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MTR FAST CHOPPER ROTOR LOSS

R. G. Fluharty

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AEC RESEARCH AND DEVELOPMENT REPORT

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PHILLIPS PETROLEUM COMPANY
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A B S T R A C T

This report gives a description of the MTR fast chopper loss and of the steps which were taken following the initial signs of faulty behavior. Although the cause of the rotor failure has not been definitely established, evidence for three of the most probable causes is examined. Photographs of the damaged rotor before and after disassembly are included. Recommendations to reduce the probability of such accidents happening are presented.

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MTR FAST CHOPPER ROTOR LOSS

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I. DESCRIPTION OF INCIDENT

On the evening of April 8, 1958, Orval Simpson and Clayton Miller were working on an automatic sample changer for the chopper preparatory to a run for a weekend. The functions they were performing were in no way connected with the operating rotor of the chopper which was spinning at a presumed speed of 6000 rpm. The following is quoted from their written description of the event:

"At 9:55 p.m., a terrible noise was heard coming from the chopper shielding. Clay immediately ran to Rack No. 1 (chopper controls) to find the cause of trouble and I ran to the main power circuit breaker and killed all power (except emergency power to operate the entrance stator motor) to the chopper. We knew immediately that the chopper rotor was breaking apart. Since I had turned off the power before Clay reached the panel control rack, there was no means of telling what had caused the trouble. The main burst of noise came in two spurts, the first spurt of noise was the loudest and lasted a few seconds then there was a period of silence of about 15 to 30 seconds at which time the second burst of noise started and lasted intermittently about 4 to 6 minutes. During this time interval, we advised everyone to stay back in case the explosion shielding should fail. Occasional spurts of noise were heard after this for the next few minutes."

When the rotor was stopped, inspection revealed that the plastic arms had disappeared, but the forgings were still suspended and the support shaft had survived the violence of the arm losses. Considerable gouging of the outer edges of the aluminum forgings was observed. Photographs of the rotor are shown in Figures 1 and 2.

On disassembly it was found that the gouging had been caused by a bolt falling from the bumper ring onto the rotor and being ground between the rotor and steel explosion shield on the outside. Most of the bolts that fasten the forgings together had been broken by tensile forces, and those which were unbroken were stretched and narrowed. Both forgings were sprung concave by 0.010 inch from center to edge. Another indication of the violence of the incident was shown in the scoring and spinning action of the rotor bumper collar and the bumper ring as shown in Figure 3.

The major rotor damage was caused by the bolt gouging the edge of the rotor. Since the bolt knocked off some of the aluminum nubs on the forgings used for the outer alignment of the plastic slits, it was not considered advisable to attempt to repair the rotor. These nubs are necessary since the plastic arms are not on the rotor radii and are therefore under torque. Some means would be required to replace the nubs to keep the arms aligned, and it is very doubtful that reasonable rotor speeds could be obtained even though repair could be made.

II. CAUSE

The cause of the rotor failure has not been proven, but the most probable cause is that the bumper bolt fell out, knocked off some of the arms, and caused the failure of the rotor clamping bolts. The major evidence for this conclusion is based upon the very loud initial burst of noise reported by the chopper personnel who were present at the time of the failure.

The second possible cause, of overspeed resulting in bolt failure and arm loss, was at first believed to be true, since a light pulse failure was recorded approximately 30 minutes before the incident. Since the speed control would call for acceleration on light pulse failure, a high speed could cause failure as reported by Seidl in BNL-278 (T-46). In this case the subsequent vibration due to the unbalanced rotor could have caused the bolt to shake loose and fall onto the rotor to cause the major damage after an initial rotor failure. The results of considerable vibration was shown by many other loose bolts on entrance and exit stators, by the breaking of the welds for the bolt tabs on the cooling fan, and by the fairly large displacement of shielding bags surrounding the rotor.

The output from a magnetic frequency pick-up was monitored by a symplitrol meter to provide a safety signal to turn off the power to protect the rotor from such overspeed, and this cause of failure would require a failure of this circuit also. This overspeed limit was set at 6500 rpm, and repeated checks before and after the incident failed to indicate any failures in this system; thus, it must be concluded that such a failure is quite improbable.

The automatic speed control was designed to essentially saturate at 6000 rpm, or the amount of error signal available at 6000 rpm is quite small. It is therefore quite doubtful that a speed greater than 6500 rpm was reached during the one-half hour period even though the acceleration time to 6000 rpm is only 45 minutes. Some misunderstanding of the latter point was responsible for the initial conclusions that overspeed caused the rotor failure. This point will be tested and actual data presented as soon as the circuit is available with the chopper control again. At the present it is undergoing modifications to disconnect the rotor drive power on light failure, etc.

The third possibility is that the rotor arms finally failed after 3 to 4 times the designed operation time of 10,000 hours. This could have resulted from final rotor bolt failure or plastic failure with or without overspeed. It is thought that the bolt failure was quite unlikely since the bolts have been checked at least 3 times during the past 4 years with no evidence whatsoever of increased length. The plastic in the arms was also monitored by keeping

pieces in the vacuum housing. A check on the dimensions of these did not show any shrinkage over a 2 year period at which time the tests were discontinued.

It seems quite probable that some of the arms were still in position when the bolt fell through. One of the reasons for this conclusion can be seen in Figures 2 and 4 where a piece of a slit arm is still intact. The fracture is that of a blow from the side and it is felt that the bolt would be necessary to cause this damage. This conclusion is also consistent with bolt contact pattern. Also, in one case the bolt was apparently stopped by the paddle where it hit one of the nubs. This is in contrast to the usual case where the bolt removed nub material as if the paddle were not there as shown in Figure 1.

III. CONCLUSIONS AND RECOMMENDATIONS

Although no conclusive statements can be made as to the cause of the failure, several points should be made which probably should be included in the use and operation of such a rotor. For the most part these are obvious from the previous discussion, but for completeness are listed as follows:

1. A routine check of pertinent rotor dimensions should probably be made at 6 month intervals, with a thorough check of all operating parts.

2. Bolts within the casting and above the rotor should be fastened by safety wire or other means of insuring their location. Allsuch bolts should be inspected whenever the chopper is disassembled for check or repair.

3. Provisions should be made for a rotor "scram" upon light pulse failure. Also, it is likely that a parallel overspeed control should be used.

4. The internal plastic pieces in the rotor should probably be replaced after three years of rotor operation. This recommendation results from the observation that the internal plastic pieces appear to have shrunk considerably. The whole assembly was found to be quite loose with as much as 1/16 inch play in some of the pieces. This resulted in mechanical failure on the inner points of the solid pie pieces where they were supported on the steel ring.

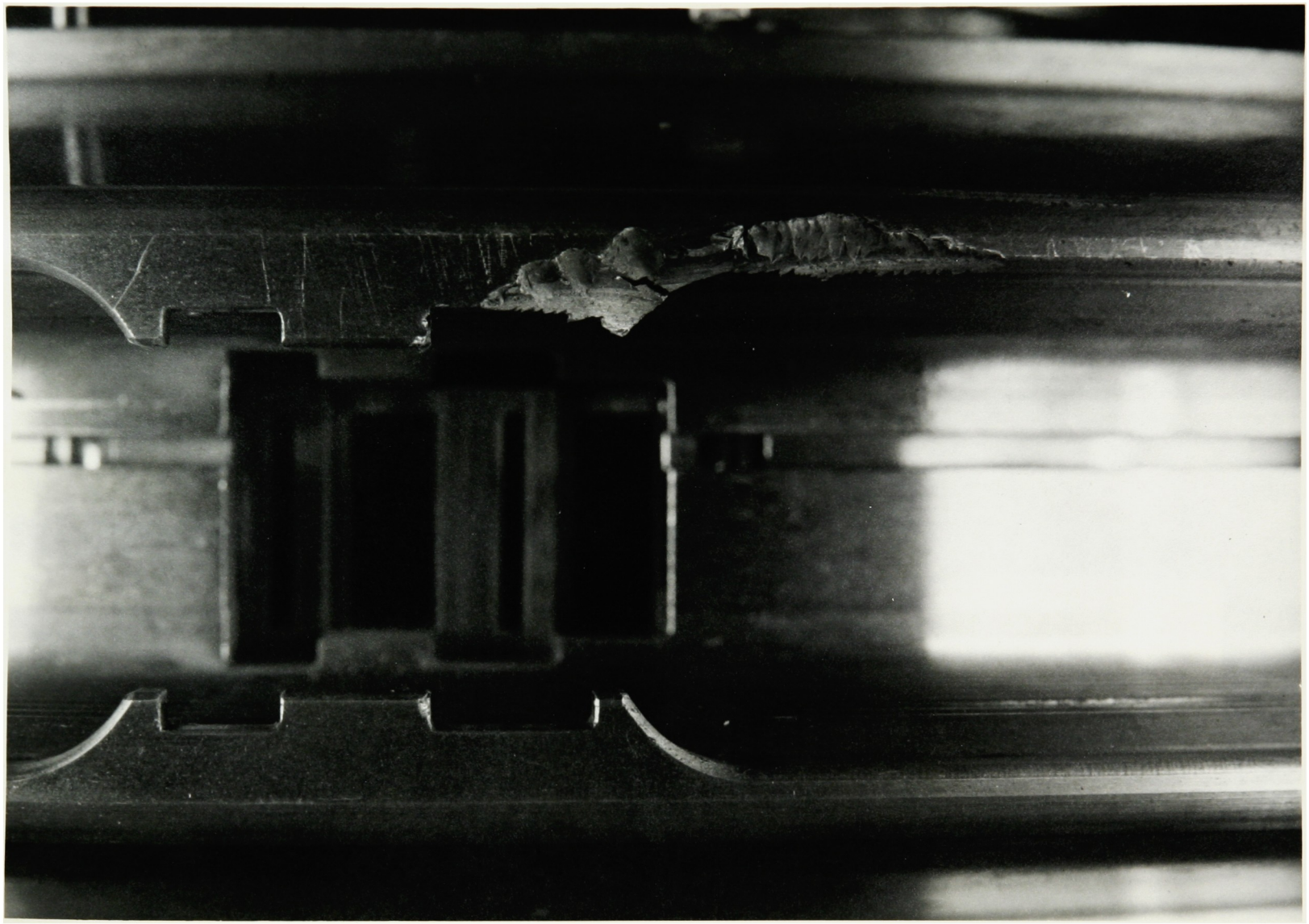

Figure 1

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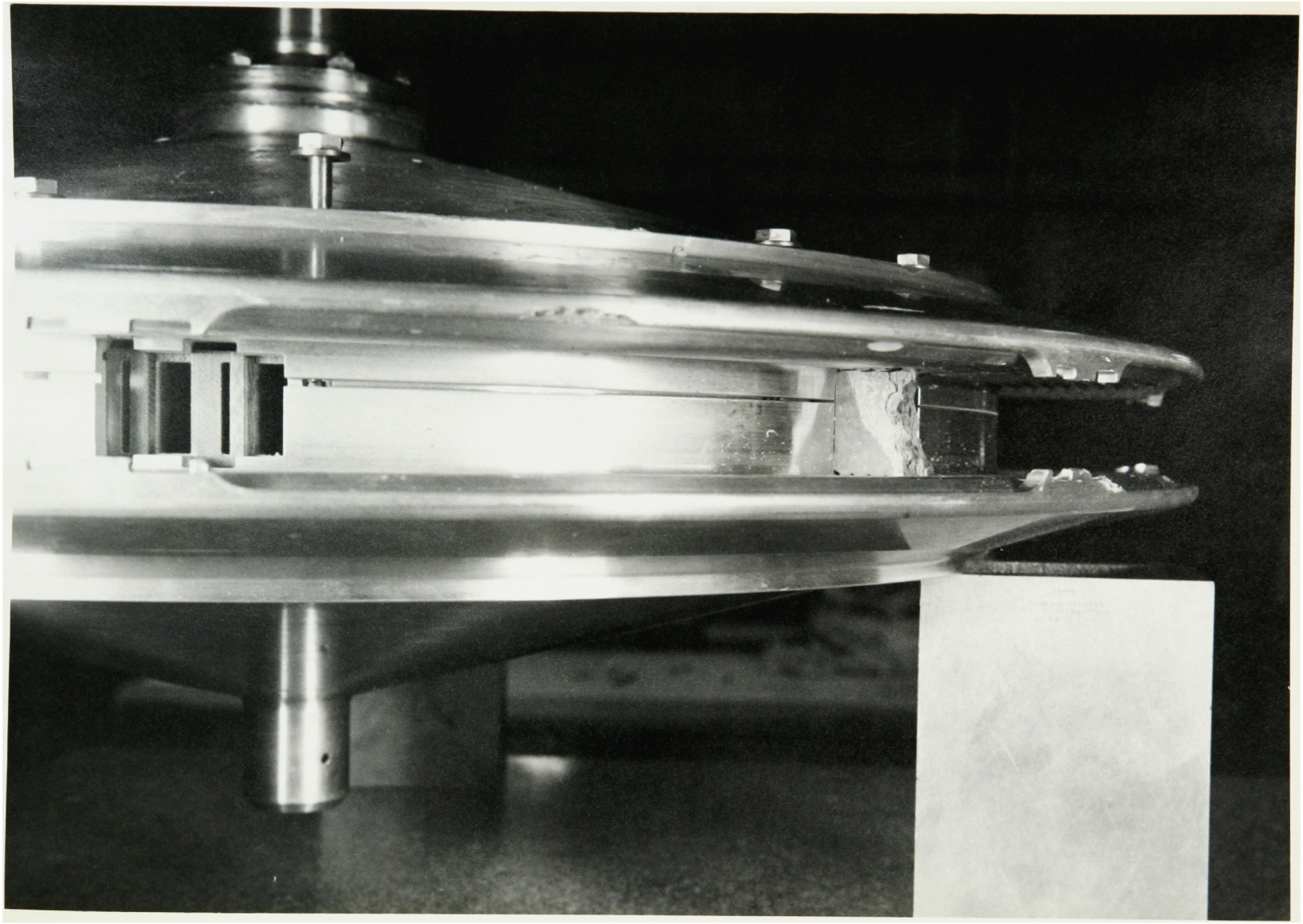

Figure 2

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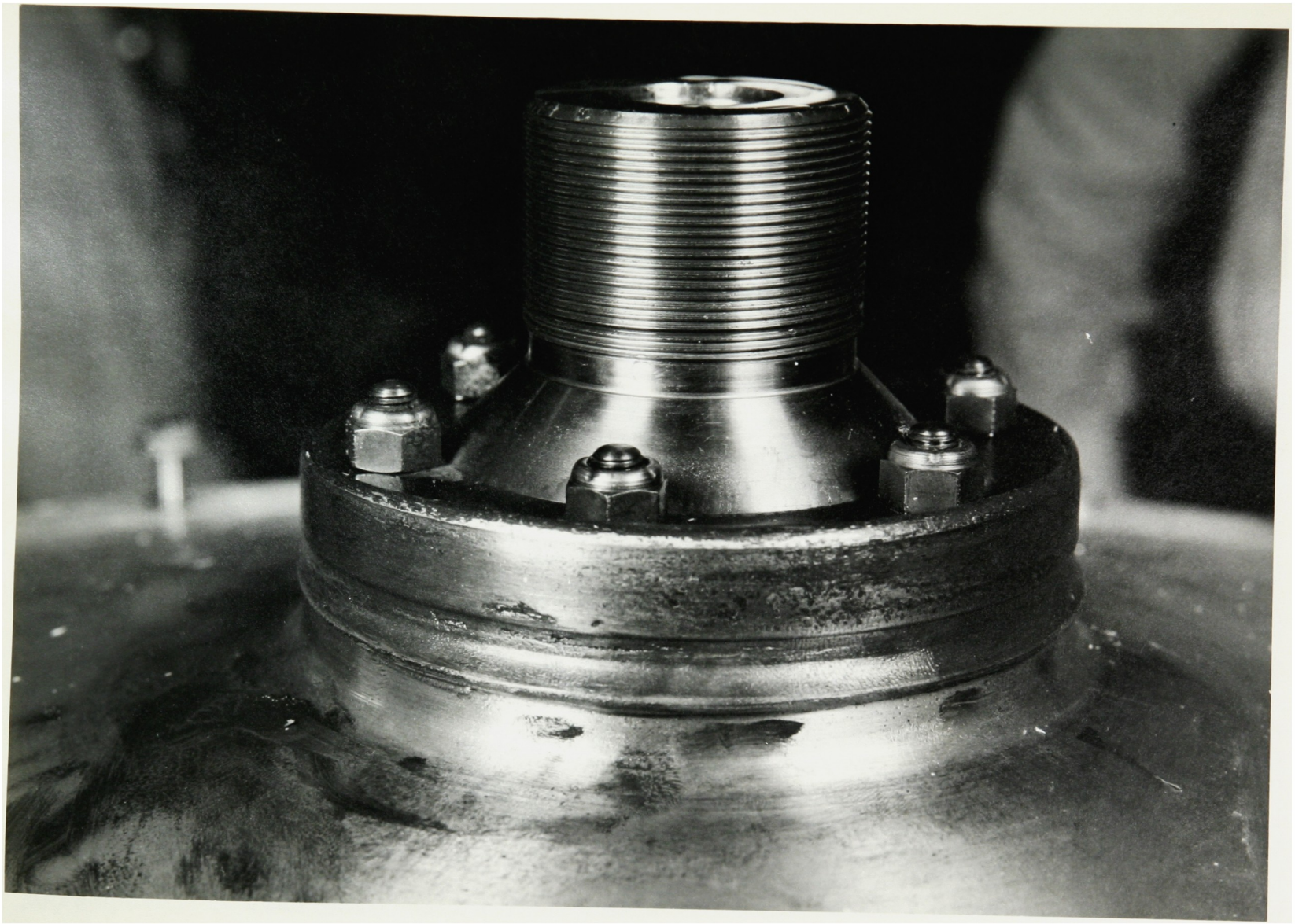

Figure 3

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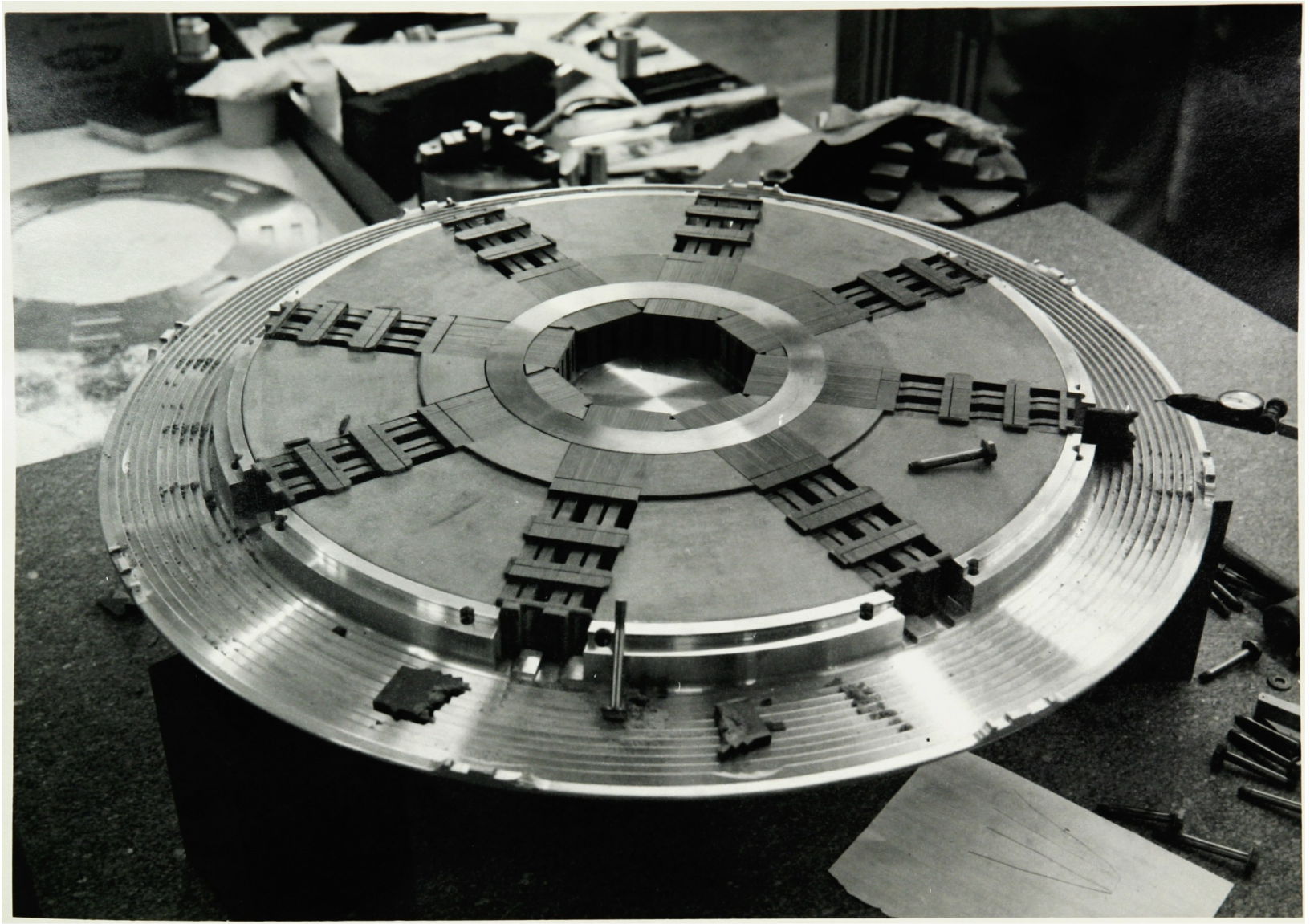

Figure 4

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