AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT NO. 10

Two openings: January 18 - 20 (2 days)
January 31 - February 1 (1½ days)

The tank was last closed on October 19, 1977 following a scheduled opening, and the 14UD operated successfully during most of the 91 days from that closure until this time. Reference should be made to Tank Opening Report No. 9, page 6, paragraph: "Machine performance after button-up" which describes that the 14UD achieved a stable 13.8 MV and then regressed to 13.5 MV operating voltage; this value, 13.5 MV, was maintained until a vacuum leak in the low energy tube forced the first of these two openings because of machine loading.

It became clear that experiments in the current schedule could not proceed until the leak was sealed and normal loading and operating voltage restored. However, at this time of the year, a significant fraction of staff is absent because of school summer holidays; more adventurous undertakings, normally entered into when there is a forced tank opening, were not envisaged, particularly because a major opening of at least three weeks was already scheduled for February 6, less than three weeks ahead. It was decided to have a two-man tank opening with the terms of reference: 'to find the leak, seal it, change the foils, have a quick look round, get out and get operating again'.

It was established that the leak was deep in the heater flange at casting No. 9 where the feedthrough makes its seal. The choices were to seal the leak with glyptal or torrseal, or to let the tube up to air and replace the faulty heater unit. Glyptal, the more fluid and more easily applied, was injected, in thin solution, with a syringe and sealed the leak immediately to the extent that normal base pressures of about 4×10^{-8} were achieved. The copper strip connection from the transformer to the feedthrough was removed as a precaution; while it was hoped that the leak at the feedthrough was a random one, it still could have been caused by local heating, or even vibration transmitted by the new more rigid connections.

FOILS:

For the first time since its installation the ANU tube-isolating valve leaked sufficiently at the foil change to cause alarm when nitrogen was let into the stripper volume. After adjustment, which took only a minute or so, a complete seal was attained and the foil change was completed normally.

OTHER MATTERS:

Chain 2, which had been performing erratically for a while, and which had not been used, was found to have stretched so that the motor 'bottomed', meaning that the emergency support, which prevents the motor falling in the event of a chain break, or tolerating too much chain stretch, was touching the tank floor. Three links were taken out of this chain.

The three chains were sticky to the touch, and not smooth and faintly oily as has hitherto been found to be characteristic; the rims of the charging pulleys were too dry, but in no way crazed (Report No. 2, page 1) and it was felt that our chain oiling procedure was inadequate. Some oil was put manually on all three rims. It was accepted that modifications must be made during the long tank opening scheduled for February 6.

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A patch of oil on the terminal spinning opposite the triode needles was quite different from previous deposits. The usual stain was a brown powder. On this occasion there was a crazy pavement pattern formed, presumably by an oil film shrinking as it dried and tearing into a number of separate irregular islands. The stain was still moist and there were a few droplets of oil which had run down the centre spinning and could be picked up at a finger touch. On the blank sides of all the column points the effect was similar, but an island had formed distinctly under each of the three needles. On the tube points the oily island effect was not noticeable.

While it was possible that the oil had come from the gas handling system it was assumed to be due to our method of oiling chains which is to apply droplets of oil for three seconds an inch above the rim of the charging pulleys. On occasions this has been done with volts on the machine and it appears that charged droplets have migrated en masse to corona regions, predominantly at the terminal.

Because of the need to button up by the end of the second day, and rough the tank overnight, the usual meticulous chain tests were confined to running them individually, without charging volts, and observing their mechanical performance. They seemed to run quite normally, without oscillations or disturbing noises. Due to a mixture of haste and forgetfulness on the part of one of the authors the terminal shorting strap was omitted for these tests, giving rise to very healthy self-charge sparks when the chains were run for too long. From the point of view of an observer, sitting alone in the bottom of the tank, a self-charge spark can inspire both great confidence in the charging system and an urgent desire to get out of the tank before the next one.

With the leak sealed, and no other fault in evidence, the machine was buttoned up.

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The 14UD ran satisfactorily for ten days at the required voltage of about 12.4 MV and it then became necessary to achieve 13 MV. High lost charge, of about 150μA could not be cleared more than momentarily by running the needle system in and out to clear the 'bad gas'. Subsequently an internal short occurred on the charging current metering for Chain 1, making diagnostics even more difficult. Units were shorted out progressively at both low energy and high energy ends of the machine in order to locate a defective unit, but without success, or even really consistent results. The chains were run individually and it was found that, for Chain 1, there was an onset of sparking, audible over the amplifier, for 25 kV on the charging inductors.

The problem of what to do next was solved in a decisive way by the machine itself when an internal short circuit dropped the charging volts to zero and current from the supply ran full scale. There was no alternative but to open the tank.

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31st JANUARY; THE SECOND OF THE TWO OPENINGS

When the charging system was examined it was found that the shimstock contact rim of the charging pulley for Chain 1 had lost a screw and the end of the shimstock had become bent away from the pulley and was in contact with the charging inductor; purely by chance the pulley had stopped in this position and produced the short circuit. It is debatable whether this fault had caused the onset of sparking at 25 kV charging voltage, and, possibly, since the charging pulleys rotate at 600 r.p.m., the succession of instantaneous shorts might not have registered on the metering circuits.

The No.1 pulley was rotated to eliminate the short circuit and then both charging and suppression voltages were turned on again to see if any breakdown occurred; during the tests the charging motors were pushed down against the stretch of the chains into the operating positions where the movable leads to the inductors might touch, or at least approach, something at ground potential. No breakdown was detected.

The screw from the shimstock was found on the floor of the tank, likewise a contact spring from a d.c. idler.

CHAINS:

It was found that a contact spring had come off one d.c. idler on each chain. There was a dramatic failure of the mechanical stabilizing idlers: some were off in each of the four castings where these idlers operate; four idlers had failed for Chain 2 (the motor of which had bottomed), and two each for the other chains. In every case the failure had been separation of the plastic pulley from the bearing. It is not in the least likely that all the idler failures had occurred since the first of these two button-ups, and therefore it has to be concluded that the chain tests in the earlier case took place while most, or all, of the failed idlers were lying in their castings, yet nothing untoward was recognized.

OILING:

Significant amounts of oil were found on the tank floor. There was no oil on the floor in the earlier opening but the condition of the pulleys and chains had provoked more generous oiling during the 10-day interim operation. Oil was seen on the centre terminal spinning, even though only 10 days earlier it had been well cleaned; again it was opposite the control needles. Fluid drops were hanging from the centre spinning, demonstrating that oil had been attracted there, had accumulated in a fluid state and been able to run down to the junction between the centre and the lower spinnings.

Remembering the high lost charge experienced prior to this opening a tentative hypothesis is that, under the voltage gradient, oil drops became sufficiently mobile to extend towards the tank wall and contribute a discharging current; such a current could heat the droplets, exacerbating the current and explaining the lost charge which failed to respond to the hitherto reliable expedient of running the points in and out a few times, i.e. a shunt path across the gas as distinct from 'bad gas' in the stablizing needle system, which can be flushed.

At this stage we are inclined to concede that our oilers are doing little or no good to the pulley rims, which is the only purpose for oiling, but are making the negative contribution of providing a contaminant at places where corona occurs. Between now and the long tank opening scheduled we do not intend to oil by the misting process (in fact the oilers have been removed) but shall rely on a careful manual oiling to see us through until the next opening.

One pellet was removed from each of the three chains.

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LOST CHARGE:

The control corona dome had a brown stain which wiped off easily, and which seemed to be consistent with mass transport of oil, presumably charged, between the terminal and the grounded mushroom. It is hard to believe that this effect is not associated with lost charge. New spark damage was observed on the terminal spinning opposite the triode needles. This, also, is held to be consistent with the concept of an "oil droplet path" between the terminal and tank wall in the triode corona region.

A.N.U. THICK "STRINGERS":

In Report No.9, page 5, it was described why we installed tube to column stringers made of quarter-inch aluminium rod rather than 0.030 inch nickel wire, which has, until now, been regarded as conventional. There was no evidence of wear on the tube corona needles in the three units each side of the terminal in which thick stringers were fitted and, as a consequence, it is intended to extend the use of them throughout the accelerator.

CHARGING CURRENT METERING:

The failure was due to spark damage on the insulating sheet which separates the pulley from ground, thus enabling current to be measured.

The 14UD was buttoned up, the above work having been carried out in a day and a half by a two-man team. On the day after the machine was gassed up it conditioned to 12.8 MV and experiments continued. The lost charge problem disappeared.

The major shutdown, originally planned for February 6th, has been postponed to the first week in April.

D.C. WEISSER

T.A. BRINKLEY

February 8th, 1978.

ADDENDUM: 14th. February 1978.

The lost charge problem recurred yesterday, though manifesting itself in a different way.

Running the triode needles in and out a few times still has a good effect, but only a transitory one.

On earlier occasions, the longer the machine was run the lower became the terminal voltage attainable; now, however, lost charge is reducible by continuing to run the accelerator and we were able to condition up to 13MV with 50 - 100 microamps of lost charge.

Lost charge is not associated with detectable x-radiation in the machine.

We have formed no conclusion at this stage.

D.C.W.
T.A.B.

It is assumed that the chain broke either because of idler failure or because the chain rode up on the dry pulley rim, touched the inductor. All chains and pulley rims were drier than usual because oiling has recently been on the sparse side, more with regard to electrostatic performance than mechanical safeguard.

SHAFT BEARINGS:

Screws holding the shaft plate on the ceiling of Unit 27 were loose, and one of them was out and lying on the floor of the unit. Both bearings were changed in this casting. The bearing on the bottom terminal casting was noisy, and was replaced. Other bearings are exhibiting slight noise and failures are beginning to occur after 5,000 hours, which is the life predicted by the manufacturers.

CORONA STABILIZING UNIT:

The opportunity was taken to ventilate the needle enclosure more effectively; 12 half-inch holes were drilled radially in the housing.

VOLTAGE TESTS:

Using a 60 kV Spellman power supply, tests were carried out 2 L.E. units and 2 H.E. units, testing each third of each unit separately. The H.E. units tested had been newly cleaned by the hitherto unused technique of blowing a jet of compressed air from an eighth inch pipe at the tube and column and collecting the flow, with disturbed dust, in a wide funnel on the end of a vacuum cleaner. A typical result for all tests was 48 kV and 120 microamps, when breakdown occurred on the annular rings on the column posts. It is interesting that corona occurs, towards the terminal, from the stringer wires before, or at the same time as it is initiated on the column. The stringer wires are known to protect the tube points and seem to perform as a third corona path, augmenting the points on both tube and posts.

MISCELLANEOUS:

While the 14UD was open measurements were made in order to design new insulation-free high-current leads from the casting transformers to heater plates. Since the inception of the machine, particles of fragmented insulation have come continually from the rubber covered welding cable originally installed, because sparking to these leads burns and breaks up the insulation. Only the permanent leads to the heater plates at casting potential will be fitted but provision will be made at the transformers for connecting the intermediate heaters if it should be necessary to operate them all. It is proposed to parallel the three 120 amp secondaries, run the permanent heaters from this arrangement, and add intermediate leads in parallel if necessary. A test has been made on a transformer outside the machine with a 400 cycle alternator; after a number of hours at 120 amps none of the secondaries showed a heat rise.

It is interesting to note that the crimped lugs on the welding cable, as originally fitted, become loose and get very hot because of voltage drop across the crimp. The secondaries deliver 0.5 volts and, in some cases, the voltage drop from secondary to load (i.e. across the entire lead) was 0.25 volts with a drop of 0.15 volts across the crimp.

A white powdery deposit at various places in the accelerator was thought to be alumina from the recirculator. The alumina was changed and also the filter.

D.C. Weisser,
T.A. Brinkley.
August 22, 1977