

AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No.47

9th to 12th October 1984
(3 days open.)

REFERENCES: Earlier Tank Opening Reports are referred to by the notation (38/4) etc, meaning Report No.38, page 4.

REASON FOR TANK OPENING

The opening was scheduled in order to attend to voltage problems.

PREAMBLE

The 14UD was last closed on 28th August. Things went well in the early stages, though the machine was used only at middle voltages for much of the first two weeks; this included nearly a week of operation below 5 MV. On 20th September, during a day scheduled for pulser tests, the machine was conditioned to 14 MV. In the latter part of the month it operated for a while between 13.5 and 14 MV, though problems with voltage stability had begun to appear. After sparks, the machine deconditioned and it took about an hour to get back to 13.75 MV. The experimental runs continued, enduring these setbacks.

There were occasional periods during which there were large disturbances on the N.M.R. trace, accompanied by 50 microamps of lost charge. During one of these episodes an experimenter noticed loud vibrations from the triode assembly. It was discovered that the lead from the triode was loose where it connected to the outside of the needle insertion shaft because the threaded cap holding the lead had "bottomed". This would also allow sag in the one eighth inch rod which connects the anode of the triode to the needle assembly. It was presumed that the electrical disturbances were breakdown between this rod and ground, precipitated by a transient voltage on the anode caused by the control circuit. When the triode mushroom was last dismantled, the rod was not retensioned. The lead and rod were tightened temporarily by putting a spacer under the cap. This cured the problem, supporting the conjecture.

By October 5th, traces from both chain pickoffs had deteriorated to the extent that they indicated failure of the cable protection resistors. These resistors were renewed at the last opening.

Unhappy about the overall performance, we made use of the fact that the current schedule was about to run out and planned a tank opening as early as possible.

On the last day of the old schedule we carried out some tests with shorting rods. The main problem was the consistent tendency of the terminal volts to dive from 13 MV to about 12 MV, then run back up, hold for a while and collapse again; all this without audible spark or effect on tube pressure. This behaviour gave rise to all sorts of conjecture, including the possibility of an intermittent short along the column, as distinct from discharges inside

the tube. Such a notion stemmed from the idea that the drop in terminal voltage was accompanied by both the tube and corona currents in the H.E. falling to zero. One idea was that the insulating properties of the nylon pneumatic tubes, which run through the whole of the H.E. column, had become unstable and were marginally sensitive to full volts. Shorting units 26, 27 and 28 individually did not establish for sure which unit was the source of the trouble, because adjacent units appeared to affect each other. However, when these units were all shorted the machine worked well at 11 MV. For ten and two thirds units this was 1.03 MV/unit, corresponding to 14.09 MV for the H.E. tube.

Hollos and Kaim (SNEAP '83) said that they reported at the Chester conference a conditioning phenomenon with the Rehovot 14UD of silent "flashes" which often left the tube vacuum unaffected, but could drop the terminal volts to zero. This effect, while possibly from similar causes, was much more extreme than our silent dives from 13 to 12 MV. The Rehovot effect seemed to be associated with severe tracking on the internal surfaces of one of the old tube sections and/or a missing set of corona needles. After replacing the tube section and needles the flashes ceased and normal conditioning was achieved.

Insulating gas

Periodic testing of the insulating gas during the operating period confirmed that moisture levels were below 10 p.p.m. and that the concentrations of hydrolyzable fluorides were consistent with prevailing corona currents.

OPERATIONAL TIME

During the 40 days since the last closure, the 14UD operated for 803 hours. This was 86% of elapsed time, excluding the days for gas transfer (42/2).

THE TANK OPENING

Because we started pumping early, the gas was out before 3.30 p.m., when the 50 minute vent to air began. The usual analytical sniff, taken inside the tank as soon as the first door was opened, determined a slightly more acrid smell than we have noticed for several tank openings. As always, the start of air circulation through the tank increased the acidity and the characteristic smell was easily noticeable inside the tower. The younger author contended that the smell was worse than usual, whereas the older author, who had been lured from the bottom of the tank to be told this, went back inside, unimpressed. An inspection of the bottom three units, (made by standing on the crossmembers), failed to show anything wrong and the machine was left to ventilate until morning when the platform would be lowered and a complete inspection made.

Exploratory tour

There was nothing to which we could point triumphantly and hold unequivocally to blame for the voltage problems which had caused us to open the machine. No rings were off, though some were looser than we cared. One tube point had drooped. The column points were all good, except for the fact that 13 of the 18 column assemblies in Unit 15 (the unit below the terminal) had one needle worn distinctly shorter than the other two. In Unit 16, all 18 were in this condition. In no case was either of the two surviving needles noticeably shorter than the

other. Above the terminal the situation was different. In Unit 13 there were two instances of column point assemblies which had short needles; in this case, there were two short needles on the assemblies, not just one. In Unit 14 there were three assemblies, each with two short needles. In all 5 cases the wear was not as dramatic as that on the single short needles in units 15 and 16. Here two things should be noted: 1) All column points in units 15 and 16 were renewed at the last opening, less than six weeks earlier; 2) the points in units 13 and 14 are the ones put in a year ago when a complete new set was installed. We feel justified in attributing the single-needle wear in the units immediately below the terminal to a different type of cause - presumably sparking.

One reason for voltage effects to be more noticeable below the terminal is that the H.E. column has a higher gradient because the second stripper occupies a third of a unit, though why this should single out Unit 16 is hard to see. On occasions we have wondered whether the terminal lens was responsible for local loading when tube points lower down the column suffered. For instance, we reported (28/2) that 5 consecutive tube corona assemblies in Unit 17 had one "melted needle". An earlier reference to our melted needles is David Weisser's talk at the 2nd International Conference on Electrostatic Accelerator Technology at Strasbourg in October 1977 (Revue de Physique Appliquée pages 1305-6) when he reported that troubles with our terminal triplet power supplies dumped beam in the tube and caused tube point failures. No column point failures were seen.

The nylon pneumatic tubes were examined through the rings without anything obvious coming to attention; however, when they were checked at the place where they emerge from the column underneath the bottom casting, one of them had a ragged appearance as though it had been rubbed hard with a wood rasp. Shreds, (tatters would be a better word), up to a quarter of an inch long, hung from the tube between where it emerged from the casting and where it was connected to its copper feedpipe. Closer inspection showed that the damage was worse at the immediate exit point where there was, in fact, a ragged hole in the pipe. There was no such appearance on any of the other 5 pipes in use, or on any of the 12 spares which had never been in use. (Photograph)

The deterioration of the chain pickoff traces was easily explained; not only had all four protection resistors been spark damaged to varying extents, but a connecting wire on the down pickoff of Chain 2 was almost touching one of the steel column wire support posts on which there were distinct spark marks. These wires are bare beryllium copper and are formed to take a path well clear of ground; the wire in question had either not been set when the resistors were renewed last time, or it had been pushed out of place during cleaning activities in the bottom of the tank.

The lower tube to column stringer in Unit 27 was loose on its post and there was evidence of minor arcing.

In unit 27, one of the tube ceramic elements had a black mark almost across it. Our impression was that it was a crack, though there is no obvious effect on the H.E. vacuum. There was no accompanying damage to points.

There were many more loose rings in the bottom three units than anywhere else in the machine. One loose ring in Unit 28 had caused erosion of its post bracket.

The correlation with the last three units of these shortcomings suggests that, taken together, they might explain the shorting rod diagnostic of trouble with these units.

A small amount of dust was found inside the port through which the gas returns from the recirculator.

And so to work!

Our experience with pneumatic actuators in the E.N. tandem taught us that it is essential for nylon pipes along the column to be in tight contact with all metal surfaces through which they pass. The pipes on the 14UD had therefore been fitted in the same way. We opened up the high energy units, cut the damaged pipe in each unit and pulled the separate lengths through the individual castings. When this was being done it was discovered that the pipe was extremely brittle at its point of contact with the lower faces of the H.E. castings (i.e. the ceilings of the units) and it broke there very easily if pushed aside. The same effect did not occur at the upper faces of the castings (the floors of the units); it was the more positive ends of the pipes in each unit which suffered. In addition, one of the neighbouring pipes was hit accidentally while the defective one was being tugged and it, also, broke easily at the casting lower surface. We then took a closer look at the pipes and found that all of them had a dirty deposit close to the surface of the casting. This had certainly been noticed before on the occasions when the pipes had been cleaned, but it was taken to be a narrow buildup of dirt which could not be wiped clean. All five of the actuator pipes in use were now suspect and we decided to remove them all and fall back on the 12 spares which have sat, unused, in the machine for 6 years. The original 6 tubes were put in two years earlier, in 1976, when we converted to pneumatic actuators (5/4). We reported some time ago (38/4) that black nylon cable ties on an outdoor T.V. antenna last much longer than white ones. We chose black pipes because the manufacturer said they were less sensitive to U.V. than white ones. In any case, we have too long neglected the old adage that all good things must come to an end. Even black nylon clearly has its limitations. We found on the insides of the original nylon pipes a grey discolouration similar that seen on shiny surfaces in the tank. There was no such deposit inside any of the 12 spares which have been in the tank for 6 years. For what it is worth, the tubes which had been in use, and had the grey deposit inside, had been fed from hitherto untapped stock bottles of SF₆ outside the tank. In addition, the pipes might have high air concentration trapped within them during normal tank opening cycles.

We were very tempted to test the strength of one of the 12 unused pipes, all of which pass tightly through a common support plate at each casting. More from timidity than willpower we resisted the urge in case a pipe did break and we caused more damage than we could cope with when removing it. Having no new nylon pipe in stock we convinced ourselves that removing the six pipes from their common plates would keep us going for the period of an average closure.

The spare pipes all ran as far as the lower terminal, where they had been tied back safely and left until wanted. We found, to our surprise and regret, that one of these spares had the same tattered appearance of the failed pipe in the bottom of the machine. All five of the functions normally used were connected to the unused spares; the cuperture (cup/aperture device in the lower terminal) was not reconnected because it has not been used for years. It has only remained in the machine because N.E.C. have always warned us against removing a very valuable diagnostic; we, in turn, have never been possessed of the courage to ignore this grave warning, even though the cuperture has, in the past, got itself stuck on CUP and forced a tank opening. The older author has been promised many times that the beam profile monitor and the cuperture would be taken out of the tank, because they are never used, and harbour dust, but these promises never come to pass.

CHARGING SYSTEM

Chains

Because of the time needed to take out all the old nylon tubes we decided to omit the now ritual chain examinations which we vowed never to forsake; however, the chains were cleaned and hand-oiled with much affection to make up for the neglect.

Idlers

The idlers were all checked and our run of success has continued; there were no loose bearings, no idlers had seized and the tyres were all satisfactory. We have had no stabilizing idler failures since we reverted to N.E.C. versions in November 1983. While the N.E.C. design is demonstrably superior to ours, we nevertheless believe that our efforts at more precise chain alignment (42/5) have played a part in giving us a year of operation without stabilizing idler failures.

Foils

The terminal foils were replaced where necessary. The Weisser valve leaked a little more than usual this time, but we have become accustomed to finding either trifling leaks or ones which are alarming at first, but pump down quickly.

Shaft bearings

We didn't listen individually to the bearings because they were all changed in May this year (45/2) and we heard no untoward noises when running the shafts to test power driver functions.

Points

When we were sitting discussing the best thing to do about the damaged column points, because we had no replacements, by a fragment of real luck, or perhaps because of kindly intuition on the part of our old friends at N.E.C., the consignment we had on order was brought down from Stores and laid metaphorically at our feet. We put new column assemblies throughout in Units 15 and 16.

Miscellaneous

Because of the dust found in the gas port, the filter in the recirculator was checked; its condition was good and the dust in the port was held to be residual. Even so, the finer dust which appears on the column might arrive through the filter.

The triode needle system was taken apart and reassembled to eliminate slack in the eighth inch connecting rod.

The four resistors on the chain pickoffs were renewed because of spark damage. Their life expectancy is so short that there is a lump in our throats when we put them in.

Cleaning

The column was cleaned as thoroughly as possible. Most of the H.E. units had been opened in order to take out the old nylon pipes, and this afforded an opportunity to clean inside them.

Button-up

The chains ran well mechanically and the charging tests were satisfactory. The doors were closed at 4.30 p.m. on a Friday and, since for once there was no clamour for the weekend time, we left the tank roughing until Monday and began the apres-buttonup conference earlier than usual. An hour after being turned on, the base pressure of the Kinney itself, valved off from the tank, was 65 microns. On Monday morning, after the Kinney had been open to the tank for the weekend, the pressure at the same place was 53 microns.

Initial performance

At first startup the machine was touchy, erratic and irritable. There were sudden drops in terminal voltage, accompanied by H.E. currents falling to zero. Again, there was neither audible spark nor vacuum response. Vacuum at both L.E. and H.E. ends suddenly worsened to mid 10⁻⁷ and this appeared to be voltage-related. We began to wonder if we had done any good at all; then the machine got bored with its own tantrums and settled peacefully down at 13 MV, running shortly after, with beam, at 13.2 MV and at 13.5 MV.

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Communication: We have received a letter from Rodger Sparks, of DSIR New Zealand, who is now the devoted custodian of the former ANU EN tandem. Rodger wrote: "I must protest at your statement in Report No.46 that the smell of a newly opened tandem is 'dank'. I would call it stimulating." We are enchanted that Rodger has become so abidingly fond of his tandem. Beauty is in the eye of the beholder, or other sensor, as appropriate.

David Weisser attended the SNEAP conference at Stony Brook, met a number of old friends and came back with interesting information and darkroom chit chat, some of which was imparted at a seminar and some more informally. David told us that N.E.C. have decided to make all chains with "hourglass" links. When he was informed of this, the sunny beam of pleasure on the face of our Alan Cooper was something worth seeing. In the early part of 1982 Alan proposed this shape to avoid stress concentration where the radius of curvature on the links was smallest, and where we were finding most cracks. We raised the idea with N.E.C. at that time and a year later asked them to make us a chain with such links (41/4). N.E.C. agreed cheerfully and the first hourglass chain was put in the 14UD at the beginning of this year (43/3).

One or two people mentioned to David that they had just received Report No.46. It surprised us somewhat that the reports should have taken so long to arrive; they are usually posted within two days of the typing date, which appears at the end.

T.R. Ophel

T.A. Brinkley

29th October, 1984.

Enclosures

Plots of particle masses accelerated, and operating terminal voltages.

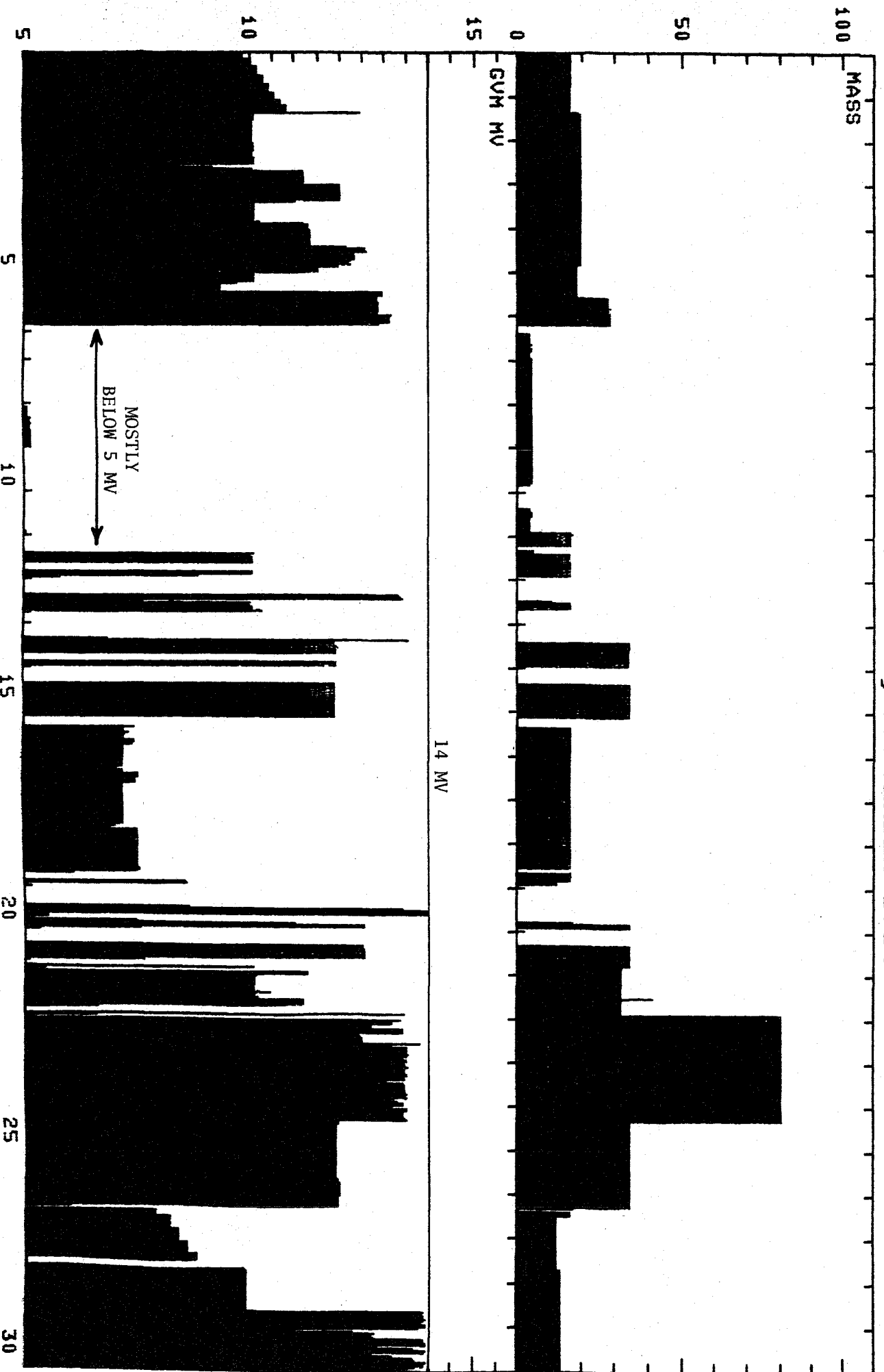
NOTE: On the plot of terminal voltages we have drawn a horizontal line at 14 MV for easy reference to performance near the nominal voltage limit of the 14UD.

Photograph

Damaged nylon pneumatic actuator tube.



14UD 10g SEPTEMBER 1984



14UD 109 OCTOBER 1984

