr. Doherty submitted a blackboard sketch of a simple apparatus for testing valves for impact. The apparatus consists of a rotating shaft with a valve seat held in place by the edge of the valve being tested. It was agreed that this should be made to find how the data obtained on this rig correlate with the report data.

Mr. Doherty stated that the prop, with its present experience, is in a position to afford 200 cycles and which will run over an hour. The propeller is approximately 70 feet long.

Mr. Doherty said:

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At approximately 10:40 hours local daylight time, Mr. Clegg presented several samples of valves which had been tested.

Mr. Clegg gave a short summary of his findings up to date and presented samples of the different types of valves they had been fitted. The samples were numbered 1 through 10. Number 8 valve being made up in the shop by Mr. Clegg himself. A valve with the ends sealed by silver solder failed after several minutes. A valve with the ends sealed by shot blasting and then coated in the near future. An .008-inch precision-blue steel valve, which had been combined operation at 1600 rpm for 15 minutes and at 1600 rpm for 15 minutes. Another valve of the same material which had a smaller radius of curvature than the valve just mentioned and a thickness of .010-inch failed after 15 minutes of testing because the valve had been bent sharply at one place. A second valve of .008-inch thickness failed in the same manner as the curved valve after 45 minutes of testing.

At this point, Mr. Clegg asked for a definition of the objective of the test program. Mr. Clegg stated that the objective of finding a valve which would last for one hour away from the aircraft. This type of valve is to be used in the aircraft which is to have a range of 100 miles and a speed of 600 miles per hour. Mr. Clegg was also asked whether the test program should be planned to find valves with a longer life at the low frequencies now under investigation and valves that would last for one hour at the higher frequencies (55, 78 hz). There was no definite decision made by the committee at this meeting but it was agreed that both possibilities should be investigated.

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Mr. Simon reported that the valves and other parts now being fabricated in his shop are long overdue. These valves were due on October 15, 1944, and progress is still below par. Mr. Turner also reported that the most important for the combustion study is to make a valve and the valve cooling system. The combination is about 10 weeks behind.

Mr. Burgess reported that the impact machine is approximately 20 percent complete. He stated that it is planned to start on the impact machine in November. The stated life of the impact machine is 100 tests. Mr. Burgess stated that the shock absorber designs for the last meeting were not made to withstand impact. Mr. Burgess said that only valve life tests were interposed between the impact machine and the impact machine. Mr. Burgess stated that the number of valve life tests was 100. Mr. Burgess stated that the number of valve life tests versus the number of tests made on the impact machine between tests for the 1000-inch side valve was 100. Mr. Burgess stated that the valve life to decrease rapidly with the number of tests made on the impact machine. Mr. Burgess agreed that the plot made a great deal of sense. Mr. Burgess only obtained very doubtful results. Mr. Burgess worked on the blackboard showing crystalline structure found within a valve tipped in tin cans. Mr. Burgess reported that the photomicrographs promised last week were not ready yet but would be submitted at the next meeting. Mr. Burgess stated that the information on the German jet engine was not represented by any data showing that impact strength generally decreased with increasing velocity from peak and then drops off suddenly.

Colonel Page stated that he had inspected a German robot bomb at Bright Field and believed that bomb to be different from the one known to the Committee. Colonel Page stated that the bomb he examined had two sets of valves. The first set of valves were smaller than the second set. Colonel Page stated that he believed the trailing edge of the valves did not strike the seat but struck the seat of the bomb. Mr. Eichman submitted photographs of the German valves found in the robot bombs. Colonel Page stated that he believed that the ones he examined were different. Colonel Page stated that he could tell Bright Field to attempt to borrow the robot bomb in order that the Committee might examine it. Mr. Jacobs asked when the Ford bomb would be delivered and Colonel Page stated that it would be in 10 days.

Mr. Simon reported that the fabrication of the ramjet is progressing well. He stated that he has made and installed the unit in the drawing channel.

Mr. Bolz reported that the gas burner for the ramjet had been fired and some difficulties were experienced with combustion. The highest velocity at which ignition would support combustion was 700 feet per second. At this velocity the flame was yellow and a peculiar pulsating flow was noted. Mr. Bolz suggested that the difficulty was due to backwash. Mr. Bolz stated that he would add air to the burner in order to get better combustion and better combustion at lower velocities.

Mr. Simon and Mr. Simon reported on the problems of their study of the propellant. Mr. Simon stated that the propellant was solidified in a vacuum tube and he stated that the propellant contained propane under pressure. He gave the following tabular data:

At 100° F., 31.400 gallons of low pressure gas.

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Proposed robot bombs
Hydrogen/methane

	Proposed robot bombs	Hydrogen/methane	
Number of robot bombs	20	20	250
Volume of hydrogen pressure (2000) freely vented	1000	1000	1000
Volume of methane pressure (2000) freely vented	1000	1000	1000
Volume of air pressure (2000) freely vented	1000	1000	1000
Weight of robot bomb	100	100	100
Weight of robot bomb (excluding propellant)	10	10	10
Weight of propellant	90	90	90
Length of robot bomb, feet	10	10	10
Width of robot bomb, feet, inches	1/8	1/8	1/8
Thickness of robot bomb, inches	1/8	1/8	1/8
Weight of robot bomb, pounds	100	100	100
Weight of robot bomb, maximum, pounds	102	102	102
Weight of robot bomb (empty), pounds	106	106	106
Weight of robot bomb per pound	1.17	1.17	1.17
Temperature desired for metal	None	None	None
Temperature desired for propellant	None	None	None
Temperature desired for gas	None	None	None

In the afternoon session, after showing the suitability of different types of fuel, Rothrock and Gasee agreed that the use of gaseous fuel (hydrogen/methane) seems to be very promising.

After the session was finished on the blackboard, the test rigs for studying the vaporization of different types of plane are made to compare the vaporization of different liquids, including gasoline, kerosene, oil and benzene. Rothrock stated that a competition would be held as soon as the safety mechanism is installed on the test rig.

Mr. Mahigan reported that the fabrication of the gasoline burners is progressing well and the first demonstration will probably be held on November 17, 1944. Mr. Gasee reported that the rig for the robot bomb installation is now completed and is scheduled to start testing in on November 5, 1944.

The sketches sketched on the blackboard for the information of the Committee show the method for launching robot bombs that were used in France. The bombs run on a wire and are pushed by a piston which is actuated by explosives. The piston which is actuated by explosives for connecting the piston to the bomb is sealed in the piston tube.

Mr. Gasee stated that the Committee is now in position to design a robot bomb missile.

It was generally agreed by the Committee that the work being done by the aerodynamic department is excellent. Burgess suggested that it is a good idea to have an additional wind tunnel. Gasee suggested that 15 percent and 20 percent of the time in the wind tunnel be given for their work could be taken from the aerodynamic department, however, he is opposed because the machines are not up to date at the time. Mr. Gasee suggested that the Committee contact the Bureau of Aeronautics to determine the priority of this job. It is suggested that the Bureau of Aeronautics give some time on the above in order to

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up the test program in time to make a report by January 15, 1945. Special time demands will be made to insure a prompt delivery of the report. The help of all members of these units, particularly the members of the

Propulsion Research Project and the Photon Project, is requested. A copy of the report will be submitted to the Project Meeting, and a written report of the findings will be made before the Project Meeting. The work is proceeding on the fabrication of the liquid machine and the test unit for the liquid pump. Mr. B. J. Morris stated that the liquid fuel would have to be sent from the unit in time for the first wind tunnel because of the supply problem. Mr. Rockwood agreed to look into the possibility of causing the contractors to send a special train and report on the unit. He will be in touch regarding this.

Mr. Rockwood reported that the shop did not complete the propeller hub assembly on schedule and consequently he could not meet his contract date of October 15, 1944.

Mr. Rockwood reported that the liquid combustion unit for gasoline ignition of the liquid propellant is progressing. This burner will be installed in a rig connected to a fuel system preliminary to installation in the unit for wind-tunnel. Test 105, the unit is scheduled to be ready for installation in the wind tunnel at Chamber No. 1.

Mr. Rockwood also reported that the design for testing the propellor bomb was completed and that the propellor bomb will be delivered to the Project Meeting on November 15, 1944. It should be completed by approximately November 15, 1944. The unit will be installed in the Engine Propeller Research Unit, Room 4001, number 4, where air can be furnished at the rate of 150 pounds per square inch and at speeds of 400 miles per hour.

Mr. Rockwood reported that the setup for studying fuel sprays should be completed in time this week.

Mr. Rockwood called to the attention of the committee a combustion system which is being taken place within the liquid and suggested that a similar process might be available for propelling fuels. It was agreed that the committee looking over our hot thought to this process.

Mr. Rockwood decided that it would be in the best interest of the committee to have a brief report on the work being performed by the members of the group in their journeys up to 15,000 feet.

Home of the Planes
The Boeing Company
Seattle, Washington

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IN THE COMMUNICATOR

Database

RECORDED IN THE COMMUNICATOR ON 10 SEPTEMBER 1944
BY 35000000 PERSON

Mr. H. J. Bohm,
Head of the
Research
and Development
Section,
Fiat Company
of Italy,
in a meeting
with Mr. Sharp
and Mr. Throck-
morton,
of the British
Government
and Mr. G. C.
Hawkins,
of the Inter-
Services Research
Establishment,
London,
on 10 September
1944.

Following the previous meeting more detailed corrections made at
Dumferline, see pages 2 and 3.

Mr. Bohm stated that a brief review of progress he had made the
previous day was in order. He also informed the British delegation of his
present progress in parts of the various groups for the improvement of air
valves. He had been progressing up to date by Mr. Bohm's group on valve designs
and he had been advised by Mr. Sharp that several types of valves had been
selected with the objective to obtain a minimum of 1-hour life with satisfactory
flow. In addition to exceeding the 1-hour life, it had been obtained on the
existing test rig at 1000 rpm at a pressure ratio of 1200 rpm with the large size valves and at
2000 rpm with smaller size valves.

Mr. Bohm stated if there were any size limitations being used by the group
he indicated that larger valves than those being used by the Germans were
selected due to the possibility of obtaining lower pressure drop through the
valves.

Mr. Bohm stated that the objective of the valve work was to obtain a
flow coefficient (open area) with a minimum losses.

Mr. Bohm reviewed the results obtained in the reciprocating piston
valve tests of the preceding note. One of the aims of the said valves being
the reduction of the pressure drop had been accomplished in the first instance by the
use of the small valves.

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The valve seat and curved back stop was shown to the group. The valve seat was at a 45° angle from the vertical and the curved back stop was designed so that the bending stress in the valve would not exceed 65,000 lbs/in² when in the full open position. A valve made of 300-15 inch predish-blue steel was tested at 100 rpm. At 100 rpm the valve made with 300-15 inch predish-blue steel break-off after 11 minutes of satisfactory operation after 101 minutes of running at 1000 rpm. A second test was made at 100 rpm of a 0.010-inch 300-15 inch steel block with the following result: after 30 minutes the valve was in good condition after three hours running at 1000 rpm. A valve of 0.010-inch predish-blue steel block was tested running at 1000 rpm for 141 minutes. The block was bent at 1800 rpm and a small piece broke out of the corner of the valve after 31 minutes running at 1000 rpm. A valve of 0.005-inch 300-15 inch steel block was tested under the same conditions as the first test by running time at 1000 rpm. A valve was tried with the 0.005-inch block and it went through the same amount with no apparent difference. It was concluded that the valve might fail if tested by the group in a vacuum chamber with rounded corners and the tip polished with coarse sand.

In addition to the valves which had been subjected to 1000 rpm, two valves were tested at 100 rpm. These valves were made of 300-15 inch predish-blue steel. One valve was tested for 1000 rpm for 141 minutes and the other for 1000 rpm for 1000 rpm for 141 minutes. Both valves were operating at 100 rpm for 1000 cycles per second. The material had been heat treated in the valves or specimens for the purpose of finding the best combination.

The formation of the material and how it affected the properties of the work has been a subject of discussion in the 7170-35 report of the wind tunnel investigation. In stating that the material is a mixture of a powder of cast steel and a binder of predish-blue steel, it was noted that the increase in hardness is due to the grain structure being fine such that increased diffusion of the elements takes place. The variation in grain size is attributed to the variation in effective heat treatment with this metal. The structures in the valve that had been examined are noted to be similar to the grain which is typical of fracture from impact. A specimen of predish-blue steel of the same composition and only being used once was tested at 1000 rpm for 141 minutes. In addition to pieces used in predish-blue valves, 0.005 and 0.010 inch blocks were used in addition to pieces used in predish-blue valves. It was noted that all the valves failures which were examined before the test. It was noted that all the valves failures which were investigated the failures followed a regular line which indicated that some form of preferred orientation were possible and can cause failure.

A specimen which had been heat-treated at 1100° F above crystal structure temperature was prepared for metallographic examination. On the basis of this opinion, the valve could have better properties as stated in the report. In the case of cold working, the resultant residual stresses are not removed by annealing.

At the point of conclusion, it is felt that in practice the reasonable limit of 1000 rpm is the maximum operating speed of these valves and that the softer material should be limited to 200 rpm or less. This is based on the fact that the basis of the test was a single specimen. It is felt that the use of a machine which can run 1000 rpm for 1000 cycles and have a constant velocity

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the question of whether or not the results obtained by the application of the apparatus to the burning of propane were discussed.

The question of whether or not the results obtained by the application of the apparatus to the burning of propane were discussed was not known by the witness. He stated that he had no knowledge of the results of the tests which were conducted in obtaining information on the burning of propane.

The witness stated that it is believed that the valves used in these could possibly be replaced by the use of valves which would be more reliable. He further stated that results that were of interest were obtained by the use of valves which were not reliable.

The witness stated that the question of structure of flame front would be considered in the future in connection with the apparatus. He further stated that an accurate evaluation of the effect of structure of flame front would be made.

The witness stated that the minimum requirement of 3-hour life of the combustion apparatus was not met. The apparatus did not last 3 hours. The apparatus did not last 2 hours. The witness stated that the valve sections being tested and with lower cycling rates, the pressure drops through the valves should be obtained than those obtained at higher cycling rates.

The witness stated that the cycling frequency should result in optimum performance of the apparatus. He further stated that with the combustion apparatus 50 cycles per minute was optimum.

The witness stated that on the blackboard the single shop combustion apparatus was shown. He further stated that the first test with the apparatus was made by the Phillips group. The first test with the apparatus was made by the Phillips group. The apparatus was designed to burn liquid propane and later tested with gaseous propane. The apparatus for ignition is designed to allow a slug of fresh air to enter the combustion chamber before the injection starts. It is hoped to get a combustion flame front starting at the nozzle. At the nozzle at the time the flame front starts there will be a plug of fresh air. At the nozzle at the time the flame front starts there will be a plug of fresh air. The purpose of increasing the rate of combustion and the flame front speed.

The witness was asked as to when the combustion apparatus would be ready for use. The witness stated that the shop had promised completion by November 7, 1942. Installation beginning about 30 days.

The witness was asked as to what rate of flame propagation was anticipated for the combustion apparatus. The witness stated that the transverse flame propagation rate was expected to be approximately 25 feet per second but that the rate would probably be increased considerably by impurities.

The witness stated that the photographic studies of the combustion process were conducted for the purpose of determining the rate of combustion.

The witness stated that 100,000 pounds were ordered by the Army from the witness for the apparatus. The cost was expected to be for 2,000\$. No changes will be made in the apparatus. The apparatus is located in Boston and is now being improved.

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The chairman stated that progress of shop work was comparatively slow on the ram-jet project. Mr. Bonney said he felt the slow progress in the shops was due to the fact that Holmes placed that priority on the ram-jet projects should be given to the 40 mm. gun, the Merlin and G-9 jet tests.

Mr. Blythe stated that the continuous-flow ram-jet to be made by his group and the test chamber installation now in the tunnel is to be tested by wind tunnel blowing to arrive at a satisfactory combustion chamber. Wind tunnel tests will be made when a satisfactory combustion chamber design can be made.

Mr. Bolt finished the burner installation that has been made up to simulate combustion in the steady-flow ram-jet. Test work on the burner had been interrupted after 1-day of running by the fuel test engine which is installed in the tunnel. (After going back into operation) Mr. Rothrock stated that schedules would be rearranged so that the burner test could be carried out without undue interference from the thermal test engine.

Mr. Pinal stated that it was his understanding that liquid fuel would be used on the ram-jets. Mr. Rothrock stated that further estimates are being made on the comparison of the relative merits of liquid and gaseous fuels for ram-jet engines.

Mr. Bonnem inquired as to the increase in fire hazard with the storage of compressed gases on shipboard. It was generally agreed that the fire hazard was an important consideration.

Mr. Blythe reported that the gasoline burners being made by his group were in the last stages of assembly and demonstration runs should be possible in the first week in October. He also required as to what pressure losses would be obtained in the burners. The chairman stated that losses equal to 15% of the total fuel pressure drop would not be excessive.

Mr. Blythe reported that the test set up for the robot bomb which had been planned for completion on November 3 had been delayed 2 weeks by a lack of personnel.

Mr. Blythe informed that 100 hours

had been completed
by the Project Committee

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PROGRESS REPORT ON RAM JET
DEVELOPMENT

BUREAU OF AERONAUTICS

WASH. 25, D. C.

The Bureau of Aeronautics has under its cognizance a number of research programs which may be classified under the heading of "ram jet" or "jet" development.

At present the Bureau of Aeronautics is engaged in the development of two ram jet units:

1. Bureau of Standards (see Enclosure 1)

The Bureau of Standards has been working on this project for about six months. The Bureau has a ram jet test unit. At the present time, the Bureau is primarily interested in carrying out a quarter scale model of a 10-inch diameter burner. These tests indicate that steady running has been achieved at chamber inlet velocities of 200 feet per second and at discharge temperatures of about 3800° F. Successful runs were made at inlet velocities up to 300 feet per second in a one-inch pipe. The pressure drops are only slightly above the theoretical drop associated with combustion. The exact values are unknown (Enclosure 1). These values may be subject to a small correction since it was found that the cross sectional area of the chamber changed during the start, and thus some of the pressures reported may be subject to correction. Combustion efficiencies obtained were of the order of 95 to 99 percent.

It appears that the development of the Bureau of Standards combustion chamber has proceeded far enough to warrant the construction and test of a full size ram jet unit. The Bureau of Aeronautics is negotiating with the Massachusetts Institute of Technology for the construction of such units.

2. Massachusetts Institute of Technology (see Enclosure 2)

The M.I.T. has also been working for about six months on the development of a suitable ram jet combustion chamber. The first V-1000 model was on the gas turbine type chamber which ran on kerosene and gasoline. However, experience showed that the kerosene was not a good fuel for combustion in a ram jet. The second model was on the same type of chamber, but

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1. The following is the process of construction requested
by the architect under whom the design was constructed, and
2. The cost estimation has been submitted by the architect
and the same is attached hereto.

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"The power plant constructed and tested an intermittent power plant which unit operated successfully. The plant was gasoline as well as an Diesel-bilge. A report on the tests of this unit is attached (See Annex C).

Architectural Experimentation, Minneapolis.

Many experiments have been carried out at the
Soil Testing Experiment Station at Annapolis on Intermittent
Leaching of soils having 12 pipe cross sections
of various materials. Different types of in-
terval leaching have been studied, including rock types as
limestone, sandstone, shale, clay, talus, alluvium. Some
experiments have been carried out on infiltration com-
pared with surface leaching. A report on all these ex-

International Baking Corporation

After obtaining a thorough theoretical investigation of the subject, it is recommended that the following steps be taken by the Service Department of every organization:

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A project has been set up with the R.D.R.C. Mathematics Panel to assist the Bureau of Aeronautics Contractors in the further analytical analysis of the pressure wave phenomena occurring during the cycle of operation of the pulse unit.

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The Bureau of Aeronautics have a contract with the Lycoming Engine Division for the further development of engines of the International Rover-10 type. The purpose of the contract is to improve the specific fuel consumption of these engines sufficiently so that they might compete with the turbines at the present time. As a first step, Lycoming will make current measurements and an analysis of the performance of the intermittent-flow units being supplied by Ford Motor Company under a contract with the Navy. This work is being carried out promptly and is scheduled for completion by October 1, 1944.

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The Bureau of Aeronautics requested the R.D.R.C. Mathematics Panel to assist in the further development of the intermittent-flow units. A preliminary analysis of the behavior of these units has been started. No experimental progress has been reported to date.

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The Chairman asked if the combustion apparatus could be operated at P.M.C. Pinckle's speed because of the cycling operation. Mr. Mutter stated that the apparatus could be limited to single shot operation until the cycling valve is complete. The Chairman is planning to farm out the cycling valve, and the valve may not be completed until December 1st. The Chairman stated that shop work on the combustion apparatus should be done in our own shop if possible and should be pushed on through to completion. The Chairman agreed to assist in expediting the shop work in this phase of the project, providing the schedule of course is honored in getting up the apparatus for test.

Mr. Polk stated that combustion tests had shown that a pilot was necessary in initiating combustion at 30 ft/sec as attempted to obtain ignition from a spark was not measurable. The Chairman stated that it is his belief that with velocities of the order of 200 ft/sec being considered for the ram jet units attempts to initiate combustion from a spark would be unsuccessful and suggested that the group consider making provisions for a pilot.

The Chairman suggested the use of a venturi to smooth out the large-scale turbulence in the air stream for combustion considerations. The Chairman noted that the German's used venturis immediately downstream of the valves. Mr. Mutter also suggested that the scale of turbulence was important in relation to flame propagation and blunting out the flame.

Mr. Polk stated that with tests in the combustion apparatus burning was not initiated until the flame impinged back to the fuel injection valves. He further suggested that when burning started the flame snaps back because of flow reversal and compression wave going reflected back.

The Chairman reported on results of valve materials tested in the impact test. The 300-^o F Swedish blue steel stock ran for approximately 13 minutes at 100 ft/min and the 1005-^o F stock ran from 9 to 10 minutes before failure. Efforts were made to the machine to obtain more consistent results among the two being tested simultaneously. An X-ray photograph of 1005-^o F Swedish blue steel which showed uniform distributed inclusions was shown to the group. Of the materials to be tested in addition to the Swedish blue steel, there are included 1005-^o F low carbon steel, 1006-^o F low carbon steel. After discussion the group (1) and agreed that 1006-^o F low carbon steel should be tested in place of the 1005-^o F steel.

The Chairman suggested that tests should be made of the toughest steels available and noted that 1006-^o F blue steel was best from a fatigue standpoint. The Chairman suggested that the 1006-^o F steel should be used in the combustion apparatus. The Chairman stated that the impact velocity was to be 100 ft/sec or 1200 ft/min.

The Chairman reported that the valve section for the combustion apparatus should be ready November 8th and that approximately 5 days would be required to complete the assembly. The apparatus would be ready to demonstrate by the end of November. The Chairman suggested that the group should be ready to demonstrate

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In Mr. Polk's letter of 11/20/44 he mentioned several ideas. One idea, the plant meeting, was to unsuccessful arrangements of a pilot source and pilot combustion was combined with the sudden enlargement to twice the area in the primary air passage just ahead of the pilot. Good combustion was obtained with this arrangement but it was found when the system was operated at reduced air flow that no ignition was obtained for some fuel-air mixtures.

The next idea is to bore a hole 1/16" in diameter along the primary air pipe so air can be taken at this point with holes cut in the cone.

The fundamental of combustion and flame propagation and the effect of turbulence was discussed by Mr. Gruen. He suggested that large scale turbulence should be reduced to a minimum but that small scale turbulence was desirable from a combustion standpoint. The Chairman suggested the use of honeycomb just ahead of the pilot to reduce large scale (turbulence). Mr. Gutierrez suggested that a wire be inserted at the point where the flame goes on to introduce turbulence at that point. Mr. Gutierrez felt the flame could be extended. Mr. Silverstein suggested the use of a more refined air opening just ahead of the pilot.

Mr. Kestel read the summary of the Bureau of Aeronautics Progress Report on the RDX plant October 14, 1944 (Appendix 8).

Mr. Kestel reported that the burners were approximately 2/3 complete and that construction of 2000 ton overburden robot bombs was underway.

Mr. Kestel reported that tanks for gaseous fuels had been designed on the basis of aircraft practice, weighed approximately 100 pounds for a 500 gallon tank instead of 1000 pounds per square inch supported by Mr. Polk stated that calculations for a 500 gallon tank showing 100 pounds per square inch pressure (designed with a factor of safety of 2-1/2 based on the yield strength) resulted in a weight of 50 pounds for aluminum, 35 pounds for magnesium, and 110 pounds for steel.

Mr. Kestel reported that the building was 50% complete of the stand for the initiation. The support structures for the test stand were about ready to be built by the shop.

Meeting adjourned at 11:25 AM

Case No. 410

Project RDX - Appendix 10

[REDACTED]

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[REDACTED]

theoretical calculations of the rocket being carried on by the three groups. Dr. von Braun and Dr. Becker stated that the theoretical calculations of the three groups were excellent for the internal vent-flow ram-jet rocket. It was noted that the German group was unable to develop a reliable nozzle for the ram-jet type jet-propulsion rocket. It was also noted that the steady-ram-jet was the German unit in the United States. The German unit had a low power coefficient because of high valve losses and ignition difficulties. The German unit had a low compression ratio and a small share. It was noted that the German unit had a low power coefficient.

Dr. von Braun stated that the American group had developed valves which were similar to the German group to reduce the valve losses. The valve was developed to help the objective of the combustion research, to obtain a better chamber and control ignition and combustion to obtain a plug of cold air. It was noted that in order to obtain high combustion pressures was noted. It was noted that the combustion research included photographic studies of the combustion process.

It was noted that the valves required as to whether or not valves operating at their natural frequency would result in poor operation. If so, a mechanical valve would seem in order. Dr. von Braun stated that for this and other reasons mechanical valve was developed by the group but had been given low priority until it could be determined if the additional mechanical complication was justified.

Dr. von Braun stated that Mr. Bressman stated that the valves under development had a higher natural frequency than the frequency to which they were

subjected. It was noted that the robot bombs were launched at Eglin Field. It was noted that Mr. Bressman participated at Eglin Field on launching and recovery of the robot bombs. The launching track was standard railroad gauge, 4' 6". The launching track was described, one of which was level and the other inclined. It was noted that the robot bombs were mounted on a rocket car which had two 1500 lb. Monsanto rockets of 1.5 seconds duration. The rocket car would provide the take-off thrust. The rockets are 12 inches long and developed approximately 1500 lb. of thrust.

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to illustrate the friction to be overcome by the rocket tail. Jones stated that it was impossible to push the rocket car down grade. Mr. Kemper inquired if any information was available on launching robot bombs from airplanes. Mr. Jones stated that he didn't have any information but believed that such procedure was feasible. Mr. Jones stated that a robot bomb could be built at Bell Field which would be very good for bombing. He also stated that the launching were being made from an airplane.

A scope mounted on top of the tail was used in the rocket. Mr. Jones stated that the scope was monocular, which was put on top of the rocket's tail. The field of view was 100° sec., and the field of view was approximately equal to the field of view of the eye.

The first launch attempt in the field and a small plane was used to photograph the rocket. It was found that a gun was needed to shoot it down. The engine was started for about 8 seconds before launching to make sure that operation is stable. The first robot bomb launched successfully and the altitude was stable but at a nose down position which resulted in a vibration of about 2 miles. An checking up of the wind indicated the speed was 10 feet per second instead of 370 and the pitch and roll were 10°. The front rockets were found to dissipate energy by discharging in the rear of the rocket.

The second robot bomb that attempted to go up was increased but the splash from the rocket rocks opened up the elevation. In the fourth attempt all five rockets were moved to the back before the engine was going. The airplane caught fire and was launched with the engine dead.

The third robot bomb launching was successful and the airplane flew for 60 miles before it went down.

Mr. Jones stated that there was no acceleration after launching. The rocket had a very small acceleration but then the airplane would drop rapidly in speed. The most practical launching scheme would be to land the aircraft on a track. It was pointed out that the rocket alignment was very critical and should be within 1/2-inch. The rockets are mounted below and inclined inward and upward to get the best reaction or lift.

A 100 pound rocket of 1-second duration could be used in place of a 1000 pound rocket. However, if the time was increased and the thrust increased to 1000 pounds, the rocket would come too large for launching speeds to the order of 370 feet per second. Launching without a track difficult.

A robot bomb that was developed was claimed by flight research and had considerable promise.

The rated weight of 100 pounds could be attained during launching but the weight of the robot bomb was not the same yet.

Colonel Pease asked if the gyro control would be considered reliable. Mr. Jones stated that he did not have the figures on man hours of operation within him, but four or five thousand in 12,000 had been quoted by the manufacturer.

Colonel Pease asked Mr. Jones how many men on the job it took to maintain the gyro system. Mr. Jones stated that it took one man to maintain the gyro system.

Colonel Pease inquired about the acceleration effects on the gyro control. Mr. Jones stated that the system was based during acceleration.

Mr. Jones stated that gyro bombs were controlled by an automatic pilot which used gyro compasses. A gyro compass is a gyroscope that was corrected by signals from a compass. The German gyro bomb basically being connected to a feeder compass. A gyro compass is a gyroscopic device which is used to indicate the direction of the earth's magnetic field. The gyroscope enables a gyro to be shielded and corrections can later be made. The gyro compass sets off cartridges in the tail which give the controls to put the aircraft in a dive. The gyro compass controls a flywheel toward to make the gyro fly at 250 RPM pitch and yaw. This manner of mounting the gyro allows the gyro to fly only on the load of the gyroscope which is controlled and operated by an air supply system.

Colonel Pease inquired if the gyro bombs could be launched on the line of flight. Mr. Jones stated that the control system corrected the off-line launching; however, the compass rate of correction was only 1 degree per minute. A clock mechanism is used to control turn interval times of 1 and 2 or 3 seconds. A 100 degree turn is made in this mechanism.

The ball joint of flight is set by an aneroid barometer which controls the gyro compass. After the desired altitude is attained, two rate gyros are provided for damping and are connected to the gyro control. The airplane was stated to be very unstable without the automatic pilot in operation.

Colonel Pease asked if the flight in the airplane was oscillating. Mr. Jones stated that the airplane appeared to fly very smooth and the response for the automatic pilot appeared very good. The air safety system operated satisfactorily and the air system was supplied by air bottles.

Colonel Pease inquired if the gyro could perform on a lower air pressure. Mr. Jones stated that no air pressure could be used but that the air supply must be present.

Colonel Pease asked if the gyro control would apply if the jet seating equipment was used. Mr. Jones stated that little in control would be needed in such a case. Mr. Jones stated that the drag coefficient was .015 for the airplane and .015 for the engine with air flow. The engine drag was cut in half when the air flow was stopped. Mr. Jacobs noted that the British had a similar system and it was successful.

Mr. Kemper asked what length of time was required for launching one of the robot bombs. Mr. Jones stated that approximately 20 minutes were required to launch a robot bomb. Mr. Jones noted that 300 feet had been suggested in a report he received which contained two fold instances of 70 miles per hour.

Mr. Jacobs stated that the test steady-low ram jet was being set up in the 11th and 12th tunnel and two of the groups were working on the combustion problem for this unit. He stated that it was his personal belief that speeds of 350 miles per hour on the steady-low ram jet would be better than the German 300 miles per hour. He stated that launching speeds of around 400 miles an hour could be required for the steady-low ram jet. Mr. Jones stated that the robot bomb requires about 200 miles per hour launching speed and that 100 miles per hour would complicate the problem. Mr. Jones stated that it was his opinion that the rocket launching scheme used in this country was better than the German 100 foot cannon rocket launching without rail ramp would be feasible if speeds were obtained in one second. 250 feet per second in one second appears feasible. Mr. Jones stated that operation of any rocket system would provide a speed of 600 feet per second in one second or one mile in 20 seconds acceleration would be required. Mr. Jacobs asked if the instruments would stand 20 g acceleration. Mr. Jones stated that he thought so but that some trouble may be encountered in the fuel system. In one case 400 feet per second attained in 1.8 seconds flew out the engine before the end of the pump was reached. Mr. Jones stated that his chief interest was in the design of automatic control for stability.

Mr. Kemper inquired if there was any interest in the use of target seeking controls. Mr. Jones stated that there was interest and that he had been working on a means of such a control for a robot bomb.

The V-2 German rocket was discussed by the group. Mr. Jacobs stated that a 600 horsepower fuel pump was used and that the missile was launched like a sky rocket. He stated that one of the missiles had landed in Sweden without explosion and appeared to have 2200 ft of velocity at the tail.

Mr. Kemper asked if Mr. Jones had any information on the use of robot bombs by the Germans. Mr. Jones said he thought he had read somewhere that the Germans had been given information on the robot bombs by the Germans prior to that he was certain. He stated that television had been developed along with radar and heat seeking equipment for control of missiles. Small size sets are already developed.

Mr. Kemper inquired if any controls were available for launching radar. Mr. Jones stated that the help to control would be from oil and aluminum.

Mr. Kemper asked if any difficulty had been encountered with fuel control. Mr. Jones stated that there had been checked on fuel 200 ft. The fuel flow controlled by impact air pressure.

Mr. Kemper asked if the jet 1400 ft per second had met any of the requirements of the German robot bomb. Mr. Jones stated that he had no interest in the small jet because it had only 1/2 the power of the current units.

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RAYSTON CONSTRUCTION

1911 - The County were carrying the £1000.00 in £100.00 notes from November
1910 - £100.00 - £100.00

John Jacobson
A. Silverstein
Albert Skumanich
L. Bressman
S. H. Turner
B. C. Bolz
W. J. Ferrell
D. D. Greenaway
J. V. Burgos
C. M. Nahigian
R. L. Rabinovitz

the minutes of the previous meeting were read and corrections made as shown on page 1 and 2.

The above expression is derived from the results of the valve tests carried out during the preceding week on the reciprocating platen apparatus. With the best results to date, without delayed valves, as obtained by this author in a 5 mm. diameter plain steel valve which operated for 45 minutes at 10 cycles per second, the failures of valves tested during the week above, in every case, began alluringly near at the same point.

The test results obtained to date with straight valves have been 103 minutes for a 1/2-inch Swedish-blue-steel valve and 60 minutes for a 1 1/2-inch Swedish-blue valve, both of which were operated at 30 cycles per second. At 45 cycles per second, the valves had lasted a maximum of approximately 6 minutes. A straight valve tapered from 1 1/2-inch thickness at the base to a .004-inch thickness at the tip has been operated for approximately 13 hours at 30 cycles per second. From the tests of straight valves, it is evident that valve life is increased but a reduction in pressure drop should be obtained. The reflex or the stop-stop being used in current tests of the curved valves has a rubber insert to cushion the impact of the valve tip.

Mr. R. G. Carpenter reported that a number of tests had been run on the impact machine, but that the results obtained are as yet not conclusive. Low-carbon steel valves did not break when tested in the impact machine but did fail by taking a permanent set or "curling." Mr. Carpenter noted that the results of these tests indicate that a valve having a low-carbon steel face is capable of inspection by some means.

J. R. Ward, agent, reported that the burner being set up by his group had been
smoking but would not burn. Some "Doughs" to work out before a demonstration could be
utilized.

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It should be noted that the burner is set up and ready for burning. It is proposed that the operation and the demonstration run could be made at the same time holes have been established at the bottom of the steam coil so that the water will circulate and a screen has been installed just ahead of the bottom of the coil. It is proposed that the burner be run in conjunction with the burner under certain conditions.

Mr. Sibley indicated that he had not been present in the laboratory or the testing house during the propagation of the flame in the tunnel. The melt had not been collected and would be collected when the end of November 14.

The meeting adjourned at 19145 p.m. and the program over. To witness a demonstration on the fuel & lubricants burner, burner and the combustion apparatus set up by the fine, modernistic company.

SECRET - 100mm lead

SECRET - 100mm lead

SECRET

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The following is the faculty conference room at U. of R. on November 21, 1950. Present:

Dr. J. P. Durand - Burlington Project

Mr. C. L. Kemper

Mr. W. M. Kline

Mr. G. A. Langley

Mr. E. L. Lincoln

Mr. J. W. Brook

Mr. V. Schow

Mr. T. F. Ferrell

Mr. D. S. Sanders

Mr. C. Ornestohn

Mr. J. Burgess

Mr. R. L. Boll

Mr. R. Bresman

Mr. J. Kunen

Mr. J. Shipp

Mr. J. Williams

Mr. H. B. Scott

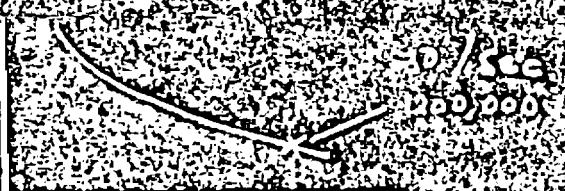
The chairman reviewed the program being carried out by the group in general and Dr. Kline and Mr. Durand and asked that the group precede their program with a short report of the results to date.

Mr. Bresman stated that with the large valves of approximately 3-inch span and 1/4 inch chord diameter vibration tests of over one hour had been run at 20 cycles per second. At higher speeds a raying at the tip was encountered. With the smaller 1/2 inch valves demonstration tests of over one hour had been run at 25 cycles per second. When the radius of curvature of the valve was decreased to a smaller than the chordal length of the valve seat, the valves had been run as long as 2 hours and 10 minutes at 30 cycles per second. When the speed was increased to 35 cycles per second, failure occurred in about a half hour and 10 minutes running time. Mr. Bresman indicated that failure in valves was typical. Mr. Bresman stated that failure in diaphragm was typical of valves that failed after considerable running time.

Mr. Kunen and talked in regard to the effect of spacing of the grill. It is necessary for support of the grill spacing would result in lower pressure drops. Mr. Kunen stated that the maximum pressure drop would be encountered when the full scale units were tested and not been determined and that the necessary support of the valves would be obtained in the 1/2 second or less minimum pressure drop. Mr. Kunen stated that pressure drops at small angles of attack obtained in the German type valves had been attained with a steady state test.

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Mr. G. H. Miller reported that tests in the impact machine had been run over a range of frequencies from 15 to 50 cycles per second. Preliminary results indicated that total number of impacts before failure was a function of the frequency of impact and not of the velocity of impact.



These preliminary results indicate that valve life is relatively independent of frequency. Mr. Miller further noted that the impact machine had a "circular" motion indicated that the total number of impacts increased with the velocity of impact in contradiction to the results of the test in the impact machine. Further tests will provide a comparison to the preliminary results.

Mr. Pinkel stated that a plastic paddle had been used in the impact machine in place of the steel paddle resulting in an increase of valve life by 2-1/2 times. When the impact paddle was replaced by a metal paddle, valve life was further increased by 2-1/2 times.

Mr. Oxstein noted that thermal expansion of the plastic material would tend to weaken the valve seat; but the maximum service temperature for the material was given as 300° F. Mr. Pinkel noted that leakage in the valves would probably remain at temperatures exceeding the service limit. Mr. Oxstein stated that the material did not oxidize or burn readily. The material had been subjected to temperatures up to 300° F in the furnace. Mr. Oxstein stated that he could bring samples of material that had been subjected to furnace tests to the meeting.

Dr. Schey and Dr. Oxstein asked as to whether or not the temperature of the valve would be lower than that in a similar position with steady-flow gas jets. Mr. Schey stated that it was his opinion that the temperature would be lower.

Mr. G. J. Schrock noted that the conditions would be similar to that of valves in the reciprocating engine.

Mr. Oxstein stated that the turbine wheels tested in the intermittent-flow rig reached higher temperatures than wheels operated in steady-flow at the same mean gas temperature.

Dr. Schey and Dr. Oxstein stated that an Italian engineer of way reported that the German aircraft company, in which cold air jets were incorporated as a factor of the cooling process, air temperatures as high as 2000° were reported to have been

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Mr. Turner stated that tests of the combustion apparatus as a single-shot device have indicated that the fuel charge was apparently stratified. The irregularity encountered in the demonstration of the unit at the last meeting was stated to have been caused by vapor lock in the fuel system. Propane in gaseous form is believed when the apparatus is heated with continuous cycling operation.

Dr. Durand inquired if the electric ignition would be used when the unit was operated continuously. Mr. Turner stated that electric ignition would be used because of the much greater rate of preburning with point ignition as compared with plane ignition obtained when the fresh charge was ignited by contact with the retarding charge of the previous cycle.

Dr. Durand stated that he had been getting together a list of Army and Navy projects in which jet propulsion was used in one form or another. A total of 15 projects are being worked on including rockets, projectiles, etc. Dr. Durand stated that the English were tremendously interested in all phases of jet propulsion projectiles, bombs, and aircraft.

Mr. Silverstein inquired if Dr. Durand had information on the latest German weapons using rockets and jet propulsion. Dr. Durand stated that very little information was available on the V-1 as a number of the units have been captured. A few of the V-1's have been sufficiently undamaged when found to indicate the general design used. Theoretical studies by the British have indicated that the V-2 rocket reaches a height of 60 or 70 miles and has a striking velocity of around 3000 feet per second. The explosive charge was stated to be one of four tons. One of the drawbacks of this type weapon was the lack of penetration caused by the high striking velocity which resulted in a relatively small surface damage area.

Mr. Nahigyan drew a sketch of the test setup for testing the full-scale internal combustion units. Two stages of blower are to be used to obtain ram pressure simulating 400 miles per hour. A large surge chamber is incorporated ahead of the test unit to damp out pressure pulses by the unit cycling. The thrust of the unit is to be measured by a liminga system somewhat similar to that used in the Br-4 tests of jet propulsion units.

Mr. Nahigyan inquired as to what accuracy might be obtainable with the thrust measuring system. Mr. Nahigyan stated that Dr. Hensel of the Toledo Scale Company had gone over the system and was of the opinion that the measured thrust could be 50% average. Dr. Durand noted that artificial damping could be incorporated in the system.

They asked Dr. Durand what valve life would be satisfactory in his opinion. Dr. Durand stated that for the given range of 500 miles valves that will operate satisfactorily for 1/2 to 2 hours should give satisfactory

Mr. Mutterperl reviewed the work that had been carried out on the steady-flow ramjet for the benefit of Dr. Durand. The over-all dimensions of the unit were given as 10 inches in diameter and 9 feet long. Mr. Mutterperl stated that a bow-type burner, for burner was being worked out by Mr. Nihlgren and an annular-type burner incorporating an annular pilot was being worked on by Mr. Bolt. Work on the burner and the steady-flow ramjet was reported to have progressed sufficiently so that tests of the ramjet should be started in about two weeks.

Dr. Durand stated that the Navy was just a little disappointed in progress made on the steady-flow ramjet. Dr. Durand stated his progress report giving the progress that had been made should satisfy the Navy in view of the progress that actually had been made.

Dr. Durand inquired if the combustion would be completed in the 3-foot long combustion chamber or if the flame would come out the tail. Mr. Bolt stated that the flame length encountered with his burner was of the order of 5 feet.

Dr. Durand stated that from his experience the problem of mixing the fuel and air was one of the greatest difficulties in combustion.

Mr. Silverstein inquired what Dr. Durand thought of the relative merits of mixing vaporized or liquid injection. Dr. Durand stated that with liquid injection the fuel had to vaporize anyway. Mr. Silverstein suggested that penetration by the liquid particles could possibly give better distribution. It was found on test of the Westinghouse unit that post-combustion was obtained with injectors giving relatively large droplets; the best with injectors giving small droplets. It is found the poorest combustion was obtained with gaseous fuel.

Dr. Durand stated that the results of the combustion work at the Easo laboratory by the Bureau of Ships should provide valuable information on the project of combustion.

Mr. Brothrock stated that his division was working on fundamental combustion problems of the fundamental type with combustion being concerned with two phases of the problem. First, the mixing process; second, the burning process. Combustion in small phenes is currently being studied. The vaporization and mixing process is being studied by test with the 3-inch diameter tube. Droplet size measurements have been attempted by indirect methods. These were the only ones successful to date.

Mr. Brothrock discussed the studies that had been made of using propane or mixture of methane and propane as fuel to eliminate the compressed air bottles needed by the Germans and thereby give an increased fuel capacity. Two main questions involved in this work is the possibility of developing a gyro that can be driven by propane gas and in the case of high altitude operation maintaining a temperature that would give sufficient vapor pressure.

M. V. Bohay showed the group some results that had been obtained on tests of impellers made by casting. A pressure ratio as high as 3.1 could be obtained in 10 hours for using the cast impeller at altitudes of 10,000 feet at the propulsive tip speed of 1750 feet per second. A factor of safety of 1.5/2 was used. Pressure ratios of 4.25 could be obtained at 40,000 feet using a tip speed of 450 feet per second. A safety ratio of 2.76 could be obtained at 40,000 feet using a speed of 1200 feet per second and would give a factor of safety of 2. The advantage of the cast construction for impeller and turbine rotor would be in reduction of cost. Mr. S. Silverstein stated that if a sufficiently cheap conventional jet propulsion unit could be made the Aeroplane would, in all probability, come out of the picture and the main advantage is a very cheap construction. Mr. Bohay stated that a larger 3120 Impeller of the same type shown to the group had a capacity of 19,216 sec.

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December 5, 1943
The Committee to Secure Cooperation in the Aeropulse Conference, Robert L. Tamm, Chairman
December 5, 1943, 3:00 p.m. - Present:

Robert L. Tamm, Chairman (Washington Office)

John C. W. Borchard

Oscar B. Schreyer

Benjamin Pindel

Carlton Kemp

Joseph H. Bain, Secretary

The chairman stated that he believed the aeropulse section of this member Committee that had been convened to discuss the liaison between the various Committees. The work of the companies, especially, Charles F. Loring, analytical and theory under Mr. Butterfield, was being developed by the Aero-pulse unit under Mr. Bressman. Test work to complete aero-pulse units for the NACA was in design by the steady-flow unit under Mr. Silverstein and in development by groups of subcontractor firms under Mr. Pindel. Seconded and the body of stimulus to keep up to date units from missiles under Mr. Schreyer. He felt that of the groups working on the several phases of the project, the first hundred or two thousand test flights as describable in the Ramjet Committee will meet with at least frequent intervals when, as has been the policy, in the past.

The chairman stated that the work on the intermediate power jets as to follow-up times of artifacts and to improve the intermediate power units will be coordinated and no new design & completely new unit for tests.

The chairman advised that there was any information as to why the aero-pulse unit had not been received from the Ford Motor Company. Mr. Tamm stated that all efforts had been made to have the fuel system on the Ford unit had not as yet been completed. Mr. Schreyer stated that the NACA laboratory at Wright Field had informed him that Col. Kellman is a consultant on jet propulsion and not a project engineer. Col. Kellman had not passed the request for a Ford-built unit on to the project head at Wright Field promptly which has resulted in some delay. Mr. Pindel advised that the board would be two weeks before the inauguration of the aero-pulse unit in the aero-pulse unit program.

The chairman stated that the heat island was ready to receive on steady-flow units and that the first steady-flow unit was being a vaporizing-type combustion chamber built down to the engine. This unit had been assembled and will be ready to receive power units in two or three days.

Mr. Schreyer advised that the plans were for testing the steady-flow units with a steady-state combustion chamber. The unit would be tested on a stand and the company would work on work-out combustion problems and it would be expected to take about a month.

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Mr. Littell stated that the Navy group working on missiles was interested in an evaluation of the steady-flow ram jet and that the missile group would go ahead with a design of the missile as soon as sufficient information on performance was available. Speed is of utmost importance in the design of a missile as the missile must be faster than any of the enemy airplanes and also the greater the velocity of the missile the greater the accuracy of fire.

The chairman noted that with the new pipe system to be installed in the Altitude Wind Tunnel a Mach number of 2 can be obtained for high speed tests.

Mr. Pinkel reported that the combustion apparatus for steady combustion in the pulsed unit had been improved to the point where good firing was obtained but the peak pressures were no where near the design pressures as shown by theory. Mr. Pinkel stated that the low peak pressures were apparently caused by slow combustion. Mr. Rothrock stated that it was his opinion that a photographic study of the combustion would be the best way to determine the cause of slow combustion.

Mr. Rothrock stated that the liquid injection burners for the steady-flow ram jet were about ready.

Mr. Rothrock reported that very little progress had been made on burner tests in the past two weeks on burner tests because of lack of altitude air. Burning had been carried out successfully at velocities up to 150 feet per second and fuel-air ratios of 31. With the higher fuel-flow rates it was necessary to inject liquid propane because of the limited capacity of the fuel system. The system is being altered to provide higher flow rates of the propellant in the gaseous state. The work on fuel evaporation was restricted to the preceding and fuel temperatures up to 750° F had been used in the tests.

Mr. Schey reported that most of the test work on the valves for the aerospike had been completed and that it was believed that a satisfactory valve design had been achieved.

The chairman asked for an opinion from the various members of the group on how much emphasis should be placed on the aerospike in comparison with the pulse jet and steady-flow ram jet. It was agreed that the phase of the aerospike program involving modifications of existing units would be phased whereas the second phase involving construction of a unit designed by the NACA would be carried through to completion or tests for the unit but the program would not be balanced. The chairman stated that he had heard that contractors had been selected for the purpose of discussing getting a contract for 1,000 missiles built in accordance with the design submitted by the NACA.

Mr. Schey showed a drawing of a turbo-jet unit incorporating a cast impeller and with a turbine to be made by casting or some other means to obtain an above airfoil profile as possible.

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~~RAM JET CONFERENCE~~

December 5, 1944

The Committee met in the Executive Conference Room at Cleveland on December 5, 1944, at 3:00 p.m. Present:

Abe Silverstein, Chairman

Robert E. Littell (Washington Office)

Alfred M. Rothrock

Oscar W. Schey

Benjamin Pinkel

Carlton Kemper

Jesse D. Hall, Secretary

The chairman reviewed the reorganization of the Ram Jet Committee that had been carried out after the last meeting of the Committee. The work of the group has been divided as follows: Analysis and theory under Mr. Mutterperl; design of the aero-pulse unit under Mr. Bressman; testing of complete aero-pulse units under Mr. Nahigyan; design of the steady-flow ram jet under Mr. Silverstein and Mr. Mutterperl; tests of the steady-flow ram jet units under Mr. Perchonok and the study of simple, cheap turbo-jet units for missiles under Mr. Schey. Meetings of the groups working on the several phases of the project will be held from time to time as desirable and the Ram Jet Committee will meet at much less frequent intervals than has been the policy in the past.

The chairman stated that the work on intermittent-flow ram jets was to follow two lines of attack. One, to improve the German-type unit as built by Ford; and two, to design a completely new unit for tests.

The Chairman inquired if there was any information as to why the aero-pulse unit had not been received from the Ford Motor Company. Mr. Kemper stated that it was his understanding that the fuel system on the Ford unit had not as yet been cleared. Mr. Littell stated that the NACA Liaison Office at Wright Field had informed him that Col. Keirn is a consultant on jet propulsion and not a project head. Col. Keirn had not passed the request for a Ford-built unit on to the project head at Wright Field promptly, which resulted in some delay. Mr. Pinkel stated that it would be two weeks before the apparatus will be completed for testing the aeropulse unit.

The chairman stated that the test stand was ready for tests on steady-flow ram-jet units. Layout of the steady-flow ram-jet unit using vaporizing-type burner units was shown to the group. This unit is being assembled and will be ready to test in a week or ten days.

Mr. Littell inquired as to what the plans were for testing the steady-flow ram-jet units. The chairman stated that the unit would be tested on a stand with a blower to supply ram in order to work out combustion problems and it would later be tested in the Wind Tunnel.

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Mr. Littell stated that the Navy group working on missiles was interested in an evaluation of the steady-flow ram jet and that the missile group would go ahead with a design of the missile as soon as sufficient information on performance was available. Speed is of utmost importance in the design of a missile as the missile must be faster than any of the enemy airplanes and also the greater the velocity of the missile the greater the accuracy of fire.

The chairman noted that with the new pipe system to be installed in the Altitude Wind Tunnel a Mach number of 2 can be obtained for high speed tests.

Mr. Pinkel reported that the combustion apparatus for steady combustion in the aeropulse unit had been improved to the point where good firing was obtained but the peak pressures were no where near the design pressures as shown by theory. Mr. Pinkel stated that the low peak pressures were apparently caused by slow combustion. Mr. Rothrock stated that it was his opinion that a photographic study of the combustion would be the best way to determine the cause of slow combustion.

Mr. Pinkel stated that the liquid injection burners for the steady-flow ram-jet unit were about ready.

Mr. Rothrock reported that very little progress had been made on burner tests in the past two weeks on burner tests because of lack of altitude air. Burning had been carried out successfully at velocities up to 150 feet per second and fuel-air ratios of .01. With the higher fuel-flow rates it was necessary to inject liquid propane because of the limited capacity of the fuel system. The system is being altered to provide higher flow rates of the propane in the gaseous state. The work on fuel vaporization was reported to be proceeding and fuel temperatures up to 750° F had been used in the tests.

Mr. Schey reported that most of the test work on the valves for the aeropulse unit had been completed and that it was believed that a satisfactory valve design had been achieved.

The chairman asked for an opinion from the various members of the group on how much emphasis should be placed on the aeropulse in comparison with the turbo-jet and steady-flow ram jet. It was agreed that the phase of the aeropulse program involving modifications of existing units would be pushed whereas the second phase involving construction of a unit designed by the NACA would be carried through to completion of tests of the unit but the program would not be extensive. The chairman stated that he had heard that contractors had been called in for the purpose of discussing getting a contract for 1,000 missiles built in accordance with the design submitted by the NACA.

Mr. Schey showed a drawing of a turbo-jet unit incorporating a cast impeller and with a turbine to be made by casting or by other means to obtain as low an over-all cost as possible.

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Mr. Schuy stated that the unit as designed should provide 900 thrust horsepower at 550 miles an hour at 5,000 feet altitude and that the specific weight would be approximately 475 pounds per thrust horsepower. The over-all diameter of the unit was approximately 25 inches.

Mr. Schuy noted that the Navy was very much interested in the cast impeller design. The chairman stated that it was his opinion that improvement in the Ford-built aero-pulse unit was the best chance for the NACA to make a substantial contribution. The group concurred in this opinion. A new set of valves of NACA design will be tested in the Ford-built unit as soon as possible after the unit arrives.

The meeting adjourned at 4:00 p.m.

Jesse H. Hall,
Secretary, Ram Jet Committee.

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November 21, 1941

The Committee met in the Executive Conference Room at AECI on November 21, 1941, at 9:10 a.m. Present:

Abe Silverstein, Chairman

Dr. W. T. Durand - Washington Office

Carlton Kemper

J. R. Turner

K. K. Nahigyan

B. Pinkel

A. M. Rothrock

O. W. Schey

V. Butterperl

J. O. Sanders

L. Ornstein

W. C. Burgess

R. L. Bolz

J. R. Bressman

A. J. Kunen

E. P. Sharp

D. F. Williams

J. H. Hall, Secretary

The Chairman reviewed the program being carried out by the group in general terms for the benefit of Dr. Durand and asked that the group precede their progress reports for the week with a brief resume of results to date.

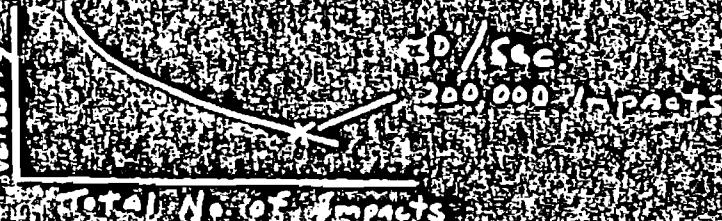
Mr. Kunen stated that with the large valves of approximately 3-inch span and 3-inch chord demonstration tests of over one hour had been run at 20 cycles per second. At higher speeds fraying at the tip was encountered. With the smaller size valves demonstration tests of over one hour had been run at 25 cycles per second. When the radius of curvature of the valve was decreased to a smaller value than that of the valve seat the valves had been run as long as 2 hours and 40 minutes at 30 cycles per second. When the speed was increased to 35 cycles per second, failure occurred in flexure after 1 hour and 40 minutes running time. Dr. Durand inquired if failure in flexure was typical. Mr. Bressman stated that failure in flexure was typical of valves that failed after considerable running time.

Dr. Durand asked if the close spacing of the grill is necessary for support. Larger spacing would result in lower pressure drops. Mr. Kunen stated that the maximum pressures that would be encountered when the full scale units were tested had not been determined and that the necessary support of the valves would depend on this maximum pressure. Mr. Kunen stated that pressure drops as small as 1/3 of that obtained in the German-type valves had been attained with steady-flow tests.

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Mr. Mutterperl reported that tests in the impact machine had been run over a range of frequencies from 15 to 60 cycles per second. Preliminary results indicated that the total number of impacts before failure was a function of the velocities of impact as shown in the following curve:



These preliminary results indicate that valve life is relatively independent of frequency. Mr. Mutterperl noted that test results at the Watertown Arsenal indicated that the total number of impacts increased with the velocity of impact in contradiction to the results of the tests in the impact machine. Further tests will be made to substantiate the preliminary results.

Mr. Ornstein stated that a plastic paddle had been used in the impact machine in place of the steel paddle resulting in an increase of valve life by 2-1/2 times. When the seat was also made of plastic valve life was further increased by 2-1/2 times.

Mr. Silverstein asked what maximum temperatures the plastic material would stand. Mr. Ornstein stated that the maximum service temperature for the material was given as 300° C. Mr. Pinkel noted that leaks in the valves would probably result in temperatures exceeding the service limit. Mr. Ornstein stated that the plastic material does not oxidize or burn readily. The material had been subjected to temperatures up to 500° F in the furnace. Mr. Ornstein stated that he would bring samples of material that had been subjected to furnace tests to the next meeting.

Dr. Durand inquired as to whether or not the temperature of the valve would be lower than that in a similar position with steady-flow ram jets. Mr. Schey stated that it was his opinion that the temperatures would be lower.

Mr. Rothrock noted that the conditions would be similar to that of valves in the reciprocating engine.

Mr. Turner stated that the turbine wheels tested in the intermittent-flow turbine had indicated lower temperatures than wheels operated in steady-flow turbines with the same mean gas temperatures.

Dr. Durand stated that an Italian prisoner of war reported that the Germans had built a turbine in which cold air jets were incorporated as a sector of the nozzle ring. Gas temperatures as high as 2000° F were reported to have been used in this turbine.

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Mr. Turner stated that tests of the combustion apparatus as a single-shot device have indicated that the fuel charge was apparently stratified. The irregular firing encountered in the demonstration of the unit at the last meeting was stated to have been caused by vapor lock in the fuel system. Propane in gaseous form will be used when the apparatus is tested with continuous cycling operation.

Dr. Durand inquired if the electric ignition would be used when the unit was operated continuously. Mr. Turner stated that electric ignition would be used because of the much greater rate of pressure rise with point ignition as compared with plane ignition obtained when the fresh charge was ignited by contact with the retreating charge of the previous cycle.

Dr. Durand stated that he had been getting together a list of Army and Navy projects in which jet propulsion was used in one form or another. A total of 15 projects are being worked on including rockets, projectiles, etc. Dr. Durand stated that the English were tremendously interested in all phases of jet propulsion projectiles, bombs, and aircraft.

Mr. Silverstein inquired if Dr. Durand had information on the latest German weapons using rockets and jet propulsion. Dr. Durand stated that very extensive information was available on the V-1 as a number of the units have been captured. A few of the V-2's have been sufficiently undamaged when found to indicate the general design used. Theoretical studies by the British have indicated that the V-2 rocket reaches a height of 60 or 70 miles and has a striking velocity of around 3000 feet per second. The explosive charge was stated to be three or four tons. One of the drawbacks of this type weapon was the deep penetration caused by the high striking velocity which resulted in a relatively small surface damage area.

Mr. Nahigyan drew a sketch of the test setup for testing the full-scale intermittent jet units. Two stages of blowers are to be used to obtain ram pressure simulating 400 miles per hour. A large surge chamber is incorporated ahead of the test unit to damp out pressure caused by the unit cycling. The thrust of the unit is to be measured by a linkage system somewhat similar to that used in static tests of jet propulsion units.

Mr. Silverstein inquired as to what accuracy might be obtainable with the thrust measuring system. Mr. Nahigyan stated that Dr. Hen of the Toledo Scale Company had gone over the system and was of the opinion that the measured thrust should be a good average. Dr. Durand noted that artificial damping could be incorporated in the setup.

Mr. Schey asked Dr. Durand what valve life would be satisfactory in his opinion. Dr. Durand stated that for the given range of 500 miles valves that would operate satisfactorily for 1-1/2 to 2 hours should give satisfactory service.

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Mr. Nutterperl reviewed the work that had been carried out on the steady-flow ram jet for the benefit of Dr. Durand. The over-all dimensions of the unit were given as 20 inches in diameter and 9 feet long. Mr. Nutterperl stated that a coil-type preheater burner was being worked out by Mr. Nahigyan and an annular-type burner incorporating an annular pilot was being worked on by Mr. Bolz. Work on the burners and the steady-flow ram jet was reported to have progressed sufficiently so that test of the unit should be started in about two weeks.

Dr. Durand stated that the Navy was just a little disappointed in progress made on the steady-flow ram jet. Dr. Durand stated that a progress report giving the progress that had been made should satisfy the Navy in view of the progress that actually has been made.

Dr. Durand inquired if the combustion would be completed in the 3-foot long combustion chamber or if the flame would come out the tail. Mr. Bolz stated that the flame length encountered with his burner was of the order of 5 feet.

Dr. Durand stated that from his experience the problem of mixing the fuel and air was one of the great difficulties in combustion.

Mr. Silverstein inquired what Dr. Durand thought of the relative merits of using vaporized or liquid injection. Dr. Durand stated that with liquid injection the fuel had to vaporize anyway. Mr. Silverstein suggested that penetration by the liquid particles would possibly give better distribution. It was found on tests of the Westinghouse unit that best combustion was obtained with injectors giving relatively large droplets; next best with injectors giving small droplet size; and the poorest combustion was obtained with gaseous fuel.

Dr. Durand stated that the results of the combustion work at the Esso Laboratory by the Bureau of Ships should provide valuable information on the subject of combustion.

Mr. Rothrock stated that his division was working on fundamental combustion problems. The fundamental work with combustion is concerned with two phases of the problem. First, the mixing process; second, the burning process. Combustion in small tubes is currently being studied. The vaporization and mixing process is being studied by tests with a 3-inch diameter tube. Droplet size measurements have been attempted but indirect methods were the only ones successful to date, such as light absorption.

Dr. Williams discussed the studies that had been made of using propane or mixture of butane and propane as fuel to eliminate the compressed air bottles used by the Germans and thereby give an increased fuel capacity. Two main questions involved in the work are the possibility of developing a gyro that can be driven by propane gas, and in the case of high altitudes operation maintaining temperatures that would give sufficient vapor pressure.

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Mr. Schney showed the group some results that had been obtained on tests of impellers made by casting. A pressure ratio as high as 6:1 would be obtained in a compressor using the cast impeller at altitudes of 40,000 feet at the surging-tip speed of 1750 feet per second. If a factor of safety of 1-1/2 was used pressure ratios of 4.25 would be obtained at 40,000 feet using a tip speed of 1475 feet per second. Pressure ratios of 2.75 would be obtained at 40,000 feet at a tip speed of 1200 feet per second and would give a factor of safety of 2. The advantage of the cast construction for impellers and turbine rotor would be a reduction of cost. Mr. Silverstein stated that if a sufficiently cheap conventional jet propulsion unit could be made the Aeropulse would, in all probability, be ruled out of the picture, as its main advantage is a very cheap construction. Mr. Schney stated that a larger size impeller of the same type shown to the group had a capacity of 39 lb/sec.

The meeting adjourned at 10:50 a.m.

Jesse R. Hall, Jr.
Secretary, Ram Jet Committee

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November 14, 1944

The Committee met in the Executive Conference Room at AECI on November 14, 1944, at 9:05 a.m. Present:

E. W. Jacobs, Chairman
A. Silverstein
A. E. Kinen
J. B. Bresman
L. R. Turner
R. E. Bolt
W. Mutterperl
D. Okrent
W. C. Burgess
K. K. Nahigyan
J. H. Hall, Secretary

The minutes of the previous meeting were read and corrections made as shown on revised pages 1 and 2.

Mr. Bresman reviewed the results of the valve tests carried out during the preceding week on the reciprocating piston apparatus. The best results to date with the curved valve was obtained with a .010-inch Swedish-blue steel valve which operated for 41 minutes at 30 cycles per second. The failures of valves tested during the week have, in every case, been failure in flexure at the same point.

The best results obtained to date with flat valves have been 103 minutes for a .012-inch Swedish-blue steel valve and 60 minutes for a .010-inch Swedish-blue steel valve, both of which were operated at 35 cycles per second. At 45 cycles per second the valves had lasted a maximum of approximately 6 minutes. A straight valve tapered from .015-inch thickness at the base to a .008-inch thickness at the tip has been operated for approximately 1 hour at 30 cycles per second. From the tests with tapered valves no gain in valve life is expected but a reduction in pressure drop should be obtained. The reflex of the top stop being used in current tests of the curved valves has a rubber insert to cushion the impact of the valve tip.

Mr. Mutterperl reported that a number of tests had been run on the impact machine but that the results obtained are as yet not conclusive. Low-carbon steel valves did not break when tested in the impact machine but did fail by taking a permanently set or curl. Mr. Mutterperl noted that the results of these tests indicate that a bimetallic valve with low-carbon steel on the face to absorb impact might offer some possibility.

Mr. Nahigyan reported that the burner being set up by his group had been running but still had some "bugs" to work out before a demonstration would be justified.

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Mr. Bolz reported that the burner setup of the Fuels & Lubricants group was in operation and a demonstration run could be made. The cone with holes had been installed at the down-stream end of the primary air duct and a screen had been installed just ahead of the pilot. Pulsating burning was still experienced with the setup under certain conditions.

Mr. Silverstein stated that a pilot had been put in the burner of the Westinghouse jet propulsion unit in the Wind Tunnel. The unit had not been tested as yet with the pilot but will be tested the night of November 14.

The meeting adjourned at 9:45 a.m. and the group went over to witness a demonstration run of the Fuels & Lubricants burner setup and the combustion apparatus set up by the Thermodynamics group.

George H. Ball

Secretary, Ram Jet Committee.

JRR:lm

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The Ram Jet Committee met in a special session at 10:30 a.m., November 11, 1944, in order to discuss work of the laboratory on ram-jets with Mr. R. T. Jones of LMAL. Present:

John H. Jacobs, Chairman

Robert F. Jones, LMAL

O. W. Schey

C. C. Kemper

Colonel Page

L. R. Turner

K. K. Nahigyan

B. P. Bolz

J. G. Whitney

H. Hall, Secretary

The Chairman reviewed briefly the work being carried out by the three groups under Messrs. Schey, Silverstein and Pinkel. He stated that in the theoretical analyses made by all three groups efficiencies for the intermittent-flow ram jet at speeds of 500 miles per hour were comparable to the Whittle-type jet-propulsion unit and appreciably better than the steady-flow ram jet. The German unit in the robot bomb results in lower efficiencies because of high valve losses and ignition so early in the cycle that energy is lost in recompression and a full charge is not attained.

The work on valves by Mr. Silverstein's and Mr. Schey's groups to reduce the losses from the valves was reviewed. The objective of the combustion research, to fill the chamber and control ignition and combustion to obtain a plug of cold air to the nozzle in order to obtain high combustion pressures, was noted. It was also noted that the combustion work will include photographic studies of the combustion process.

Colonel Page inquired as to whether or not valves operating at their natural frequency might result in poor operation; if so, a mechanical valve would seem in order. The Chairman stated that for this and other reasons mechanical valve was being considered by the group but had been given low priority until it could be determined if the additional mechanical complications are justified.

In reply to the chairman's inquiry, Mr. Bressman stated that the valves under test had a slightly higher natural frequency than the frequency to which they were being cycled.

Mr. Jones showed some pictures of robot bombs being launched at Eglin Field and reviewed the work in which he had participated at Eglin Field on launching and controlling robot bombs. The launching track was standard railroad gage, 500 feet long. Two tracks were used; one of which was level, and the other inclined upward at an angle of 60°. The robot bombs were mounted on a rocket car which had shoes for restraining on the rails. Five 9000 lb. monsanto rockets of 1.8 seconds duration are mounted on the car to provide the take-off thrust. The rockets are approximately 10 inches in diameter, 45 inches long, and developed approximately 8,000 horsepower at the end of the run.

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To illustrate the friction to be overcome by the rockets Mr. Jones stated that 15 men were unable to push the rocket car down grade. Mr. Kemper inquired if any information was available on launching robot bombs from airplanes. Mr. Jones stated that he didn't have any information but believed that such procedure was feasible. Mr. Jones stated that a robot bomb had caught fire at Eglin Field and that such a fire would be hazardous if the launching were being made from an airplane.

Mr. Jacobs inquired as to what fuel was used in the rockets. Mr. Jones stated that the fuel was monsanto block, which was a dry fuel. The rockets developed 160/sec/fuel and weight of fuel was approximately equal to the weight of the case.

In the tests at Eglin Field an F-20 airplane was used to photograph the robot bomb in flight and a P-51 was used to shoot it down. The engine was started 20 seconds before launching to make sure that operation is stable. The first robot bomb launched successful and the airplane was stable but at a nose down pitch which resulted in a flight of about 2 miles. In checking up it was found that the speed was 310 feet per second instead of 370 and the pitch was set too low. The front rockets were found to dissipate energy by discharging past the rear rockets.

In the next two launchings attempted the pitch was increased but the splash from the front rockets burned off the elevator. In the fourth attempt all five rockets were moved to the back. Before the engine got going the airplane caught fire and so was launched with the engine dead.

The next try at launching was successful and the airplane flew for 60 miles before it was shot down.

Mr. Wetterperl asked Mr. Jones if there was any acceleration after launching. Mr. Jones stated that there was a very small acceleration but that the airplane had to be launched at flying speed. The most practical launching scheme would be one that did not require a track. It was pointed out that the rocket alignment with the center of gravity was very critical and should be within 1/2-inch of a c.g. The rockets are mounted below and inclined inward and upward to get alignment with the center of gravity.

Two 40,000-pound rockets of 1-second duration could be used in place of the five 9,000-pound rockets. However, if the time was increased and the thrust reduced the angle of pitch would come too large. Launching speeds to the order of 600 feet per second would make launching without track difficult.

Mr. Jacobs noted that the V-2 was launched without a track and had considerably higher speeds.

Mr. Jones stated that the airplane could be stabilized during launching but that nothing had been tried along that line as yet.

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Mr. Kemper inquired if the man hours in building the gyro control is considered high. Mr. Jones said that he didn't have the figures on man hours but he didn't think it was out of line. He noted that \$2,000 had been quoted for the whole unit.

Mr. Jacobs asked if Mr. Jones had any figures on the air bottles used in the gyro units. Mr. Jones stated that the air bottles weighed at least 100

Colonel Page inquired about the acceleration effects on the gyro control. Mr. Jones stated that the gyro was caged during acceleration.

Mr. Jones stated that robot bombs were controlled by an automatic pilot similar to those used in conventional aircraft. Directional control was by the gyro compass which had a drift of $1\frac{1}{2}^{\circ}$ per minute that was corrected by magnetic compass. The German robot bomb had an air log connected to a reader counter which controls a radio transmitter to send out signals after a given distance which enables a fix to be made and corrections for later shots. The reader counter sets off cartridges in the tail which set the controls to put the airplane in a dive. The gyro used for control was tilted upward to make it sensitive to roll, pitch, and yaw. This manner of mounting the gyro allowed control with only one instead of the usual two gyros. The controls are operated by an air relay system.

Mr. Nahigyan asked if the robot bomb had to be launched on the line of flight. Mr. Jones stated that the control system corrected the off-line launching; however, the compass rate of correction was only 3° per minute. A clockwork mechanism is used to control turns after take off and 2 or 3 consecutive turns can be made with this mechanism.

The altitude of flight is set by an aneroid barometer which controls the pitch and may be set for the desired altitude. Two rate gyros are provided for damping and are connected to the rudder control. The airplane was stated to be very unstable without the automatic pilot in operation.

Colonel Page asked if the flight by the airplane was oscillating. Mr. Jones stated that the airplane appeared to fly very smooth and the response to the automatic pilot appeared very good. The air relay system operated very satisfactorily and all the air system was supplied by air bottles.

Mr. Turner inquired if the gyro could be run on a lower air pressure. Mr. Jones stated that lower pressures could be used but that the air supply had to be clean.

Mr. Jacobs asked if the same control would apply if target seeking equipment was used. Mr. Jones stated that aileron control would be needed in such a case. Mr. Jones stated that the drag coefficient was .015 for the airplane and .015 for the engine with air flow. The engine drag was cut in half when the air flow was stopped. Mr. Jacobs noted that the British had used jet fighters against the robot bombs successfully.

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Mr. Kemper asked what length of time was required to launch one of the robot bombs. Mr. Jones stated that approximately 20 minutes was required to launch a robot bomb. Mr. Jones noted that tactical use had been suggested in view of the accuracy attained up to distances of 75 miles.

Mr. Jacobs stated that a steady-flow ram jet was being set up in the Altitude Wind Tunnel and two of the groups were working on the combustion problem for this unit. He stated that it was his personal belief that speeds of 550 miles an hour for the steady-flow ram jet would be better than the German unit. Mr. Mutterperl stated that launching speeds of around 400 miles an hour would be required for the steady-flow ram jet. Mr. Jones stated that the robot bomb requires about 240 miles per hour launching speed and that 400 miles per hour would complicate the problem. Mr. Jones stated that it was his opinion that the rocket launching scheme used in this country was better than the German slotted cannon. Rocket launching without rail ramp would be feasible if speeds were obtained in one second. 350 feet per second in one second appears feasible but Mr. Jones stated that he didn't know of any rockets that would provide a speed of 600 feet per second in one second. Approximately 20 g acceleration would be required. Mr. Jacobs asked if the instruments could stand 20 g acceleration. Mr. Jones stated that he thought so but that some trouble may be encountered with the fuel system. In one case 400 feet per second attained in 1.8 seconds blew out the engine before the end of the ramp was reached. Mr. Jones stated that his chief interest was in the design of automatic pilot for instability.

Mr. Jacobs inquired if there was any interest in the use of target seeking controls. Mr. Jones stated that there was interest and that he had been working on a missile with such a control to attack robot bombs.

The V-2 German rocket was discussed by the group. Mr. Jacobs stated that a 500 horsepower fuel pump was used and that the missile was launched like a sky rocket. He stated that one of the missiles had landed in Sweden without explosives and appeared to have a group of crochets at the tail.

Mr. Kemper asked if Mr. Jones had any information on the use of robot bombs by the Japs. Mr. Jones said he thought he had read somewhere that the Japs had been given information on the robot bombs by the Germans but that he wasn't certain. He stated that television had been developed along with radar and heat seeking equipment for control of missiles. Small size sets are already developed.

Mr. Kemper inquired if any results were available on jamming radar. Mr. Jones stated that work being carried out on the use of tinfoil and aluminum powder for radar jamming.

Mr. Turner asked if any difficulty had been encountered with fuel control. Mr. Jones stated that each engine was checked for fuel flow. The fuel flow is controlled by impact air pressure.

Mr. Mutterperl asked if Mr. Jones had noted any trends in requirements of the services. Mr. Jones stated it appeared to be of definite interest in the smaller size having approximately $\frac{1}{2}$ the thrust of the current units.

The meeting adjourned at 12:20

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Jesse H. Hall
Secretary, Ram Jet Committee

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November 7, 1944

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The Committee met in the Boardroom Conference Room at AECI on November 7, 1944, at 9:05 a.m. Present:

B. M. Jacobs, Chairman
D. W. Sehey
J. P. Bresman
R. L. Bolz
L. M. Nahigyan
L. P. Turner
J. O. Sanders
W. C. Burgess
A. E. Kunen
A. Silverstein
S. Pinkel
D. Great
L. Omstein
V. Matterperi
B. J. Mittell
J. H. Hall, Secretary

The minutes of the previous meeting were read and corrections made as shown on revised page 3.

Mr. Bresman reported that two aluminum grills for curved valves had been completed. Tests with valves of .010-inch stock with a good fit on the seat resulted in failures in 2 or 3 minutes at 1500 rpm with a rubber stop stop. A valve made with approximately 1/16-inch clearance at the mid chord point when the tip rested on the seat lasted for 2 hours and 15 minutes at 1500 rpm before failure occurred. The failure was in flammes and appeared to have been caused by too sharp a bend in forming.

Mr. Kunen stated that in observing operation of this valve the valve tip hit first and the valve then flattened to fit the seat. The Chairman suggested that the valve being made for the combustion apparatus should have clearance of 1/16-inch as used in tests of valves in the reciprocating piston apparatus.

Mr. Bresman stated that a curved valve made of .010-inch stock had been run at 1500 rpm and failed after 41 minutes running. Mr. Bresman reported that straight valves made of .006-, .010-, and .012-inch Swedish-blue steel stock had been tested. The .006-inch valve failed after 26 minutes at 1500 rpm. The .010-inch valve failed after 67 minutes at 1500 rpm; and the .012-inch valve failed after 103 minutes at 2100 rpm. Mr. Bresman noted that both straight and curved valves had a tendency to vibrate with steady airflow.

Mr. Nahigyan asked if the best valve designed should be tested in the Ford unit. The Chairman stated that it was the purpose of the group to design an EACA unit and that possibly some features of the German unit could be incorporated to advantage. The fuel system from the Ford unit could possibly be used on the EACA unit.

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The Chairman asked if the combustion apparatus being set up by Mr. Pinkel's group could be used for cycling operation. Mr. Turner stated that the apparatus would be limited to single shot operation until the cycling valve is complete. The shop is planning to farm out the cycling valve and the valve may not be completed until December 7. The Chairman stated that shop work on the combustion apparatus should be done in our own shop if possible and should be pushed on through to completion. The Chairman agreed to assist in expediting the shop work on this phase of the project, providing Mr. Pinkel's group follows through in setting up the apparatus for tests.

Mr. Bole stated that combustion tests had shown that a pilot was necessary in obtaining combustion at 130 ft/sec as attempts to obtain ignition from a spark was not successful. The Chairman stated that it is his belief that with velocities of the order of 200 ft/sec being considered for the ram jet units attempts to obtain ignition from a spark would be unsuccessful and suggested that the group working on combustion consider making provisions for a pilot.

Mr. Mutterperl suggested the use of a venturi to smooth out the large scale turbulence in the air stream for combustion considerations. The Chairman noted that the German's used venturis immediately downstream of the valves. Mr. Mutterperl suggested that the scale of turbulence was important in relation to flame propagation and blowing out the flame.

Mr. Bole stated that with tests in the combustion pipe the burning was not satisfactory until the flame snapped back to the fuel injection valves. The Chairman suggested that when burning started the flame snaps back because of flow stoppage and compression wave being reflected back.

Mr. Mutterperl reported on results of valve materials tested in the impact machine. The .005-inch Swedish-blue steel stock ran for approximately 13 minutes before failure and the .005-inch stock ran from 9 to 10 minutes before failure. Adjustments are being made to the machine to obtain more consistent results among the valves being tested simultaneously. A Kony photograph of .005-inch Swedish-blue steel which showed uniform distributed inclusions was shown to the group. Of the materials to be tested in addition to the Swedish-blue steel there are included: inconel, heat-treated Swedish-blue steel, and low-carbon steel. After discussion by the group it was agreed that high-carbon steel should be tested in place of the low-carbon steel.

Mr. Silverstein suggested that tests should be made of the toughest steels known. Mr. Kinner noted that Swedish-blue steel was best from a fatigue standpoint.

Mr. Ornstein inquired as to what velocity of impact had been observed in the reciprocating piston apparatus. Mr. Kressman stated that the impact velocity was approximately 60 ft/sec at 1200 rpm.

Mr. Turner reported that the valve section for the combustion apparatus should be completed by November 5th and that approximately 2 days would be required to install. The chairman asked if the apparatus would be ready to demonstrate by the next meeting. Mr. Turner stated that the equipment should be ready to demonstrate by that time.

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Mr. Bolz reviewed the work done since the last meeting. After unsuccessful arrangements of ignition source and pilot, combustion was obtained with the sudden enlargement to twice the area in the primary air passage just ahead of the pilot. Good combustion was obtained with this arrangement but sometimes when the apparatus was operated pulsating combustion was obtained for some unknown reason.

The next scheme to be tried will be some enlarging the primary air pipe to twice the area at the pilot with holes cut in the zone.

The fundamentals of combustion and flame propagation and the effect of turbulence was discussed by the group. It was agreed that large scale turbulence should be reduced to a minimum but that small scale turbulence was desirable from a combustion standpoint. The chairman suggested the use of honeycomb just ahead of the pilot to reduce large scale turbulence. Mr. Nuttnerperl suggested that a wire be inserted at the point where the flame goes out to introduce turbulence at that point to find out if the flame could be extended. Mr. Silverstein suggested the use of a screen for a 50% opening just ahead of the pilot.

Mr. Littell read the summary of the Bureau of Aeronautics Progress Report on Ram Jets, dated October 23, 1944. (Appendix 2)

Mr. Nahicvan stated that the burners were approximately 2/3 complete and that the setup for tests of Ford-built robot bombs was underway.

Mr. Rothrock stated that tanks for gaseous fuel, when designed on the basis of aircraft practice, weighed approximately 100 pounds for a 500 gallon tank instead of the 1000 pounds previously reported. Mr. Bolz stated that calculations for a 500 gallon tank working at 100 pounds per square inch pressure designed with a factor of safety of 1-1/2 based on the yield strength resulted in a weight of 50 pounds for aluminum, 85 pounds for magnesium, and 110 pounds for steel.

Mr. Nuttnerperl reported that the fluting was 50% complete for the steady-flow ram jet installation. The support structures for the test stand were about ready to go into the shop.

Meeting adjourned at 11:25 a.m.

Jesse H. Hall,
Secretary, Ram Jet Committee

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PROGRESS REPORT ON RAM JETS
BUREAU OF AERONAUTICS
October 25, 1944

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The Bureau of Aeronautics has under its cognizance a number of ram jet developments. The general status of these projects is as follows:

A. Continuous-Flow Ram Jet Units.

1. Bureau of Standards (see Enclosure 1)

The Bureau has been working during the past six months on a burner for a ram jet unit. At the present time, preliminary tests are being carried out on a quarter section of a 10 inch diameter burner. These tests indicate that steady running has been achieved at chamber inlet velocities of 200 feet per second and a discharge temperature of about $2600^{\circ} F.$ (Successful runs were made at inlet velocities up to 300 feet per second in a one-inch tube.) The pressure drops are only slightly above the theoretical drop associated with combustion (the exact values are shown in Enclosure A). These values may be subject to a small correction since it was found that the cross sectional area of the chamber changed during the test, and thus some of the pressures reported may be subject to correction. The combustion efficiencies attained were of the order of 95 to 99%.

It appears that the development of the Bureau of Standards combustion chamber has proceeded far enough to warrant the construction and test of a full size ram jet unit. The Bureau of Aeronautics is negotiating with Fleetwings Aircraft for the construction of such units.

2. The Massachusetts Institute of Technology (see Enclosure 2)

M.I.T. has also been working for about six months on the development of a suitable ram jet combustion chamber. Initial experiments were on the gas turbine type chamber with air-stanized gasoline. However, experience showed the apparent superiority of pressure-stabilized gasoline injected *co*-stream. A small combustion chamber has been built and run.



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The first test of a 37 mm. gun (see item in Enclosure D) in flight was carried out at the end of last year. Good gas pressures were obtained at all the different pressures. The velocity was limited by the air pressure of about 100 psi. The mobility was good.

A second test was attained in a sealed up version of the gun which had been built and run. This gun has a combustion chamber 3 inches in diameter and 8 inches long. The maximum available air velocity is as high as 240 mph. The gun was not yet completed. This velocity is not limited by mobility but is the limit of velocity so far as the gun can be supplied. Combustion efficiency is not yet determined, but it is estimated at 80%.

(Information in this section is classified information.)

The Bureau of Aeronautics is negotiating with Fleet Air Armament for the construction and testing of rail-jet and ram-jet units. They would provide the design of the combustion chamber.

10. Reaction Motors Incorporated.

On 20/3/44 the Bureau of Aeronautics requested the R.M.I. to undertake the design, construction, and testing of a pulse-jet unit for the V-111 unit. No report has yet been issued.

11. Interspace Research Unit Inc. (Aerojet Motor)

Reaction Motors Incorporated. (Enclosure C)

Reaction Motors have constructed and tested an intermittent type of ram-jet unit. The unit operated successfully with 100 octane gasoline as well as on Diesel oil. A report on the tests of this unit is attached (See Enclosure C).

12. Engineering Experiment Station, Annapolis.

Preliminary experiments have been carried out at the Engineering Experiment Station at Annapolis on intermittent types of ram-jet units varying in size from 6 inches diameter to 1/2 inch diameter. Different types of inlet valves have been studied, including such types as Kielholz valves, poppet valves, rotary valves. Some tests have also been carried out on intermittent combustion units without valves. A report on these tests is being prepared.

13. Aerojet Engineering Corporation

Aerojet has been making a thorough theoretical investigation of the propulsive parameter with a view to increasing the efficiency of the impulsive units. Only preliminary experiments have been run thus far. A comprehensive report is now being prepared.

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To N.D.R.C. Mathematics Panel

A project has been set up with the N.D.R.C. Mathematics Panel to assist the Bureau of Aeronautics' contractors in the further theoretical analysis of the pressure wave phenomena occurring during the cycle of operation of the Aeropulse unit.

To Lycoming Engine Division

The Bureau of Aeronautics has a contract with the Lycoming Engine Division for the further development of engines of the intermittent-flow ram-jet type. The purpose of the contract is to improve the specific fuel consumption of these engines sufficiently so that they might compete with the turbo-jet engines. As a first step, Lycoming will make careful measurements and an analysis of the performance of the intermittent-flow ram-jet units being built by Ford Motors under a contract with the AAF. This work is just being started. Two units are scheduled for delivery to Lycoming by November 1, 1944.

To NACA

On June 30, 1944, the Bureau of Aeronautics requested the NACA to undertake the design, construction, and test of an intermittent-flow ram-jet unit. A preliminary analysis of the behavior of these units has been started. No experimental progress has been reported to date.

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HEREIN IS UNCLASSIFIED

DATE 10-22-2014 BY SP&D

October 22, 1944.

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The committee met at the office of the Bureau of Standards, Washington, D. C., on October 22, 1944, at 9:00 a.m. present:

A. E. Jacobs, Chairman

G. E. Holmes

J. Kunen

R. M. Bohay

E. S. Gruenbaum

H. R. Sharp

A. H. Bartholomew

D. F. Prichard

R. L. Bahigian

J. G. Anderson

L. B. Cole

F. J. Dressman

A. J. Goss

W. H. Mutterer

C. Purcell

D. Green

E. Ornstein

J. Hall, Secretary

The minutes of the previous meeting were read and corrections made as shown on revised pages 2 and 3.

The chairman called that a brief review of progress to date precede the regular progress reports of the various groups for the information of Mr. G. E. Holmes. The progress made to date by Mr. Bohay's group on valve designs was reviewed by Mr. Kunen. He stated that several types of valves had been tested with the objective to obtain a minimum of 1-hour life with satisfactory results. Valve life exceeding the 1-hour minimum had been obtained on the reciprocating piston apparatus at 1200 rpm with the large size valves and at 1500 rpm with a smaller size valve.

Mr. Holmes asked if there were any size limitations being used by the group. Mr. Kunen stated that larger valves than those being used by the Germans were tested in view of the possibility of obtaining lower pressure drop through the valve.

Mr. Bohay stated that the objective of the valve work was to obtain a valve that would open fully and have minimum losses.

Mr. Dressman reviewed the results obtained on the reciprocating piston apparatus during the preceding week. One of the nine grille and valves being made by the shop had been completed and tested. The grille which had a straight

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valve seat and curved back stop was shown to the group. The valve seat was at a 60° angle from the vertical and the curved back stop was designed so that the bending stress in the valve would not exceed 65,000 lbs/sq.in. in the full open position. A valve made of .0005-inch Swedish-blue steel stock failed after 45 minutes, at 1500 rpm. The valve made with .010-inch Swedish-blue steel stock was still in satisfactory condition after 181 minutes of running at 1500 rpm. A second test was made with a valve of .010-inch Swedish-blue steel stock with the rolling grain spanwise and the valve was in good condition after three hours' running at 1500 rpm. A valve of .010-inch Swedish-blue steel stock was tested at 1800 rpm and a small piece broke out of the corner of the valve after 31 minutes running. A valve of .010-inch stock was tested under the same conditions and failed after 57 minutes running time at 1800 rpm. A valve was tried with the tip over-hanging the grill by a small amount with no apparent difference in results. It was noted that the valves currently being tested by the group have been made with rounded corners and the tip polished with many cloth.

Mr. Butterperl reviewed the valve tests that had been conducted to date by Mr. Silverstein's group. It was noted that valve life of 24 minutes and over had been obtained with the valve operating from 40 to 50 cycles per second. Various materials had been tried in the valve test programs for the purpose of arriving at the best combination.

Mr. Ornstein of the Metallurgical group reviewed the metallurgical work that had been carried out in conjunction with the valve test work of the Wind Tunnel group. Mr. Ornstein stated that examination had shown that the structure of Swedish-blue steel varied with the thickness of the stock. It was noted that with increase in thickness the grain structure changes were such that increased thickness should result in increased resistance to impact. The variation in grain structure with thickness was attributed to the variation in effective heat-treatment with thickness. The fractures in the valve that had been examined were noted to be through the grain which is typical of fracture from impact. A chemical analysis had been made of the Swedish-blue steel currently being used for valve tests and elements were found in addition to those used in Swedish-blue steel manufactured before the war. It was noted that in the valve failures which had been investigated the fractures followed a straight line which indicated that polling seems or preferred orientation were possible causes.

A specimen which had been heat-treated at 1100° showed crystal structure changes that appeared to be better from metallurgical standpoint. Mr. Ornstein stated that it was his opinion that the valve should have spring properties as a result of heat-treatment, instead of cold rolling with the resultant residual stresses.

It was pointed out that variation in hardness within reasonable limits did not change the modulus of elasticity of the material and that the softer material would have better impact resistance. Specimens had been prepared on the basis of the work of the Metallurgical group and will be tested in the impact machine which is scheduled for completion in November.

The results of a report by the Metallurgy Arsenal on high velocity impact tests was reviewed.

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The use of the impact machine and the question of whether or not the results may be directly applicable to valve design was discussed.

Mr. Silverstein noted that the reasons for valve failures were not known by him, but that the impact machine may be used in obtaining information on the cause of failure.

Mr. Turner noted that if simple valves were used tests could possibly be made just as rapidly in the valve test apparatus with results that were of direct value.

Mr. Turner suggested that the variation of structure with thickness would make tests with varying valve thicknesses an incorrect evaluation of the effect of material thickness.

Mr. Silverstein noted that meeting the minimum requirement of 1-hour-life valve tests was no particular improvement over the German design. It was pointed out that with the valve designs being tested and with lower cycling frequencies lower pressure drop through the valves should be obtained than with the German valves.

The question of what cycling frequency should result in optimum performance was discussed. Mr. Turner stated that with the combustion apparatus 30 cycles per second would be obtained.

Mr. Turner sketched on the blackboard the single shop combustion apparatus being constructed by Mr. Pinkal's group. The first test with the apparatus will be made using liquid propane and later tests with gaseous propane. The inlet valve for operation is designed to allow a slug of fresh air to enter the combustion chamber before the injections start. It is hoped to set a combustion process that will allow a slug of fresh air to fill the nozzle at the time the inlet valve closes for the purpose of increasing the rate of combustion and pressure rise.

Mr. Holmes inquired as to when the combustion apparatus would be ready for tests. Mr. Turner stated that the shop had promised completion by November 7, and that tests should begin in about 10 days.

Mr. Sanders inquired as to what rate of flame propagation was anticipated in the combustion apparatus. Mr. Turner stated that the transverse flame propagation rate was expected to be approximately 25 feet per second but that this rate would probably be increased considerably by turbulence.

Mr. Turner stated that the photographic studies of the combustion process should give the information necessary for designing a satisfactory combustion chamber.

Mr. Holmes stated that 1,000 robot bombs were on order by the Army from Ford and that the next order was expected to be for 2,000. No changes will be made in the robot bomb design unless data is gotten out to show how improvements can be made.

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The chairman noted that progress of shop work was comparatively slow on the ram jet projects. Mr. Schey said he felt the slow progress in the shops was serious. Mr. Helms stated that priority on the ram jet projects should be exceeded only by turbine and jet projects.

Mr. Silverstein stated that the continuous-flow ram jet to be made by converting the Westinghouse installation now in the tunnel is to be tested by using a blower to arrive at a satisfactory combustion chamber. Wind tunnel tests will be made when a satisfactory combustion chamber design can be made.

Mr. Bots sketched the burner installation that has been made up to simulate combustion in the steady-flow ram jet. Test work on the burner had been interrupted after 1-day's running by the fuel test engines, which is installed in the same test room, going back into operation. Mr. Rothrock stated that schedules would be arranged so that the burner tests could be carried out without undue interference from the fuel test engines.

Mr. Pinal stated that it was his understanding that liquid fuel would be used for the ram jets. Mr. Rothrock stated that further estimates are being made on the comparison of the relative merits of liquid and gaseous fuels for use with ram jets.

Mr. Kinnon inquired as to the increase in fire hazard with the storage of liquefied gases on shipboard. It was generally agreed that the fire hazard would be an important consideration.

Mr. Nahigyan reported that the gasoline burners being made by his group were in the last stage of assembly and a demonstration run should be possible by the next meeting. Mr. Nahigyan inquired as to what pressure losses would be allowable in the burners. The chairman stated that losses equal to 15% or the loss due to combustion should not be excessive.

Mr. Nahigyan reported that the test set up for the robot bomb which had been scheduled for simulation by November 3 had been delayed 2 weeks by a delay in contract negotiations.

The meeting adjourned at 10:30 a.m.

Jesse B. Hall,
Secretary, Ram Jet Committee

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CONFIDENTIAL INFORMATION

October 24, 1964

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The Committee met in the Executive Conference Room at ARRL on October 24, 1964, at 9:30 a.m. (ARRL)

Mr. E. H. Jacobs, Chairman

Colonel F. R. Page

Mr. M. Rothrock

Mr. R. P. Cole

Mr. Simon

Mr. K. K. Hargrave

Mr. D. Pinkal

Mr. W. Schay

Mr. J. B. Bressman

Mr. E. Kuman

Mr. G. Burgess

Mr. Matterperl

Mr. D. Piment

Mr. R. Johnson

Mr. R. Hall, Secretary

Mr. E. Kuman, Acting Secretary

The minutes of the previous meeting were read and with several changes were approved.

Mr. Kuman gave a short summary of his test program to date and presented a chart showing the different types of valves that had been tested. He reported that he has 9 grills and a number of valves being made up in the shop at the present time. A valve with the trailing edge sealed by silver solder failed after several minutes. A valve with the end sealed by shot blasting is to be tested in the near future. An .008-inch Swedish-blue steel valve failed after combined operation at 1500 rpm for 46 minutes and at 1800 rpm for 2 minutes. Another valve of the same material which had a smaller radius of curvature than the valve seat and a thickness of .010-inch failed after 16 minutes of testing because the valve had been bent sharply at one place. Straight valves of .008-inch thickness failed in the same manner as the curved valves after 46 minutes of testing.

At this point, Mr. Jacobs asked for a definition of the objective of the test program. Mr. Jacobs stated that the objective of finding a valve which would run for one hour came from the Army. This type of valve is to be used in a missile which is to have a range of 400 miles and a speed of 550 miles per hour. There was some question as to whether the test program should be planned to find valves with a longer life at the low frequencies now under investigation or to attempt to find valves that would last for one hour at higher frequencies. Since there was no definite decision made by the Committee, Mr. Kuman stated that he would investigate both possibilities.

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Mr. Turner reported that the large valve and other test unit parts now being fabricated in the shop are long overdue. These parts were due on October 15, 1944, and progress is still slow. Mr. Turner also reported that the nozzle mount for the combustion study rig is nearly complete and the valve housing should be completed in about a week.

Mr. Mutterperl reported that the impact machine is approximately 20 percent completed. He stated that it is planned to test on the impact machine all of the shock absorber ideas of the last meeting. Tests have been made to find the effect of valve seat condition on valve life. Mr. Mutterperl submitted a plot of valve life versus the number of tests made on the valve seat without refacing between tests for .005-inch blue-steel valves. This plot showed the valve life to decrease rapidly with the number of tests made on a valve seat without refacing. It was agreed that this plot made a great deal of the data previously obtained very doubtful. Mr. Mutterperl sketched on the blackboard a peculiar crystalline structure found after a valve dipped in tin had been tested. Mr. Burgess reported that the photomicrographs promised last week were not ready yet but would be submitted at the next meeting. Mr. Burgess stated for the information of the Committee that an Arsenal representative had given him data showing that impact strength generally rises with striking velocity to a peak and then drops off suddenly.

Colonel Page stated that he had inspected a German robot bomb at Wright Field and believed this bomb to be different from the one known to the Committee. Colonel Page stated that the bomb he examined had two sets of valves. The first set of valves were smaller than the second set. Colonel Page stated that he believed the trailing edge of the valves did not strike the seat but struck each other. Mr. Buskirk submitted photographs of the German valves sent here by Dr. Lewis and Colonel Page stated that he believed that the ones he examined were different. Colonel Page stated that he would call Wright Field and attempt to borrow the robot bomb in order that the Committee might examine it. Mr. Jacobs asked when the Ford bomb would be delivered and Colonel Page stated that it should arrive soon.

Mr. Mutterperl reported that the fabrication of the ram jet is progressing and provisions are being made to install the unit in the wind tunnel.

Mr. Bola reported that the gas burner for the ram jet had been fired and some difficulties were experienced with combustion. The highest velocity at which the unit would support combustion was 20 feet per second. At this velocity the flame was yellow and a peculiar pulsating flow was noted. Mr. Jacobs suggested that the difficulty was due to backwash. Mr. Bola stated that changes will be made in the burner in order to get better combustion and to support combustion at higher velocities.

Mr. Rothrock and Dr. Simon reported on the results of their study of storing gaseous fuels. Dr. Simon stated that the most promising method is the storage of propane under pressure. He gave the following tabular data for the storage of 500 gallons of low pressure gas:

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	Propane	Propane	Lethane
Temperature of storage, °F.	100	100	100
Type of tank	Insulated	Insulated	Insulated
Section of tank, square inches	144	144	144
Weight of fuel, pounds	2420	2115	1732.5
Length of 1.44' radius tank, feet	10	16.6	10
Thickness of wall - steel, inches	1/8	1/4	1/8
Thickness of wall - aluminum, inches	1/8	9/16	1/8
Weight of tank - steel, pounds	309	1507	502
Weight of tank - aluminum, pounds	182	1165	182
Weight of insulation (cork), pounds	156	0	156
Loss of fuel, pounds per hour	0.917 (.056%)	0	2.34 (.112%)
Purposes	Necessary	Unnecessary	Necessary
Temperature effect on metal	None	None	Terrific
Tank pressure, pounds per sq. in.	14.7	35.5	14.7

Mr. Simon also sketched curves showing the suitability of different types of fuel. Messrs. Rothrock and Jacobs agreed that the use of gasoline fuel in the intermittent unit seems to be very promising.

Mr. Rothrock sketched on the blackboard the test rig for studying the vaporization of liquid fuels. Plans are made to compare the vaporization of different fuels, including gasoline, fuel oil, and kerosene. Mr. Rothrock stated that a demonstration would be held as soon as the safety mechanism is installed on the rig.

Mr. Mahigan reported that the fabrication of the gasoline burners is progressing and that a demonstration can probably be held on November 7, 1944. Mr. Mahigan also reported that the rig for the robot bomb installation is progressing. Parts are scheduled to start coming in on November 8, 1944.

Mr. Jacobs sketched on the blackboard for the information of the Committee the method of launching robot bombs that were used in France. The bombs run on a track and are pushed by a piston which is actuated by explosives. The slot provided in the cylinder for connecting the piston to the bomb is sealed by tubes.

Mr. Jacobs stated that the Committee is now in a position to design a continuous-flow unit for the Army missile.

It was generally agreed by the Committee that the work being done by the shops is moving unreasonably slow. Mr. Burgess suggested that if a shaper and lathe were placed in the wind tunnel, 95 percent of their work could be taken out of the shop. This policy, however, is frowned upon because the machines stay idle part of the time. Mr. Schey suggested that the Committee contact the shop in order that the shop appreciate the high priority of this job. It was agreed that pressure should be brought to bear on the shops in order to expedite the work.

The meeting adjourned at 11:00 P.M.

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October 17, 1944

The Committee met in the Executive Conference Room at AERL on October 17, 1944, at 9:10 a.m. Present:

R. J. Jacobs, Chairman
A. E. Rothrock
A. S. Kuman
L. R. Turner
D. Gireen
K. G. Mahigyan
B. Pinkel
A. Silverstein
J. O. Sanders
O. W. Schey
W. Mutterperl
W. C. Burgess
H. A. Buckner, Acting Secretary

The minutes of the previous meeting were read and approved as read.

Mrs. Kuman reported that the grill used for testing had been revised and now has a reflex top. Swedish-blue steel, brass, low-carbon steel, and bronze valves have been tested. Swedish-blue steel valves of 0.006-inch thickness lasted 18 minutes and 3 minutes at 1500 and 1200 rpm, respectively. The valves of 0.008-inch thickness were improperly made and consequently lasted only about 2 minutes. The valves of 0.010-inch thickness failed after 25 minutes of operation at an engine speed of 1500 rpm. The brass, the low-carbon steel, and the bronze valves gave very poor results. Mr. Kuman stated that he is planning to run tests to give a curve of valve life versus closing time.

Mr. Kuman passed the valves around for inspection. From the examination of the valves it was apparent that the failure was caused by the end of the valve striking the seat. Several recommendations were made to avoid this type of failure. Mr. Silverstein suggested that the ragged end of the valves be sealed and that the end of the valve be stiffened by some method. Mr. Rothrock suggested that a spring should be located at the end of the valve seat to decelerate the valve more gradually and Mr. Mahigyan made design revisions in this method. Mr. Pinkel recommended that the edge of the valve be surled. Mr. Schey suggested that the trailing edge of the valve seat be made wider in order to provide an air cushion and to distribute the stress over a larger area. Mr. Burgess suggested that the ribs in the valve seat be run spanwise. Mr. Kuman agreed to consider these recommendations in laying out future test work. It was generally agreed that some type of shock absorber should be provided to eliminate this type of failure.

Mr. Burgess pointed out that a to date direct comparison of valves is not possible because of the changing condition of the valve seat. Mr. Kuman added that the problem of the valves is to determine the fabrication of the valve holds

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up the test program an unreasonable length of time. It was agreed that the Committee should give thought to means of fabricating quickly and cheaply a large number of these valve seats.

Mr. Burgess reported that photomicrographs of the frayed edges of valves that have failed will be submitted at the next meeting. Mr. Mutter reported that no valve tests had been made during the past week, but work is proceeding on the fabrication of the impact machine and the test unit for the wind tunnel. Mr. Silverstein stated that liquid fuel would have to be used for the unit when tested in the wind tunnel because of the supply problem. Mr. Rothrock agreed to look into the possibility of using high-pressure storage tanks for gasoline fuels and report on the results at the next meeting.

Mr. Turner reported that the shop did not complete the work for his test rig on schedule and, consequently, the test rig will not be ready to run before October 24, 1944.

Mr. Nahigyan reported that the fabrication of the gasoline burner for the wind tunnel unit is progressing. This burner will be installed in a rig connected to an air system preliminary to installation in the unit for wind-tunnel tests. The unit is scheduled to be ready for installation in the wind tunnel by November 7, 1944.

Mr. Nahigyan also reported that the setup for testing the robot bomb is nearing completion and that it appears that the development of the valves will hold up the project. All parts should be completed by approximately November 14, 1944. The unit will be installed in the Engine Propeller Research Building, cell number 4, where air can be furnished at the rate of 130 pounds per second and at simulated airspeeds of 400 miles per hour.

Mr. Rothrock reported that the setup for studying fuel sprays should be ready to run some time this week.

Mr. Turner called to the attention of the Committee a combustion system in which burning takes place within the liquid and suggested that a similar process might be feasible for vaporizing fuel. It was agreed that the Committee should give further thought to this process.

The Committee decided that it should act in an advisory rather than a directory capacity in regards to work being performed by the members.

The meeting adjourned at 11:50 a.m.

Howard A. Buckner, Jr.

Howard A. Buckner, Jr.,
Acting Secretary, Rocket Committee.

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RAM JET CONFERENCE

October 10, 1944

The Committee met in the Executive Conference Room at AERL on October 10, 1944, at 9:15 a.m. Present:

B. M. Jacobs, Chairman
 R. K. Bahigian
 L. R. Turner
 O. W. Schey
 A. M. Rothrock
 D. Girent
 W. Mutterperl
 D. C. Burgess
 A. E. Human
 J. B. Bresman
 J. O. Sanders
 R. A. Buckner, Acting Secretary

The minutes of the previous meeting were read and approved as read.

Mr. Bresman reported on the results of the Swedish-blue steel valve tests of his group and passed the valves around for inspection. These results are shown in the following table:

Valve thickness (in.)	Grill details	Lif. before fraying (in.)	Engine speed (r.p.m.)
.012	Aluminum seat and top	4	1200
.010	Aluminum seat and top	12	1500
.010	Aluminum seat and top	18	1800
.008	Rubber top	45	1200
.008	Rubber top	25	1500
.015	Reflex top	5	1500
.015	Rubber top	9	1500

All these failures were believed to be due to impact. Mr. Schey asked if the test rig was not harder on the valves than actual operating conditions. Mr. Bresman stated that the opening is about the same, but the closing is different. Mr. Schey suggested spring steel as a material because it has a tensile strength of about 200,000 pounds per square inch as compared with 125,000 to 150,000 for Swedish-blue steel. Mr. Bresman stated that the grill is being reinforced and 0.006-inch valves are being made. Mr. Jacobs stated that the tests are showing that the trend should be toward smaller and thinner valves. A discussion followed on the advisability of making tests of German valves to compare with our test results, but no action was agreed upon.

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Mr. Burgess reported on his tests of straight valves on curved seats and passed the valves around for inspection. The 0.005-inch steel valve, when tested at 50 oscillations per second and a steady-flow grid velocity of 250 feet per second (145 feet per second average for intermittent flow), failed after 5 minutes. The coil of this valve ran sparsely. The same thickness valve with the coil in otherwise and with an inconel backing lasted 27 minutes. Mr. Burgess stated that the inconel backing had practically no reaction relative to the valve. A 0.005-inch steel valve dipped in tin failed after 5 minutes of testing. Valves made from brass spring stock of 0.007-inch and 0.008-inch thickness failed after 9 minutes and 55 minutes, respectively.

Mr. Turner reported that the burner elements for his rig are in the shop and would probably be finished by October 15, 1944. The setup is progressing and it is planned to use gas either propane or propane and butane from bottles. Mr. Turner stated that the unit could probably be fired without the glass on October 17, 1944. Mr. Turner also reported that his calculations indicate that an application of the intermittent-flow burner to the existing jet-propulsion unit components would theoretically increase the efficiency 20 percent and the power output as much as 50 percent.

Mr. Rothrock stated that the 20-mm test equipment on his burner is 100 percent satisfactory.

Mr. Maliguss reported that he has two gasoline burner designs being fabricated in the shop at the present time.

Mr. Matterperl reported that the tests of his combustion rig are about ready to start. The rig consists of a rectangular duct mounted inside a circular duct connected to the altitude exhaust. The rectangular duct has a quarter-inch lip to support a pilot light. These tests will be made before the complete unit is tested in the wind tunnel. Mr. Matterperl stated that it was planned to use liquid fuel, but it was pointed out that it had been decided previously to use gaseous fuel in order to expedite the tests to check the theory.

Mr. Matterperl submitted a blackboard sketch of a simple apparatus for testing metals for impact. The apparatus consists of a rotating shaft with two strikers that hit the edge of the valves being tested. It was agreed that tests should be made to find how the data obtained on this rig correlate with other valve test data.

Mr. Jacobs stated that the group, with its present experience, is in a position to design valves for a 15-cycle unit which will run over an hour before failure. This unit would be approximately 6 feet long.

The meeting adjourned at 11:00 a.m.

Howard C. Buckner, Jr.

Howard A. Buckner, Jr.,
Secretary, Pan Jet Committee.

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ARMED FORCES CONFERENCE

October 3, 1944

The Committee met in the Executive Conference Room at AFRL on October 3, 1944, at 9:05 a.m. Present:

B. H. Jacobs, Chairman

A. K. Nahigyan

L. B. Turner

O. W. Schrey

D. Okrent

B. Pinkel

W. Mutterperl

W. C. Burgess

J. H. Bressman

J. C. Sanders

L. Wolfenstein

J. H. Hall, Secretary

The minutes of the previous meeting were read and approved as read.

A valve assembly taken from a German robot bomb was shown to the group. Mr. Schrey stated that Dr. Lewis had asked for the valve to be returned at an early date in its original condition as he intends to use the valve at a meeting of the Budget Committee. Measurements desired should be taken as soon as possible so that the valve assembly might be returned in accordance with the request of Dr. Lewis.

The construction details were examined and discussed by members of the group. Mr. Bressman reported that the valve-test program on the large valves being tested in the reciprocating-piston apparatus had been completed. The results of the test work on the large valves were reviewed. Included in the investigation were the effect of valve thickness, seat material, speed, and top-stop construction on valve life.

The method used for forming the valves which had been tested was discussed. The current method of forming the valve by means of a sheet-metal brake was believed to be undesirable from a stress standpoint. Suggested methods for forming included laying the material on a form and shot blasting, wrapping the material on a roll to obtain the proper curvature, and annealing the material on a form followed by heat treatment.

Mr. Burgess reported on results of the valve tests conducted during the preceding week in the intermittent-flow apparatus in the Duct Laboratory. A comparative test had been made of inconel and Swedish-steel stock. The inconel material gave considerably longer life but it was pointed out that the single test could not be considered conclusive. Steel valves made up with the rolling grain of the material spanwise and chordwise were compared. The valve with

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spanwise-rolling grain gave considerably longer life. The valves with spanwise- and chordwise-rolling grain were made of .005-inch stock. A valve with spanwise-grain made of .008-inch stock ran for a longer time before failure than the .005-inch-thick valve but did not open fully. Mr. Pinkel noted that the spanwise-grain valves should be better from the standpoint of fraying in the tip.

Mr. Bresman stated that their tests had shown opposite results but since the failure of the valves in their tests had been by tearing, the indicated better-fraying resistance noted in the test of the smaller size valves in the Duct Laboratory may be significant. In order to determine the impact resistance of materials being considered for valve construction, tests are being planned by Mr. Silverstein's group for studying impact resistance in a simplified test apparatus. This work will precede further tests of valves and is being set up on a simplified test apparatus in order to make a large number of tests in the minimum time.

Mr. Sanders reported on results of further calculations he had made for supercharging the intermittent ram jets. These calculations had been made on the basis of a pressure ratio of 1.5. The results indicated a fuel consumption of 1.2 lbs/hp hr at a fuel-air ratio of .015.

The inlet temperature to the turbine turned out to be higher than the previous limit. Additional calculations will be made for temperatures at and below the previous set limit of 1000° F.

Mr. Turner discussed calculations he had made on the application of the intermittent-flow burner to a Whittle-type unit. The calculations made were based on attempting to attain an optimum installation. Further calculations will be made based on application of the intermittent-flow burner to the existing jet-propulsion unit components.

Mr. Wolfenstein showed a sketch that he had made for supercharging the intermittent-flow ram jet by use of an axial-flow compressor ahead of the valves driven by a gas turbine through which part of the gas passed, the balance of the gas being carried out through a nozzle directly.

Mr. Turner reported on the status of the combustion apparatus. The estimated completion date for the apparatus was stated to be October 15, 1944.

Mr. Butterperl reported on the status of the steady-flow ram-jet installation for tests in the wind tunnel. The design work on the installation, except for the burner, was reported to be complete. It was noted that the unit must be ready to go into the tunnel for tests in about one month, if it is fit into the tunnel schedule.

The burner design for use in the steady-flow ram-jet installation was discussed. Messrs. Nahigyan and Boli sketched proposed burner arrangements on the blackboard. Mr. Nahigyan stated that his group could design and test a cone-type burner using gasoline as the fuel within the time limit set, provided priority could be given this job over others currently being worked on by his group. The question of priority to enable this design to go forward will be looked into after the meeting.

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The Chairman asked Messrs. Mutterperl and Bolz to meet with him for a few minutes after the meeting of the group had adjourned to discuss the possible designs for gas burners.

The meeting adjourned at 11:45 a.m.

Jesse H. Hall

Jesse H. Hall,
Secretary, Ram-Jet Committee.

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RAY JET CONFERENCE

September 26, 1944

The Committee met in the Executive Conference Room at AERL on September 26, 1944, at 8:10 a.m. Present:

B. L. Jacobs, Chairman

D. Current

L. R. Turner

J. C. Sanders

H. Mutterperl

W. C. Burgess

J. R. Bresman

J. K. Euman

J. H. Hall, Secretary

The minutes of the previous meeting were read and corrected as shown on revised page 2.

Progress made during the preceding week in valve tests and design was reviewed. Mr. Bresman reported the results of tests of five valves in the reciprocating piston apparatus. All of the valves were tested with a full rubber mat as a top-stop. The first valve was made of .010 inch stock and was tested with an aluminum grill at 1200 rpm. The valve failed after 14 minutes running.

The second valve tested was made of .008 inch stock and failed after 11 minutes running with an aluminum grill at 1200 rpm.

The third valve tested was made of .012 inch stock and failed after 33 minutes running with a bakelite grill at 1200 rpm.

The fourth valve tested was made of .015 inch stock and was still in good condition after 101 minutes of running with an aluminum grill at 1200 rpm.

The fifth valve was made of .012 inch stock and failed after 2 minutes running with an aluminum grill at speeds between 1600 and 1800 rpm.

The tests by Mr. Schey's group on the large size valves were scheduled for completion by September 27.

The Chairman noted that the work in the shop for Mr. Schey's group on valve construction and Mr. Pinkel's group on the combustion apparatus would have to be given relative priority. It was agreed that the combustion apparatus would have priority until the tests of the large valves are completed, at which time one man from the combustion apparatus job can be taken off to continue the valve construction work.

The aluminum grill for testing the next smaller size valves by Mr. Schey's group was shown. The range of valve sizes to be tested in the reciprocating piston apparatus was discussed. It was agreed that two of the small size valves should be tested in the reciprocating piston apparatus in a side by side arrangement. These valves are to be made up as an addition to the order for valves being made up for Mr. Pinkel's group for the combustion apparatus.

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Mr. Kutterperl showed drawings that he had made up of a new valve design that had been made by Mr. Silverstein's group. The valves were designed to utilize a flat valve with the valve seats and top-stop curved to reduce operating stresses. The ribs in the grill were designed so that thickness and spacings could be varied. Valve thicknesses from .004 to .012 or possibly .016-inch will be tested in the new design.

Mr. Turner reported on the status of the combustion apparatus being set up by Mr. Pinkel's group. The valve-seat grill for the combustion apparatus is scheduled for completion by October 9. The fuel injection equipment still appears to be the controlling factor as to when the combustion apparatus would be ready for operation. A simplified plunger-type injection pump for injection of the propane is being considered as the best method of getting the combustion apparatus operating at the earliest possible date.

Mr. Rothrock reported that the vaporization setup for liquid fuel tests should be running in about one week. Continuous injection of the fuel will be used first but the apparatus can be changed for intermittent injection tests.

Mr. Sanders reported on the progress he had made in calculations for supercharging ram jets. Mr. Sanders stated that his calculations were not sufficiently completed to obtain any conclusions.

The physical arrangement for the turbine blower and bleed valves for the supercharging system utilizing the peak pressure and the intermittent-flow ram jet for turbine was discussed. The Chairman suggested that Mr. Sanders consider pressure ratios considerably lower than the 2:1 pressure ratios used in the initial calculations, and lean mixtures of the order of .015 fuel-air ratios.

The Chairman suggested that the group give some thought to suitable bleed valve designs for operation at high temperatures. It was suggested that the valves should be automatic if possible and that 1000° F. would be the upper temperature limit in the valve designs. The discussion of valve designs for high temperature work indicated doubt that automatic valves could be made to operate satisfactorily in the high temperature range.

Mr. Silverstein reported on progress made toward getting a steady-flow ram jet installation tested in the Altitude Wind Tunnel. Mr. Silverstein sketched the steady-flow ram jet installation currently being considered for tests in the Altitude Wind Tunnel. The setup consisted of the Westinghouse jet propulsion installation with the burner and turbine removed and modified to obtain the proper passage for a steady-flow ram jet installation. Mr. Silverstein pointed out that reduction of losses to an absolute minimum was very important in steady-flow ram jet operation. The burner arrangement to obtain the minimum pressure loss for use in the steady-flow ram jet installations was discussed.

The meeting adjourned at 11:00 a.m.

Jesse H. Hall,
Secretary, Ram Jet Committee.

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CONFERENCE

September 19, 1944

The Committee met in the Executive Conference Room at AERL on September 19, 1944, at 2:10 p.m. Present:

H. H. Jacobs, Chairman
Wm. Peiaraisen
A. M. Rothrock
D. Orent
J. C. Sanders
A. E. Kunnen
D. W. Schey
J. R. Bressman
L. R. Turner
B. Pinkel
W. Mutterperl
E. I. Nahigyan
W. C. Burgess
Cassey R. Hall, Secretary

The minutes of the last meeting were read and corrections made as shown on revised page 1.

Progress on valve tests and designs made during the preceding week was reviewed. Mr. Kunnen reported that their best results obtained to date were with a valve that ran 93 minutes in the reciprocating piston apparatus before failure occurred. Nine valves had been tested in the reciprocating piston apparatus during the week. Mr. Bressman reported the conditions and results obtained from the tests of the nine valves.

The first and second valves tested were made of .012 inch stock and were run with rubber seats at 1200 rpm. The first valve did not have a rubber pad insert as a top stop and failed in 35 minutes. The second valve tested with a rubber pad insert as a top stop and ran 79 minutes without failure. The speed of the second valve was increased to 1500 rpm and failure was noted after running 4 minutes.

The third and fourth valves were made of .015 inch stock and were tested with a rubber seat at 1200 rpm. The third valve did not have a rubber pad insert for a top stop and failed in 10 minutes. The fourth valve was tested with a rubber pad insert for a top stop and failed after 21 minutes running.

The fifth and sixth valves were made of .010 inch stock and were tested under the same conditions as the third and fourth valves. The fifth valve did not have a rubber pad insert for a top stop and failed after nine minutes running. The sixth valve had a rubber pad insert for a top stop and failed after 19 minutes running.

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The seventh and eighth valves tested were run under the same conditions as the third and fourth valves and were made of .008 inch stock. The seventh valve, which had no rubber pad insert for a top stop, failed after 2 minutes running. The eighth valve, which had a rubber pad insert for a top stop, failed after 7 minutes running.

The ninth valve tested was made of .012 inch stock and had an aluminum seat and a rubber top stop. The grill was made of aluminum alloy, furnace brazed. The valve was run for 93 minutes at 1200 rpm and was found to be in good condition at the end of the test. The speed was increased to 1700 rpm and failure occurred after 2 minutes running.

Further tests are planned for valves made with the .008 inch and .010 inch stock with a full rubber matt for the top stop. Other tests to be conducted will be with the rubber insert as the top stop with steel seats.

The Chairman suggested the use of aluminum top surface for tests and it was agreed that such tests would be conducted in the near future. The results of the tests were discussed by the group with respect to the valve thickness. It was suggested that bakelite seat material be tried in the reciprocating piston apparatus. It was decided that .012 inch stock would be used for all seat materials tested and that tests would be run at 1200 rpm. The speed will be increased to 1800 rpm for the best combinations.

Mr. Turner discussed an analysis he had made on the effect of valve thickness when the valve size is scaled down.

Mr. Mutterperl reviewed progress made by Mr. Silverstein's group on valve tests. It was reported that most of the work done during the past week was toward getting the intermittent flow apparatus operating satisfactorily. Several valves made of .002 and .004 inch stock, which had been tested to destruction, were shown to the group. Mr. Mutterperl stated that considerable trouble was encountered in synchronizing the intermittent and steady flow air streams. The test section used in the apparatus, which was equipped with a steel grill, was shown to the group. Mr. Turner noted that the valves had apparently been cut out by shears and suggested that the edges be ground to eliminate the stress set up in the shearing process.

Mr. Mutterperl reported that no further action had been taken by his group with respect to the continuous flow ram jet. He stated that a report entitled "Design Study of High-Speed Long-Range Guided Missile" has been prepared by his group. The Secretary will obtain a copy of the report and circulate it to members of the group.

Mr. Sanders reported on four schemes that he had considered for possible use as a means for supercharging ram jets. The first scheme investigated was the use of the turbine which utilized peak pressures bled off the combustion chamber, to drive the blower. The second scheme considered was the use of a blow down type turbine connected to a unit with multiple combustion chambers. The third

method considered was the use of constant pressure turbine for a blower, the fourth scheme which was given very little consideration was the use of an engine driven blower. The schemes were discussed by the group and the first scheme appeared to be the most promising. For further analysis of the problem Mr. Sanders will place most emphasis on the first scheme.

The Chairman asked for any further results on the use of aeropulse unit as a burner for the Uniflow type unit. Mr. Pinkel stated that his group would make a short analysis to survey the problem.

Mr. Turner reported on progress made in getting the single shot burner apparatus in operation. The design of the fuel valve turned out to be one of the most difficult parts of the apparatus; however, all parts including the valve sections will be completed or in the shop within 4 or 5 days.

The meeting adjourned at 10:50 A.M.

Jesse H. Hall,

Secretary, Ram Jet Committee

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Revised Minutes
RAM JET CONFERENCE
September 12, 1944

The Committee met in the Executive Conference Room at AERL on September 12, 1944, at 9:30 a.m. Present:

B. J. Jacobs, Chairman
Wm. Peierlsen
O. W. Schey
J. Richard Turner
A. S. Kunen
John R. Bressman
H. Butterperl
H. Hall, Secretary

The minutes of the last meeting were read and corrections made as shown on revised page 2.

The Chairman asked for a progress report on the various groups on valve designs and tests since the last meeting. Mr. Butterperl stated that they were considering the use of nickel steel in their designs of valves. Tests had been made of valves made up in accordance with Mr. Jacobs' proposal using .008 inch stock. The valves tested in the intermittent-flow apparatus designed by Mr. Silverstein's group did not open sufficiently to contact the upper wall.

Mr. Bressman reviewed the results of the valve tests made by Mr. Schey's group in the reciprocating piston test apparatus. The three valves tested were shown to the group. The first valve was run 56 minutes at 720 rpm and 35 minutes at 900 rpm. The valve failed in the tip section during the last 5 minutes of running. The valve was made with .012 inch stock with a Rockwell C-25 hardness at the tip. It was tested with a rubber seat and at atmospheric exhaust which resulted in a very small air flow.

The second valve was run for 45 minutes at 1200 rpm and failed during the last 11 minutes of running. The second valve was made of .012 inch stock, not annealed and was tested with a rubber seat and altitude exhaust.

The third valve failed during the last 4 minutes of a 30-minute test run. The valve was made of .015 inch stock and was tested with a rubber seat and with altitude exhaust.

Valves made with .010 inch stock are currently under tests by the group and valves made with .008 inch stock were scheduled for tests following the .010 inch valves.

Smaller valves than the ones currently under tests, as well as the current test size, will be tested with an aluminum alloy grill and soft seat material. These valves were reported under construction by Mr. Schey's group.

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The Chairman noted that with the grill built up by welding the 52-S alloy being used would be annealed by the heat from welding.

Mr. Schey raised the question as to whether or not the method used to form the seat stock into the curved profile of the valve would affect the serviceability of the material under high stresses.

Mr. Kunen reported that the Metallurgical Laboratory group have tried annealing the seat stock and then heat-treating it back to the original state but had obtained poor results and had given up the work. Various means for bending the valves, annealing and heat-treating were discussed by the group. Mr. Breasman stated that inconel seat material was being considered for tests because of its high impact strength.

Mr. Kunen showed charts of valve position plotted against piston position obtained with the reciprocating piston test rig. A chart was also shown of pressure plotted against piston position that had been obtained.

Mr. J. C. Sanders entered the meeting at this point.

Mr. Schey inquired as to the adequacy of tests of valves larger than the size to be used in the actual design and tested at slow speed. It was the opinion of the group that tests using large valves at slow speed should give accurate results from a comparative standpoint and may possibly be more severe than tests of valves of the smaller size.

Mr. Schey stated that it was his opinion that the valve tested by his group indicated failure by impact on the flat surface and suggested that a rubber seat on the top surface be tried.

Mr. Kunen stated that tests were planned for a rubber seat at the top only and comparative tests with a rubber seat at the bottom only.

Mr. Turner suggested that the impact stresses could be reduced by increasing the seat area. He noted, however, that increasing the seat area would reduce the area for air flow but that if a workable valve can be attained in this manner the loss should not be too serious.

Mr. Mutterperl sketched a valve design his group had worked out in which the valve in the full open position was faired in. The tip of the valve was made with a slight clearance so it would not strike the fairing if it opened past the full open position.

The test program to be followed to arrive at satisfactory valve designs was discussed. It was agreed that tests should proceed as planned to determine the effect of thickness and seat material effects on valve life.

The Chairman inquired as to what had been done toward getting a continuous flow ram jet test started in the wind tunnel. Mr. Mutterperl stated that some thought had been given to following up the Westinghouse jet propulsion unit tests with the unit operating as a ram jet by removing the turbine and compressors. The Chairman stated that it was his opinion that the conversion did not appear as

likely to give good results in a new design made for the specific purpose of steady-flow ram-jet.

Mr. Turner stated that the ejector effect of the vaporizing fuel in the fuel spray might be used for overcoming pressure drop in the burner system of ram-jet and other similar installations.

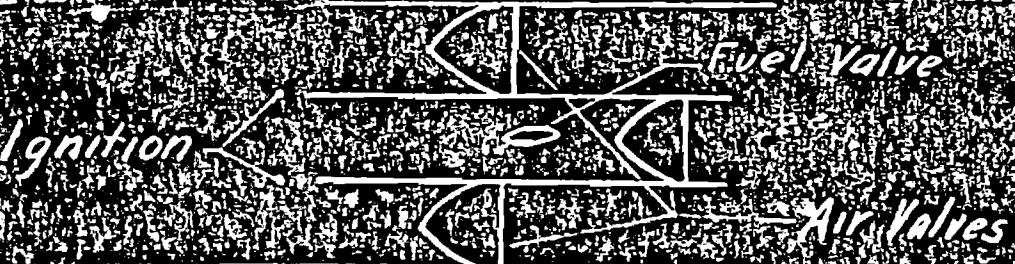
Mr. Sanders read the summary of a report he had written, entitled "A Preliminary Evaluation of the Explosion Jet Propulsion Engine", and briefly reviewed some of the results he had obtained.

The Chairman asked Mr. Sanders to make a study of methods of obtaining a small amount of boost for ram jets with the simplest possible machinery. The purpose of the boost is to obtain good starting and ground running characteristics.

The Chairman stated, for Mr. Sanders' information, that the principal interest of the group is in the intermittent-flow ram-jet, and also the objective of the research being carried out on ram jets for the Navy and the missile for the Army.

The group discussed the possibilities of using the intermittent-flow ram-jet as a burner for the Whittle type unit for increased power and efficiency. It was agreed that such an application of the intermittent-flow ram-jet system offered considerable promise but that future work along that line should wait successful results on the intermittent-flow ram-jet installations now under consideration. The Westinghouse and General Electric jet propulsion units with the necessary high frequency valve operation would be considered at that time.

Mr. Turner reported on progress made by Mr. Pinkel's group in setting up the combustion test apparatus. The scheduled completion date was given as September 18. The fuel system to be used in the apparatus was sketched on the blackboard by Mr. Turner as shown on the following sketch:



The meeting adjourned at 11:45 and the group went over to observe operation of the intermittent-flow apparatus set up by Mr. Silverstein's group for valve tests.

Jesse H. Hall
Secretary Ram Jet Committee

JHH:ink

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Approved Minutes
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September 5, 1944

The Committee met in the Executive Conference Room at AERL on September 5, 1944, at 9:10 a.m. Present:

B. W. Jacobs, Chairman

J. O. Wapchover

R. C. Richard Turner

G. M. Petersen

A. M. Rothrock

J. C. Bressman

A. J. Kinner

M. Mutterperl

A. D. Johnson

Mr. George M. Lewis

Carlton Kemper

Edward R. Sharp

Abe Silverstein

Jesse H. Hall, Secretary

The minutes of the special session on August 24, 1944 were read and approved as read. The minutes for the regular meeting on August 29, 1944 were read and corrections made as noted on revised pages 1, 2, and 3.

The Chairman asked for a report of progress made on valve designs since the last meeting. Mr. Mutterperl stated that tests being made by his group had been interrupted by failure of the chamber in the Engine Research Building. The intermittent-flow test equipment is expected to be ready for test runs by the next meeting.

Mr. Kinner reported that one straight and three curved valves designed along lines similar to the German design had been tested by his group in the reciprocating piston apparatus. The straight valve broke in a very short time because of high flexure stresses near the base. The curved valves opened to a full open position against a flat surface to reduce flexure stresses. The first curved valve tested failed by chipping at the tip. A second valve was tried with the tip in the annealed condition but chipped more extensively than the first. Mr. Bressman noted that there was some doubt as to whether or not the second valve was fully annealed. The third valve was cut with the rolling grain of the material perpendicular to the length of the valve. This valve split near the tip along the rolling grain lines, and chipped at the tips. Bakelite and lucite seats were used in the tests and both seat materials failed. None of the four valves tested lasted more than a few minutes before failure. It is planned to use rubber seats in latter tests.

Dr. Lewis, Mr. Kemper and Mr. Sharp entered the meeting at this point. Dr. Lewis stated that he felt the group should get valves of the proper construction to be tested in the German type unit in the laboratory.

Mr. Bressman stated that valves of one and one-half inch length and three inches width were being made up.

The Chairman read excerpts from a British report concerning possible future improvement to be expected in German robot bombs.

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Dr. Lewis inquired as to what was desirable in seat material and the possibilities of the material under consideration for meeting these requirements. The Director expressed doubt that some of the material that had been mentioned, for seat construction, would be satisfactory from a heat standpoint.

Mr. Jacobs noted that the valves he had observed in some of the German units did not indicate that the valves had been subjected to high temperatures.

Mr. Schenck noted that the valves may receive heat through the grill and other paths in addition to direct transfer from the combustion gases.

Dr. Lewis inquired as to what seat material was used in the German unit. Mr. Jacobs stated that the valves seated on the aluminum alloy grill along the side but that he was not sure about the seating at the tip.

Mr. Silverstein entered the meeting at this point.

The results of tests at Wright Field on the German unit in the wind tunnel were discussed. Mr. Silverstein stated that the test results showing less drag in the sealed condition than was obtained with flow through the valves was to be expected. Mr. Silverstein noted that it might be possible to calculate the approximate valve opening from the drag increase caused by flow through the inlet.

Dr. Lewis inquired as to what might be called the optimum valve opening. The Chairman stated that it was the objective of the group to obtain a valve that would open fully. In the discussion of the valves Mr. Turner noted that tests had been run with double size valves at 1200 rpm, but that the next step would be to test the valves at actual size at full speed.

The Chairman asked for a progress report from Mr. Pinkel's group on combustion work accomplished since the last meeting. Mr. Turner stated that Dr. Williams of the Fuels and Lubricants Division had obtained some interesting results in combustion tests he is running on another project. In tests of a conical-combustion chamber with rear ignition, central ignition had been tried and the explosion report was of much higher intensity than with the regular rear ignition. This indicated that probably ~~central~~ central ignition would result in greater power than rear ignition in intermittent ram jet installations.

Mr. Turner sketched on the blackboard the layout of equipment his group was constructing for combustion tests. The air supply was from a 7,000 c f M capacity blower and pressures up to approximately 40⁰ water should be attained. The foot in which the valves were located was 9⁰ square. The blower capacity would allow velocities up to 200 ft/sec in the combustion chamber. A glass window is to be incorporated in the top of the test unit to provide means for observing the valve action. The length of the combustion chamber is to be full size and the area is to be $\frac{1}{4}$ full size, to obtain the half scale combustion chamber previously agreed on.

Mr. Turner stated that the first type combustion to be tested is by ignition at the front and allowing the flame spheres to drift down stream and when the first sphere reaches the nozzle it should be of sufficient size to fill the opening.

Dr. Lewis inquired as to whether an analysis had been made of the effect of resonance on flow in the German unit. Mr. Silverstein stated that the resonant frequency was of the same magnitude as the frequency of the German unit on the basis of assuming the unit acts as an organ pipe of the same length.

There was some discussion on the effect of simplifying assumptions in calculating the organ pipe frequency of the German unit.

Dr. Lewis stressed the importance of the time element in obtaining results for the Army and Navy projects. It was suggested that results obtained within two months would be of great interest but the results obtained in eight months might be too late to be of interest.

Mr. Turner gave a brief review of the construction status of the combustion test apparatus. Delivery of the glass window appears to be the greatest delaying factor but according to quoted delivery time, the glass should be available in a little over two weeks.

The tests to be run in the test cell of the Jet Propulsion Building on the Ford-built German type unit were discussed. It was noted that the air and fuel consumption of the unit were the most important factors according to Colonel Keim.

Mr. Rothrock described some fundamental combustion tests carried out in the Fuels & Lubricants Division. Gaseous mixtures had been burned in a very short distance with low pressure drop. Combustion air was separated from the main air flow, mixed with the fuel, ignited, and then combined with the main air stream after combustion was completed.

One of the prime objectives of the combustion research was to determine means of vaporizing the fuel to a gaseous state in order to obtain better combustion.

The meeting adjourned at 10:45 a.m.

Jesse H. Hall

Secretary, Ram Jet Committee

JHR:mk

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Revised Minutes of

RAM-JET CONFERENCE

August 29, 1944

The Committee met in the Executive Conference Room at ARL on August 29, 1944, at 9:15 a.m. Present:

E. N. Jacobs, Chairman

B. W. Schey

J. Silverstein

R. H. Ennis

M. Jeierenan

B. Pinkel

F. Kunen

R. H. Ennis

D. Johnson

J. H. Hall, Secretary

The minutes of the previous meeting were read and corrections made as shown on revised page 2.

The progress made on the project for development of a missile since the special meeting on August 24, 1944 was reviewed. Mr. Silverstein sketched a design his group had worked out using a Whittle type unit mounted behind the war head and fuel tanks. The air was taken in at the nose and was ducted over the outside of the war head and fuel tank back to the power unit.

Mr. Silverstein pointed out that with this arrangement a greater length was available between the c.g. and the tail than was the case with the previous two designs considered and should result in better stability. The designs shown had a 25-foot overall length. Mr. Pinkel suggested the use of a glider fuel tank or dropable wing tips incorporating fuel tanks for increasing range. The suggestions were discussed and it was agreed that the use of dropable fuel tanks or glider tanks did not appear promising with the range given in the directive but should be given serious consideration if the range was increased to the order of 1,000 miles. Mr. Silverstein stated that his group would make some calculations on the use of dropable fuel tanks.

The Chairman at this point gave a brief review of the Jet and Turbine Power Plant Committee discussions concerning development of the missile for the Army at the August 23, 1944 meeting. As a result of action taken at the meeting Allis Chalmers, Westinghouse, and General Electric are investigating the possibilities of simplification of their jet propulsion units with the idea of increasing production. The Chairman stated that Colonel Keirn was scheduled to be at the laboratory on September 1 and that at that time a meeting of the Ram-Jet Committee to include only members would be held for the purpose of clarifying the details so that the work on the mock up to be tested would proceed.

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Mr. Rothrock came into the room at this point. The Chairman read a letter from Dr. Barnard to the Washington Office stating that it was his belief that the Germans were using ether or alcohol or ethers possibly from Fischer synthesis gas as the fuel for their robot bombs. This belief was based on the observation of the fuel tanks of the robot bombs. Dr. Barnard had observed from the fuel tanks of one of the robot bombs that had been brought to this country, Mr. Rothrock was told by the Chairman, a comment on Dr. Barnard's observations. Mr. Rothrock pointed out that Dr. Barnard's statements that conventional hydrocarbon fuels were better than higher alcohols or ethers on the basis of burning rate and the heat of combustion alcohol or ethers gave a greater range of combustible fuel and that was significant.

It was agreed that range of combustion mixtures was an important consideration in the general properties of the data. A discussion followed on the combustion problem and burning of lean mixtures. It was agreed that ordinary gasoline should be considered as the fuel to be used in the Army missile.

Mr. Rothrock agreed to prepare a reply to Dr. Barnard's letter.

The Chairman stated that the Bureau of Ships has assigned Standard Oil Company of New Jersey a project for fundamental research on combustion. A copy of the proposed research program was turned over to Mr. Rothrock by the Chairman. With this information Mr. Rothrock left the meeting at this point.

The Chairman read a letter from the Washington Office assigning Research Authorization E-110 to cover design studies, E-111 to cover construction of test units and E-112 to cover testing on the Army project. The letter reprinted outlines to cover proposed work under Research Authorizations E-111 and E-112 by September 5, 1944.

The Chairman reviewed some information he had obtained from Colonel Koenig on the results of tests Wright Field had made on the German robot bombs. The fuel rate was stated to be 2800 pounds per hour at 400 miles an hour with a little drop in fuel rate with speed. The gross thrust at 400 miles an hour was stated to be 820 pounds corresponding to 850 thrust horsepower. Net thrust was given as 410 pounds at 400 miles an hour and increasing to 650 pounds at 200 miles per hour. Drag measurements at 400 miles an hour showed 375 pounds drag with flow and 200 pounds drag with the unit sealed in the cleaned up condition and 400 pounds drag with flow and 315 pounds drag with the unit sealed in the dirty condition.

Several discrepancies between the Wright Field data and the data obtained from the British were discussed but no conclusion could be made because of the lack of information on test conditions and methods used.

It was agreed that the tests to be run at this laboratory would be with a fairing nose and tail and that the power plant would have to overcome this amount of drag as far as that net thrust could be used in calculations made by the laboratory.

Progress made since the last regular meeting on valve designs and combustion chamber studies was reviewed. Mr. Johnson reported on tests that had been made of the valve according to Mr. Jacob's proposal of .015 inch stock. The valve opened approximately 1/2 of the full opening and could be taken through the critical speed at which the valve vibrated at 2800 cycles per minute. Valve vibrations started at an entering air velocity of 200 feet per second and stopped down at around 240 feet per second. Valve thicknesses down to .008 of an inch will be tried in this valve design. The second valve design being tested by Mr. Silverstein's group had been made with .004 inch stock and 3/4 inch effective chord length. No flutter was encountered in the tests but it was believed that the stock used was too heavy and further tests will be made using .005 inch stock and .002 inch stock.

Mr. Muntarper stated that the intermittent-flow apparatus being made up by his group will be ready to demonstrate by the next meeting. Mr. Kunen reviewed some calculations he had made on the constant volume cycle using assumptions considered to be practical. Curves were presented showing the effect on efficiency of combustion time. An efficiency of 7.0% attained with a .002 second combustion time was reduced to 5.8% efficiency with .008 second combustion time. The objective of the study was to determine the effect of the time element of the different cycle phases on combustion chamber length. The study showed that a combustion chamber length of over 4 feet in length was not necessary from an efficiency standpoint.

Means for taking care of high decelerations encountered in valve operation were discussed. This included the use of rubber seat, resilient seat construction, resilient valves and grids made of plastic with proper resilient properties.

Mr. Turner reported on a twin system spring loaded valves designed with the valves commanded by a linked system.

The problem of getting up combustion testing equipment in a minimum time and the scale to be used was discussed by the group. It was agreed that a unit similar to the German unit with valves that would close very rapidly should be used as a single shot system. The scale should not be less than 1/2 size. The Chairman asked Messrs. Pinkel, Schay and Rothrock to meet in his office after lunch for the purpose of determining the best location for the combustion test setup.

The meeting adjourned at 1:00 p.m. when Mr. Schay reported that the reciprocating piston unit was ready for demonstrating valve tests.

John R. Hall,
Secretary Ram Jet Committee

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REF ID: A6510

August 24, 1944

The Committee met in the Executive Conference Room at ARRL on August 24, 1944 at 10:30 a.m. The members present were:

H. C. Jacobs, Chairman
C. E. Schrey
A. P. Kunnen
J. R. Dressman
Richard Turner
W. Pejarcson
Benjamin Pinkel
W. Mutterperl
A. D. Johnson
T. H. Hall, Secretary

The Ram Jet Committee added a special session for the purpose of discussing proposals to meet the Army's specifications for a missile.

The Chairman asked for a progress report concerning the results of the survey made by each of the three groups. Messrs. Pinkel and Turner stated that their survey showed that four German units could be used if the range is 100 miles or under. For most ranges over 100 miles it is their opinion that the Whittle-type unit should be used.

Mr. Kunnan stated that a survey he had made indicated that the Whittle-type unit would be the most desirable if the range was 400 miles or over. Mr. Mutterperl stated that his calculations showed the Whittle-type unit as being best for most ranges and would come nearer to meeting high-speed specifications than any arrangement with the German type unit.

Mr. Silverstein stated that it was his opinion that 550 miles per hour may be a little high even with the Whittle unit.

Mr. Mutterperl presented a chart showing performance factors and means for meeting the performance factors, utilizing various power plants, including conventional engines, jet engines, and steady and intermittent flow ram jets.

Mr. Silverstein stated that his group was studying front and rear positions for the power unit installation.

Mr. Mutterperl showed a layout that he had made with the Whittle unit located at the rear using an annular inlet and axial jet. The second layout which he had started was shown with the Whittle unit located in front and the discharge made in the form of segments of an annulus. The location and arrangement of the discharge had not been completed on the layout. The possible losses and other factors involved in the discharge jets for this installation were discussed. The maximum diameter of the envelope for the two layouts was 43 inches.

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Estimated figures on the proposed design includes 7,700 pounds fuel, 9,000 pounds gross weight, 12% overall thermal efficiency and 1.14 pounds fuel consumption per thrust horsepower hour and a range of 400 miles.

Calculations will also be made on the designs for ranges of 400, 700 and 1,000 miles. Mr. Mutterperl noted that in making the design study assumptions involving drag and take off were considered questionable.

The specific proposal to be submitted as a recommendation was discussed and it was agreed that the Whittle type unit was the most desirable propulsion unit in view of the specifications laid down and further studies would be made on the unit designed along the lines followed in the layout shown by Mr. Mutterperl.

The meeting adjourned at 11:15 a.m.

Jesse E. Hall,
Secretary, Ram-Jet Committee.

JRR:mk

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RAM-JET CONFERENCE

August 22, 1944

The Committee met in the Executive Conference Room at A.M.C. on August 22, 1944 at 9:15 a.m. Present:

Mr. Jacobs, Chairman
Dr. George W. Lewis
Mr. Edward B. Sharp
Mr. Oscar M. Schey
Mr. Richard Turner
Mr. Feiereisen
Mr. Silverstein
Mr. Benjamin Pinkel
Mr. Mutterperl
Mr. E. Littell
Mr. Carlton Kemper

Mrs. Jesse H. Hall, Secretary

The minutes of the previous meeting were approved as read. Mr. Mutterperl, however, had a correction to a statement he had made which was recorded in the minutes of the previous meeting. The value of 27 cycles per second frequency for Mr. Jacobs' valve design should have been given as 100 cycles per second.

The Director of Research reviewed projects received by the Committee from the Army and Navy for research on ram-jet installations. The Navy project had only one specification, which was to keep the diameter down to 20 inches. Steady-flow and intermittent-flow ram jets are included in the Navy request. The Army has requested research on a specific installation. The Army request is for research that will lead to development of a missile that will have a range of 400 miles at 650 mph, and will carry a 4000 pound war head. As a result of the Army request, Dr. Durand called a conference in Washington to discuss the proposed research. The research is to include power plants that obtain oxygen from the air and is, therefore, not to include rocket propulsion. The aerodynamic aspects of the Army project will be worked out by LMAL. Mr. Jones, of LMAL, has carried out research which has resulted in improvement of the stability and control of the missile.

The Director suggested that the first phase of the Army project should be a survey of the possibilities of attaining the specifications as laid down, and to determine the approximate size and cost of a missile that will meet the specifications. Dr. Lewis noted that the German robot bomb was estimated to cost \$3000.00.

Dr. Lewis stated that he had recently talked with Mr. Coombs about tests of the German robot bomb at the Royal Aircraft Establishment. Mr. Coombs stated that the unit had overheated on ground tests. (Mr. Jacobs stated that Wright Field had used a blower at the inlet for their tests which had an annular slot to give a jet of cooling air over the outside surface with satisfactory results.)

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The Chairman asked for a progress report from the various groups. Mr. Mitterperl reported on some calculations he had made on the effect of loss of Q in the inlet system. His calculations showed that with 135 percent Q , and one slug of air per second, 1750 pounds thrust could be obtained, which would give 8.44 percent thermal efficiency at 500 mph. With 0 (zero) Q , the thrust was reduced to 1350 pounds, and the efficiency to 6.55 percent. Corresponding fuel consumptions were 1.63 pounds per thrust horsepower-hour, and 2.07 pounds-per-thrust-horsepower-hour, with 135 Q and 0 (zero) Q respectively. A model of a valve, built in accordance with the design Mr. Mitterperl had shown at the meeting of August 15th, was shown. Mr. Kunen reviewed the progress that had been made on the design and construction of the reciprocating piston test unit for inlet valves. Two valve designs that had been worked out by Mr. Kunen's group during the past week were presented. In one of the valve designs, the valve was designed to bend during the high pressure period, and with a rapid decrease in pressure, the energy stored by bending would be released to assist in rapid opening of the valve. Mr. Pinkel stated that it was his belief that the pressure drop would be too slow to obtain good results with this design feature.

At this point, Mr. Schey inquired of the Director of Research as to what priority should be assigned to the ram-jet projects. The Director stated that the research should carry an A priority but should be considered along with other A priority projects.

Dr. Lewis stated that Colonel Keirn had just called and that the first Ford built unit would be ready in a day or two. It was suggested that it would be very desirable to get one of the Ford units for tests in the Altitude Wind Tunnel and for Colonel Keirn to visit the laboratory to discuss the tests. Mr. Silverstein noted that the tunnel was at present closely scheduled.

Mr. Turner reviewed progress that had been made on the twin system designed by his group. He stated that obtaining proper timing was a difficult problem. Attempts were being made to avoid low pressure suction in the system, but low pressure suction may be necessary at low speeds. Strange efforts are being made in the design to get a full charge. Mr. Turner stated that long nozzles would be beneficial for slow speed operation. Mr. Jacobs inquired as to the extent of losses that might be anticipated with long nozzles. Mr. Turner stated that in tests he had conducted with long nozzles on single-cylinder exhaust pipes, there had been little loss in mean jet velocity with length. Mr. Kemper inquired as to what lengths had been used. Mr. Turner stated that lengths up to 4 feet had been tested. Mr. Turner noted that in the German design, the combustion-chamber-to-tail-pipe air ratio was approximately 2, and that with 2000 ft/sec nozzle velocity, ram pressures could not maintain proper combustion chamber velocities. With an area ratio of 4:1, approximately two times the power should be obtained with only a small increase in over-all diameter.

The Director raised the question as to whether the work was leading away from good ground operation to attain optimum operation at high speed. It was agreed that this point was well taken and the suggestion was made that a jettisonable tail pipe be used to improve ground operation. The Chairman

asked for quantitative statements on the improvements that appeared possible for the performance of the German unit. Mr. Pinkel stated that it appeared possible to get from 4 to 5 times the power at twice the efficiency. Mr. Muttarparl stated that efficiencies of the order of 8-1/2 percent appeared obtainable in comparison with 3 percent of the German unit. The Chairman stated that it was the objective of the group to get as close to the theoretical performance as possible by an experimental approach and in accordance with the general objective as previously stated. A specific installation had been requested on which to work and now had been received. The Chairman read the letter that had been written by the Washington Office to this laboratory concerning the research to be conducted on the proposed missile for the Army. A copy of the letter from the Army to the Washington Office, setting up the requirements, was also read. The Chairman reviewed several methods of attack on the power plant installation that could be used to meet the Army requirements. Types mentioned were the Whittle type, the continuous ram jet, and a Chinese copy of a German unit.

The next meeting for the group was set for Thursday at 9:00 a.m. The three groups were requested to survey the different possibilities of meeting the Army requirements and make sketches by the next meeting. Preliminary estimates for the group to work on included 9000 pounds gross weight with a thrust of 1200 pounds and possibly up to 1500 pounds needed to attain the 550 mph velocity requirement.

The meeting adjourned at 11:25 a.m.

Jesse H. Hall

Jesse H. Hall

Secretary Ram Jet Committee

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RAM JET CONFERENCE

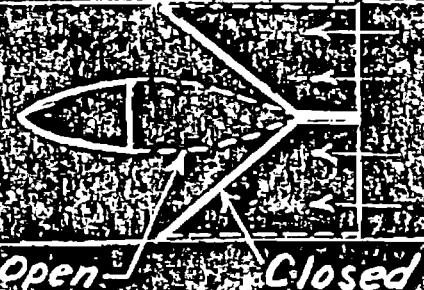
August 15, 1944

The Committee met in the Executive Conference Room at AERL on August 15, 1944 at 9:15 a.m. Present:

E. N. Jacobs, Chairman
Benjamin Pinkel
L. Richard Turner
O. W. Schey
W. Mutterperl
A. D. Johnson
A. E. Kunen
J. E. Bresman
Carlton Kemper
J. H. Hall, Secretary

The minutes of the meeting of August 5, 1944 were approved as read.

Progress made on valve designs and tests was reviewed. Mr. Mutterperl reported on the results of the test his group had made on their own design and the model supplied by Mr. Jacobs. The valve design made up by Mr. Mutterperl's group was destroyed by flutter early in the tests. The test results on the valves supplied by Mr. Jacobs showed comparatively high pressure losses. A valve design based on the two valves tested was sketched on the board as shown in the following sketch:



Mr. Mutterperl stated that a valve of this design would be made up and tested.

Mr. Kunen discussed the results of further calculations on the valve design he had shown at the previous meeting. The spring constant was found to be high because of the inertia of the valves used in the design and revisions were made to reduce the inertia of the moving parts, but the reduction in inertia by the revision was not considered sufficient to make the design promising. Mr. Jacobs suggested that valves should be designed to utilize the inertia effects to throw the valves open if possible.

A discussion followed on the possibilities of the use of a combination of valve frequency and inertia to accomplish better valve operation. The effects of losses in air and charge efficiency caused by inlet valves was discussed.

Mr. Turner showed drawings of a twin system using a common inlet and the linkage

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system between two sets of valves. The explosion pressure from one combustion chamber in this design is used to open valves in the second combustion chamber. The explosion pressure is used to set springs in the linkage that are triggered by small motion of the valves on opening to rapidly complete the valve opening to the full open position. The group agreed that this valve system offered many advantages, but that simple valves would be given first consideration. The construction of the more complicated valve system would proceed in order to be ready for test later in the program.

Mr. Johnson gave further details on the valve tests previously reported by Mr. Mutterperl. He described the type of flutter encountered in testing valve design submitted by Mr. Jacobs at air velocities of 80 ft/sec and 250 ft/sec. A frequency of 80 ft/sec was stated to be approximately 1650 cycles per minute. Mr. Kunen raised the question as to whether frequency of the order of 27 cycles per second in steady flow tests should be considered objectionable. It was agreed that a valve should not be thrown out on this score until it had been submitted to intermittent flow tests.

Mr. Kunen discussed the design, on which his group was working, of a valve test chamber mounted in place of the cylinder head on a single-cylinder engine to utilize the reciprocating piston of the engine for intermittent flow testing. The design included a throttle valve downstream from the rectangular test section. The valves under test were bolted on the front of the test section and glass windows were provided to observe valve motion.

Progress during the week on combustion chamber designs was next discussed. Mr. Mutterperl discussed an analysis he had made on a ram-jet system designed to handle one slug of air per second. Fifty cycles per second and 2000° F mean temperature were assumed. This resulted in a combustion chamber having a volume of 7 cubic feet, exit area of .62 square feet, inlet area of 3 square feet, and with dimensions of 24 inches diameter and 28 inches long. Combustion chamber velocity was 200 ft/sec. The performance of this unit at a fuel-air ratio of .032 was 1700 pounds thrust with a fuel consumption of 1.65 pounds per thrust horsepower hour at 500 mph and over-all efficiency of 8.4 percent. This compared with 1066 pounds net thrust and 6.84 percent efficiency for the Whittle-type unit.

The Chairman asked for a discussion as to what velocities would be desirable in the combustion chamber. A discussion followed on combustion chamber velocities and the effect of this velocity on combustion and efficiency of the cycle. It was agreed that compromises that serve to increase losses, in order to improve combustion, should not be made until proven necessary. Tests on combustion chamber designs would be made to determine limiting velocities that could be allowed from a combustion standpoint. Mr. Turner suggested that combustion should be started from a series of sparks along the axis of the combustion chamber. It was pointed out that flame, started by a spark, could move with the stream and still constitute satisfactory combustion. This was contrasted with the steady flame that must be maintained in the steady-flow type of ram-jet.

The size of combustion chamber and its relation to exit area was discussed. Mr. Mutter perl stated that his group was considering an area ratio of 5:1, and Mr. Turner stated that his group was considering an area ratio of 4:1. In the discussion of the various velocities in the system, it was pointed out that entrance velocities of 200 ft/sec at 500 mph could be used and still maintain pressure recovery between 80 and 85 percent q. It was agreed that combustion chamber velocities should be of the order of 200 ft/sec or higher provided efficient combustion could be attained.

Mr. Pinkel showed a drawing of a test setup to study combustion chamber design. The setup consisted essentially of a mount for a complete unit with means for measuring thrust and a source of air at pressures up to 40 inches water with a surge chamber mounted just immediately upstream from the unit on the test. The unit would be mounted vertically and would, therefore, allow fuel to drop into the surge chamber in the event of leaks occurring when the unit was not in operation. The possibility of explosions occurring in the system and means for prevention or control of such an explosion to render it harmless were discussed at length. Mr. Pinkel is to submit the proposed setup to the Laboratory Safety and Security Committee for recommendations. The possibility of mounting the proposed test rig in a horizontal position is also to be looked into.

During the next week, the group is to continue work on combustion problems and is to study possibilities of using a single-shot system or other schemes that will allow getting combustion tests under way as soon as possible.

Jesse H. Hall

Jesse H. Hall,
Secretary,
Sam Jet Committee.

JHH:db

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RAM-JET CONFERENCE

August 8, 1944

The Committee met in the Executive Conference Room at AECI on August 8, 1944 at 9:15 a.m. Present:

E. H. Jacobs, Chairman
Benjamin Pinkel
L. Richard Turner
O. M. Schey
A. M. Rothrock
J. Mutterperl
A. D. Johnson
A. E. Kunen
Wm. Petersen
J. H. Hall, Secretary.

The minutes of the meeting of August 1, 1944 were approved as read.

Progress made during the preceding week on inlet-valve designs was reviewed. The discussion concerned the question of what is desirable in valve designs and drawings and models of proposed valves. Mr. Kunen stated that he felt that automatic valves should be considered first, but with spring-loaded-automatic valves, the losses would likely be high. Mechanical designs to get around this loss were being considered by his group. Mr. Pinkel suggested that the spring-loaded valve offers too much restriction if operated from pressures existing during the charging part of the cycle. He pointed out that the valves should be operated by the explosion pressure, but that a time lag would be involved which indicated the need for energy storage. Mr. Turner stated that his calculations showed that an area greater than two-and-one-half times the exit nozzle area was required on the inlet side for good charging.

Mr. Mutterperl exhibited a model of an automatic valve which he stated would open with a pressure equivalent to three inches water existing at the leading edge. Mr. Kunen presented a drawing of a valve design consisting of air foils pivoting back of the leading edge and held shut by coil springs. Mr. Kunen stated that with his design after a small movement of the air foils had taken place, the airfoil lift assisted in opening, and when the velocities dropped, the loss of lift allowed the springs to close the valve. Mr. Turner pointed out that with sealing at two points with a pivot between, as used in Mr. Kunen's proposed valve, a difficult problem arose, because contact at one edge, with clearance at the pivot, would allow opening at the other edge. Mr. Schey stated that a small amount of spring action at the contact edges could be used to compensate for clearances.

At this point Mr. Jacobs briefly discussed the starting procedure of a German ram-jet unit which he had observed on a recent trip to Wright Field.

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He stated that considerable difficulty was encountered in starting the unit and that the first explosion was very violent. From this observation, he stated that it was very apparent that valves to be used in this type unit must be mechanically strong to withstand the violent initial explosion.

Mr. Turner discussed calculations which he had made on valve acceleration impact. His calculations showed that valve motion with respect to acceleration and impact considerations attain optimum conditions in the range between 45 and 90° maximum movement. Mr. Turner presented drawings of two valve designs of the automatic type and stated that some work had been done on a mechanical design valve using Geneva type motion. Mr. Jacobs exhibited a model of a valve which was very similar to the German model except for a flap at the trailing edge made by bending the sheet stock used in the valve.

In the discussion of valve characteristics, Mr. Turner pointed out that full opening was needed to get good area ratio between inlet and exit. Mr. Mutterperl stated that full closure was necessary to prevent losses. In connection with the rapidity of pressure rise that might be attained for automatic valve closure, Mr. Jacobs said that pressure rises up to detonation were attainable.

At this time Mr. Jacobs asked for comments as to which valves should be used in the first test. Mr. Schey suggested that simple valves should be tested first if these tests could be carried out rapidly and the designs ruled out if desirable. The group agreed with this suggestion.

In connection with the combustion part of the cycle, Mr. Jacobs stated that, in his opinion, the inlet valve should stay open until combustion started, to prevent loss in pressure between valve closure and start of combustion. He also stated that combustion should start at the back, or combustion should be completed very rapidly. The group concurred with these ideas. It was suggested that a twin system be used with ignition controlled by valve timing. Mr. Pinkel said this idea had been included in one of the designs by his group.

Work for the ensuing week by the various groups is to include further work to complete the valve designs believed most promising to the point where construction of the models could be started. Tests of valves are to be started as soon as the designs are completed and the valves can be constructed. The valves are to be static tested first to determine flow characteristics. After static tests are completed, tests will be made in a device utilizing a reciprocating piston downstream from the valves or other intermittent-flow schemes to simulate operating conditions.

The scale of the models to be used for flow tests was discussed. It was agreed that model sizes to be used in tests would be determined by the practical factors involved by the particular design and that individual test groups would determine what size models to use with the general idea that actual operating conditions would be simulated as closely as practicable. Drawings and sketches of combustion systems are to be made by the various groups for presentation and discussion at the next meeting of the Committee. The Chairman emphasized the

need to get tests underway in order to get results as soon as possible. The Ram-Jet projects should be considered a full-time job for some junior staff members so that the projects will be kept moving.

The meeting adjourned at 11:10 p.m.



Jesse H. Hall,
Secretary, Ram-Jet Committee.

JHH:db

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RAM JET CONFERENCE

August 1, 1944

The Committee met in the Executive Conference Room at AECI on August 1, 1944 at 12:00 noon. Present:

E. E. Jacobs, Chairman
Benjamin Finkel
L. Richard Turner
Abe Silverstein
A. D. Johnson
W. Mutterperl
O. W. Schey
A. E. Kunen
Carlton Kemper
Jesse H. Hall, Secretary

Visitors

Sir B. Melville Jones
H. S. Muir
B. Lockspiser
R. E. Littell

1. The Ram Jet Committee met with Sir B. Melville Jones and Messrs. Muir and Lockspiser as visitors in order to obtain any additional information that the British had available on the German robot development. Sir Melville discussed some of the work being carried out by the British on supersonic flight. He stated that a rocket, with five cameras arranged to record the movement of the unit as it slowed down through the sonic range, had been built into a jet unit to obtain supersonic velocities. Another line of attack was to drop lead weights with small wings from 35,000 feet altitude with data being recorded by telemetering. The Miles Company is scheduled to build an airplane with thin wings and jet unit built by Power Jets, Ltd. Sir Melville stated that it was his private belief that the airplane would not attain speeds over 600 miles per hour but that some information would be obtained from the project.

2. Sir Melville stated that in order to get a ram jet in the air as soon as possible, a ram-jet unit was being installed in part of the cooling ducts of a Mustang. This project will be ready for test soon and may add 50 miles per hour to the top speed.

3. The Germans have laid down sites for launching robot bombs of the ten-ton size mentioned in the papers. Sir Melville stated that he had heard some talk of robot bombs as large as 80 tons. Mr. Muir read from his notes the information that he had obtained on the German robot bombs currently being used. He stated that some of the robot bombs were equipped with radio transmitters to enable the Germans to follow their course. The weight analysis made by the British showed 45 percent bomb load, 33 percent structure, and 22 percent fuel, power plant, and controls. The power plant was stated to weigh 400 pounds and the total weight 800 pounds. The wing loading was

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- 2 -

was calculated to be 87 pounds per square foot, and the stalling speed was estimated at 200 miles per hour from the calculated drag curves. The dive at the end of the flight was originally controlled by time clocks, but later models were believed to be equipped with an airlog on the nose to control the dive. Instead of coming in under power, some of the recent versions of the robot bomb glide silently and then dive.

4. Information given on the ram-jet unit was that explosion pressure was between three and four atmospheres, the air flow from seven to nine pounds per square inch, and the fuel consumption from three to four and one-half pounds per hour per pound of thrust. The thrust was estimated at 590 pounds at 400 miles per hour from calculated drag curves. The natural frequency of the valves was stated to be around 200 cycles per second, which was well above the operating range.

5. In combating the robot bombs, the British tried to shoot them down during the climb. The turn after takeoff occurs from three to four minutes after launching. About one-third of the units launched arrive in London. Quite a number are shot down by fighter planes and anti-aircraft, and recently, balloons have been used more effectively. In a ten-day period, approximately 3600 were launched, of which approximately 1200 reached London, and approximately 2400 made land fall. Blast effect of the exploding bombs was said to be very bad, as the bombs were equipped with a very sensitive fuse, and would explode on contact with buildings well above the ground.

6. Mr. Jacobs stated that the laboratory was interested in the ram-jet cycle as a power plant installation, but would work on specific ram-jet installations for missiles if requested. Messrs. Turner, Mutterperl and Kunen discussed theoretical analyses which they had made on steady-flow and intermittent-flow ram-jet cycles. Mr. Jacobs noted after this discussion that if the theoretical performance is approached, the power and economy of the ram-jet approaches that of the Whittle type unit.

Jesse H. Hall

Jesse H. Hall,
Secretary, Ram-Jet Committee.

JHH/db

~~CONFIDENTIAL~~

Kc P/R/P

V. Emergency

Combustion process

Initial conditions of fuel & air
Fuel assumed negligible
Burnt gas assumed constant pressure
Mass of fuel burnt = m_f
equation of the first law of thermodynamics

$$\delta U = \int \left(\frac{\partial U}{\partial T} dT + \frac{\partial U}{\partial P} dP + \frac{\partial U}{\partial m} dm \right) + P_{ext} \delta V - Q_f \delta T_f$$

where

δU internal energy change

A, B constant thermodynamic constants (Referred
to standard conditions of fuel)

For combustion at constant pressure combustion

$$\frac{P}{P_0} = \frac{P_f}{P_0} e^{\frac{Q_f}{R} \left(\frac{1}{T_0} - \frac{1}{T_f} \right)}$$

or $P_f = P_0 e^{\frac{Q_f}{R} \left(\frac{1}{T_0} - \frac{1}{T_f} \right)}$

being P_0 initial pressure

at final temperature

$$I_1 = \frac{3}{4} \sqrt{2} \left(\frac{1}{2} \sin \theta + \frac{1}{2} \cos \theta \right) = \frac{3}{4} \sqrt{2} \sin \left(\theta + \frac{\pi}{4} \right)$$

a)

$$I_2 = \frac{3}{4} \sqrt{2} \left(\frac{1}{2} \sin \theta - \frac{1}{2} \cos \theta \right) = \frac{3}{4} \sqrt{2} \sin \left(\theta - \frac{\pi}{4} \right)$$

The intensity of the light at the output of the polarizers in figure 1 (parts 1, 2 and 3) is given by $I_{\text{out}} = I_1 + I_2$.
The intensity of the light at the output of the polarizers in figure 1 (parts 1, 2 and 3) is given by $I_{\text{out}} = I_1 + I_2$.

$$I_{\text{out}} = \frac{3}{4} \sqrt{2} \left[\sin \left(\theta + \frac{\pi}{4} \right) + \sin \left(\theta - \frac{\pi}{4} \right) \right] = \frac{3}{4} \sqrt{2} \cdot 2 \sin \theta \cos \frac{\pi}{4} = \frac{3}{4} \sqrt{2} \cdot 2 \sin \theta \cdot \frac{1}{\sqrt{2}} = 3 \sin \theta$$

The main reason for the
impasse is the lack of
confidence in the
ability of the FCA

to make progress in
negotiations.

It is also felt that the
FCA has been too
aggressive in its
demands.

FM 1-13

1. The FCA has been
very aggressive in
its demands. This
has caused a
lot of friction
between the two
parties.

1) The expansion of the gas is adiabatic
2) The initial temperature is constant
3) The final pressure is constant

4) The final temperature is constant

5) The final volume is constant

6) The final density is constant

7) The final velocity is constant

8) The final mass is constant

3

For training and local passenger traffic

AT

AMAR

$$\frac{P}{2} \cdot \frac{P}{2} = \left(\frac{P}{2}\right)^2$$

CONCERN

Pr. 1 P.

$$2T \cdot P \cdot V^2 \cdot S$$

4

Power of flight motor

For a given weight of aircraft

the optimum value of

$$V = \sqrt{\frac{W}{2T}}$$

is given by

$$W = M \cdot V^2 \cdot A + T$$

where M = mass of aircraft

A = area of wing

T = thrust of engine

V = velocity of aircraft

$M = W - T / V$

and $A = C \cdot V^2$

$C = \text{constant}$

$W = C \cdot V^2 \cdot A$

is given by

$$W = C \cdot V^2 \cdot A + T$$

or $W = C \cdot V^2 \cdot A + T$

$W = C \cdot V^2 \cdot A + T$

$W = C \cdot V^2 \cdot A + T$

$W = C \cdot V^2 \cdot A + T$

$W = C \cdot V^2 \cdot A + T$

$W = C \cdot V^2 \cdot A + T$

7. *Amber in May*

AV = $(V - V_0)/V_0$

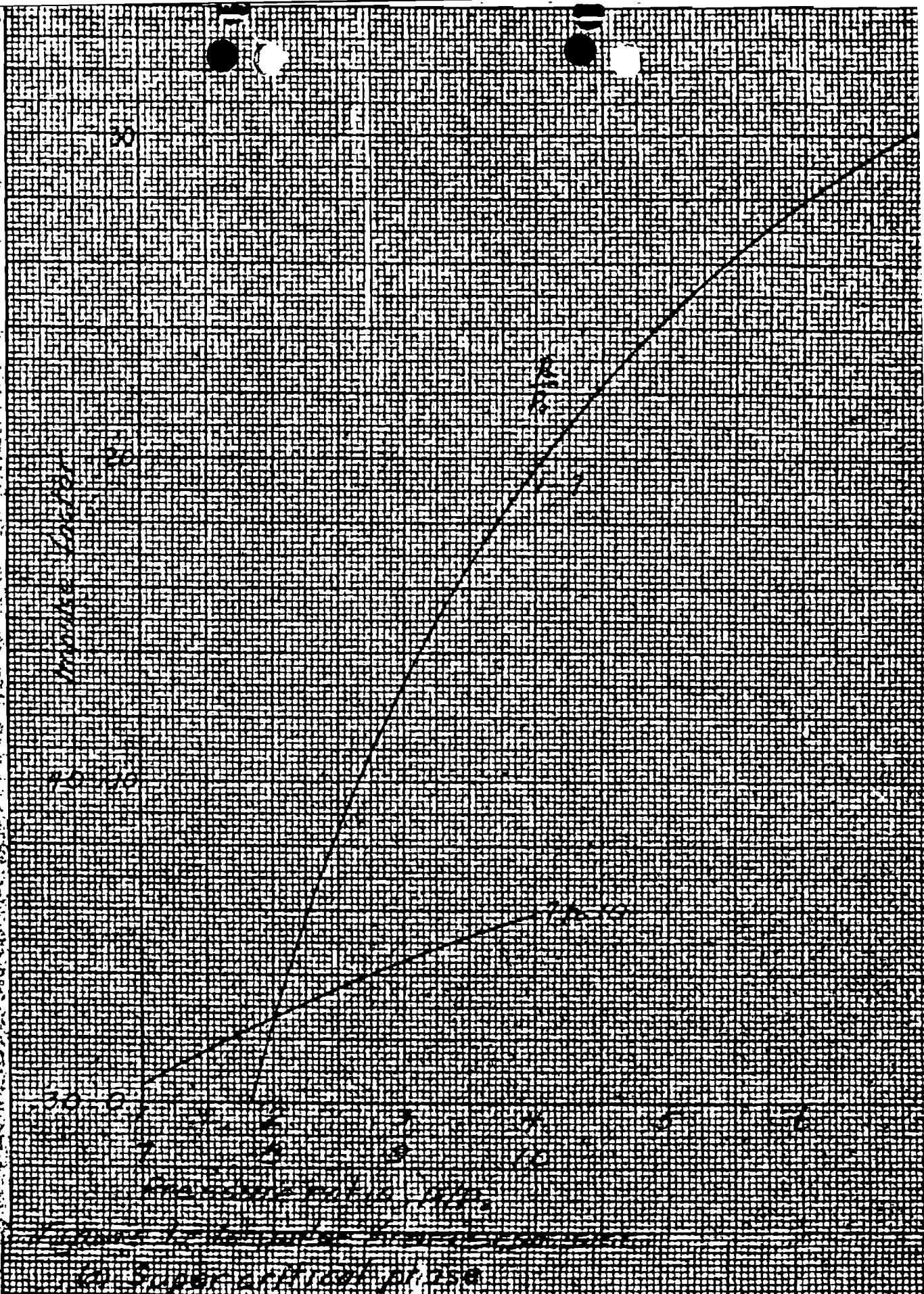
Amber = $\frac{1}{2} \ln(1 + AV)$

type = $\text{YEAR} \times \text{TYPE} / (V_0 + V) = \frac{1}{2} \ln \frac{V_0}{V}$

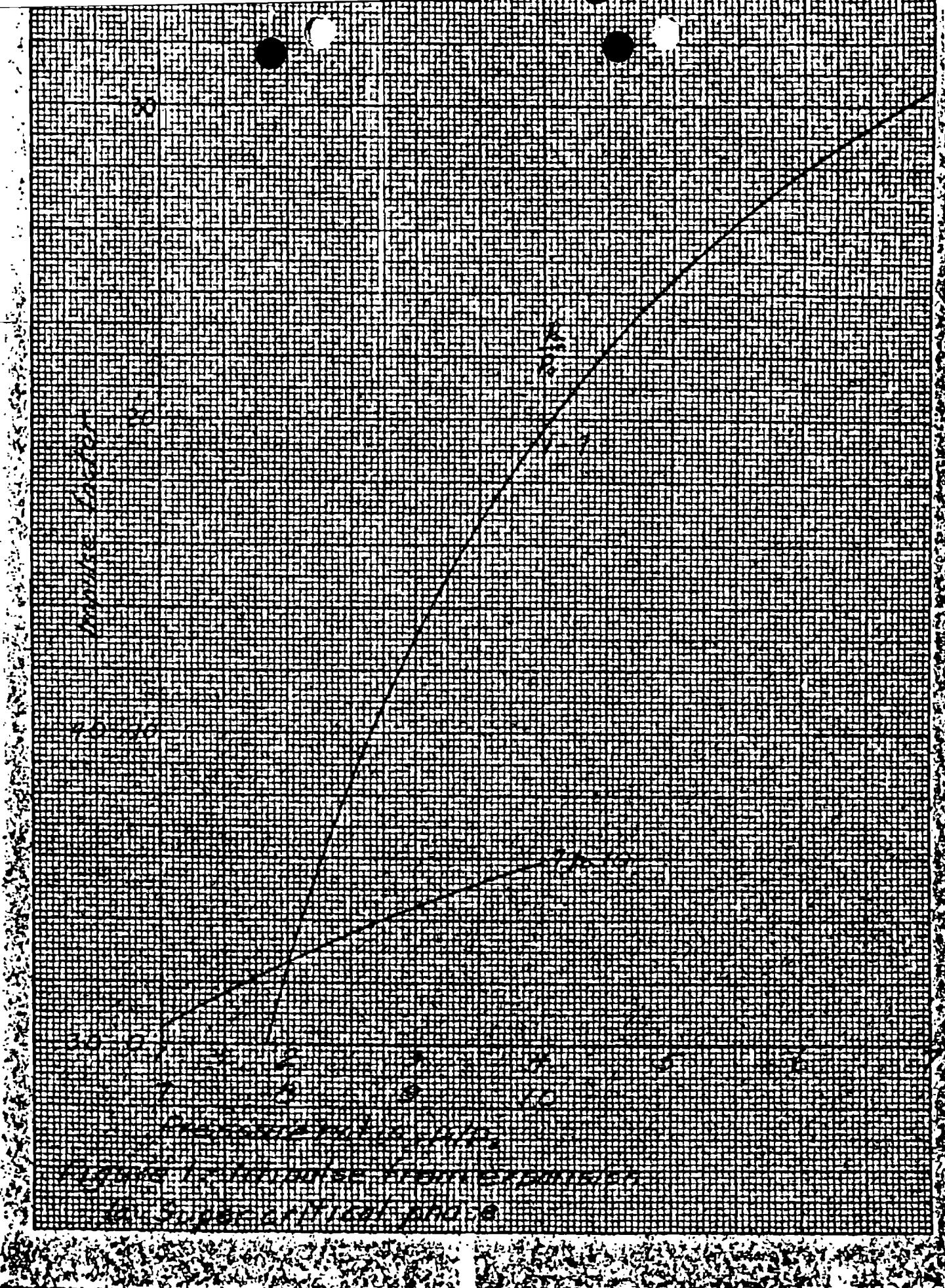
NOPAD

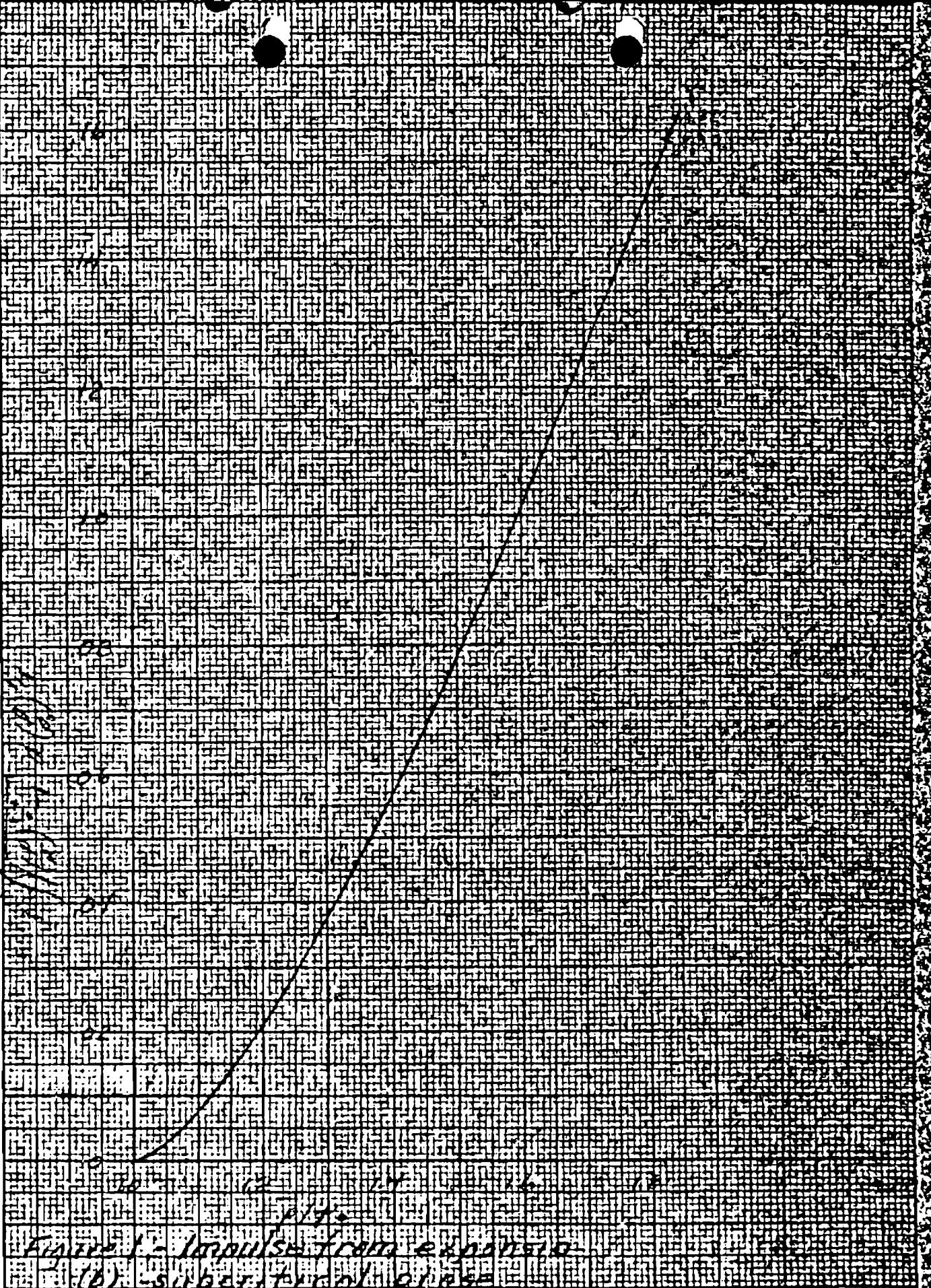
Amber = $\frac{1}{2} \ln(1 + AV)$

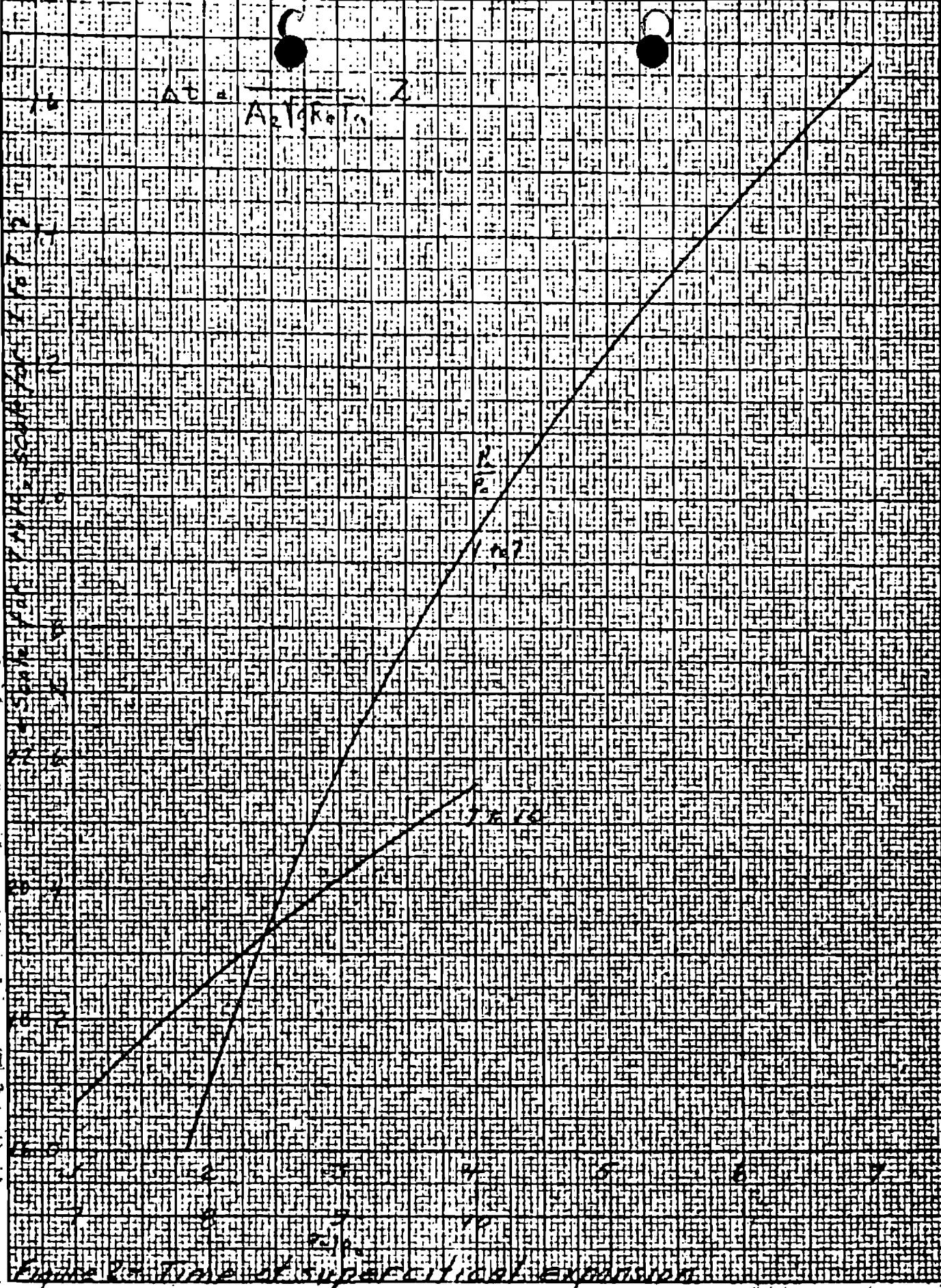
Figure 5 shows the approximate
expansion of the system. The column passing
through V has constant fuel-air ratio and
constant air density. The column passing through
the region of mass pulsed flow and passes
into the constant shape pp. 12
which corresponds to 400 cm.
The expansion of the system
is shown in Figure 5. It is seen
that the flow can be divided
locally speed and into the total system
is constant. The



100 200 300 400





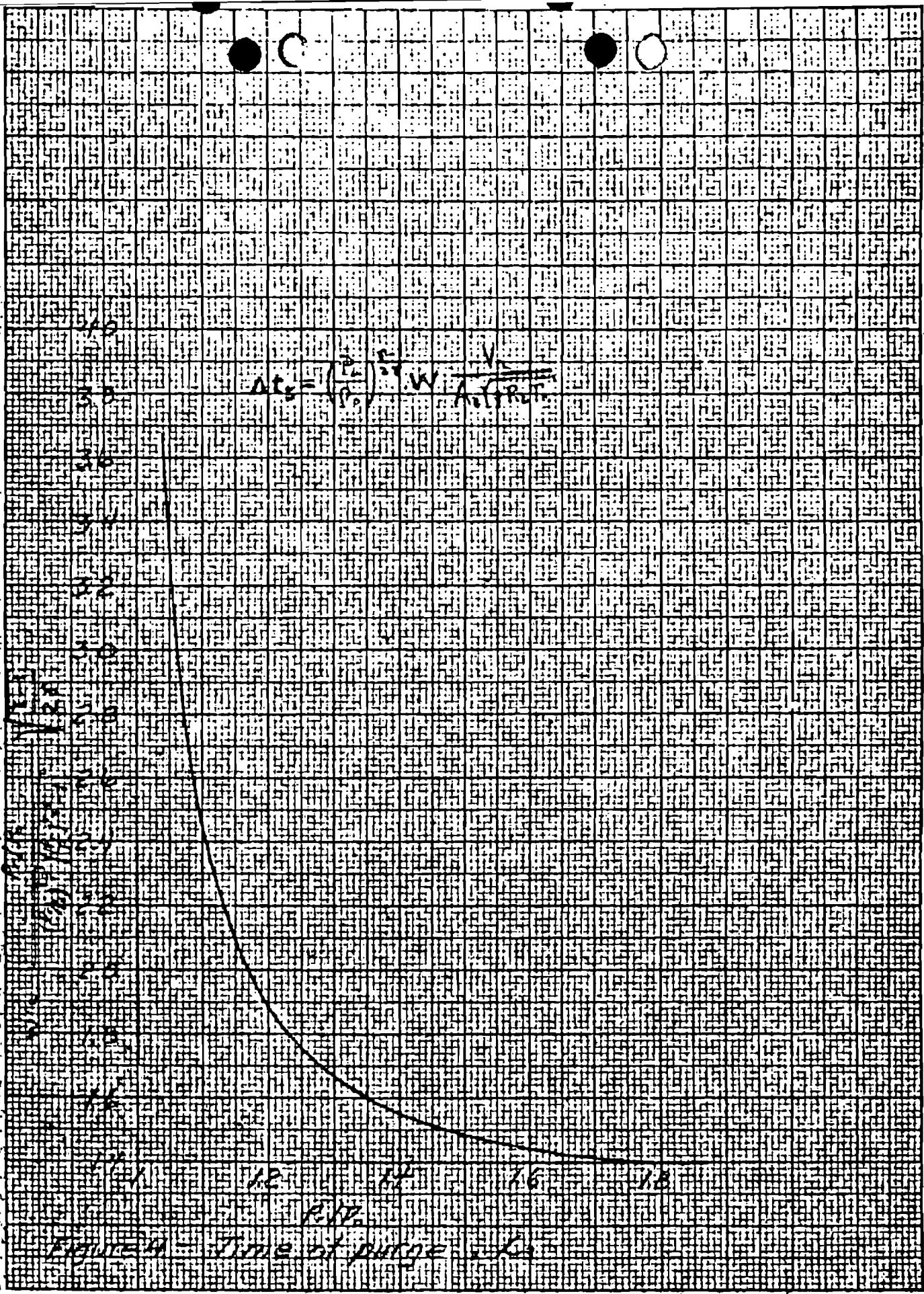


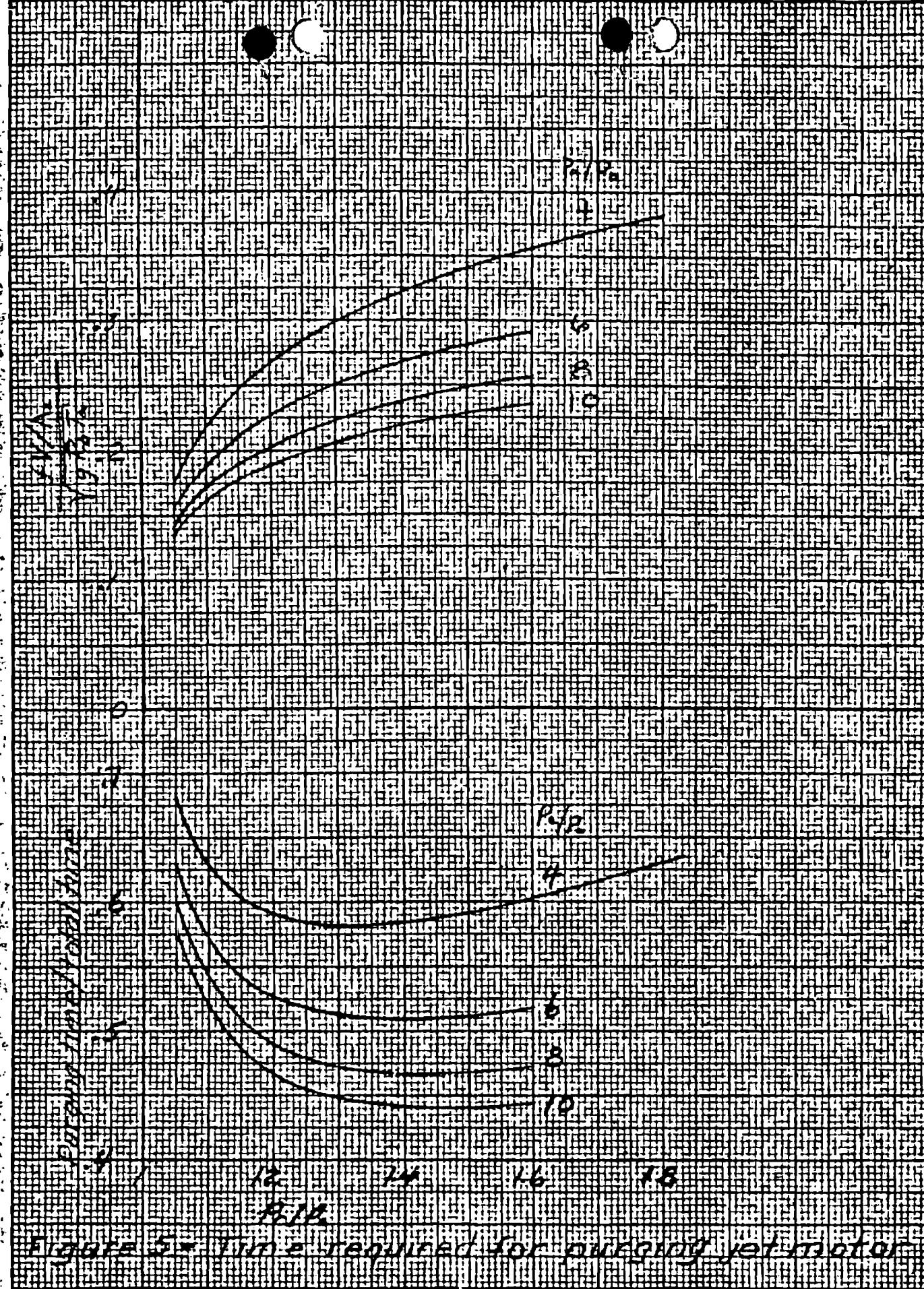
A 100

Figure 10.20. 100 x 100 grid

14759

14759





Julius Rosenberg ET AL.

Referral
National
Aeronautics
And Space
Administration

No. 19

Appeal to: Mr. Miles Wagner
Freedom of Information Officer
Nat'l. Aeronautics & Space Admin.
Washington, D.C. 20546

REFFERAL

Reviewed by: esly / JSP

Packet #19

AGENCY Natl. Aeronautics & Space Admin.

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1 Perl(HQ) 65-59312	416	5/19/51	HQ letter to CV	2	2
2 Perl(HQ) 65-59312	431	6/4/51	CV LHM TO HQ	9	9
3 Perl(HQ) 65-59312	444	6/7/51	NASA LETTER TO HQ	1	1
4					
5					
6					
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9					
10					
11					
12					

CD TOP SECRET

WFO-CLEVELAND

May 19, 1951

DIRECTOR, FBI

(1)

WILLIAM PEEL, aka
William Butterpearl
ESPIONAGE - R
PERJURY

32444

PERSONAL ATTENTION
STRICTLY CONFIDENTIAL

B1

You are advised that with respect to the information appearing in report concerning the jet fighters, Mr. Robert Bell, Security Officer, NACA, has advised that his inquiries concerning this matter have developed that the information apparently refers to the P-80 fighter plane which was either in production or about to be placed in production as of August, 1944. It was suggested, however, that the information as indicated concerning these jet fighters may have appeared in a communication sent out by the Air Corps in 1944, at which time they were soliciting competitive bids for the production of a plane to meet certain specifications. It was pointed out that as a result of this invitation for competitive bids the P-80 jet fighter was subsequently built.

Mr. Bell stated that it would be rather difficult for them to locate any specific records concerning the P-80 without having additional identifying information. He suggested, however, that it might be possible to obtain more definite information through the Air Corps, and particularly to ascertain the date and specifications as set forth in their invitation for competitive bids with respect to this jet fighter. Accordingly, an effort is being made to obtain this additional information through the Bureau's liaison with the Department of the Air Force.

Mr. Bell also advised that with respect to the information concerning the air compression engine, according to the experts at the National Advisory Committee for Aeronautics this engine undoubtedly referred to the Westinghouse jet engine which was known as the J-31 or I-16 engine used in the XP-59 jet plane. It was pointed out that generally speaking the data concerning this air compression engine might have referred to other jet engines which are being used today, but that as of August, 1944, only the J-31 or I-16 engine was in existence.

65-39312

RECEIVED MAY 19 1951
RECORDED MAY 22 1951

65-59312-416

cc: Buffalo
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Mr. Bell advised that this information pertaining to the J-31 or X-16 Westinghouse jet engine was available to subject Perl in view of the fact that he had been in charge of the testing of the XP-59 airplane which used this engine. According to the records of the NACA, the XP-59 had been completed for testing purposes prior to August, 1944. Further, it was definitely evidenced that Perl had a connection with this plane by reason of a memorandum which he submitted on March 19, 1945, recommending a raise in salary for one of the engineers who worked on the XP-59 plane under his supervision.

It might be noted here that the XP-59 airplane was produced by the Bell Aircraft Company, at which company Andrei I. Schevchenko, representative of the Soviet Government Purchasing Commission, was assigned in 1944. While it is indicated that the information concerning this air compression engine emanated from Schevchenko, this has not been conclusively established, for which reason additional investigation is presently being conducted on the possibility that Perl may have been the source of this information.

This matter should receive expeditious attention.

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FEDERAL BUREAU OF INVESTIGATION
UNITED STATES DEPARTMENT OF JUSTICE
900 STANDARD BUILDING
CLEVELAND 13, OHIO

JUNE 4, 1951

IN REPLY PLEASE REFER TO
FILE NO. 65-2730

X
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Mr. Tolson
Mr. E. Clegg
Mr. Clegg
Mr. Glavin
Mr. Nichols
Mr. Rosen
Mr. Tracy
Mr. Tamm
Mr. A. Felt
Mr. Behan
Mr. Ladd
Mr. Kline
Miss Gandy
Mr. Tamm
Miss Gandy

Director, FBI

Re: WILLIAM PERL, Aka.
ESPIONAGE - R; PERJURY
(Bufile 65-59312)

Dear Sir:

Rerep SA JOHN B. O'DONOOGHUE, 5/17/51, Cleveland;
Bulets dated 5/19/51 re the "Lexington Report" and re info
concerning air compression engine (probably I-16 or J-31
engine).

31

The following persons were interviewed concerning
this information:

PRIATE AGENCIES

FIELD OFFICES

ED BY ROUTING

SJ OF [redacted]

5/23/51 PM/MSK

AL W. YOUNG, Chief, Altitude Wind Tunnel
Branch, Engine Research

MARTIN J. SAARI, Chief, Section B, Altitude
Wind Tunnel

BEN PINKEL, Chief, Materials and Thermodynamics
Research Division

PIES DESTROYED

47 NOV 22 1960

G. MERRITT PRESTON, Chief, Flight Research
Section

ALL INFORMATION CONTAINED
HEREIN IS UNCLASSIFIED
EXCEPT WHERE SHOWN
OTHERWISE

RECORDED - 57

INDEXED - 57

EX - 133

HANDED BY [redacted]

25

165-59312-431
JUN 6 1951



JBO'D:mmk
65-2730

CCs: Buffalo 65-2003
New York 65-15387
Washington Field 65-5543
CV File 65-2726

CLASSIFIED BY [redacted] 2-27-79
EXEMPT FROM E.O. 13526, CATEGORY 2
DATE OF DECLASSIFICATION INDEFINITE

403
65 JUN 13 1951

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Sec 4

Director, FBI

According to the above mentioned persons, PERL worked on the P-59 doing theoretical compilations concerning the aerodynamics affecting the engine installation on the P-59. The P-59 utilized the I-16 General Electric jet engine (now known as the J-31) which was one of the earlier jet engines produced in this country. It was, however, preceded by the IA, a General Electric jet engine which was the first engine worked on at NACA Cleveland. The first IA was received at NACA, Cleveland in the Fall of 1943 and work on this engine was limited to a relatively small group. After PERL's arrival in Cleveland in December, 1943 he was assigned to assist on the experimentation of the propulsion system of the P-59. All agreed that PERL had access to any material he desired at that or any other time, including secret with the exception of Atomic Energy Commission data.

It was the concensus of opinion that the data concerning the experimental model of an air compression engine was generally accurate but appeared to be the statement of a layman who had seen a jet engine for the first time. As to Paragraph 1, each person contacted advised that the statement "...it was indicated the quantity of the chambers had something to do with the curtailment of combustible fuel..." was very confusing, and made little if any sense. The fact that the number of the chambers was considered optional and that there were to be ten combustion chambers was generally a true statement.

Paragraph 2 is entirely accurate insofar as it refers to General Electric jet engines which in 1944 were limited to either the I-16 or IA.

Paragraph 3 again would indicate an early jet since the present compression of air reaches approximately six atmospheres.

Paragraph 4, the temperature of 1760° Fahrenheit appears to indicate an early jet engine.

Paragraph 5 is a very general description of the combustion chambers of any jet engine.

Paragraph 6. None of those contacted were able to understand Paragraph 6 with the exception of G. MERRITT PRESTON, who advised a person with little or no engineering background might well describe the rear turbines in such a manner.

Director, FBI

It is pointed out that all the scientists contacted advised that by the Spring of 1944 PERL had an intimate knowledge of the workings of jet engines and would be able to describe one in complete detail at that time. They all stressed the information concerning the air compression engine as stated to them would appear to be a description proffered by a person with a limited or no engineering background.

Miss RUTH VANDERHOOF, Mail and Files Section Chief, made available abstracts to all General Electric and Bell Aircraft material on file in her section, and in addition furnished the complete preliminary data reports on the P-59.

Lexington Report and General Data Re PERL

BEN PINKEL, previously described, has advised that he knew of no social acquaintances of PERL and regarded him as somewhat "stand-offish". He described PERL as one who appeared to be a "true scientist" whose one aim in life was the development and expansion of pure science. He recalled on several occasions that PERL had been invited to visit the homes of fellow employees but that PERL had in each instance refused.

According to PINKEL, PERL had no access to Atomic Energy Commission material, and it was pointed out by PINKEL that if anyone had given PERL the Lexington Report or other Atomic Energy Commission restricted data prior to November, 1949, it would necessitate a wrongful intent on the part of the person so doing. PINKEL explained this by stating that prior to November, 1949 no clearance had been requested for PERL and there would therefore be absolutely no reason to furnish PERL such data. He stated that after the request for clearance was made in November, 1949, it could well be that someone would have given PERL Atomic Energy Commission restricted data with the idea that PERL was, in their opinion, reliable and trustworthy, and that it was only a matter of days before he would get Atomic Energy Commission clearance. PINKEL stressed that he knew of no such instance, however, and offered the suggestion only for what it was worth.

PINKEL further advised that ALFRED BOBROWSKY was very unpopular and although he had no knowledge of any relationship between BOBROWSKY and PERL, he could hardly believe they would be compatible since they were direct opposites. The only persons

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with whom PERL appeared to be closely acquainted in any degree were ABE SILVERSTEIN, Chief of Research, and MILTON KLEIN, who has since resigned from NACA.

Dr. ROBERT F. SELDEN was recontacted on May 21, 1951 and he advised it was possible that PERL and BOBROWSKY may have associated infrequently although he knew of no instance of such association.

SELDEN was asked to furnish some suggestion as to how PERL could have acquired a copy of the Lexington Report and he offered the suggestion that PERL was very close with ABE SILVERSTEIN and that a copy of the report had been charged out to SILVERSTEIN for some time. He stated he had no direct knowledge that anyone had ever permitted PERL to see the Lexington Report or any other Atomic Energy Commission data, but stated that copies could have been left around for some time and PERL might have gained access to a copy in an illegal manner.

Mrs. EVELYN FLEMING, nee Lasch, 27888 Osborne Road, Bay Village, Ohio, advised she served as secretary to ABE SILVERSTEIN from 1944 to 1950. She described PERL as a close friend of ABE SILVERSTEIN, and the only other apparent associates of whom she knew were MILTON KLEIN, MAURICE NUCKER, ARNOLD RIEDMAN and LAWRENCE MARCUS.

Mrs. FLEMING stated that PERL had access to secret data and that while she had been secretary to SILVERSTEIN she had maintained records of all secret data maintained in SILVERSTEIN's office which was released to scientists at NACA. Before SILVERSTEIN became Chief of Research, FLEMING had no Atomic Energy Commission clearance, however, she had access to SILVERSTEIN's desk, file cabinets, and safe, but at no time did SILVERSTEIN maintain Atomic Energy Commission or NEPA data therein. It is her opinion that if SILVERSTEIN had such material in his possession he would either have to carry it on his person or return it to the Administration Building. She noted that SILVERSTEIN constantly kept a leather briefcase in his possession.

Mrs. FLEMING advised she did not get Atomic Energy Commission clearance until approximately two months before she left NACA in early 1950. She advised that the Lexington Report sounds familiar but is certain she would recall handling it and is positive she handled nothing which contained the Atomic Energy Commission restricted data classification.

She also advised that SILVERSTEIN was particularly

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careful as to Atomic Energy Commission data as everyone at NACA was; all were deeply aware of the Atomic Energy Act of 1946.

Miss ALMA WILDY, secretary to Dr. J. C. EVVARD, Chief, Supersonic Propulsion Division, advised she had taken over the records maintained by Mrs. EVELYN FLEMING when Dr. EVVARD assumed his present position at the time ABE SILVERSTEIN became Chief of Research. Prior to that she had worked in the same office with Mrs. FLEMING as secretary to Dr. EVVARD and in Mrs. FLEMING's absence as secretary to ABE SILVERSTEIN. Miss WILDY advised she knew of no instance wherein PERL would have had access to the Atomic Energy material although she pointed out she herself had no access to such material. She stated that at no time did Mr. SILVERSTEIN maintain Atomic Energy material in his safe to her knowledge.

She did recall, however, that in March, 1948 while ABE SILVERSTEIN was on annual leave in Florida, EVELYN FLEMING required access to SILVERSTEIN's safe. However, Mrs. FLEMING had either forgotten or had not had the combination to this safe and was forced to wire SILVERSTEIN in Florida for the combination. SILVERSTEIN advised FLEMING of the combination by return wire and this wire was then placed in the Mail and Files Section of the Lewis Flight Propulsion Laboratory. It was WILDY's opinion that only she, Mrs. FLEMING, ABE SILVERSTEIN, and one other person who had assisted Mrs. FLEMING in opening the safe were aware of this telegram with the exception of the clerk who filed it in the Mail and Files Section. She pointed out that PERL was then on leave without pay at Columbia University and would have no knowledge of this incident.

However, in May or June, 1949 Mrs. FLEMING went on a six-weeks leave and Miss WILDY during the course of her daily work required access to SILVERSTEIN's safe. She asked Mr. SILVERSTEIN for the combination but at that time he did not have it with him. She recalled the telegram and was able to secure it from Mail and Files. After opening the safe she advised she realized that this telegram presented a security problem and she instructed the Mail and Files Section to destroy it and later explained to Mrs. FLEMING what she had done. The combination to this safe remained the same until 1950 when it was changed while Miss WILDY was on leave some time between June 3 and July 10.

Miss WILDY advised she furnished the above information solely because of its peculiarity and stated there was never any indication that PERL had opened this safe himself or had any

Director, FBI

knowledge of the combination thereto. She stated that during the day the safe was closed but was left on day lock which would necessitate a mere twist of the dial to open it.

Miss WILDY advised that the only people with whom she had seen PERL were HAROLD CHAMES, who is now in private business in New York, ABE SILVERSTEIN, and possibly MAURICE TUCKER.

Miss WILDY also furnished a list of secret documents which had been charged out to PERL as is reflected by her records. This list is set forth immediately hereinafter.

* S E C R E T *

- *Compressibility Effects on Cascades of Low Cambered Compressor Blades, by Baily and Jefferson. R.A.E. (2-3-45)
- *Preliminary Discussion on Impulsive Duct Engine Used for German Flying Bomb, by Howell, Richards, and Nock. R.A.E. (2-13-45)
- *Examination of a German Rocket Motor Used for Assisted Take-Off, by Staffs of Engine Dept. and Metallurgy Div. Tech. Note EA 204, R. A. E. (2-13-45)
- *Curve Sheets - MX-544 - Cleaned Up Run Test 32, Wright Field 20 Ft. Wind Tunnel (German Buzz Bomb). (1-25-45)
- *Summary Report on Combustion Research - January 1943 to July 1944, National Bureau of Standards. (2-13-45)
- *Report No. E. A. 224/13, TN No. Aero 1502 - Tests of PZG76 Flying Bomb Motor, by A. D. Baxter, D. E. Whaley, and C. Kell. R. A. E. (2-13-45)
- *Jet Propulsion Combustion Chamber Research - Navy contract NOa(s) 5152 - Progress Report for Month of February 1945 - dated March 3, 1945 - by H. C. Hottel, MIT, Dept. of Chemical Engineering. (5-3-45)
- *Progress Report on the Flow Phenomena at the Inlet of a Tube Travelling with Supersonic Velocity, Report No. Eng. Div. 18/44 - National Physical Lab. OSRD, Liaison Office. Ref. No. I-A-390, by G. H. Lean. (6-2-45)
- *Supersonic Flow past Bodies of Revolution, by M. J. Lighthill, B.A. of the Aerodynamics Division, N.P.L. (Fluid Motion Panel, Aeronautical Research Committee) (6410-1030). (9-7-45)

Director, FBI

"Subsonic and Supersonic High Speed Tunnel Tests of a Fairied Doubled Wedge Aerofoil, by W. F. Hilton, and F. W. Pruden of Aerodynamics Division, N.P.L. (Aerodynamics Subcommittee, Aeronautical Research Committee). (9-7-45)

* S E C R E T *

ISIDORE WARSHAWSKY, Instrument Service Section, advised he has known PERL since 1939 when PERL first became employed by NACA at Langley Field. According to WARSHAWSKY PERL, who then lived in a small home owned by the Chief of Police of Hampton, Virginia, SIDNEY HARMON, LAWRENCE ~~KARCUS~~ and his wife CELIA ~~KPSTEIN~~, and other persons whom he described as the "young, single, New York and Chicago Jewish people", associated to some extent at Langley Field during the period 1939-1942. He described this association as having meals together and occasionally holding dances and other "mild forms of entertainment". He pointed out that PERL was not particularly socially inclined and was more interested in pursuing his studies of physics and related problems. However, on occasion WARSHAWSKY visited PERL at his room in Hampton, Virginia where both listened to records.

WARSHAWSKY pointed out that he was transferred to Cleveland in 1942 and PERL came to Cleveland in late 1943. Their association at Cleveland has been very limited, and in general restricted to luncheon meetings at the NACA cafeteria. He pointed out that PERL usually had luncheon with MILTON KLEIN and that he would join them quite often although there was never any pre-arranged plan to their luncheon meetings. He also recalled that ALFRED BOBROWSKY was a late eater and perhaps on occasion did have luncheon with them although he could recall no specific instance. He also recalled that on occasion PERL had luncheon with a young girl whom he believed was employed in the 8' x 6' SSWT. He was unable to recall this girl's name but advised he was certain that PERL's relationship with this girl was merely a casual, workingtime acquaintance.

WARSHAWSKY advised PERL had access to secret data but not to Atomic Energy Commission data. WARSHAWSKY himself has had Atomic Energy clearance since June 8, 1948 but he pointed out that in all that time he has read only three Atomic Energy Commission documents, and these documents referred to instruments. He explained that he had clearance only for the purpose of being able to discuss problems with scientists who desired to purchase or have made new instruments necessary in their work in Atomic Energy matters. It was his capacity to approve or disapprove the purchase of such instruments.

Director, FBI

WARSHAWSKY advised he had not heard of the Lexington Report and it was his opinion that no one with Atomic Energy Commission clearance would furnish PERL Atomic Energy Commission restricted data unless the person did so maliciously. He did point out, however, that PERL's reputation as a mathematician was considerable and that it may well have been that someone working on the nuclear propulsion of aircraft problems could have requested PERL to do some theoretical analysis. He felt, however, that the problem could be given to PERL without disclosure of any restricted data, since such an analysis would of necessity involve only pure mathematics and/or physics.

WARSHAWSKY pointed out that he and BOBROWSKY had disagreed violently on many occasions while BOBROWSKY was working on shielding problems for the NEPA project but that despite this he felt it was not likely that BOBROWSKY would have furnished PERL any restricted data.

He noted that PERL was transferred to the Materials and Stresses Building in late 1949, and that while in that building he was engaged in a concentrated study of the physics of solids preparatory to becoming involved in the nuclear field. He stated it would be possible that PERL may have required some restricted data in adequately covering this field but he could see no reason for PERL having access to Atomic Energy Commission restricted data.

WARSHAWSKY advised that while he and PERL were employed at Langley Field he, WARSHAWSKY, used to visit New York at least once a year and definitely recalled being in New York City on December 7, 1941. He advised, however, that he was certain he had never made a trip to New York with PERL, nor does he ever recall seeing PERL while visiting New York City. WARSHAWSKY also advised he was a member of the CCNY alumni club at NACA Cleveland and he is certain that PERL has never participated in the activities of this club.

During the course of the interview WARSHAWSKY advised he had never been a member of the Communist Party nor any organization declared subversive by the Attorney General or House Un-American Activities Committee. He stated he recalled a great deal of talk concerning anti-Fascist organizations during the Spanish Civil War but was certain he had never attended any of their meetings nor had he ever contributed funds to these organizations.

Reference is made to Paragraph 2, Page 2 of Bureau letter dated May 19, 1951 concerning information furnished by Mr. ROBERT BELL in regard to the Lexington Report. Referenced letter indicates

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Director, FBI

that copies #87A of the Lexington Report and 88A were, according to NACA records, charged out to ABE SILVERSTEIN during the same period.

Miss IRENE M. KIVES, secretary to the Director, Lewis Flight Propulsion Laboratory, NACA, Cleveland Airport, has advised that copy 87A was charged out to Dr. LAWRENCE O. ROCKWAY in October, 1948, exact date unknown; recharged to ABE SILVERSTEIN on November 2, 1948; and subsequently recharged to ALFRED R. BOBROWSKY during November, 1948, exact date unknown. There is pointed out that copy 88A was not charged out to SILVERSTEIN until November 29, 1948, and in all probability both copies were not in SILVERSTEIN's possession at the same time.

Miss KIVES, who furnished the records of charge-outs of the copies of the Lexington Report as is reflected in referenced report, is continuing her efforts to narrow the exact dates of charge-outs, and will furnish these at a future date.

Very truly yours,

R. J. Abbaticchio

R. J. Abbaticchio Jr.
Special Agent in Charge

NETLEY, W. E. COL. U. S. A.
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LAMBERT FIELD, CALIF.

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MERRITT FIELD, CALIF.

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FOR AERONAUTICS
1724 F STREET, NORTHWEST
WASHINGTON 25, D. C.

TELEPHONE: LIBERTY 8-2046

June 7, 1951

Director
Federal Bureau of Investigation
U. S. Department of Justice
Washington 25, D. C.

Attention: Mr. Elmer F. Emrich

Dear Sir:

Attached is the copy of the report
"Wind-Tunnel Tests of the Gorgon IIA and
IIB Airframes. II - Power-Off Longitudinal
and Lateral Stability and Control" which
was inadvertently omitted from the attach-
ments to Dr. Dryden's letter of June 6, 1951.

Very truly yours,

~~EX-246~~ EX-246
EX-246 PROCESSING

JUN 9 1951

Robert L. Bell
Security Officer

Attachment

RECORDED - 81

EX-130

65-59812-444

JUN 9 1951

25

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133 Det
56 JUN 15 1951

Julius Rosenberg ET AL.

Referral
National
Aeronautics
And Space
Administration

No. 20

APPEAL TO: Mr. Miles WAGGONER
Freedom of Information Act Office
National Security Agency - Espionage Act Division
Washington, D.C. 20546

REFERRAL

Reviewed by: /

Packet # 8

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FEDERAL BUREAU OF INVESTIGATION
U.S. DEPARTMENT OF JUSTICE

CC-150

TOP SECRET

December 16, 1950

To: COMMUNICATIONS SECTION.

Transmit the following message to:

SACs, CLEVELAND
WASHINGTON FIELD

URGENT

WILLIAM PERL, WEP-R.

DATA OBTAINED THROUGH LIAISON WITH NACA, WASHINGTON, INDICATED THAT INFO FURNISHED TO MGB-REPRESENTATIVE-NYC-PERTAINING TO HIGH SPEED AND LONG RANGE, HIGH ALTITUDE JET FIGHTER PLANE APPARENTLY WAS OBTAINED FROM REPORT RECEIVED BY NACA JANUARY THIRTY FIRST, FORTY FOUR, FROM THEIR WEST COAST REPRESENTATIVE, COPY OF WHICH REPORT MADE AVAILABLE TO CLEVELAND LABORATORY OF NACA. FURTHER DISCRETE INQUIRY BEING MADE BY NACA TO DETERMINE IDENTITY NACA OFFICIAL CLEVELAND HAVING CUSTODY THIS CONFIDENTIAL REPORT AND AVAILABILITY SAME FOR EXAMINATION BY PERL. CLEVELAND AND MTC MAY DISCONTINUE EFFORTS TO LOCATE XP EIGHT ONE DATA IN FILES NACA PENDING RECEIPT OF COMPLAINT FROM BUREAU RE ABOVE. IS

EEF:hc *ls*

65-59312

cc: New York (by mail)

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