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DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No. 53

Two openings:
27th to 29th May 1986
(3 days open.)
11th to 12th June 1986
(2 days open)

REFERENCES: Earlier Tank Opening Reports are referred to by the notation (38/4) etc, meaning Report No. 38, page 4. Glossary of terms and abbreviations at end of report.

REASON FOR TANK OPENING

The opening was mainly scheduled to renew terminal foils. The replacement of Chain 2 and the exchange of 8 column posts for new ones were also anticipated.

PREAMBLE

Before beginning, we report that we have just had a private communication from JAERI which strips us of one of our 'world's firsts' by just one month. In November 1984 we found our first cracked post ceramics, including the very badly damaged one, (48/3 two references, 48/4). The bad post was sent to N.E.C. and they commented that they had not heard of any other pelletrons having this problem. We had told N.E.C. of our chains being run without charging volts, giving rise to negative buildup on the terminal with consequent successive discharges down the ungraded column; they felt this was a likely explanation. (See 49/1 for the general discussion).

In October 1984 the JAERI staff noticed a crack in one of the posts in their Module 15. They took the post out and we understand that it came apart completely. There had been no unusual symptoms in the vicinity of Unit 15 before the tank was opened and it was assumed that, as it was only one of the 4,320 ceramics in the machine, the likelihood was that it had an inherent defect. We are attempting to identify common factors in the ANU and JAERI experiences and will report what we find out as soon as we can.

Now, to continue with this report:

The 14UD was last closed on 25th March. In a day or so it was running happily at 13.6 MV and continued to perform well at about this voltage whenever it was needed. There were no problems and the accelerator ran from the end of April into May at just above 14 MV.

During the night of 1st May, while the machine was peacefully running double stripping nickel near 14 MV, there was a tank spark after which it refused to go back to high voltage. The next day the younger author watched regular sparking through the inspection windows and was able to establish that it was occurring near the top of the post carrying column corona points in Unit 15.

Double stripping operation with nickel, subjects the units between the terminal and the second stripper to extremely high gradients. Because there is no charge state selection in the terminal, some charge states not focused by the terminal triplet strike the tube electrodes, producing electrons. In addition, all the electrons from the second stripper foil may not be suppressed. The combination of these two sources of electrons produces xrays in the H.E. end of the machine which partially ionize the SF6. Such ionization causes up to 50 microamps of lost charge which has the effect of lowering the potential of the units near the second stripper. To keep the energy constant in double stripping mode, the terminal must rise in voltage to compensate. Typically, the terminal rises by 0.15 MV with a new terminal stripper foil to 0.30 MV for a well-used one.

What gradient will units 15 to 19 experience under these conditions? With no beam in the machine, and 14 MV on terminal, the high energy gradient will be 14/13.67 MV per unit, or 1.02 MV per unit. A new terminal foil will produce enough radiation to increase the terminal volts by 0.15 MV, this increases the unit 15 to 19 gradient to 1.09 MV per unit. The terminal foil is usually changed when the beam intensity falls to half its initial value; by then the terminal voltage would have increased by 0.3 MV over the no-beam voltage. This produces a gradient near the terminal to 1.15 MV per unit, or the no-beam equivalent of 15.7 MV if the whole 13.67 units in the high energy end shared the burden equally. This operating mode is normal for the Canberra 14UD. It should not be surprising if a component failed in units 15 to 19 under such stress. We shorted out Unit 15 and continued at voltages up to 12.7 MV.

OPERATIONAL TIME.

During the 62 days since the last closure, the 14UD operated for 1120 hours. This was 78% of elapsed time, excluding the days for gas transfer (42/2), a great improvement on the humiliating 43% recorded in the last report.

THE TANK OPENING.

Exploratory tour.

There was a lot of the fine grey dust on polished surfaces which we have seen so often. The terminal was coated heavily, as were the rings on each side of it, and the relatively new perspex shaft sections in the L.E. column. Below the terminal the shaft sections, put in new at the last opening, had little obvious grey dust.

In Unit 15 we found one of the most remarkable failures we have yet seen in the 14UD. The top column corona assembly on one of the posts was missing; the nine assemblies below this position had fallen onto one another in a cascade. Two of the needle discs had disappeared. All the needles on the remaining discs had melted away entirely, allowing the holders to fall almost vertically downwards. All the assemblies were hanging so loosely that they could be flipped up with one's fingertip, yet the assemblies below the cascade, which had not fallen, were still tightly screwed. The effect was as though the fixing screws had all been loosened and the assemblies had just fallen freely, one on the other. (See photographs). The uppermost post bracket, from which the assembly was missing, was loose at the rivet attachment as though the rivets stretched. All affected brackets were severely spark eroded.

It was easy to believe, though not beyond doubt, that the assemblies had loosened so markedly because material from fixing screws, or their brackets, had been removed during the sparking and also might have contributed to the grey dust, along with the 30 evaporated column corona needles.

Everything else in Unit 15 seemed to be normal and none of the tube corona assemblies had moved; however, we believed that their needles looked very blunt.

In the terminal the crossover wire carrying positive voltage to the doubling inductor of Chain 3 had broken away and was only contacting intermittently. The d.c. idlers had broken, or missing, contact springs. Both the standard and the "new improved" versions (52/5) had failed.

And so to work!

CHARGING SYSTEM:

Chains:

The composite Chain 2, which we put together at the last tank opening (52/3), was taken out (after 16,938 total operating hours) and replaced by a brand new chain which had arrived from NEC. The new chain had hourglass links and also a slight chamfer which we only discovered when spooling the chain before installing it.

Chains 1 and 3 were not examined for cracks in the links.

Idlers:

The stabilizing idlers were not inspected and the exchange of chains in the number 2 position was made without moving any of them.

THE COLUMN.

Posts.

Four new posts were put in Unit 15 and four more in Unit 10 where an historic crack had been shorted out for some time. The end electrodes of all 8 posts were bonded according to the new A.N.U. practice, (51/2; 52/4,5).

Corona Points.

New column points were put in Unit 15 where the "po[illegible]de"/ had been found. There was a column corona bracke[illegible]s at the assembly off and put it on Post 3 instead, together with the corresponding "pointless plane". One drooped point assembly, at position 20/2/7, was replaced with a new one, as was its neighbour at 20/2/8.

Shafts.

A closer inspection than was made during the exploratory tour revealed that the L.E. perspex shaft sections, put in new 6 months earlier, were not only coated with the grey powder, but had developed "snail tracks", (11/6; 13/2; 50/5; 50/6). The shaft sections closest to the top of the column, Units 1 - 3, were the worst affected. At this stage we associate the onset of snail tracks with arrival of the grey powder. The H.E. shaft sections, new at the last opening, had no grey powder and no snail tracks.

STRIPPERS.

The terminal foils were renewed. We noticed that the beam spot on the foils we took out was partly off the foil and onto the frame at one edge. We adjusted the stripper assembly by 2 mm to correct the consistent displacement. Tne origin of this alignment error is not clear.

INSULATING GAS.

There has been no recurrence of lost charge since changing the Vivalyme late in January this year. There was no evidence of brown stain near the corona triode points; this is consistent with zero lost charge.

Button-up.

During the charging tests, Chain 3 behaved at 6 kV as though breakdown was occurring , though none could be seen. The inductor leads were moved and the fault went away.

Initial performance.

There were no problems with the accelerator at startup; in fact, the first scheduled group of experimenters took the machine as soon as it was gassed up and ran at about 13.5 MV for several days without sparks or instabilities. Following a 14.3 MV spark and a weekend of 13.5 MV double stripping nickel operation, 50 microamps of lost charge were observed. The SF6 bdp and moisture tested satisfactorily and there were no x-rays or vacuum correlations. The poltergeist symptom of the sum of triode and lost charge equal to a constant did not appear. We reached a tentative conclusion that particulates on the tank wall act as sources of corona.

A week [illegible] button-up the machine sparked when it was being conditione[illegible] MV. Subsequently, rapid jumps in the H.E. tube pressu[illegible] 5 MV. The younger author carried out a series of d[illegible] rods and came to the conclusion that the trouble was in Unit 20. Units 18, 19 and 20 were conditioned. The instabilities in H.E. vacuum and xray jumps reduced in frequency and intensity up to 1.05 MV/unit. After a series of sparks the vacuum suddenly recovered from 3.4E-08 to 2.7E-08 while the xray flux jumped from 600 Hz to 7,000 Hz (above 330 keV). An hour of conditioning later the xray flux reduced again to below 1,000 Hz The units continued to condition up to 1.07 MV/unit, at which point all the rods were removed. The machine then went to 14 MV stably, and with no xrays above background of 200 Hz.

The benighted and dejected experimental group was now beset by severe problems with the terminal stripper actuator. The situation was reached when it took three hours to change a foil. Attempts, varying between valiant and foolhardy, were made to persuade the pneumatic foil changer to operate by playing a heatgun on the SF6 bottle to increase its pressure. We finally realized that the array of 9 solenoid valves separating the SF6 intake from exhaust manifold were only rated at 150 p.s.i. differential, therefore the actuator bottle was slowly emptying into the 14UD. In addition to this, the overpressured valves, not being used, raised the exhaust manifold pressure, interfering with the operation of the valve needed. The overpressure also made the second stripper actuator operate so quickly that it caused the magnetic coupling to jump a pole, putting the foils out of alignment. The leaking valves also emptied the chain oiler into the machine. We could just manage to change foils by using the manually operated valves on the side of the tank. Clearly it was time to open the machine.

The Second Opening.

We found that, in three or four units each side of the terminal, the buildup of solid material on the backs of the column corona assemblies had significantly less material than in other units. Chunks of yellow bdps, millimetres square, were attached to the rings and the castings, particularly in units 1 - 6 (see photographs). The tank wall was gritty, especially near the L.E. end.

We dealt first with the stripper actuator. Testing while we watched led us to a 6 cm long spark damaged area in the nylon pipe below the column. Even when the pipe was repaired the actuator continued to operate unreliably. Eventually we changed a square section teflon gasket for a lubricated o-ring and appeared to have no more trouble.

Tube corona point 20/2/9 had sagged down onto the one below it. A high voltage tester was used to measure the voltage gradient at 90 microamps corona current in air. The drooped gap withstood 8.0 kV while the remainder varied from 4.5 to 6.2 kV. Resetting point 9 re-established the typical gradient, even without replacing the affected points. This failure was due to insufficient tightening of the point assemblies after the last drooped point was repaired in Unit 20/2. It is likely that the drooped point contributed to the voltage instability and large xray fluxes. This is made more likely because the affected gaps were at the end of the tube at the electron deflecting region.

Just for the sake of completeness, and to establish a baseline of performance, the gradients of the other two tube sections in that unit were measured. We discovered that tube ceramic 20/3/10 had resistance of 8 megohms at 1 kV. This was ascribed to spark-induced deconditioning which coated the inside of that tube insulator with titanium. We valved off the pumps and introduced oxygen from the ion source into the tube to act on the sputtered titanium in the hope that it would oxidize it. The next day, after evacuating the tube, a further voltage test indicated a resistance of 10 megohms. The tube was left in. The 14UD had once again been playful with us, providing two possible causes of the problem in Unit 20, when only one would have been quite enough.

The rings and tank wall were tacragged to eliminate lost charge. An attempt was made to clean the large buildup of bdp using a saturated solution of sodium carbonate. While this readily dissolved the yellow buildup, the procedure was much too slow. We shortened the new chain by 3 links and buttoned up.

Initial performance.

The machine gave no more trouble and was soon operating up to 14.2 MV. Lost charge was zero and the foil changer changed foils.

D. C. Weisser.

T. A. Brinkley

18th June 1986.

Enclosures:

Plots of particle masses accelerated, and operating terminal voltages.

NOTE: On the plot of terminal voltages we have drawn a horizontal line at 14 MV for easy reference to performance near the nominal voltage limit of the 14UD.

Photographs:

1). Closeup of top of post in Unit 15. The point assembly is missing and its mounting bracket is very loose.

2). The "cascade" of corona point assemblies in Unit 15.
3). BDP's on the backs of column points in Unit 1.
4). BDP chunks spark blasted onto rings and castings.

Glossary of terms and abbreviations:

BDP or bdp, breakdown products.
Powers of 10 are expressed in exponential notation, e.g. 3.4E-08
The order in which an accelerated particle passes positions in the machine is used to number them, thus Unit 1 is the first unit and units 14 and 15 are each side of the terminal, Unit 28 is the last. Tube electrode 19/2/7 is Unit 19, tube section 2, electrode 7. Column corona assembly 6/12 means Unit 6, 12th assembly down.

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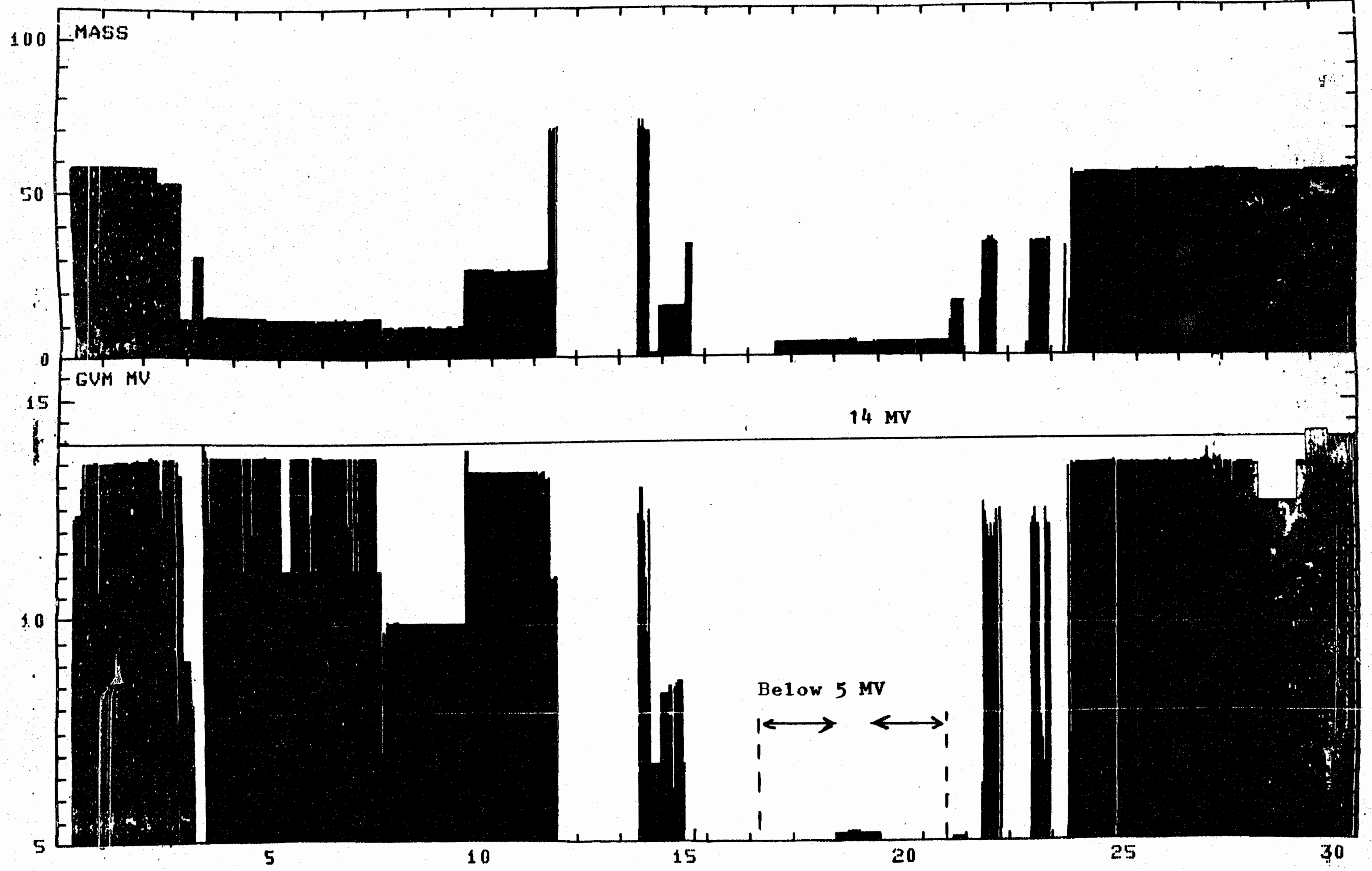
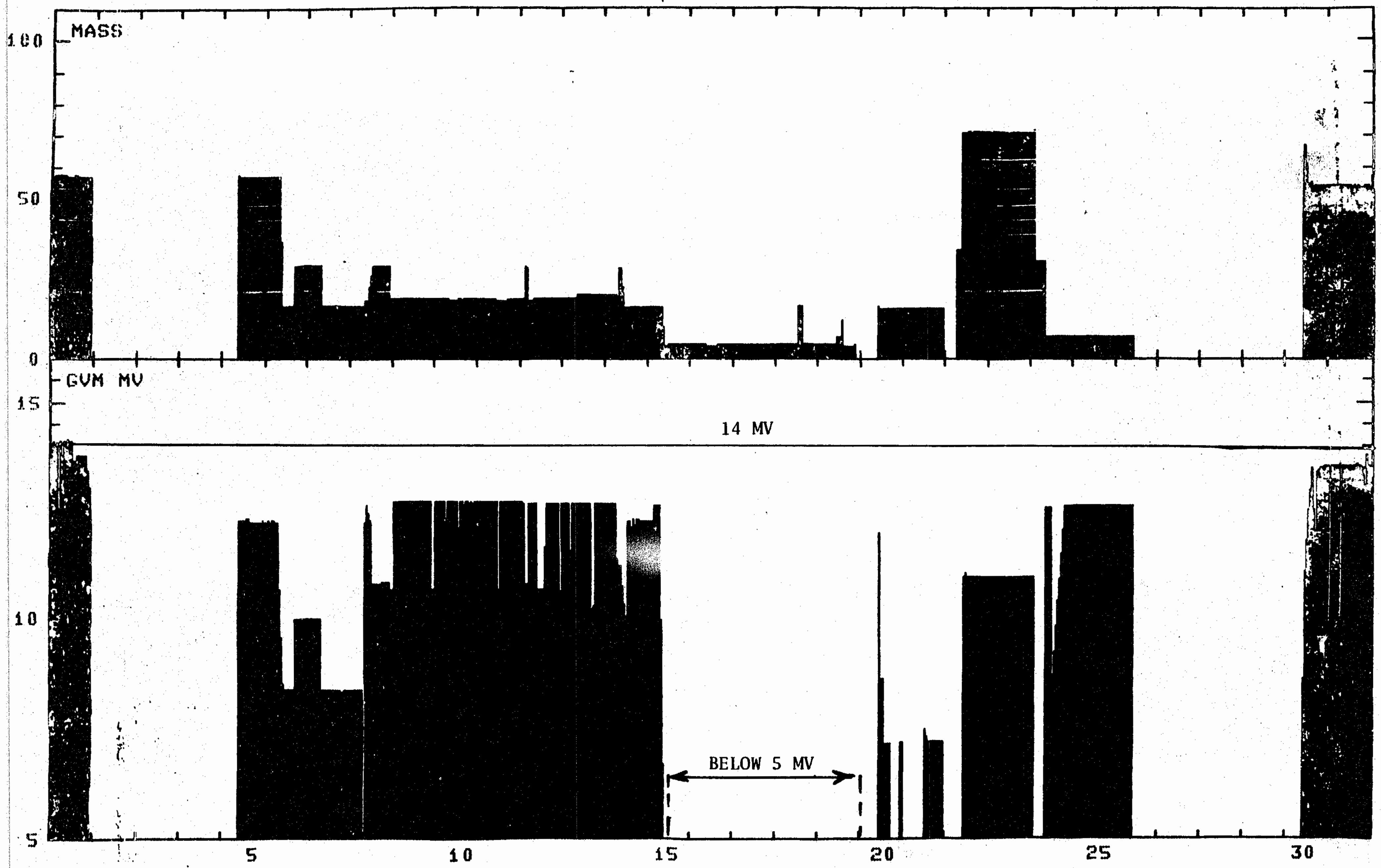
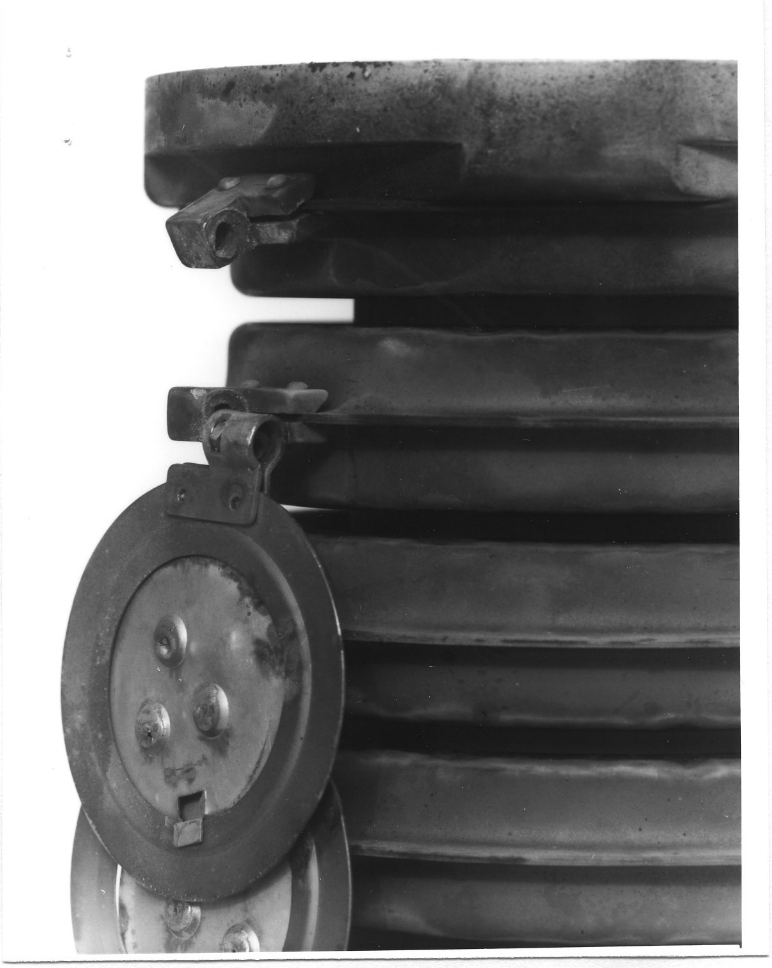
14UD log APRIL 1986



14UD log MAY 1986





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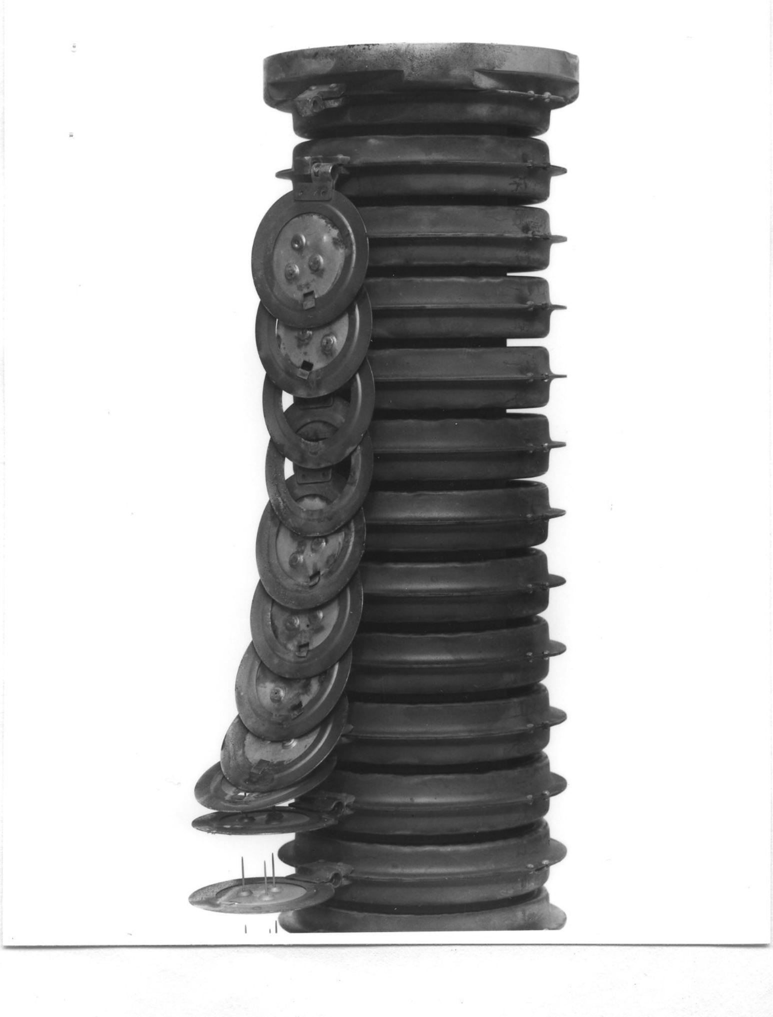

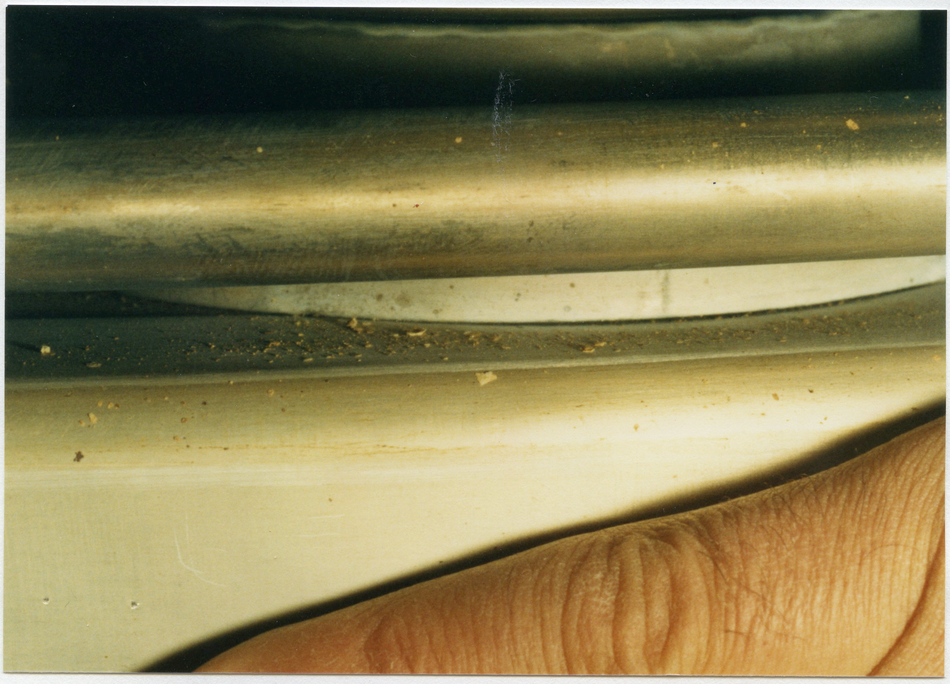

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