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CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

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SECURITY INFORMATION

COUNTRY	USSR (Kuybyshev Oblast)	REPORT	[redacted]
SUBJECT	Turboprop Development Project at Zavod No. 2, Kuybyshev	DATE DISTR.	25 August 1953
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USAF review completed.

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

[redacted]

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JUMO 022 AIRCRAFT TURBOPROP DEVELOPMENT PROJECT AT ZAVOD NO. 2

Physical Characteristics and Performance

[redacted]

2. The characteristics of the 022 turboprop engine are as follows: 25X1
maximum horsepower - 4500 ps (one German ps is equal to .973 hp),
length - 4 meters,
maximum diameter - 1000 mm,
weight - 1350 kg (without propeller or reduction gear),
turbine - 3 stage,
pressure ratio - 4.5,
airflow - 20 kg/sec,
exhaust cone - fixed, and
propellers - 2 contra-rotating.
The only power figure [redacted] was that the 022 developed 4500 ps; there "was no thrust since the turbines absorbed all of the power" /which, [redacted] is incorrect/. The weight figure of 1350 kilograms may have some measure of accuracy since "the Soviets always wanted the weight of 25X1

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(Note: Washington Distribution Indicated By "X"; Field Distribution By "#".)

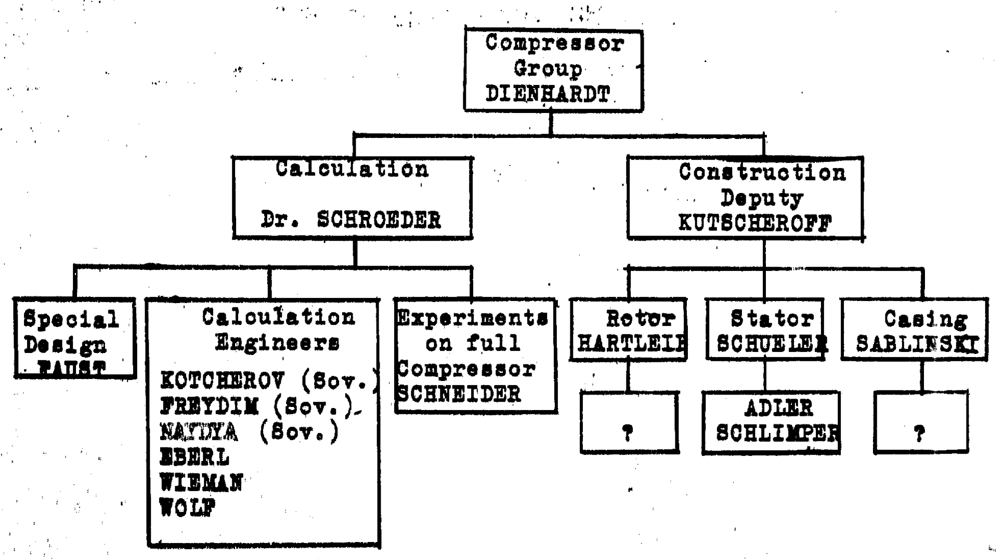
25 YEAR RE-REVIEW

the engine below 1400 kilograms", and BRANDNER said, "the engine was weighed after completion and came out to be 1350 kilograms". [redacted] 25X1

Compressor Design Group

3. This group was headed by DIENHARDT, with Dr. SCHROEDER responsible for the theoretical calculations of the compressor assembly and KUTSCHEROFF in charge of the construction section, which made the drawings from the theoretical calculations furnished by Dr. SCHROEDER's section. From these drawings the shop fabricated the compressor components.

4. The construction section was divided into three units, rotor, stator, and casing. [redacted] 25X1 [redacted] developing components for the single-stage compressor rig and pressure relief valves for the 022 compressor /see page 11, Sketch No. 3; and page 14/.



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JUMO 022 Compressor

[redacted]

6. The blade profiles used for the 022 compressor were a modification of the Goettingen and NACA series. [redacted] 25X1 Only a few of the tables for the profile series were available at Zavod No. 2, which made the job drawn out and tedious for SCHROEDER's calculation section. Most of the NACA blade profile information was gained by reading reports and magazine articles (the Zhukovskiy profiles were tried but proved to have an excessive thickness/chord ratio, as a

result the Goettingen series were the basis for the compressor blading).

7. The construction section (headed by KUTSCHEROFF) constructed the compressor drawings from theoretical data furnished by the calculations section (headed by Dr. SCHROEDER). These drawings, in turn, were handed over to the shop which fabricated the actual components. When a new blade design was introduced, it was standard practice for the shop to fabricate one blade, cross section it in three places (see page 10), and send it back to the construction section for checking. These solid blade cross sections were then projected on the wall and compared with the master profile projected from the drawing. The shop would continue production of the blade form if the profiles checked within the allowable tolerance (unknown).

8. The stator blades were welded to the compressor casing. They were rolled to shape from sheet steel and welded at their trailing edge. A major difficulty encountered was failure because of vibration (breaks occurred in the blades and mountings).

9. The compressor rotor blades had dovetailed feet. (See page 10, Sketch No. 2). The sides were inclined at an angle. A retaining pin insured positive locking. Rotor blades with fir tree root design were also tried, but discarded since the fabrication of such blades took much longer than the dovetailed type.

10. The clearance between the rotor blades and the compressor casing was about 1.5 to two millimeters. To diminish the effects of disruption of the airflow caused by excessive and uneven clearances, the rings (shroud ring attached to the casing surrounding the rotor stage) were lined with graphite. /[redacted] the material was graphite and not a mixture of enamel and talcum powder as had previously been reported by FAUST in [redacted]7 The lining material had a brown color and was about 1.5 to 2 millimeters thick. The material used to line the rings was one continuous piece ([redacted] graphite blocks were used to maintain a minimum clearance in the turbine rotor stages). (See page 10, Sketch No. 3.) Centrifugal forces cause a radial lengthening of the blades which permits the blades to scrape the lining, and make their own paths in them. The tip clearances were held to a minimum by this method. 25X1 25X1 25X1

COMPRESSOR PRESSURE RELIEF SYSTEMS

Hydraulically Operated Flat Type Shutters

11. During the testing of the 022 compressor, surge or stall difficulties occurred, especially during the starting operation. The first attempt to overcome this problem was a set of eight to ten shutters arranged around the compressor entrance. (See page 11, Sketch No. 1.) These shutters were hydraulically operated by a piston which translated motion to kinematic linkages, which raised and lowered the shutters as neede. This required a piston for each shutter. During starting the shutters were raised to reduce the airflow, and lowered flat during normal engine operation. These shutters were not successful, and a second method using an "airfoil shutter" system was tried.

[redacted] 25X1

Hydraulically Operated Airfoil Shutters

12. This system consisted of a series of airfoil shaped shutters arranged around the compressor entrance. All shutters were interconnected with a circular linkage. (See page 11, Sketch No. 2.) These shutters were operated by a hydraulic piston which acted against a kinematic control linkage which operated all of the shutters simultaneously. This system also was unsuccessful.

Pressure Relief Valves

13. The final modification of the pressure relief system resulted in the use of two escape valves operated by action of an oil pressure actuating piston. [redacted] (See page 11.) 25X1
The unit consisted of one piston which operated a shutter valve (butterfly type) contained in each air escape port (there were two escape ports; each having a shutter valve which was connected by a steel rod). The center of this connecting rod was in turn mated to a forked arm, which was operated by the action of the piston movement (operated by oil pressure). The shutter valve was mounted slightly off center so that when it was in the fully open position the upper tip was about five millimeters from the edge of the exit. The lower tip of the shutter at this point was level with the mounting base flange. (See page 12.)

14. The first design had two pistons, one for each shutter valve. Another design used had four blow-off valves. This was modified to the single piston operating the two interconnected shutter valves (this system was used as of October 1950).

15. The base of each pressure relief valve covers the area between the fifth and sixth compressor stator stage (including the area above the fifth rotor stage). (See page 12.) The actuating piston is located between the two blow-off valves. The complete unit is located at the top dead center position of the engine. [redacted] 25X1 the relief valves are side by side and not one behind the other, as has been reported [redacted] 25X1

16. The diameter of the blow-off valves (aluminum alloy casting) was 100-110 millimeters, the bottom case (made of sheet steel) on which the valves were fitted measured approximately 200-250 millimeters x 400-500 millimeters. The vertical height of the valve section was 100-120 millimeters.

17. [redacted] the engine lubricating system [redacted] 25X1 25X1 the pressure relief valve unit was connected to it in some manner. (See page 13.) During starting, an engine driven booster pump kept the oil pressure over a specified valve so that the actuating piston is operating because of the incoming oil pressure. This action opens the butterfly valves in the relief valves, allowing air to be bled off. Upon attaining a predetermined rpm the oil pressure falls below a minimum value so that the oil flow to the actuating piston is automatically cut off from the system, causing the relief valves to close. [redacted] at what engine rpm the valves opened or closed. 25X1 The loaded spring then loses its tension, pulling the piston back and closing the butterfly valves (a double

acting piston was tried, that is, oil pressure oprating in both directions, but this was discarded because of oil leakage in the seal when the piston traveled backwards). This pressure relief unit removed enough of the air flow to insure starting without pressure surge. [redacted] 25X1

SINGLE STAGE COMPRESSOR TEST STAND

18. [redacted] the development of the single stage compressor test stand. It was ready for operation in 1950. (See page 14.) 25X1

19. The air inlet leading to the compressor entrance was a conventional grid type. The mass air flow was controlled by the insertion of a flow adjusting orifice (Messblende), built to German DIN standards, in the diffuser section (there were as many as 10-12 orifice plates which could be used to simulate the required test conditions).

20. The compressor, when tested, was driven by a modified JUMO 004 turbo-jet engine. The engine had three turbine stages; one absorbed the JUMO 004 compressor power; the other two absorbed the power of the compressor unit on test. The test rig had a capacity of testing either one compressor stage or two compressor stages, the 004 power unit being inadequate for higher powers.

21. One reason for the long delay in developing the 022 compressor was the failure to complete the single stage test stand until 1950. This was the only one at Zavod No. 2 and all of the test work had to be done on this stand. Many cases of mismatching the compressor rotor stages and improper blade angles could only be rectified by continuous testing on the single stage compressor test stand before going into the full scale testing of the compressor.

Test Procedures

22. The compressor stages were tested individually and by pairs. Each time a different compressor stage was tested the inner "bullet" and outer compressor casing had to be changed (this was because of the difference in rotor wheel sizes). After successful single-stage tests were completed, successive pairs of compressor stages were tested, i.e., stages one and two, stages three and four, stages five and six, etc. (never odd pairs such as two and three, or four and five, etc.) More than two compressor stages were never tested at on time, since the JUMO 004 power unit had such a low power output. During the testing procedure (duration of test period is not known) the following data were taken:

   a. Mass air flow.

   b. Inlet air temperature.

   c. Inlet air pressure.

   d. RPM.

   e. Temperature and pressure before and after every stator and rotor stage.

   f. Direction of stream flow after each stator and rotor stage.

23. There were three methods in use for measuring the stream pressure and direction of flow. One of the instruments used was called a Staukugel (pressure sphere). This was a metal ball-shaped device consisting of five internally drilled channels which led to a manometer bank. (See page 15.) This instrument was made and used in Germany during the war and a few of them were shipped with the original engine parts to Kuybyshev. The Staukugel (ball-shaped measuring instrument) came in two or three sizes, all within 15-20 millimeters diameter.

24. The Staukugel was lined up with the longitudinal axis of the compressor casing by zeroing the calibrated scale mounted on the exterior of the casing (see page 15). During the compressor testing procedure the ball was lined up with the flow until the maximum pressure could be recorded (by observing the manometer tubes). At the same time the pointer would indicate the direction of the flow over the instrument.

25. The second method of measuring stream pressure and direction was by using standard Prandtl tubes. This method was more accurate than the aforementioned Staukugel. Sometimes both instruments were used together, i.e., one at the top and one at the bottom, as a check against each other. [redacted] the instrument used in the third method of measuring stream pressure and direction once. It was disc-shaped and was called a seegerische Messcheibe (measuring disc). 25X1

GAS TURBINE STARTER PROJECT

26. [redacted] the compressor of the small gas turbine starter for the 022. At first an axial flow compressor unit was designed and tested, but discarded in favor of a centrifugal flow type compressor. The rated output was 80 hp (ps, which is equal to .973 [redacted] horsepower). (See page 16.) Test runs on the unit had included 180 separate starts on a test stand, which incorporated a water brake to absorb the power. 25X1 25X1

27. [redacted] 25X1

SOVIET COMPRESSOR PROJECT 25X1

28. In 1948 BRANDNER and KUZNETSOV returned from an engine factory located in the Urals [redacted]. Soon after they had arrived orders were received to modify the design of the single stage compressor stand (in 1949) so that a Soviet compressor could be tested.

29. [redacted] Soviet blueprints of an axial flow compressor. [redacted] the Soviet compressor could be tested on the single stage compressor test stand, which was to be put into operation at Zavod No. 2. To do this [redacted] the pertinent compressor dimensions, etc. [redacted] the blueprints 25X1 25X1

furnished by the Soviets. The drawings were new and were not stamped with any classification. All of the drawing numbers and titles had been cut out before the German group received the blueprints (only the dimensions remained). All of the printing was in Russian, and it was easy to see that the drawings had been made by the Soviets because "there was no style or form to the drawings. The lines were heavily drawn and not sharp and neat; they were not drawn to German drafting standards".

30. [redacted] 25X1 the compressor can be summed up as follows:

a. The Soviet compressor was probably about 80 millimeters smaller in diameter than the 022 compressor.

b. Rotor blades appeared longer and with more twist than the 022 blades. The type of blade attachment was not known.

c. The rotor wheels were built "heavier" than the 022, i.e., thicker and more massive looking.

d. [redacted] there might have been eight stages. 25X1

e. It did not appear to be similar to the 012, 022, or 003 compressor.

31. BRANDNER had stated that the compressor had been built and test run at the factory in the Urals, where he had been working. It had not run under its own power. Only motoring tests had been completed, and for this reason it was decided that single stage testing should be made.

32. The redesign of the single stage compressor test stand to accommodate the Soviet compressor wheels was completed at the end of 1949. The parts, such as nose inlet, outer casings, etc., had been built in the workshop and were lying around at the beginning of 1950. All that had to be done was the installation work. [redacted] 25X1 no tests on the Soviet compressor had been made at Zavod No. 2.

33. The blueprints of the Soviet compressor were put into the archives at Zavod No. 2. [redacted] possibly WIEMAN, who conducted compressor testing on the single stage compressor test stand, would know more about the ultimate fate of the projected test program [redacted] 25X1 [redacted] the project had been abandoned). 25X1 25X1

GERLACH GROUP

34. Approximately 40 engineers, including Dipl. Ing. GERLACH, came from a factory near Moscow to Zavod No. 2 in the fall of 1949. [redacted] 25X1 [redacted] they had been working on a diesel aircraft engine project. [redacted] 25X1

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1. Comment. Probably 80 German horse power (ps) is meant inasmuch as the German measure is used earlier in the report; however, the text does not fully clarify the meaning.

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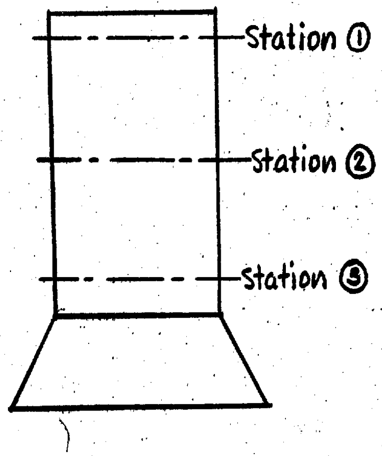
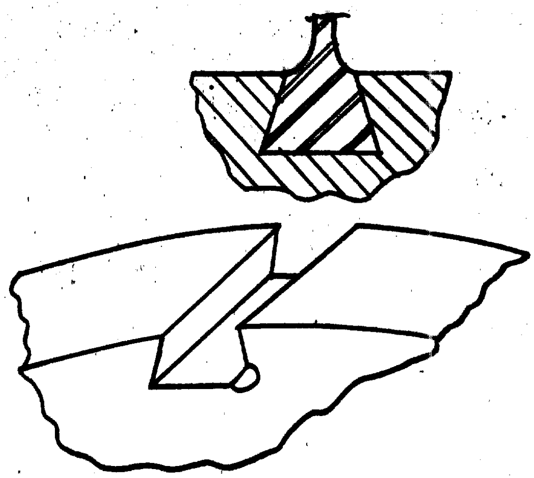
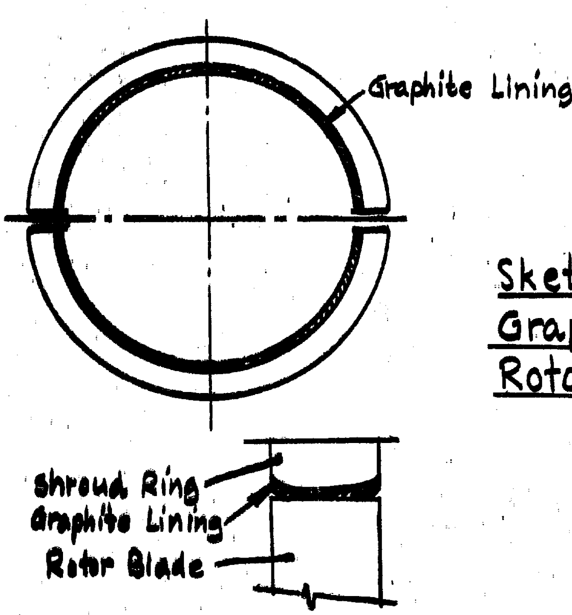


Sketch #1
Location of Stations for
Compressor Blade Profile checks



Sketch #2
Mounting of
Compressor Rotor Blades



Sketch #3
Graphite Lining of Compressor
Rotor Shroud Rings

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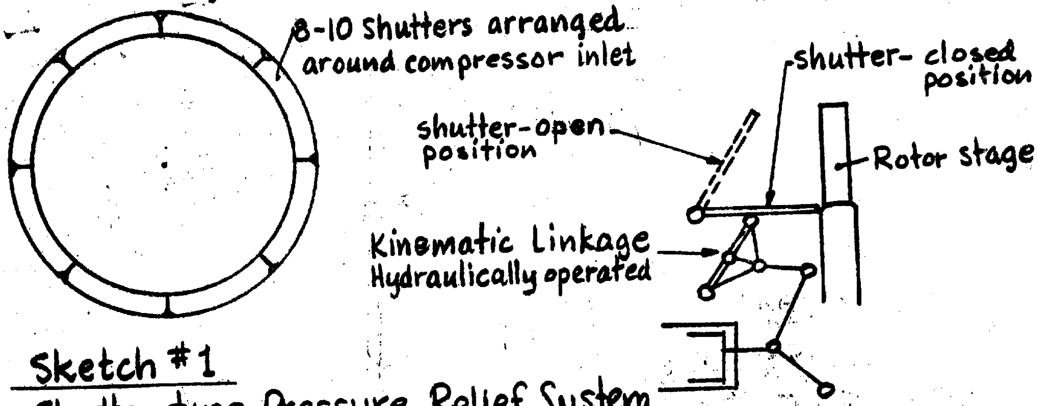
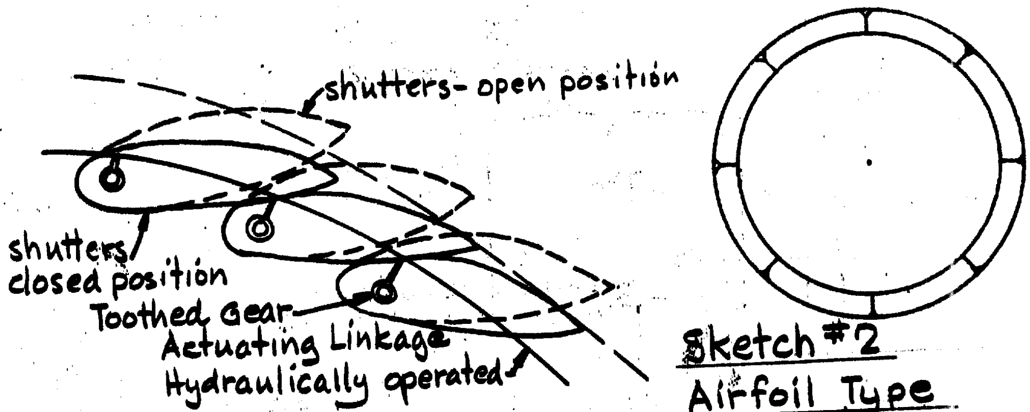
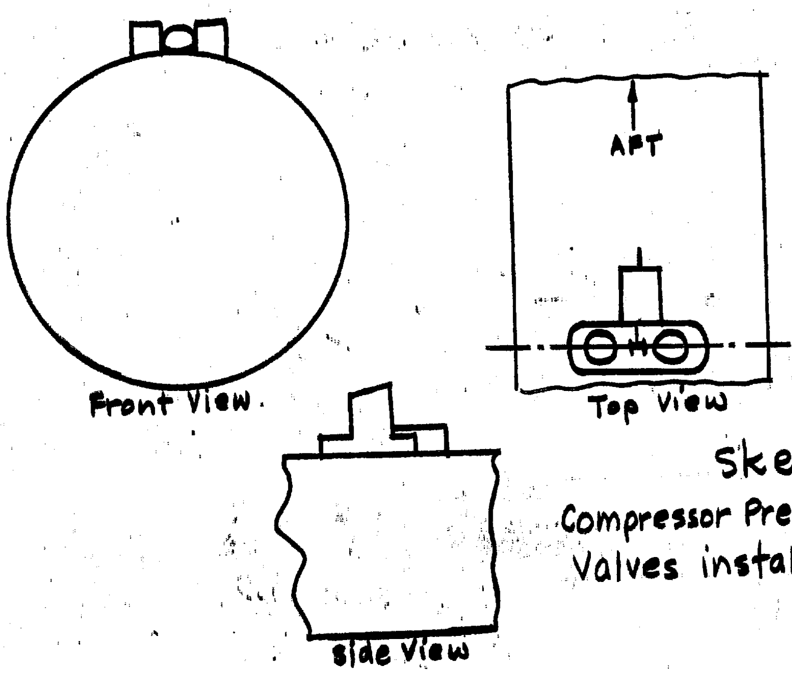


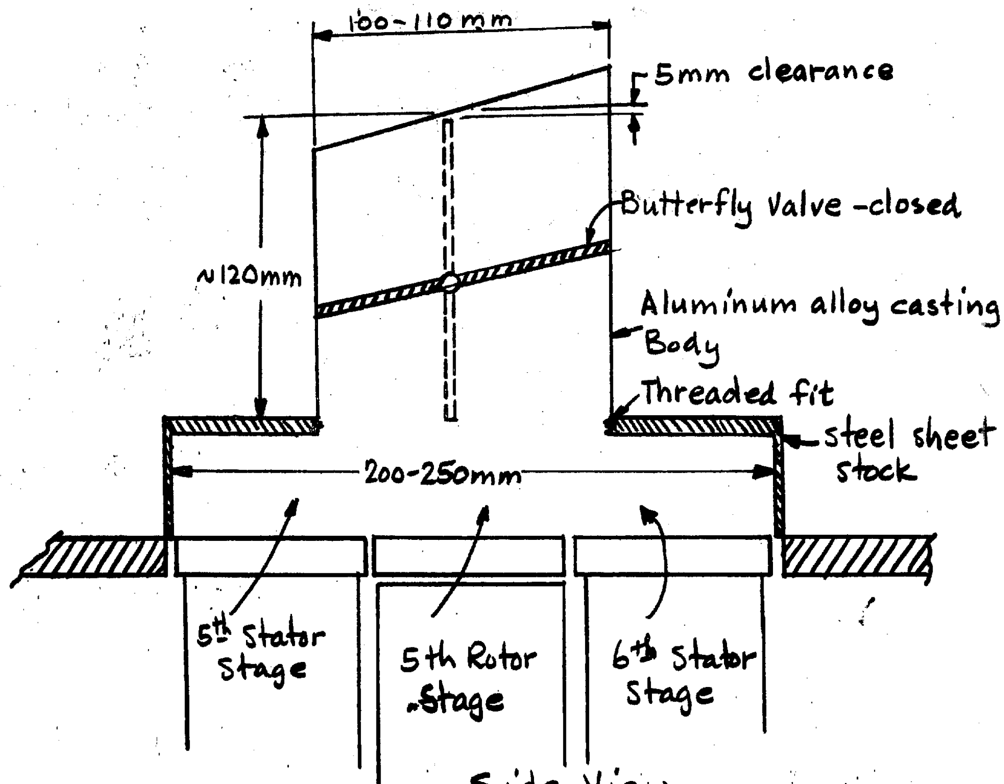
Sketch #1
Shutter type Pressure Relief System



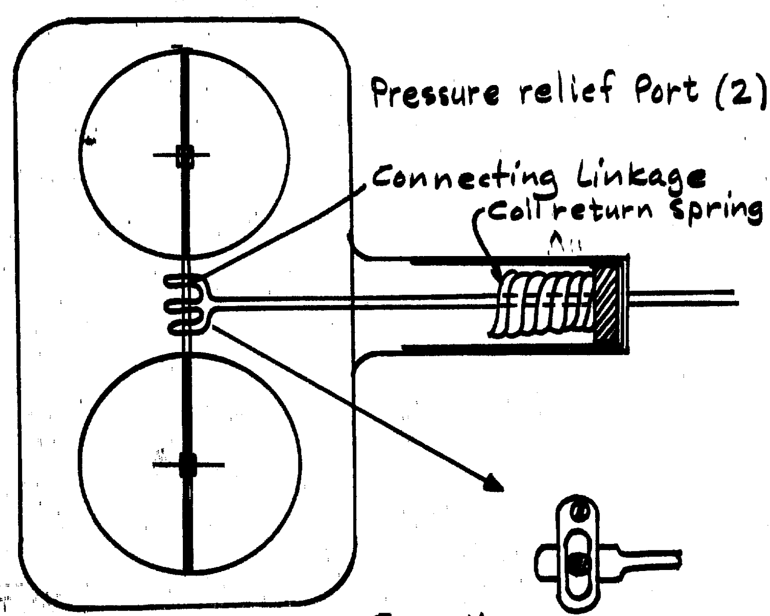
Sketch #2
Airfoil Type
Pressure Relief System



Sketch #3
Compressor Pressure Relief
Valves installation



Side View



Top View

Compressor Pressure Relief Valves

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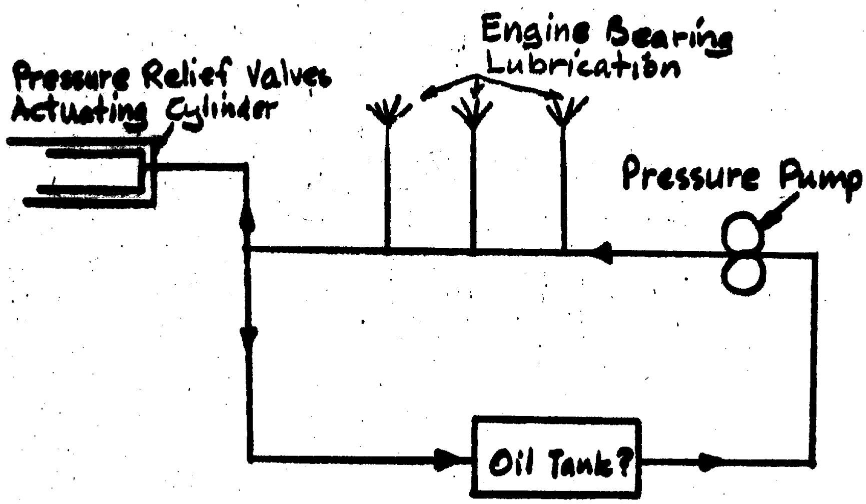

Schematic of Pressure Relief Valve Operation

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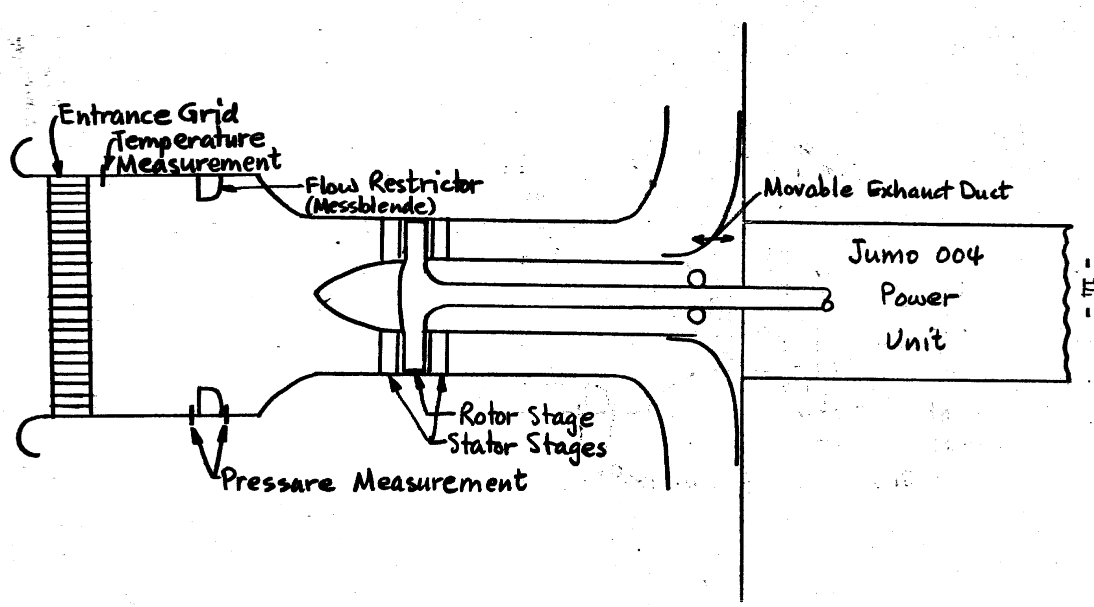
Schematic of Single Stage Compressor Test Stand



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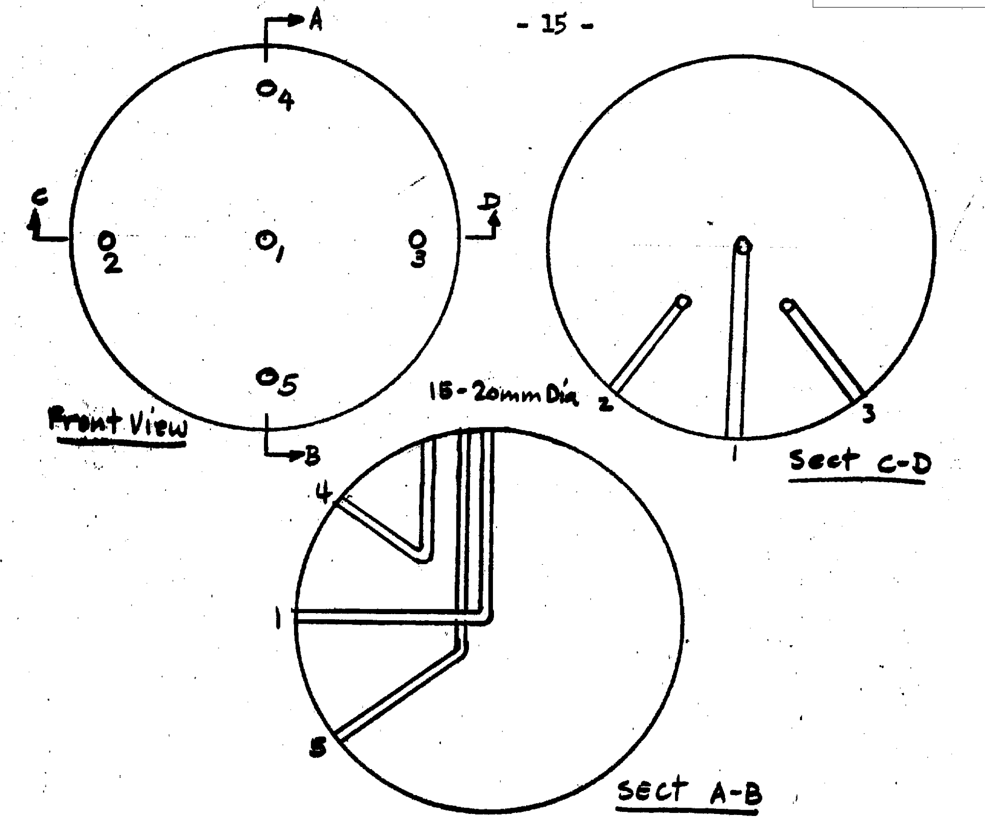
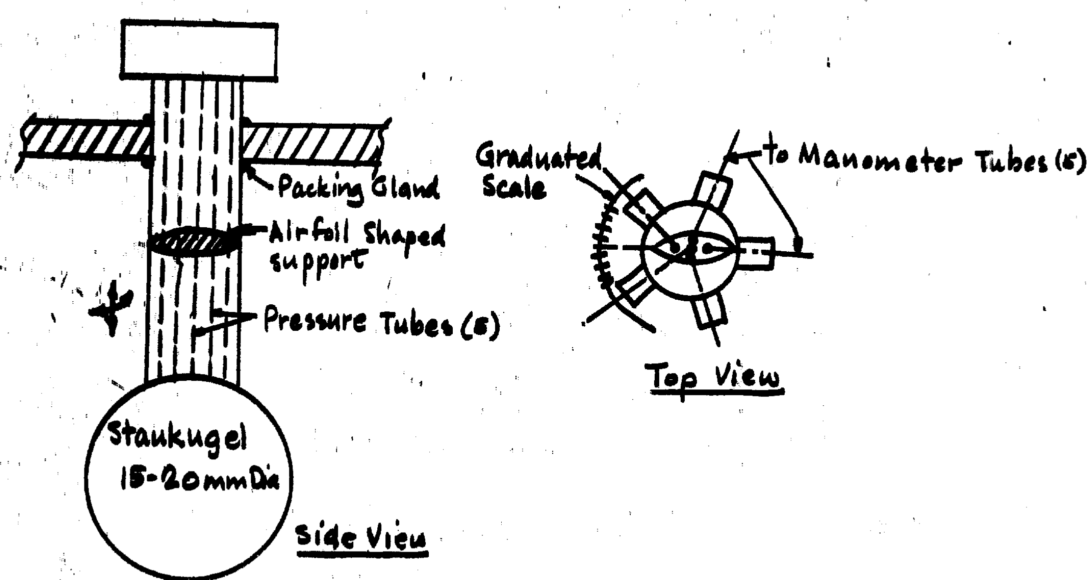
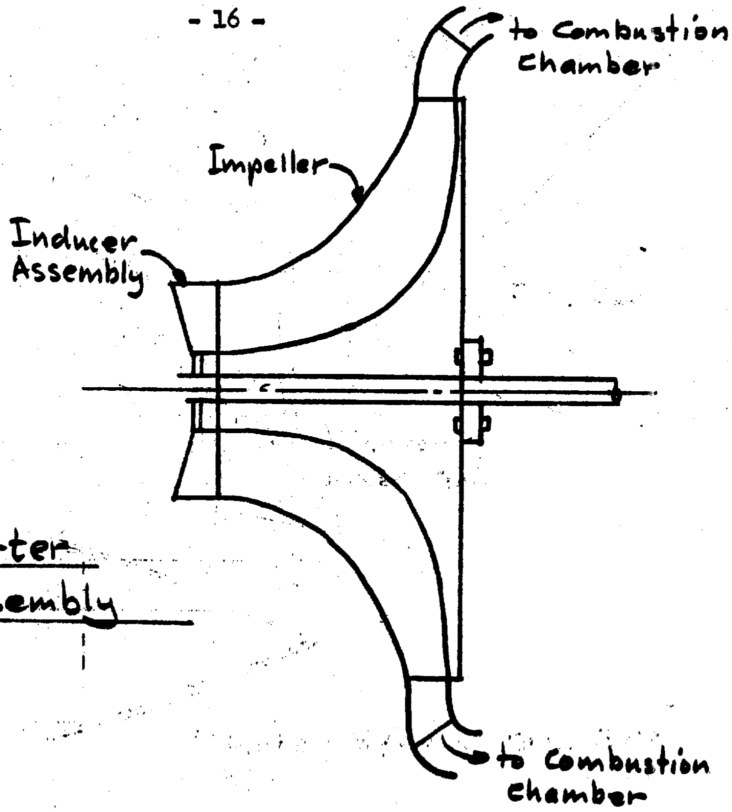
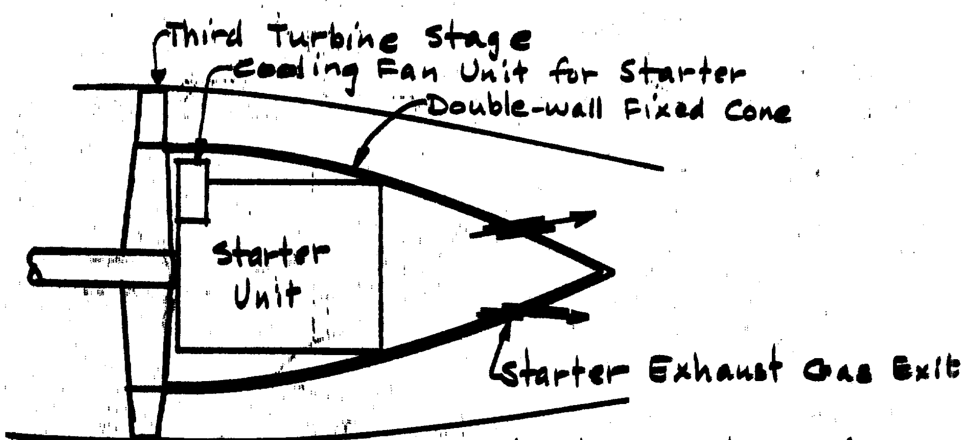




STAUKUGEL (Pressure Sphere) INSTALLATION



Sketch #1
Gas Turbine Starter
Compressor Assembly



Sketch #2
Gas Turbine Starter Installation
in Jumo 022 Engines