AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT NO 72

27 April - 9 May 1990

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Reasons for Tank Opening

Change terminal stripper foil and general inspection.

Immediate History

The 14UD was last opened from Nov 21 to 27 Nov 1989. In December it was conditioned to over 16 MeV. It has run 1886 hours at up to 15.5 MeV. There have recently been tank sparks unheralded by conditioning. This is consistent with particulates in the SF_6 space whose movement and charging, randomly detonates sparks. We will be looking for such particulates and their sources. In the previous opening, severe spark marks were evident on the lips of charging chain pellets and on their sides. There have been charging instabilities on all chains as exhibited by glitches on the oscilloscope traces. The threshold for these glitches is about 1.12 MV per unit which corresponds to 15.37 MV for the full high energy end of the machine. Investigations were undertaken using shorting rods to see whether the instabilities were associated with the transit of the chain through units with gradient on them or associated only with chain going through units containing idlers. In order to pursue these tests, all units in the high energy end, except 24 and 25, which had no idlers, were shorted out. The glitch threshold remained as it was at 1.12 MV per unit, appearing to exonerate the idlers. The intention during this tank opening is to remove all spark marks from the lips of pellets in order to see whether the chain stability threshold is intrinsic or whether the machine can stably be run above 15.37 MV.

Tank Close Reports

Because of the long interval during which the accelerator was closed, there were several significant improvements done outside the 14UD, because we had the time and resources to attempt them. These will be described now before the tank opening report itself.

Ioniser Frit Blockages

We have used many techniques to try to clear surface blocked ionizer frits, ranging from the delicate electropolishing to the more brutal file, with varying degrees of success.

Our latest solution to surface blockages, from Alistair Muirhead, uses spark erosion of the face of the frit. The first attempt was using distilled water as the electrolyte and tungsten as the electrode. As with all great ideas, the first try was not successful; the erosion took place at the frit tube weld and not across the frit face.

For our second attempt, kerosene was the electrolyte and copper the electrode. We eroded the face in 30 second bursts, inspecting the frit each time. We considered a uniform finish across the frit as the correct time to stop eroding. This required 8 to 10, 30 second long erosion periods.

To remove kerosene from the frit, warm water with 2% RBS detergent was used. It was then rinsed in demineralised water and then flushed with alcohol. Heating to 1300°C in vacuum finished the cleaning cycle and also removed any lost braze material and other junk.. To test flow through the frit, we timed the displacement of 300 mls of water by passing nitrogen gas through the frit at 60 psi. It takes 20 seconds for a virgin frit to displace 300 mls of water, and our reconditioned frit took 21 seconds.

There has not been a need to put the reconditioned frit into service yet, but we feel confident about the outcome when we do.

New Ion Source Lens

As part of the injector upgrade of the 14UD scheduled for early 1990, new beam optics requires the elimination of the gridded Einzel lens at the exit of the pre-acceleration tube and for its optical function to be taken over by controlling the entrance lens effect of the pre-acceleration tube. The magnification of this lens is optimised by increasing the distance from the entrance of the pre-acceleration tube to the position of the cone, to about 345 mm. In part of that space, a new electrode is inserted that is immersed in the entrance lens region of the pre-acceleration tube. This new electrode is split into four quadrants which not only control focussing properties, but will also allow beam steering adjustments. The lens has been satisfactorily tested with a single power supply and the four power supply system is almost complete. There would appear to be some problems associated with the new optical properties of this interim injection system in that the level 5 slow chopping might be less effective than it has been previously. This has deleterious effects on the chlorine-36 program which uses a 50 to 1 chopper ratio on the stable isotopes. These effects are under investigation.

Low Terminal Voltage Operation of the 14UD

Rutherford backscattering experiments are using carbon 12 and the detection facilities of the Enge spectrometer. The terminal voltage was operated at 2 MV with units 1 and 2 only live. Gas stripper was used to produce single plus and double plus carbon-12. This worked satisfactorily; with 730 na injected, a 1+ beam of 225 na was analysed.

New Chain Power Supplies

New power supplies have been bought from NEC which will enable computer control of the charging volts for AMS measurements. The power supplies are manufactured by Glassman to NEC requirements and were installed 5 Oct 89. Unfortunately, the negative power supply has given consistent trouble with component failures associated with tank sparks. The supply has been taken apart and inspected. The grounding arrangements have been much improved. Since completion of these modifications, there have been almost no further difficulties.

Ion Beam Implanter

The NEC 5SDH-4 has been installed in Nuclear Physics premises for the new Department of Electronic Materials Engineering. The accelerator was installed on schedule and passed its acceptance tests readily. We would like to applaud the efforts of Chip Cichon, the NEC implanter implanter.

Lost Charge

For several years, the accelerator has consistently shown lost charge indications of the order of 10 micro amps. Investigations by Doug Stewart have revealed that G-MOV spark protection devices, which were put across the column and tube current metering feedthroughs, had insufficient and unstable resistance to ground, even at the nominal operating voltages. When these GMOV's were removed, the lost charge went to zero. It would appear that intermittent shorting or low impedance of the GMOV's on low energy column current, were confused with worries about instabilities in unit 1 in the accelerator. It now appears that those instabilities were just a figment of the GMOV imagination. The entire accelerator was conditioned to 1.25 MV per unit in subsections of 4s and 5s, directly after the tank opening. By 12 December, the machine was conditioning at 16 MV.

Large Recirculator SF_6 Purification

In the absence of the production of breakdown products because of the removal of corona point distribution system, the large SF_6 purifier recirculator has been turned off in January 1990. We are monitoring SF_6 breakdown products using our breakdown product detector and have observed no noticeable breakdown products above background, since the installation of the resistors.

Tank Faraday Cup

This Faraday cup continued to give intermittent sticking problems in spite of being treated with doses of oil into its pneumatic actuator.

Buncher Cryostat

After a long period in which there was no experimental need for the superbuncher, a new program has started up requiring its use. When last used, there were vacuum leaks associated with the helium pre-cool line. These vacuum leaks were confirmed. The superbuncher cryostat was removed from the beam line in order to repair the vacuum leaks and condition the resonator up to operating gradient. An opportunity was taken to hydrogen condition the resonator in order to attempt to improve its operating Q, which had deteriorated as result of shipment from the United States to Australia. This hydrogen conditioning would appear to have been successful in increasing the Q from 3.3 to 3.8×10^{-7}. Special thanks go to Doug Stewart and Bob Ball in persevering with this hydrogen conditioning against the lethargic responses of the elder author.

Water Leak - Inflection Magnet Power Supply

There was a cascade of water down through the tower and the tank of the accelerator on March 6. A rubber hose providing cooling water in the magnet power supply located at Level 4 failed, presumably due to old age. The power supply and a good part of the tower was flooded. These hoses have now been replaced with higher quality equipment. It wasn't until quite recently, that is May 10, that we discovered that some of the water had gotten into the high voltage feedthrough protection cylinder around the suppressor power supply voltage feed thru. This humid condition around the feedthrough and its protection resistors, resulted in chain glitching seen on the chain pickoffs at around 35 kV inductor voltage. When this area was dried and mylar insulation replaced, all the chain glitching has disappeared. It would appear that this glitching has been a feature at least from March 6 and somehow, even earlier. Perhaps there have been other occasions when this lowest point of the tank has gotten water in it.

Exploratory Tour

The tank was surprisingly clean and odour free, considering the long time it has been closed and in operation. In fact, it's probably the cleanest its ever been. This is attributed to the replacement of the corona point voltage distribution system with the resistor distribution system. Nevertheless, there was a general coating on all the electrostatic surfaces of a grey-white power. This coating was thickest in the region of unit 15 on the rings and casting covers and lower terminal where there were fresh spark marks. One could conclude from this that some of this white powder is newly produced as a result of tank sparking. Close examination of the spark marks, revealed that some of them had black discolouration associated with them. The first photograph shows one such spark mark. In the second photograph, one sees a small speck of black material that has an oily content and is debris from the chains. This gunk is a combination of oil, put on the chains to stop self charge, and abraded material from chain transport system as well as perhaps, spark degraded SF_6. We view such specks, and there are many of them, especially in the high energy end, as initiating points for the random sparking seen in the accelerator over the past period. There is evidence, however, that the condition and voltage and spark threshold of even the first 6 units of the machine, has degraded over the past several months. While in February, the 14UD was able to comfortably run the first 6 units to 7 MV for experiments, it had to operate 7 units for 7 MV to get an acceptably low spark rate i.e. zero. Since there is no evidence of such black lumps of material on these units, one would have to interpret the degradation of performance to the buildup of the grey powder. Although there is some evidence, as mentioned before, that the grey powder is produced during sparks in normal operation, it is still likely that some significant fraction of the grey powder is an historic burden in the accelerator and in particular, residing in the reservoir flanges at the ends of unreconditioned column posts.

We chose to take the opportunity of this tank opening to install a set of power points, one pair each at the base of each supporting steel rope. This was done in order to minimise the snaking of light leads and power leads across the floor of the platform and to cater for future installation of additional fixed lights. The platform checker plate was raised so that Pyrotenax could be installed under the floor to supply these power points. We should not have been surprised to find that there was a substantial amount of under-the-bed fluff in these semi-sealed volumes of the platform, This gave us a wonderful opportunity to clean this area which hasn't been opened probably for twelve years.

Chains

As mentioned before, another major intention was to inspect the chains and remove spark marks which had been seen on chain 2 and chain 3. During the inspection, it was noticed that chain 1 had very substantial lip-to-lip spark marks. Further inspection uncovered two areas of major radial sparks to a region of the chain with the lip-to-lip spark marks. The lip-to-lip spark marks affected about 46 pellets with the radial spark marks occurring one near either end of the 46 pellet length. But there was worse news to come since it was noticed that the nylon links in this region also had been damaged. See photographs of the radial and lip spark marks as well as damage to the nylon. The nylon had surface cracks along the direction of motion of the chain. This is to be contrasted with cracks across the direction of motion in the previous nylon damage associated with breakdown products and mechanical stress. We take the present longitudinal marks on the nylon as witness marks of sparks, electrical discharge from lip-to-lip and along the surface of the nylon caused by sparks along the chain. Further investigation showed, as it had on chain 2 and chain 3 during the last tank opening, that there were matching spark marks on the electrodes which protect the casting idlers. (see the last photograph). Although in the previous tank opening good intentions required that the electrodes be replaced with ones with a 2-1/8" inside diameter rather than 1-7/8" inside diameter of the present ANU ones, this program was little more than initiated. We are presently in consultation with Robert Rathmell at NEC in order to arrive at an acceptable protection electrode shape that is consistent with the satisfactory performance of such electrodes that NEC has provided in other accelerators. Chain no 1 was removed from the accelerator. We chose to close the machine with just two chains, number 2 and number 3, which were still operating with our old style small diameter spark protection electrodes. The rationale for this was that we couldn't produce a new agreed design in time for this tank opening and having only two chains would enforce a voltage limit on the accelerator under which conditions, further damage to the chains would be less likely. Chains 2 and 3 were removed for cleaning and removal of spark marks and then reinstalled. All of their spark protection electrodes showed no evidence of sparking during this last episode. We will use careful inspection of both chains and spark protection inductors at the next tank opening to evaluate the efficacy of the low voltage operation with the present protection electrodes.

NEC has also expressed concern to us about the column resistor assemblies being too close to the chain. We see at the present time, no evidence of sparking between the chain and the column resistors.

Resistor Test Program

All resistor sub-sections were tested at 30 kV and found to be within original specifications. We have taken this opportunity to test a new design of tube resistor. The successful design now working in the 14UD uses a pair of radially mounted 20 kV resistors in series to span each gap of the accelerator tube. The new design uses a single 40 kV resistor mounted tangentially to span each gap of the accelerator tube. Photograph shows the installation of such resistors across the 8-gap tube section in casting 13.

Stringers

The tying of the column to the tube was re-introduced in the 14UD to limit the apparent stresses put on the accelerator tube during sparks. These stresses were evidenced by the melting of corona points on the flanges of the accelerator tube which would normally be connected to stringers. Putting the stringers between the flanges and the appropriate ring, eliminated the melting of these corona points. From then onward, we successfully operated the machine with stringers and retained them when the compressed geometry tubes were installed. The presence of stringers and the installation of resistors were boundary conditions that led to the resistor values which produce a uniform gradient on the entire accelerator tube, but a lower gradient on those column gaps which span the new 8-gap tube sections. Since there is now evidence that the voltage limitation of the 14UD may well be dominated by column effects, rather than tube effects, it is desirable to put more stress on those column sections associated with the 8-gap tube section. However, as one does this, and keeps stringers in place, too high gradients would be put on the 8-gap tube section. This stress can be reduced somewhat, if the stringers connecting the ends of the 8-gap tube section to the column are removed. Then the extra stress goes on not only the 8-gapper but the 11-gappers either side. We will evaluate whether the elimination of such stringers introduce unacceptable damage to the accelerator tube, perhaps as evidenced by damage to resistors rather than in an analogous way to the damage we have seen on corona points. The pair of stringers on either side of casting 26 were removed as a test.

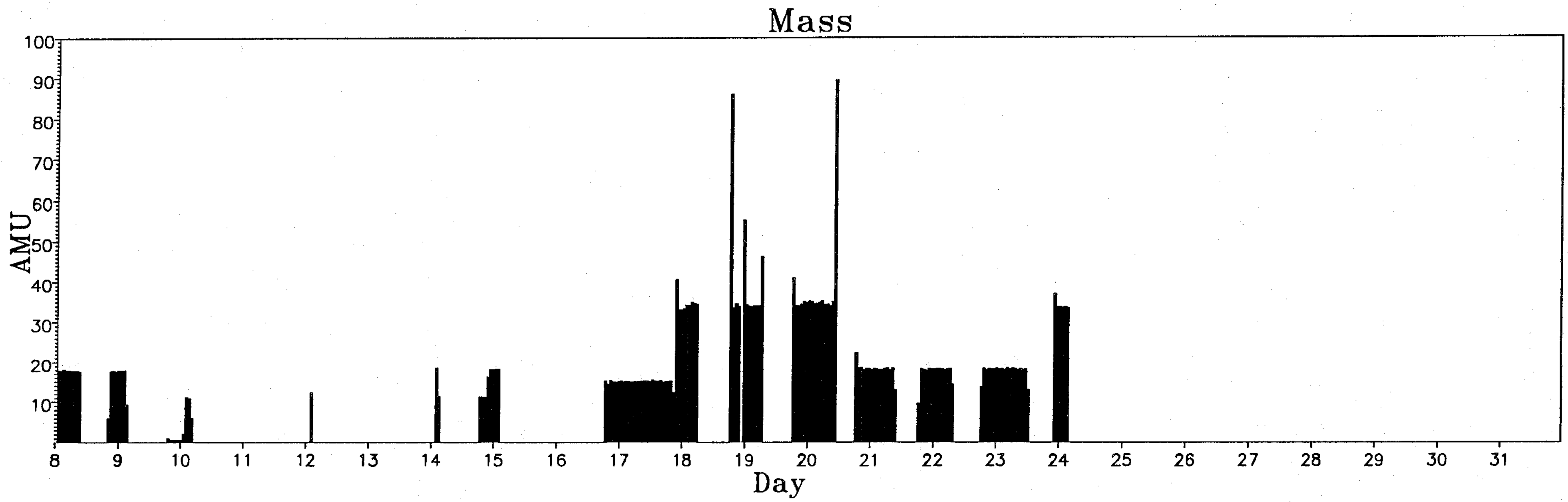
Cleaning and Closing

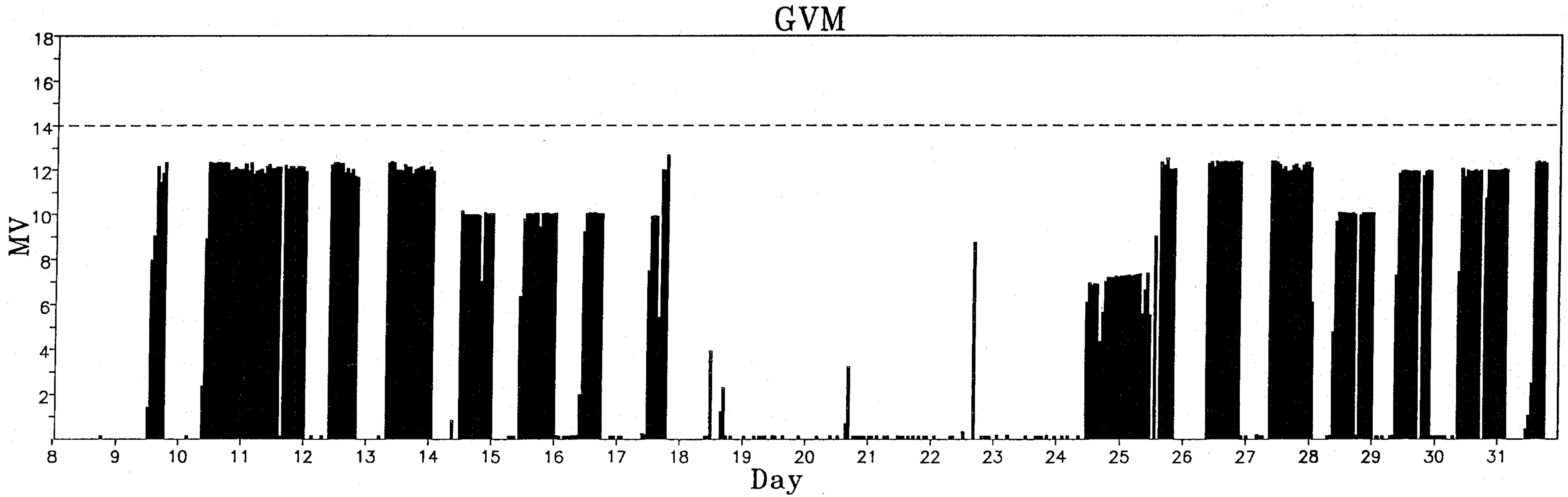
The accelerator was generally clean. All spark marks were rubbed down with emery paper and the entire column ring assembly was cleaned with chamois and dilute RBS water solutions in the usual way. The high energy column was blown off and the low energy column was not. The accelerator was closed on Tuesday 8th May 1990.

Subsequent Performance

At start up with two chains we once again had difficulty with chain no 2 slipping for the first several hours of operation. Subsequent to that and the finding and eliminating of the water in the suppressor feedthrough for the chains. Both chains operated up to 85-100 micro amps satisfactorily and the accelerator operated to 12.3 MV satisfactorily. There were however, in the order of four sparks at 12.3 MV over the first 12 hours. These may well be due to our neglecting to blow off the low energy column or they could have nothing to do with it at all.

14 UD log – MAY 1990





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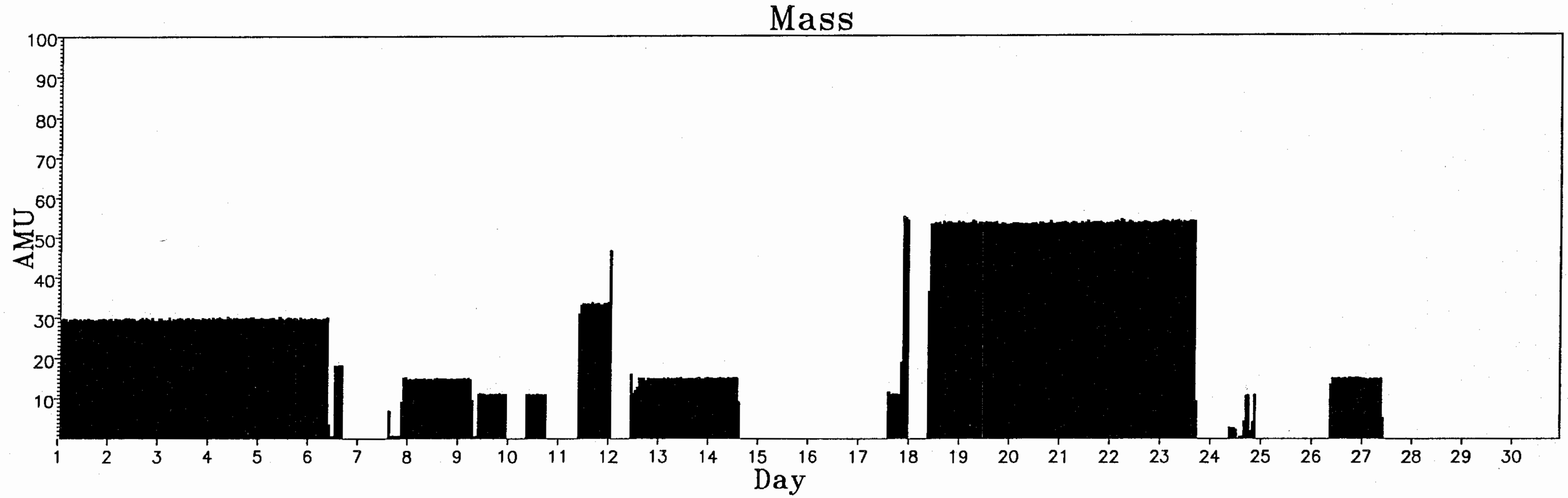

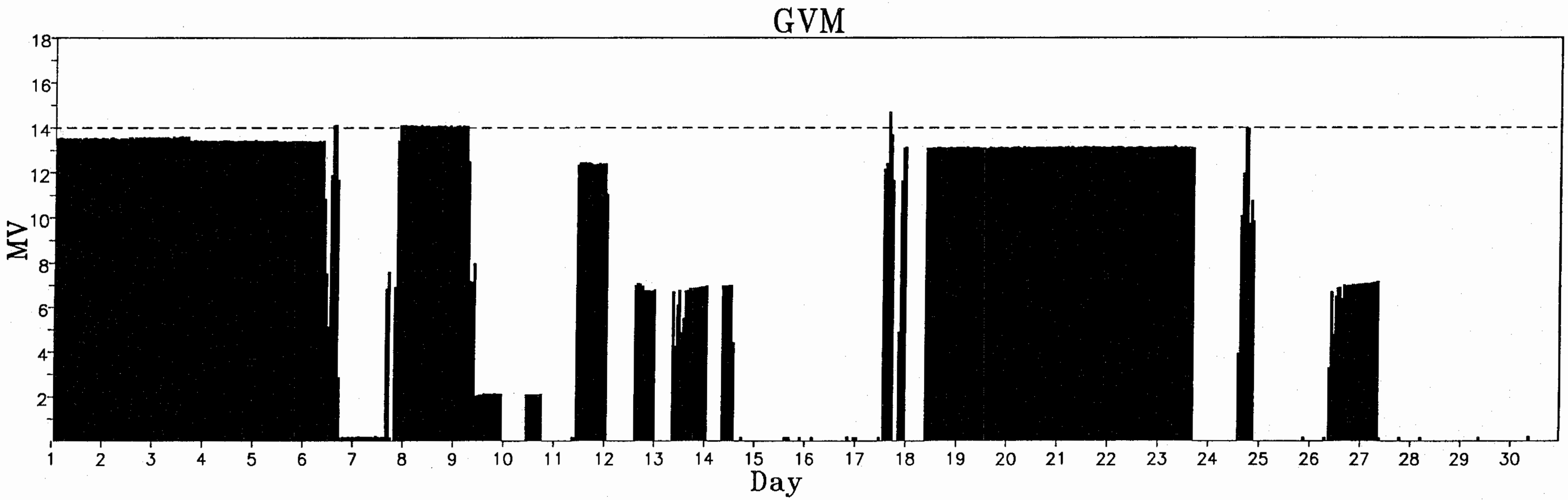

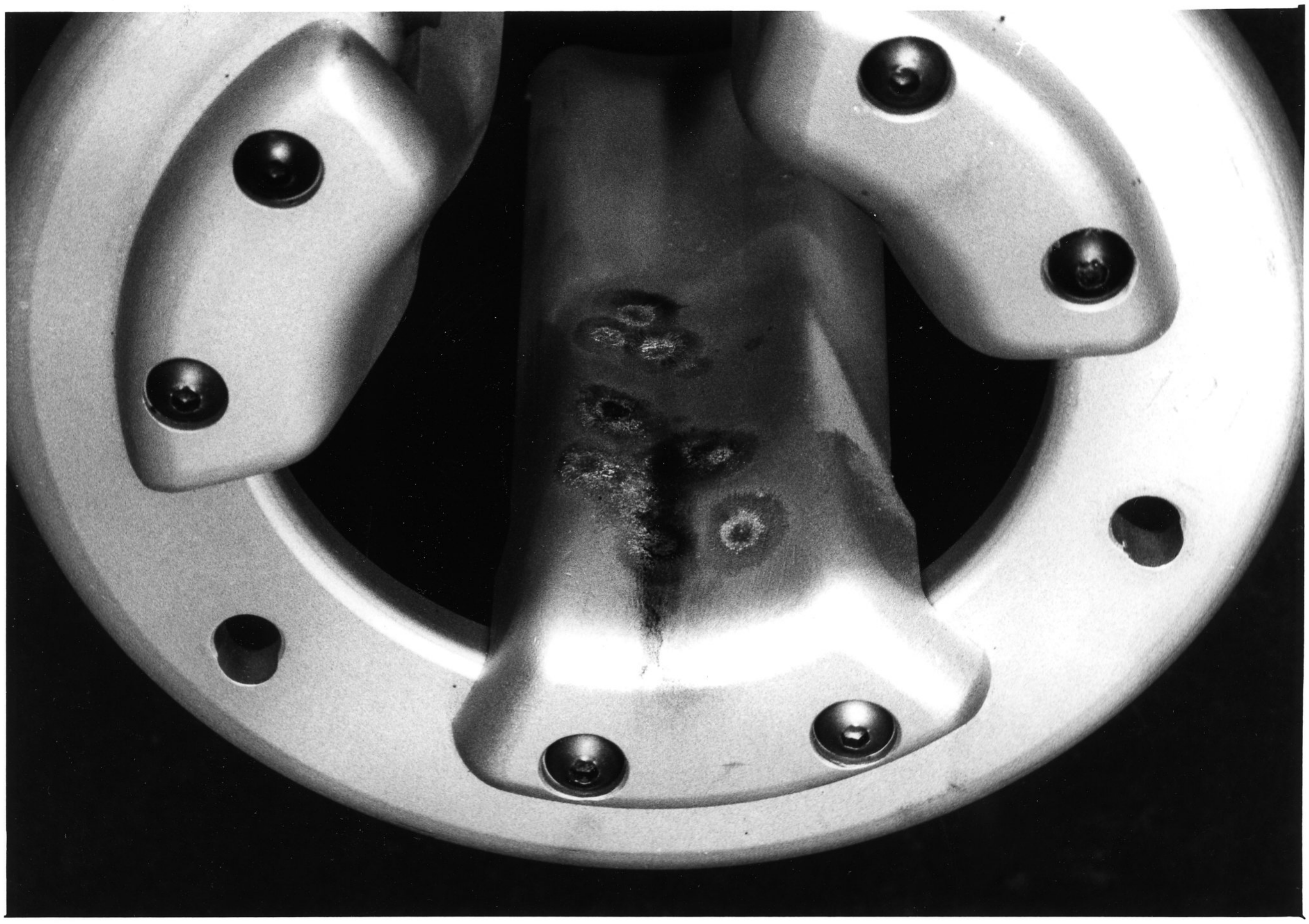

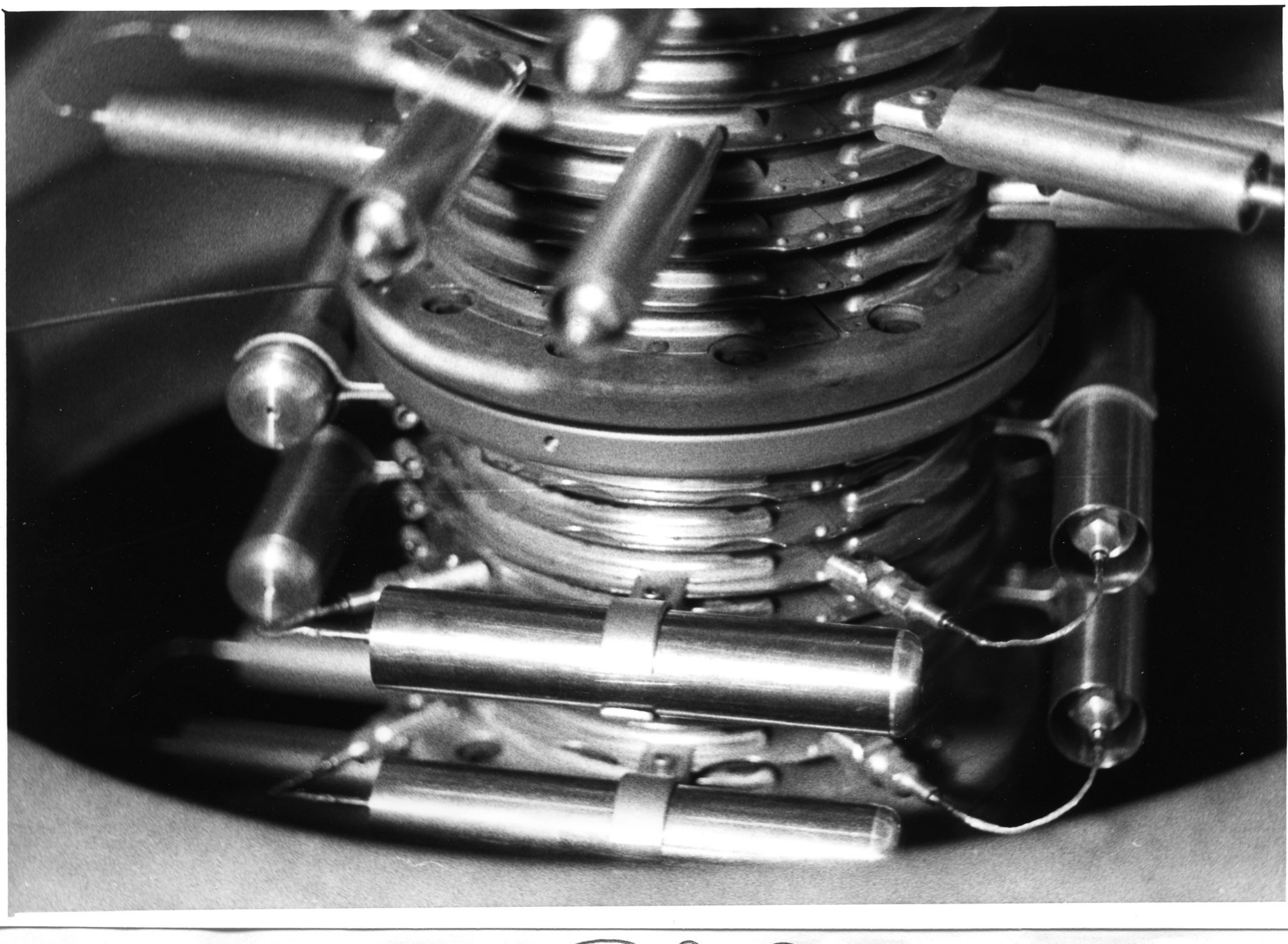

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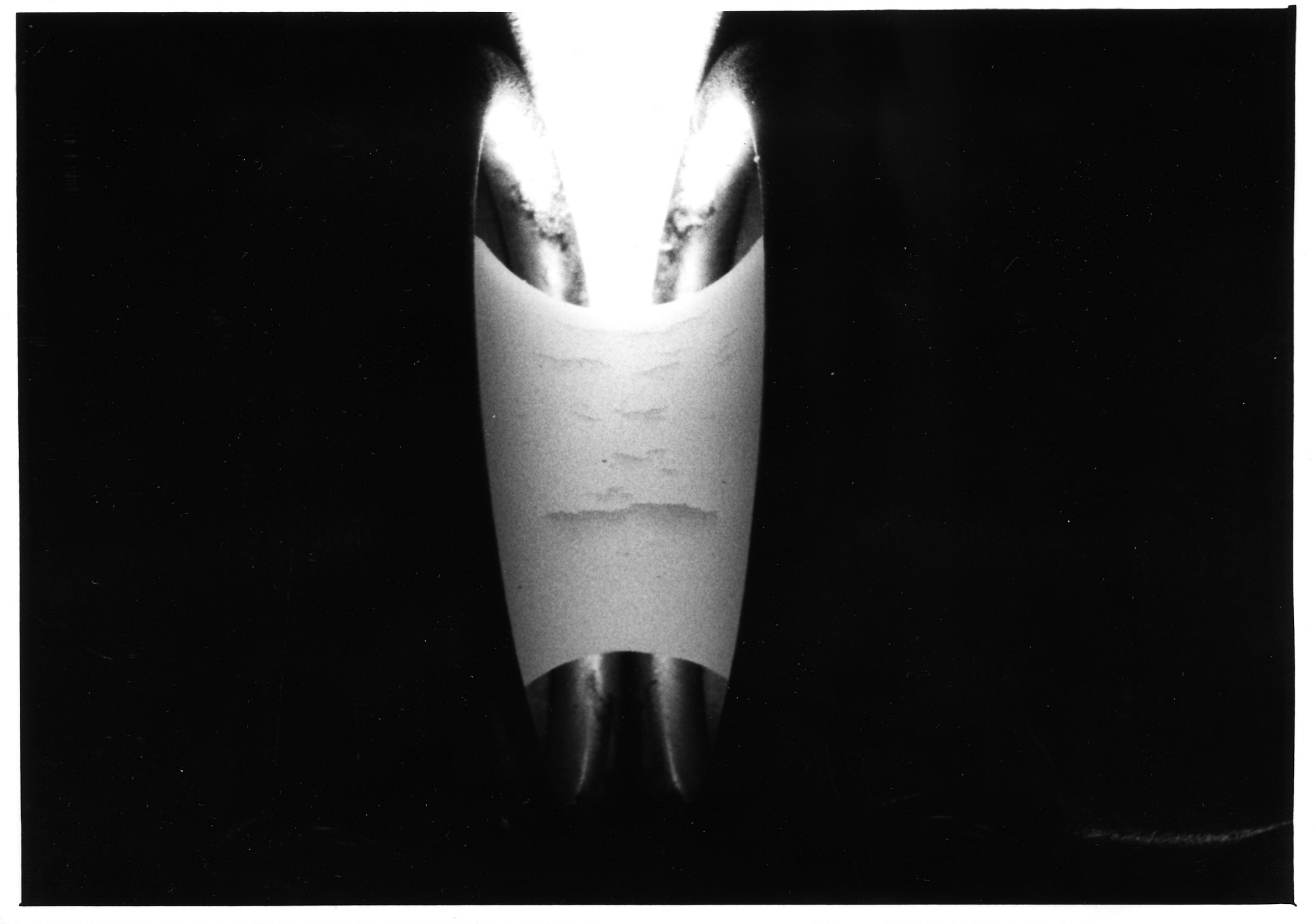

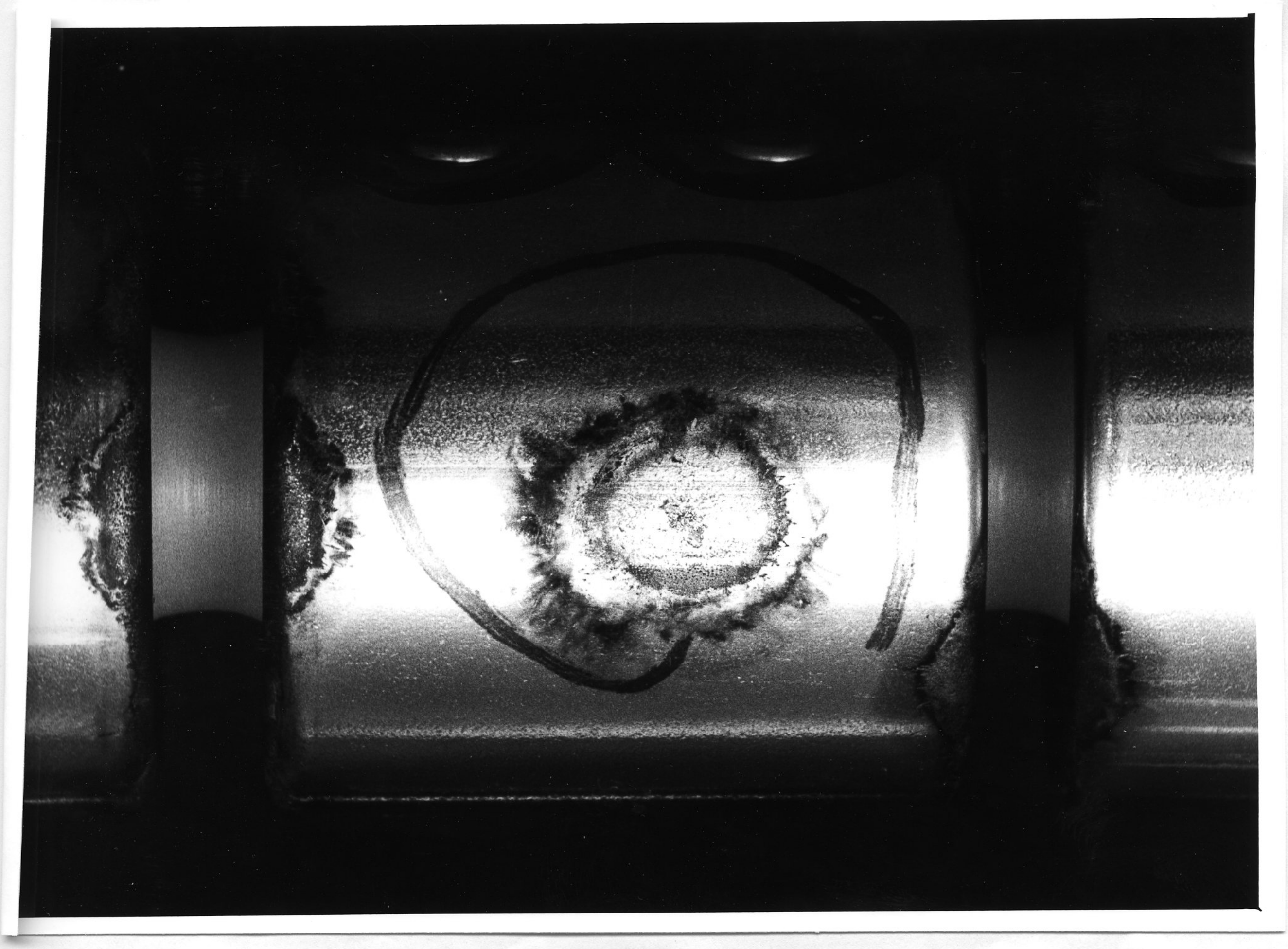

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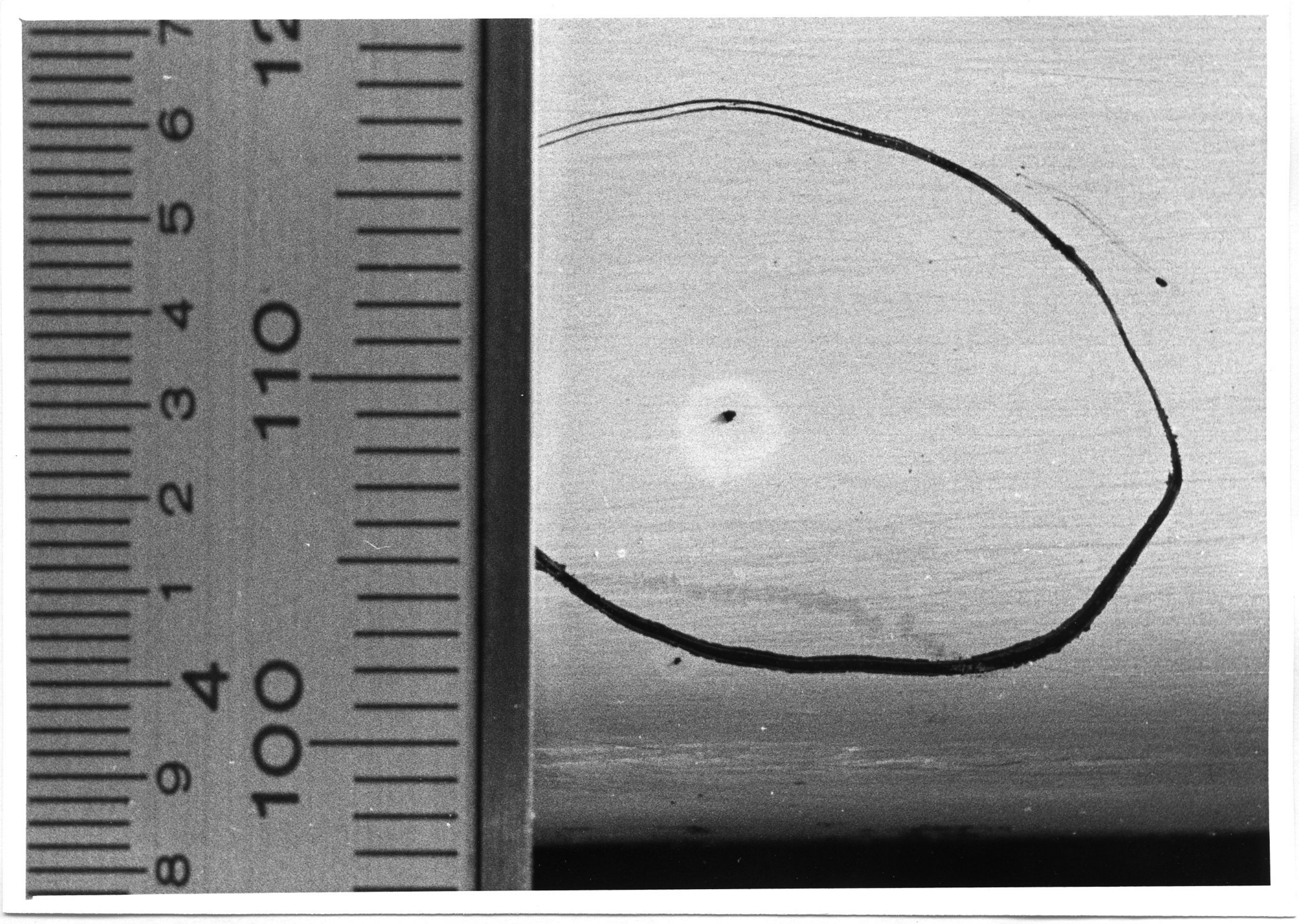

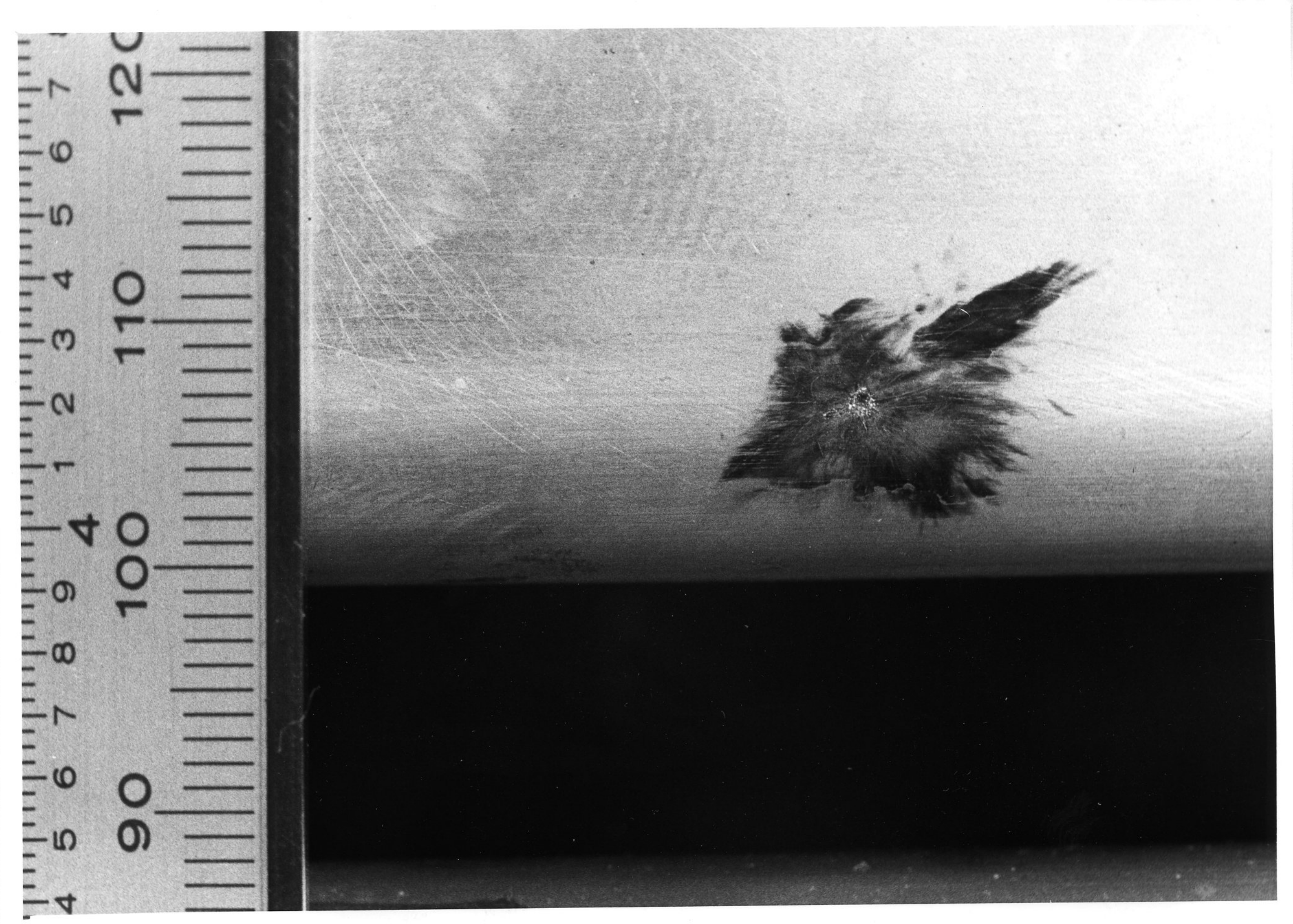

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