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CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

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SECRET

COUNTRY	USSR (Kuybyshev Oblast)	REPORT	
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THE SOURCE EVALUATIONS IN THIS REPORT ARE DEFINITIVE.
THE APPRAISAL OF CONTENT IS TENTATIVE.
(FOR KEY SEE REVERSE)

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Comments:

1. For Besymyanka on Page 6, read Bezymyanka.
2. In Paragraph 22, LEBEDYEV is more correctly LEBEDEV, SAIMIKUV is possibly ZAYMYKOV, and MOIZYEV is probably MOISEYEV.

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C O N F I D E N T I A L

REPORT

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COUNTRY : USSR

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TURBO-PROP ENGINE A-022

1. The official Soviet designation for the former JUMO Turbo-prop engine was "Object A-022." This engine was constructed in the Soviet experimental factory "Zavod 2" at Kuybyshev. The acceptance tests for this engine were begun in May or June 1950. However the first engine failed during the 100 hour test when the propeller separated from the engine because of faulty gears in the gear box. However, the engine passed the official 100 hour Soviet acceptance test in September 1950. During these acceptance tests this engine employed no nacelle coverings, but it used an exhaust gas duct, which was delivered from an unknown aircraft plant. The A type engines at Zavod 2 were produced with serial numbers 1 to 25, and later serial numbers from 101 to approximately 135. The last serial number on the test stand that I can remember was 135. Beginning with the engine serial No. 14, the A type engines were sent away for flight testing after preliminary water brake tests and propeller tests at Zavod 2. Serial numbers 101 to 135 were modified A type engines to be used in the M-022 (double A) turbo-prop engine. I can give no details concerning installation of the A type engine in any particular aircraft. However German personnel believed very strongly that the A-022 turbo-prop engine was being built in Soviet aircraft engine plants. The German technical personnel heard rumors that production of this engine had begun in late 1950.

C O N F I D E N T I A L

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2. The A-022 turbo-prop engine has a 14 stage axial flow compressor, 12 injection nozzles, a 3 stage turbine, and a fixed cone. Estimated weight of this engine is 1.5 tons, maximum rpm. 7,700, maximum horsepower at take-off 5,800 to 6,000 horsepower (later versions of the A type were in the 6,000 horsepower range). This horsepower was the shaft horsepower plus thrust converted into horsepower. Maximum tail pipe temperature 600°C below idling rpm., maximum operational exhaust temperature 550°C, fuel consumption at maximum rpm. 245 to 248 grams per horsepower, operational air pressure at least compressor stage at maximum rpm. 5.2 to 5.4 kilograms per square centimeter, pressure at intake 110 to 120 millimeters mercury. (Both the above mentioned pressures were measured on the water brake test stand. The A-022 turbo-prop engine had provisions for the use of two 4-bladed counter rotating propellers, or one larger 4-bladed propeller. The normal version was with the two counter rotating propellers (having a diameter from tip to tip of between 6 to 6.5 meters). Long test runs of the A-022 could not be made with the single propeller due to the vibration of this propeller on the test stand.

3. The following is a general list of materials used in the A-022 turbo-prop engine:

Air intake: light metal alloy
Compressor housing: sheet steel
Reinforcement beams: welded sheet steel
Compressor wheels No.1 through 5: a one piece machined solid metal wheel
Compressor wheels No. 6 through 14: a solid one piece steel wheel
Combustion chambers: heat resistant steel
Turbine shaft: steel
Turbine wheel: steel
Turbine blades: solid steel construction inserted in the turbine wheel by the "Christmas Tree" method.
Stators in compressor: The initial stators were made from steel, but in later versions of the A-022, the stators in compressor stages 1 through 6 were made from light metal and in stages 7 to 14 of steel.
Turbine ring inserts: The turbine ring inserts varied during the entire time of my stay at Zavod 2. The first turbine ring inserts were of graphite, later light metal, ceramics, and finally of an aluminum-bronze substance. The aluminum-bronze substance achieved the best results and was used exclusively in the M-022 engine.
Compressor guide ring inserts: plastic which could be scratched with a knife or file.

All items not requiring strength or heat resistance were made from light metal.

4. I have made a schematic diagram of the turbo-prop engine type A-022 [see page 10]. Drawings showing the cooling system of the outer wheel of the combustion chamber, the air flow into the combustion chamber, a cross-section of the combustion chamber showing injection nozzles, a cross-section showing the mounting of the auxiliary equipment, drive shafts, and the location of the main braces of this engine are also included [see page 11].

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5. The following is the testing procedure used in the A-022 turbo-prop engine. The shaft horsepower was measured by the use of a three disk water brake connected to the engine in a ratio of 1:1 and in turn connected to a motor generator unit. [For a diagram of the water brake test stand see page 12 ; see page 13 for a detailed drawing of the water brake test installation, and page 14 for a front view of the water brake test stand as seen from the engine shaft.] Upon delivery of an engine to the engine test stand it is first inspected by the test stand inspectors. After passing the inspection the engine was mounted on the test stand for the breaking-in run. The breaking-in run consisted of rotating the turbine shaft of the engine, by means of the motor generator, up to 200 rpm. and maintaining 200 rpm. for two to three minutes. Then the motor generator was stopped and the assistants timed the duration of rotation before the engine came to a halt. During this run out time technicians listened for any noises. The only method of detecting failures in construction was the ability of the technicians to detect noises by listening.

6. The second break-in run was the same as the first, except that 500 rpm. was maintained for three minutes. If the engine did not continue to run for 30 to 60 seconds, the process at 500 rpm. was repeated until that time was achieved. The same process was repeated at 1000 rpm., and later at 2000 rpm. The only criteria for passing the break-in runs was that the engine had a noiseless operation.

7. During the first actual running of the engine the following procedure was in effect. The engine was started by revolving the turbine shaft to 800 rpm. with an electric motor. When 800 rpm. had been achieved, the ignition switches were turned on. The electric motor was increased to 1100 rpm. and the throttle of the engine was opened gradually. Between 800 and 1100 rpm. the two starting fuel nozzles were injecting fuel into the combustion chambers and it was burning. At 1100 rpm. the main fuel valve was turned on and the fuel was burning from all injection nozzles. At this point, the speed of the electric motor was increased to 2300 or 2500 rpm. (it was up to the trained operator of the test stand to judge at what point between 2300 and 2500 rpm. the turbo-prop engine was gaining power on its own). When this was determined the electric motor was disconnected. The rpm. of the engine was then increased to the idling rpm. of 3500. After a short run at 3500 rpm. the fuel is gradually cut off and the engineers begin listening once more. When the rpm. is reduced to 1500, a time check is once again made. The run out time for a good engine at 1500 rpm. was two minutes.

8. In the next test when all necessary adjustments had been made, the same procedure was followed to get the engine rotating at 3500 rpm. At this point a technician entered the test chamber and checked to see if there were any loose connections or fittings. When this check had been made a preliminary fuel combustion test was made. During the next ten minutes the engine was increased from 3500 rpm. to 6500 rpm. At 6500 rpm. the four circular air outlet vents were supposed to automatically close. These outlet vents are located aft of the fifth or sixth compression stage. If these vents do not close automatically, a technician entered the chamber and closed them. Oil pressure kept the vents open up to 6500 rpm., but at 6500 rpm. the regulator cut off the oil pressure in the vent system and the vents were closed by spring pressure.

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When the vents were closed, the rpm. was increased to 7250 rpm. and then the engine was run for ten minutes at this rpm. At 7250 rpm. a fuel consumption and oil quantity test was made. When this was done, rpm. was reduced slowly and the vents were watched. At 1500 rpm. a stop-watch test was once again made. This test completed the breaking-in runs.

9. The first turbine test run employed the same procedure as before to achieve 7250 rpm., but this rpm. was a corrected rpm. to standard atmospheric conditions. The corrected rpm. was computed by the following formula:

$$\text{rpm corrected} = \frac{273 + 15}{273 \pm \text{Air Temperature}} \times (\text{rpm, in this case } 7250)$$

10. This turbine test run was made at four different rpm's.: 7000, 7250, 7400, and 7700. At the corrected rpm., a load is put on by use of the water brake in seven increments up to three-fourths of maximum power rating at the designated rpm. At each step fuel consumption, oil temperature, exhaust temperature, air intake temperature, air pressure, and oil quantity flow were measured. At each load stage operation of the engine lasted for ten minutes. When the loads were to be increased, they were decreased in the same increments and the engine ran for five minutes at each stage. The throttle was then decreased to 6500 rpm. (at which point the air vents were watched) and then decreased to 3500 rpm., where the same readings mentioned above were made. The throttle was then closed and time tests were made at 1500 rpm. The same procedure was used on all four above stated rpm's.

11. The performance characteristics test used the same four rpm. ratings as shown above. The procedure for bringing the engine to a designated rpm. remained the same. At the corrected rpm. a five increment load test was made. Each increment lasted for five minutes and the last load was always the maximum power rating at the designated rpm. If the exhaust temperature was over 550°C the maximum load test would not be run. In decreasing the loads the engine maintained the designated rpm. and the loads were decreased in five increments with each increment lasting for five minutes. If the engine met the specifications, it was removed from the test stand and sent back to the factory for installation of auxiliary equipment and the propeller flange. The engine then went to one of three places: propeller test stand, flight testing, or to the development sections. The engines that were to be sent to flight test were also sent to the propeller test stand for a preliminary five hour test.

PROPELLER TEST STAND PROCEDURE

12. The tests conducted on the propeller test stand were made in order to determine the capabilities and limitations of the regulator, propeller gear box, auxiliary equipment and to make the twenty-five, fifty, and one hundred hour test runs. The performance figures obtained from the water brake test stand were used in the testing of the same engine on the propeller test stand. In addition experiments were made to obtain performance data on the propeller test stand, but this data proved to be inaccurate and therefore the performance data testing was not conducted on the propeller test stand. Upon arrival at the

propeller test stand the engine contained all auxiliary equipment that would be needed for installation on an aircraft except for cowlings and nacelles. The engine was mounted on the propeller test stand and the propellers were installed. The propeller test stand had additional measuring equipment for the measuring of all auxiliary equipment (such as volt-and ammeters, and pressure instruments). The hydraulic system for propeller feathering is installed in the aircraft, but the test stand incorporated this system in its makeup. Special vents were constructed for cooling of the generators mounted on the engine. Normal cooling would be achieved in flight by ram air. After all connections were made the engine was turned a few times by hand and a visual inspection was made. The tests performed on the propeller test stand were as follows:

Starting tests: The engine was started and the number of rpm. increased for a short time and then the engine was shut off. These runs were only five minutes in duration and at the end any necessary adjustments were made.

Functional testing of auxiliary equipment: The engine was started and all measurements as to output and capacity of auxiliary equipment were made. A fuel consumption test was also made at this time.

Time runs: At the beginning a twenty-five hour and fifty hour time run were made. Later one hundred hour time runs were incorporated in the program. For certain experiments occasionally two hundred hour time runs were made. Each hour of a time run consisted of: five minutes with the engine operating at take-off output, 7700 rpm. and approximate fuel consumption of 1460 kilograms per hour, and between 5800 and 6000 horsepower; twenty five minutes of so-called "increased cruising speed with 7400 rpm., 1270 to 1300 kilograms of fuel per hour; and thirty minutes of cruising speed with 7250 rpm. and270 to 280 grams of fuel per horsepower per hour. During the time runs, the engine was cut off at the end of each five hour period, Occasionally at the end of this five hour period the operator was ordered to make five take-offs. The fuel and oil filters at the end of these five take-offs were inspected and a visual inspection of the entire engine was made. At the end of the visual inspection the next five hour period began. Occasionally during a fifty hour test, after thirty-five hours had been run, the operator was told that the last fifteen hours were to be run without stopping the engine at all. Every hour in the fifty hour, twenty-five hour, and one hundred hour tests consisted of the prescribed minute breakdown of five minutes of take-off power, twenty-five minutes of "increased cruising speed," and thirty minutes of cruising speed. At the end of fifteen hours of constant operation the operator was told to make five take-offs.

TURBO-PROP ENGINE TYPE M-022

13. At the end of 1950 the design office began working on the M version of the 022 turbo-prop engine. In the fall of 1951 the first engine was installed on the water brake test stand. In November 1951 the propeller test stand was completed by the German workers. During the spring, summer, and fall of 1952 test runs of fifty

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and one hundred hours were conducted on the propeller test stand. The state acceptance tests were scheduled for the M-022 during the winter of 1952/1953. Several times all preparations were made for this testing, but they were stopped. In the spring of 1953 the German workers were told that the project had been abandoned. During the test runs (spring and summer of 1952) the plant was visited continuously by Soviet engineers and technicians. During the winter of 1952/1953 several M-022 propeller test stands were manufactured and delivered to unknown Soviet plants. I know definitely that construction drawings for the M test stand were made for delivery to Soviet plants. The Soviet engineers and skilled workers who came to Zavod 2 were from the engine factory at Besymyanka. Besymyanka is a northeast suburb of Kuybyshev. These engineers and technicians were trained by the German personnel in the construction and testing of the M engine. In the fall of 1952 the plant began receiving components (such as complete turbine wheels, turbine guide vanes, compressors) and other parts supplied by Besymyanka. The first deliveries of these parts were of very poor quality and had to be rejected. Little by little as quality was improved at Besymyanka, the Zavod 2 plant decreased production of the component items. At the beginning of 1953 Zavod 2 assembled only the engines from components delivered from Besymyanka. At this time the German technical personnel were spending the majority of their time on "Object K", "Object D", and "Object AF-2." At the end of 1952 and the beginning of 1953 rumors circulated again through Zavod 2 that the M-022 turbo-prop engine was being flight tested at Kazan. In addition it was also rumored that during March to May 1953 that an aircraft being flight tested had crashed. At this time many Soviet personnel arrived and investigated assembly procedures, quality, and testing procedures of the M-022 engine. Particular attention was paid to the engine suspension and connection components. From that time on all engines that were scheduled for flight testing were required to undergo a special testing program. Soviet personnel supervised both the propeller test and the water brake test of all M-022 engines. Upon completion of the functional tests on the propeller test stand, the engines were covered with grease, packed in crates, and shipped to an unknown destination.

Description of the M-022 Engine

14. The M engine comprises two A-022 turbo-prop engines put together side-by-side and employing a common gear box. The A engine was modified only in the fact that the intake section was changed, and supports binding the two engines together were incorporated. The suspension system comprises a box shaped, welded sheet steel, lateral brace and one longitudinal box shaped, tapering welded sheet steel spar. The M-022 engine employed two 8 meter counter rotating square tipped propellers. The maximum rpm. was 7700, idling rpm. 3500, and the maximum horsepower was computed by adding the horsepower of the two A-022 engines and multiplying that by a gear loss factor. I did not know exactly what this loss factor was, but did not believe that it was lower than 0.900 and believed that it fell between 0.88 and 0.90. The A-022 engine combined to form the M-022 engine were from serial numbers 101 to 135. In addition other engines from serial numbers 1 to 25 were modified and also made into M engines. Four engines from serial numbers 101 to 135 were kept for special turbine tests. There were seven different turbines used in these experiments.

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The seventh and last was the one incorporated in all M type engines. This was easily achieved in that all parts were completely interchangeable, and the old turbines were removed and replaced by the new turbines. The M version could not be tested on the water brake test stand; therefore half of the M engine (one A-022) was tested at one time using similar testing procedure as for the A-022 engine. With the modification of the intake it was found that there was no measurable reduction of power in the newer engines; in fact because of the improvements in the turbine and compression components, performances were obtained up to 6200 horsepower. An additional reason for this higher horsepower rating was the fact that higher tail pipe temperatures were allowed. Special hot runs were also made on the water brake test stand. Hot runs were made by opening the air vents and impeding the air intake. These test runs were conducted in order to measure temperatures in the combustion chamber before the turbine guide vanes. Fifty hour tests were made on the water brake test stand in the form of hot runs. Temperatures were high enough to make the guide vanes glow. The water brake test stand was constructed at Zavod 2, but by the time the latter M versions were tested the water brake was too old and could not give the required loads. Upon completion of the water brake tests one-half of an M engine (one A-022) was returned to the production section where two halves were put together and all auxiliary equipment added. The engine was then sent to the propeller test stand to be tested as a complete M engine.

15. /For a drawing of a complete M engine, see page 15 ./ The first test runs on the propeller test stand were made in order to test the common gear box. Ruptures and breaks occurred approximately four times in the gear box while it was on the propeller stand. Many different gear box designs were tested on the propeller test stand. During one hundred hour tests in the fall of 1953, many Soviet dignitaries witnessed the testing procedure of the M-022 turbo-prop engine. After seventy-five hours had elapsed, the gear box failed. This failure caused a great deal of tension between the Soviet and German designers and specialists. The Soviet director ordered the construction of a gear box from entirely different materials and blamed the failure on the poor workmanship of the German personnel. After twenty-five hours the gear box designed by the Soviets also failed, and the German designs and materials were used once again.

16. The following is the procedure employed on the propeller test stands for the complete M-022 engine: Both "A" engines were started at the same time by the depression of a single button. Each individual engine was started by its own starting turbine; the entire starting procedure was completely automatic. By the depression of the button a small electric motor, attached to each starting turbine, rotated the starting turbine to a prescribed rpm. When the rpm. was reached, fuel was injected automatically into the starter turbine. When the starter turbine reached 400 rpm., it was slowly connected by an automatic clutch to the main turbine. When the main turbine was rotating at 600 rpm., fuel was injected and ignited through the two main starting nozzles. The starting turbine drove the main turbine until 1000 rpm., was reached. At this rpm. the operator opens the throttle

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and the main turbine increases to 1800 or 2000, at which time the starting turbine automatically uncouples from the main turbine and is automatically stopped. The operator then places the throttle at the idling position and from this point on the testing procedure is the same as that used in the A-022 engine.

"OBJECT 012," TURBO-JET ENGINE

17. The Soviet designation for the former JUMO 012 engine was "Object 012." Between twelve and fifteen of these engines were produced at Zavod 2. The official plant test was conducted during the winter of 1948; but the offical Soviet acceptance test was not made at Zavod 2. However the German personnel learned that the 012 turbo-jet engine had passed the Soviet acceptance test at another unknown factory. The 012 turbo-jet was an axial flow turbo-jet engine with a twelve stage compressor, one turbine, a variable exhaust cone, and contained a compressed air starter. This engine had a 3000 to 4000 kilogram thrust at a maximum rpm. of 8000.

"OBJECT K"ENGINE

18. "Object K" was a turbo-prop engine designed to replace the M-022 engine. "Object K" employed a sixteen to eighteen stage compressor, a five stage turbine, and eight oval air outlet vents, and had a maximum rpm. of approximately 8000. An interesting feature of "Object K" was the variable guide vanes in the first stage of compression. The appearance of the "Object K" engine was very smooth in comparison with either the A-022 or the M-022 in that all auxiliary equipment was built into the outer casing of the engine. Approximately six "Object K" engines were produced, and the first K engine arrived on the water brake test stand between May and June 1952. The first propeller test was made during March and April 1953. The main problem encountered with the K engine was the freezing of the compressor.

"OBJECT AF-2" ENGINE

19. This engine was a turbo-prop engine and was believed to be the pilot model for "Object K." Only one engine of this type was built, and that was during the beginning of 1952. The project was dropped when the entire engine blew up, destroying the test stand as well as the engine itself.

"OBJECT D" ENGINE

20. "Object D" was similar to "Object K" except that the compressor had been modified. This engine was designed for higher altitude work. The first engine of type "Object D" was delivered to the water brake test stand in June 1953.

21. The altitude test chamber and stand had been shipped from Dessau to Zavod 2 in 1946. It was planned to install this altitude test chamber at Zavod 2. The initial construction work for the replacement had been begun but was stopped at the end

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of 1949. In the winter of 1950/1951 many Soviet personnel appeared and packed all parts of this altitude test chamber and shipped them to an unknown destination. There was never an altitude test chamber in operation at Zavod 2.

22. The following is a list of three Soviet flight test personnel with whom I had contact.

Flight test engineer - LEBEDYEV

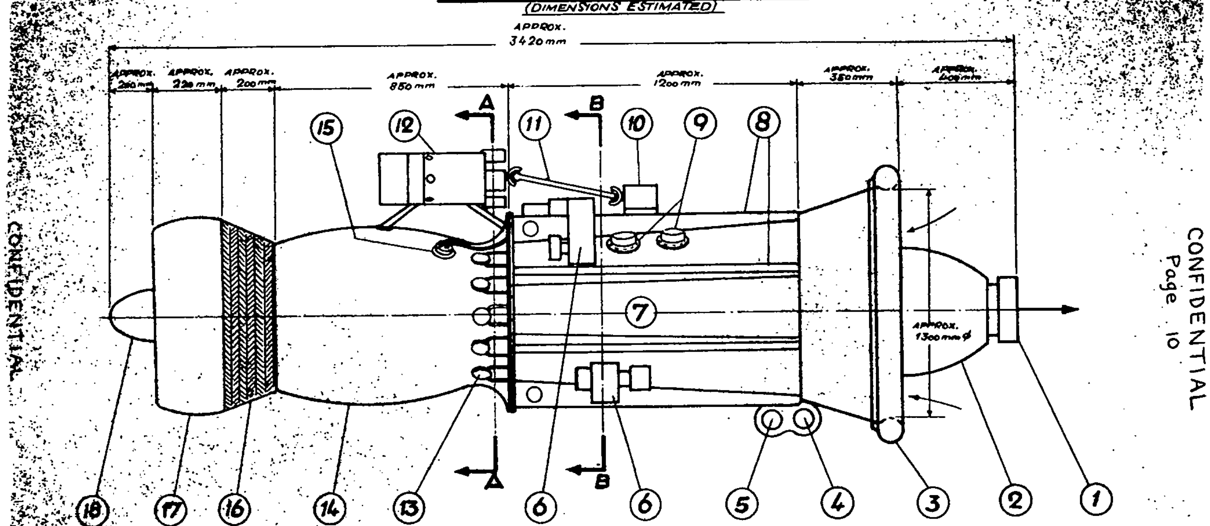
Deputy flight test engineer - SAIMIKUW

Mechanic - MOIZYEV

TURBO PROP ENGINE TYPE A022

SIDE VIEW (MEMORY SKETCH)

(DIMENSIONS ESTIMATED)



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LEGEND:

1. AIRSCREW FLANGE
2. REDUCTION GEAR
3. AIR INTAKE
4. OIL DRAIN PUMP OF REDUCTION GEAR
5. MAIN PUMP FOR LUBRICATION OIL
6. UPPER AND LOWER SUPPORTS OF AUXILIARY EQUIPMENT
   UPPER SUPPORT CARRIED:
   TWO ELECTRIC POWER GENERATORS 24V, 2 KW
   R.P.M. PICK UP FOR TURBINE RPM
   HYDRAULICS PUMP, AIR COMPRESSOR,
   VACUUM PUMP
   LOWER SUPPORT CARRIED
   FUEL PUMP
   PRESSURE PICK UP FOR AUTOMATIC HYDRAULIC CONTROL DEVICES
   R.P.M. PICK UP FOR AIRSCREW RPM
7. 14-STAGE COMPRESSOR
8. REINFORCEMENT BEAMS OF COMPRESSOR HOUSING
9. AIR OUTLET VENTS
10. AUTOMATIC RELEASE COUPLING DEVICE OF STARTER TURBINE
11. DRIVE SHAFT WITH UNIVERSAL JOINTS
12. CENTRIFUGAL FLOW STARTING TURBINE
13. 12 INJECTION NOZZLES
14. COMBUSTION CHAMBER
15. NENE TYPE INJECTION NOZZLE AND IGNITION PLUG ARRANGEMENT FOR STARTING
16. THREE-STAGE TURBINE
17. EXHAUST PIPE
18. FIXED EXHAUST CONE

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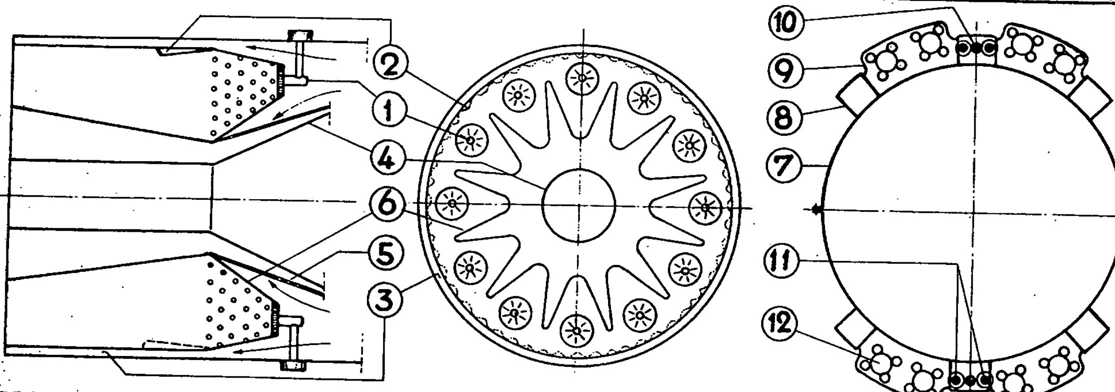
TURBO-PROP ENGINE TYPE A022

(MEMORY SKETCH)

LONGITUDINAL SECTION
OF COMBUSTION CHAMBER

CROSS-SECTION : A
THRU COMBUSTION CHAMBER
WITH INJECTION NOZZLES

CROSS-SECTION : B
WITH SUPPORTS AND DRIVE MECHANISMS
FOR AUXILIARY EQUIPMENT



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LEGEND:

1. FUEL INJECTION NOZZLE
2. INNER AIR BAFFEL TO COMBUSTION CHAMBER
3. OUTER AIR BAFFEL FOR COOLING OUTSIDE OF COMBUSTION CHAMBER
4. TURBINE SHAFT HOUSING
5. AIR HOLES FOR SHAFT COOLING. AIR COMES FROM 8TH OR 7TH COMPRESSION STAGE
6. COMBUSTION CHAMBER (ONE INTEGRAL PART)
7. COMPRESSOR STAGE-HOUSING MADE FROM TWO SEMI CIRCULAR SECTIONS
8. REINFORCEMENT BEAMS FROM SHEET STEEL (POINT #8 ON COMPLETE ENGINE DIAGRAM)
9. UPPER & LOWER SUPPORT FOR AUXILIARY EQUIPMENT (POINT #6 ON COMPLETE ENGINE DIAGRAM)
10. DRIVE SHAFT FOR AUXILIARY EQUIPMENT, THIS DRIVE SHAFT EXTENDS FROM INTAKE HOUSING TO SUPPORTS
11. COG WHEELS CONNECTING DRIVE SHAFT TO DRIVE-MECHANISMS FOR AUXILIARY EQUIPMENT
12. DRIVE-MECHANISMS FOR AUXILIARY EQUIPMENT

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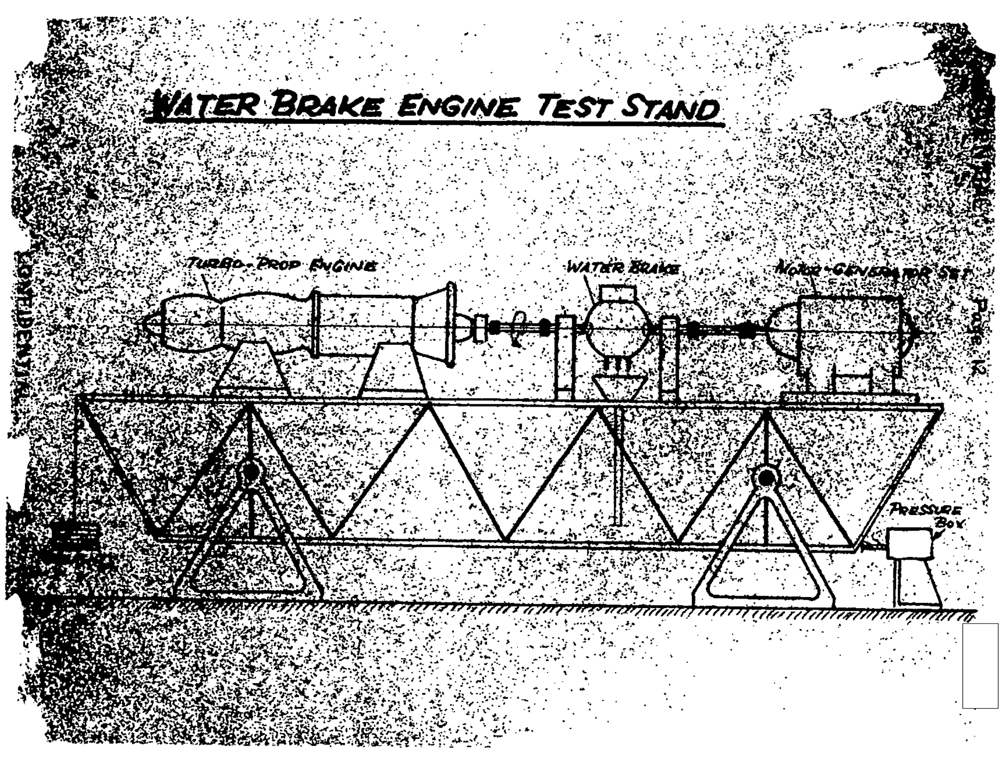
WATER BRAKE ENGINE TEST STAND
TURBO-PROP ENGINE
WATER BRAKE
MOTOR-GENERATOR SET
PRESSURE BOX

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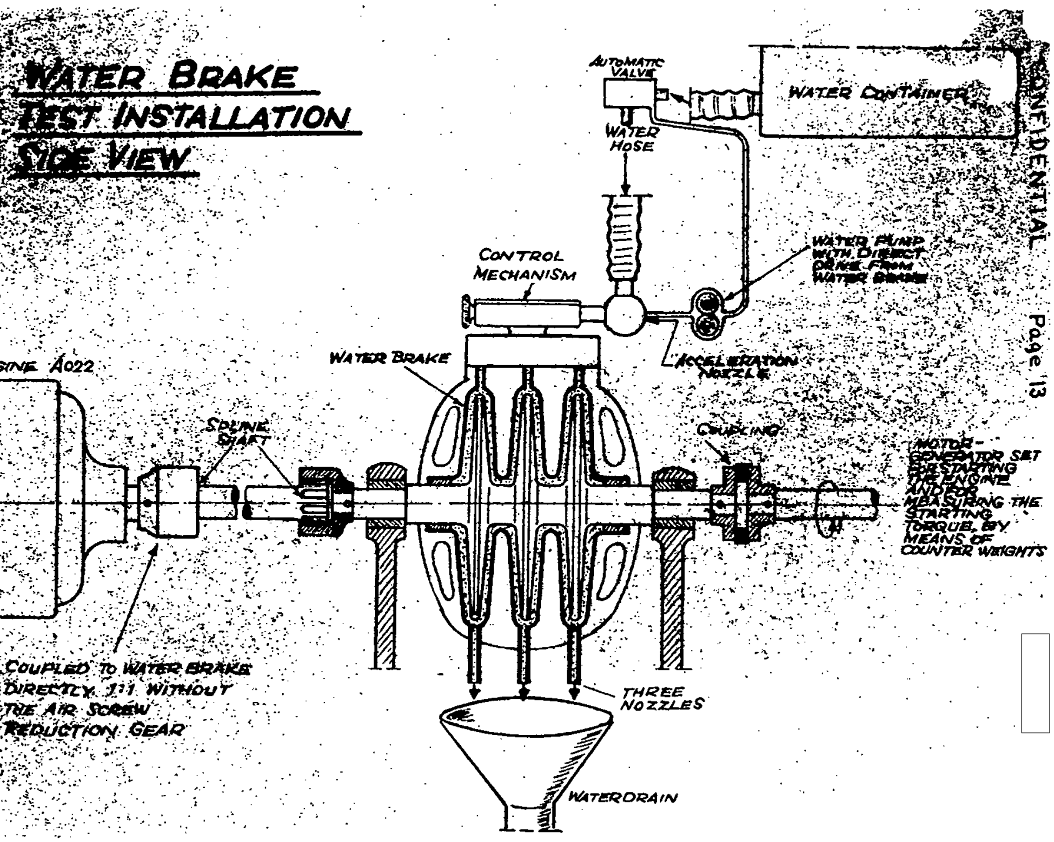

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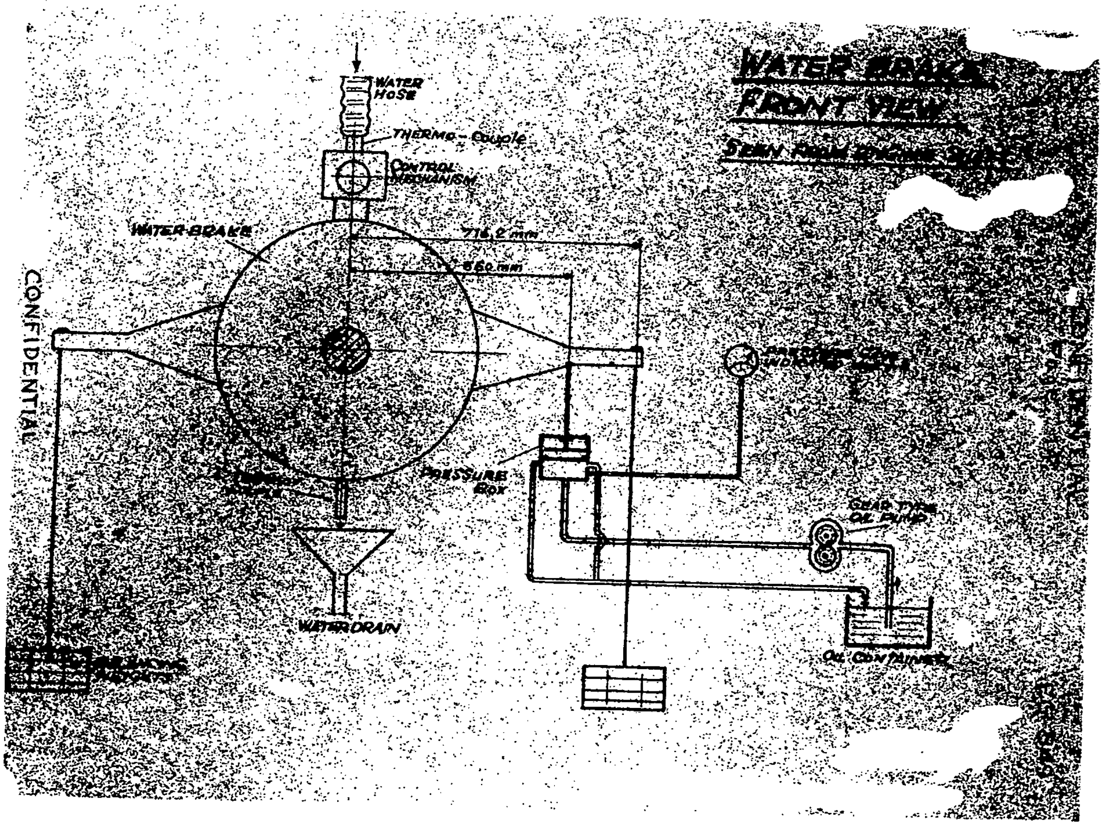
WATER BRAKE
FRONT VIEW
WATER HOSE
THERMO-Couple
CONTROL MECHANISM
WATER-BRAKE
550 mm
PRESSURE BOX
GEAR TYPE OIL PUMP
OIL CONTAINER
WATER DRAIN

TURBO-PROP ENGINE TYPE "M 022"

(MEMORY SKETCH) TOP VIEW

FRONT VIEW OF GEAR

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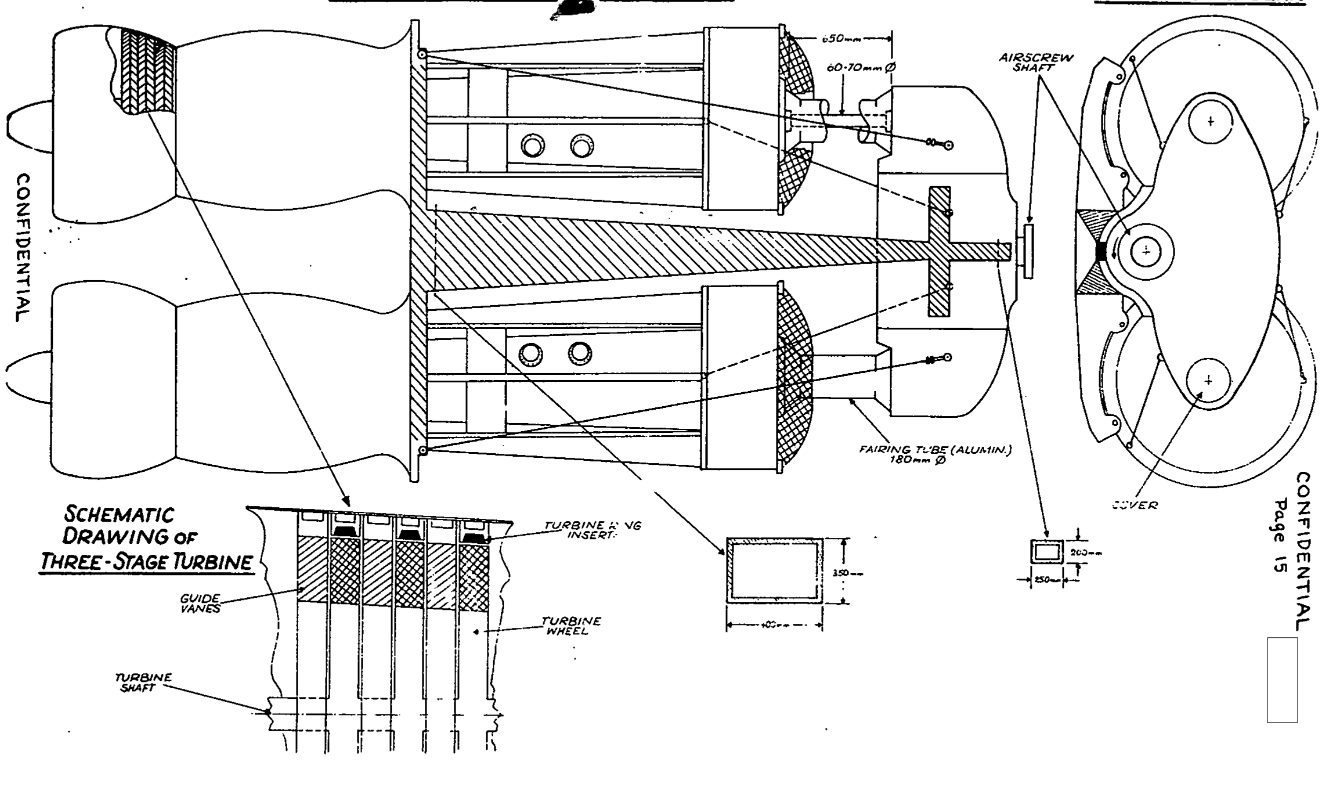

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