AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No. 61

This report covers our update to a compressed geometry tube and the first trials of resistors instead of corona point assemblies. There were several tank closures and re-entries for adjustments and testing purposes. The period involved was:

12th January to 12th April 1988

D. C. Weisser **T. A. Brinkley**

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

16.7 MV - THE AUSSIE UPGRADE.

We break the tradition of the sequential presentation of Tank Opening events and tribulations, to highlight and condense the most important constituents of this very successful upgrade.

I. COMPRESSED GEOMETRY TUBE.

A. 12% more insulation.

B. 45° electrodes.

C. Active gas treatment of electrodes to minimize charged particle emission sites.

D. "Clean room" assembly, installation and alignment procedures

II. COLUMN PERFORMANCE IMPROVEMENT.

A. Reduction in coatings on rings, castings and terminal.

B. Control of column-tube coupling by alignment tension spokes.

c. Reduction in particulates.

The items listed are only roughly in order of importance. The deletion of any one item might well have a drastic impact on the success of the upgrade. Certainly we would not willingly forego any of the items.

RESISTORS.

We are developing resistor protection hardware for the 14UD. The second set of 34 prototypes is presently installed in Unit 14 where the resistors have experienced approximately 100 full terminal sparks at between 14 and 16.75 MV. There is no indication of any failure, or change in resistance to the 1% accuracy to which we can measure.

A full set of resistors will be installed in the 14UD in January 1989 in order to report on three month's use at the 5th International Conference on Electrostatic Accelerators and Associated Boosters, 24 to 30 May 1989. We expect to be able to recommend a commercial manufacturer at the conference.

REASON FOR THE TANK OPENING:

The opening was scheduled in order to complete the tube update begun in July 1987 (59/1,2,3; 60/3) and to replace tube corona point assemblies in one of the units with resistors.

Preamble.

The 14UD was last closed on 30th October. It ran well, apart from beam intensity problems which we eventually interpreted as due to misalignment of the terminal foil stripper. On 30th November it was clear that it would be unfair to experimenters to endure the low intensities until the next scheduled opening in January; accordingly we took out most of the gas. The next day, after taking out the rest of the gas, and ventilating the tank, we went in at 1.30 p.m. for a quick fix.

The alignment of the stripper was not at fault; instead, we found that most of the foils were broken. We had survived for a month on a few good foils at the start of the train, and tatters from there onwards. We concluded that, when it was re-installed with its new load, the stripper had been roughed with a somewhat different interpretation of the procedure than usual.

No other work was carried out in the tank and very little cleaning was done. We buttoned up at 6.30 p.m. the same day.

Operational time.

During the 72 days since the October closure, the 14UD operated for 831 hours. This was 52% of elapsed time, excluding the days for gas transfer and the short opening early in December. The days of neglect of the 14UD during the Christmas and New Year holiday are included in elapsed time and counted against us. (42/2).

The Tank Opening

We took out the gas on 11th January and went into the tank the next morning. There was no detailed exploratory tour on this occasion. We were in the machine, not because there had been a failure, but to take out the entire tube and put back an updated version.

Plan for column voltage tests.

The first stage of our plan was to take out the tube, clean the column in the normal way, then gas up again in order to see how well the column would take volts without a tube. A column only test was last carried out fifteen years ago, at installation of the 14UD. On that occasion, 17th February 1973, Jim Ferry, of N.E.C., achieved 18.1 MV with 115 psia SF6.

There are factors which should lead to improved column voltage performance now, as well as factors which should reduce the maximum voltage of the column. Improved terminal shape and casting cover shape (14/2; 21/2,3) should reduce the peak fields by 10%. However, one gap in 18 in each column has now been shorted to match the column to the compressed geometry tube, making a decrease of 5.5%. As well, the second stripper reduces the H.E. column length by 2.4%. Thus we might anticipate an overall improvement of 2% if the tests were performed at 115 p.s.i.a.

We didn't want to test the column at pressures as high as as 104 p.s.i.a., let alone 115 p.s.i.a., since ceramics in posts had cracked when the machine operated at 104 p.s.i.a. and suffered episodes of reverse bias sparking. We therefore planned to test at up to 94 p.s.i.a. Merely multiplying 18.1 MV by the pressure ratio, and using the expected 2% improvement, we would anticipate at least 15.1 MV at 94 p.s.i.a. This is general evidence that the terminal voltage does not quite scale with SF6 pressure and so 15.1 MV should be viewed as an easily achievable goal.

And so to work!

On 13th January we began to take out the tube. We found that it was convenient to remove lengths of three tube sections at a time. By 3 p.m. we had removed the tube from 12 units.

We had two separate teams working; the "in-tank" team took the tube out, worked on other matters in the machine and cleaned and gassed up and out as tests necessitated. The "tube-update" team concentrated entirely on their long project; they separated the lengths into individual tube sections before external cleaning, drilling and tapping of four holes in the flange and flange pressing. In a clean room, they removed electrodes, cleaned the sections, fitted new electrodes and re-assembled the sections into lengths of two or three. The outside diameters of the flanges were aligned by a special jig designed by Alan Cooper and Howard Wallace. When assembled, the lengths were helium leaktested. This, of course, was an ongoing process which continued steadily over the period when the column was cleaned and voltage tested, and when other modifications were carried out.

On Tuesday, 19th January, we gassed up the machine to 83.3 p.s.i.a. with the entire tube removed and began voltage testing. Surprisingly the machine sparked first at 12.6 MV after reaching 83.9 p.s.i.a. It only achieved 14.55 MV after 26 sparks. The column was observed through viewing ports to try to localize and/or understand the reason for such a low sparking threshold; pre-discharge light-emitting events were seen through all windows with 75% of events seen in the H.E. column. This is consistent with particulates on the column and rings. To confirm that moisture could not be the cause of the voltage limit, the alumina dryer was carefully reactivated and the SF6 recirculated for 24 hours. There was no improvement; the SF6 was pumped out.

A thorough examination convinced us that nothing obvious was wrong and that there were no loose particulates on the H.E. rings. However,the rings were maple-coloured from years of rubbing with tac-rags, the effectiveness of which we have sung in loud praises in these reports since tac-rags first came to our notice. Gritty, mobile particulate matter, not the colour of a film, has always been our concern. In some locations, the bionic layer had crazed and lost lumps; this convinced us that the rattan rings were undesirable. The coating was thicker in the H.E. end, possibly because chain oil, radiation and breakdown products may play a role in the buildup of the deposits. Experimentation by Howard Wallace with most readily available degreasing agents, led him to settle on acetone as efficient and environmentally acceptable. Adding 30% water to the acetone improved its cleaning ability impressively, and also seemed to reduce the acetone fumes, because of which respirators were brought into compulsory use.

The efficacy of respirators was soon found to be adversely affected by beards. The younger author, to set an example, shaved his grizzled beard of long growing. This made him look younger still, considerably increasing the visual differential between himself and the older author, who has never had a beard up his sleeve to remove at times of cosmetic expediency. All but one of the technicians possessing ungrizzled beards of varying profusion and style, failed to follow the younger author's sacrifice; they adhered to their embellishments and were consequently forbidden the delight of cleaning the rings with acetone. The younger author, and beardless Howard Wallace, cleaned the rings, helped by Justin Strong and anyone beardless who could be lured, or threatened, into the tank from among the staff. The distaff side, so eminently qualified to wear respirators, did not seek the equal opportunity to enjoy them.

The rings were rubbed with pads of Scotch-Brite dipped in acetone/water. (Scotch-Brite is a very effective general purpose scouring pad made of fine fibres matted densely together and resembling, if anything, the coat of a badly neglected synthetic dog). Next, rags soaked in acetone/water were looped round each ring, then pulled to and fro. The rags and scourer pads quickly became clogged with residue; they were renewed until little further material was removed. This entire procedure was repeated three times. Even after the last miserable pass, some material remained.

After much cleaning, and then blowing with nitrogen, we went over all the rings at 10 kV with the resistance tester, looking for fragments of lint, or anything else which could cause trouble. On Thursday 4th February, we closed up and next day gas was put in and voltage tests of the column began.

Voltage tests.

At 84 p.s.i.a. there were sparks at about 12.4 MV. so we ran out the old 'wet gas' excuse. At least there were no precursor sparks, justifying the exhausting cleaning effort. At this stage, the younger author, who can never seem to leave well enough alone, attempted to improve the chart recorder scale calibration and screwed up the GVM calibration instead. Careful recording of corona currents, and the orientation of the calibration knob with respect to the Southern Cross, allowed re-establishment of the GVM calibration with only a 7% over estimate of true voltage. Of course, we couldn't measure that error until the tube was installed and a proton beam was analyzed. The unknown GVM calibration added a bit of spice and anguish to all subsequent column tests. However, all voltages quoted in this report have been corrected for the error.

But back to the volts! 12.4 MV was disappointing and the SF6 was still damp. Doug Stewart, an old softy without the heart to watch a grown man cry, suggested conditioning subsections with shorting rods. He was haughtily (and tearfully) informed that "columns don't condition" and that, if he were an accelerator expert, he'd know that. Since this was the only suggestion that anyone made, we decided to try it.

The machine was shorted in halves and conditioned for about 5 sparks, getting to 1.14 MV/unit. With this complete, and the SF6 now drier, the whole column went to 14 MV, accompanied by about 12 sparks. At the time we thought it was 15 MV! New dogma: "Columns *do* condition." With the enthusiasm of converts we proceeded to condition 3 and 4 unit sections for a "standard" 10 sparks per configuration to 1.18 MV/unit. The whole machine subsequently achieved 14.5 MV, an improvement of 0.5 MV, and was allowed to spark 10 times for no obvious improvement or deterioration.

The absence of a better idea led us to increase the SF6 pressure to 94 p.s.i.a. The machine then achieved 15.7 MV. We decided it was time for more shorting rod conditioning in 3's and 4's up to 10 sparks at 1.30 MV/unit. At this stage we tested Unit 14, into which we were going to install the resistors, to the same gradient.

Another bizarre episode of GVM calibration messing occurred because the Terminal Volts digital voltmeter became non-linear. We don't think this introduced too much additional confusion.

The full machine now achieved 15.9 MV (though we thought it ws 17.12 MV), and then sparked, displaying classical spark induced deconditioning, a phenomenon always associated with accelerator tube effects, rather than column effects. (See diagram). Thus we have two strong pieces of evidence that columns exhibit conditioning and deconditioning phenomena, previously ascribed only to accelerator tubes. This perception overthrows our "understanding" and interpretation of the conditioning process and refocuses attention on column cleanliness as a crucial parameter for machine performance.

Yet another session of shorting rod conditioning for 10 sparks again recorded up to 1.25 MV/unit, somewhat worse than the 1.3 achieved before. Full column tests achieved 16.17 MV, but now displayed spark induced deconditioning. It was decided to quit these tests because we thought that 1). the 17.4 MV indicated, (really 16.17), was enough for the upgrade, and 2). that the new Vivalyme as usual put dust all over the rings, which were causing the limit on volts, and 3). we wanted to get the resistors installed.

We began to take the gas out in the afternoon. Next day, we found the column was very dusty from the new Vivalyme, as predicted. Once again the column was cleaned, this time with a man inside. We have sometimes almost envied people who have machines with columns you can climb about in, and have fun, independent of where the platform captain wants to be, and it occurred to the cleaning team that, now the tube was out, we should make the best of our opportunity. One man inside the column, and four outside, is a very efficient way of cleaning. It was to the abiding regret of the older author that it was kept from him that we had a man in the column. He pointed out that he had never been inside the column and it was pointed out, in return, that even if he managed to get in, it would take four people to get him out, if anyone felt like getting him out.

During this opening we installed a set of resistors on one of the posts in Unit 14. The resistor assemblies comprise Welwyn 800 megohm resistors, cantilevered from one end, coaxially inside stainless steel tubes. The free end of the resistor supports an electrode serving as half of a decoupling capacitor and spark gap. A pair of resistors in series grades each column gap. The free ends of resistor pairs are connected with a one-turn loop of tinned copper wire. All the resistors are mounted on one side of a single column post, (photo).

After gassing up to 94.5 p.s.i.a. on 16th February, Unit 14, containing the resistors, was tested to about 0.9 MV/unit where sparking commenced, accompanied by downward voltage ticking. No improvement on this value was achieved, so Units 12 and 13 were added to 14 for further tests. In this combination, the volts were still strictly limited at about 0.95 MV/unit for Unit 14, but the ticking vanished. The shorting rods were deployed to have Units 7 - 14 live. These went to 1.14 MV/unit when Unit 14 had 0.9 MV across it. This distribution of lower volts across the resistors when the corona graded units had 35% more gradient, was a satisfactory basis for continued testing up to 15.45 MV. All rods were removed and the column went to about 13.7 MV, sparking in that region 10 times. The now standard 3 and 4 unit conditioning followed with additional tests of Unit 14. After only L.E. column conditioning, the terminal achieved 15.65 MV with 10 sparks. Standard H.E. subsection condidioning followed and again the rods were removed to achieve 15.5 MV for a total of 29 sparks. In retrospect, Unit 14 must have been detonating these sparks since it would have had to be at its 0.95 MV spark threshold. [0.4cm]

Finally, one of the rotten interconnecting wires between the resistor ends had finally parted, causing continuous sparking, easily seen through a viewing port. We took a few photographs of the fireworks display through a window, to feed our confusion. Because we were satisfied with the apparent voltage achieved, 16.7 MV, (really 15.5 MV), we took out the gas and went in the tank to have a look.

Victory! There was no measurable change in value to 1% to any of the resistors themselves. The connecting wires between some of the resistors were burnt through due to the high fields caused by the inductance of the loop. There were spark marks between adjacent tubes and the aluminium electrodes were badly spark eroded. The connecting wires were thin, 0.6mm, because we had found that thicker wires tended to pull the resistors off centre in their tubular shields, leading to a narrow gap at which there could be breakdown. Next time, lower inductance connections should be fitted.

The resistor design was improved by 1). replacing the inductive, single strand loop with thin copper braid, 2). redesigning the capacitor/spark gap electrode from titanium and changing its shape, 3). monitoring the resistors on both sides of the column post to increase the tube to tube distance. See photograph of the new installation.

Installation of the Compressed Geometry Tube.

On 25th February we began to install the compressed geometry tube.

There being no tube in the machine, we began by checking the alignment of the tank itself. We have a datum point underneath the analyzing magnet; on this, we position a theodolite, pointing vertically upward. On top of the tank there is a very robust support into which we can place an optical target, or downward looking telescope; this provides a second reliable external datum point.

The tank, and both ends of the stripper, were all on line; we therefore had a basis for locating all the lengths of three tube sections which were made coaxial in the clean room by the Cooper/Wallace jig.

David Weisser's new tension devices, for holding the tube on alignment, were brought into use, replacing the original compression rods. (photo). The devices, which are adjusted and perform much like the spokes of a bicycle wheel, promptly became known as spokes. They are made of 1.5mm stainless steel, are electrically similar to stringers and tolerate vertical movement of the tube for segment replacement. The Cooper/Wallace jig displayed its versatility by locating new tube lengths precisely onto the aligned upper flange of the last length to be put in position.

Installation of the tube went smoothly, therefore quite rapidly. By the afternoon of the second day, seven units were completed. Careful procedures were always followed in order to keep one end of the growing tube capped to prevent 'chimney' effect and the ingress of dust.

Mishap!

In the late afternoon of 26th March a knot slipped in a nylon rope with which a length of tube was being suspended before positioning between Units 20 and 21.

The tube fell onto a glass optical target in the top of the last section to be installed, shattering the target which was left in position until the last moment in order to keep the tube clean. Glass fragments fell into the tube; some went right through and landed on Al-foil below the analyzing magnet. The tube sections themselves were not obviously damaged, but the avalanche of glass fragments throughout seven units of tube, meticulously prepared and installed, cast profound gloom over the whole enterprise. It was Friday afternoon and too late to more than dwell despondently on the situation over the weekend.

By Monday, the individual despondent dwellers all had arrived at the conclusion that there was no alternative but to dismantle the entire tube, separate the individual sections and extract every bit of glass.

All the newly installed tube lengths were removed and the individual sections separated in the clean room. Visible glass fragments were extracted with a vacuum cleaner. Throughout the total tube involved, about 70 large to medium glass fragments were taken out of the tube and probably the same number of small pieces. The insides of the tubes were blown with filtered compressed nitrogen again as they had all been in the previous procedure. This activity also uncovered a couple of missing electrodes in one tube section installed previously.

Tube Re-assembly.

On 4th March we began re-installing the H.E. tube already stockpiled by the clean room team. These tube sections previously were in the L.E. end where they had a softer life than those in the thirteen and two thirds unit H.E. end. Progress was halted when it was discovered that three untreated heater electrodes had been installed by mistake. It also seemed that, whenever the tube reached a non-standard interface, such as the second stripper or the terminal, progress slowed while studs were shortened, or screws were lengthened.

All the tube assembly and disassembly soon consumed our twice augmented supply of coined Al-wire gaskets. We made our own coining press to manufacture coined, but touch-welded gaskets.

A completely new second stripper was assembled and a pneumatic actuator was built. This apparatus is almost identical to that in the terminal, designed by Bob Turkentine, and shares the feature of driving the foil chain at the beam end, as well as at the distal end. (50/4; 51/4)

On Friday 18th March the tube was under vacuum. Heater tapes (1kW rating) were hung vertically along the tube and doubled back on the other side; the complete tube and vacuum system, from top of the tank to the bottom, was heated by 8 tapes held to the tube with copper wire. Tube and tapes were wrapped with Al-foil and baking begun. After 3 days at 120°C, the pressures were 1×10^{-7} L.E. and 1×10^{-6} H.E. After the Al-foil and tapes were removed and the tube cooled, all bolts were re-torqued. The pressures then improved to 3×10^{-8} and 6×10^{-7} On 29th March leak testing with a residual gas analyzer revealed no leaks. The entire tube, with all bellows, pumps and stripper flanges, had been put together without a single leak, or so we thought. The assembly and installation teams were well pleased with themselves.

The tank was closed for voltage tests on 12th April. When it was gassed up next day a leak became apparent. We opened up again, located the leak on the rear flange of the L.E. mid-section pump, (not the tube!) fixed it and closed up once more. This had escaped re-torquing! More leak testing was performed, this time with a properly calibrated helium leak detector in the terminal.

Visitor from N.E.C.

We are always delighted when anyone from N.E.C. comes to see us and were lucky to have Leo Parpart, who was effectively "in the district" (Bombay!) drop in at this point in the proceedings to see how things were going with the compressed geometry upgrade. In the N.E.C. tradition, Leo spent a lot of time in the tank working to help us. He also conducted most of the high voltage conditioning sessions.

Corona Points.

At the end of the tube installation we installed new tube corona points throughout. They were adjusted following current tests with the resistance tester at 5kV across each gap. The column points were not changed, apart from the resistors put experimentally in Unit 14.

Corrosion of copper shorting straps.

In January, one gap on each unit was shorted with a standard copper strap. On inspection, many of these straps were found to be corroded to looseness on the aluminium brackets. Presumably this corrosion was caused by a combination of the chemical effects of water used in cleaning the machine dissolving acidic SFG6 bdp's. This, added to spark currents, caused the corrosion. The copper straps were replaced by aluminium ones to eliminate the dissimilar metal junction. A special gel, used in aluminium wiring, was applied to the joint before assembly.

Voltage Tests.

Volts were put on the tube for the first time on 15th April. The first spark occurred at 8.4 MV. Ten sparks, and two hours later, it reached 10.1 MV, when shorting rod conditioning of the H.E. end commenced. Standard 10-spark conditioning of Units 15 - 17 resulted in the gradient increasing from 0.87 MV/unit to 1.12. Units 15 - 19 live achieved 1.11 MV/unit in 10 sparks over 70 minutes. Then the full machine went to 11.5 MVin 7 sparks.

Various combinations of the remaining H.E. units were then conditioned for the next 10 hours. With all rods out, the machine hit 13.23 MV. A NaI detector was mounted opposite the terminal to monitor x-rays > 0.1 MeV. Conditioning is dominated by vigorous pulsed x-rays superimposed on a continuous background with increase smoothly with increasing gradient. (Fig.2)

Standard subsection conditioning of the L.E. end was cut short by a broken nylon "shorting" rod and so the SF6 was pumped out on 18th April. We popped briskly back into the tank and found that the L.E. midsection pump had been put back in a slightly different position where it deflected the rods sufficiently to cause them to jam in the casting contact fitting.

From 19th to 21st April, at an SF6 pressure of 85 p.s.i.a., the accelerator was conditioned in subsections, followed by full machine evaluations during which it reached 15.3 MV (we thought it was 16.5).

The G.V.M. calibration.

It was time to put a proton beam through the machine to confirm the GVM calibration. The beam wouldn't go through! The cuperture had struck again. Old, experienced readers of these reports might remember (47/4) that tank pressure changes during gas transfer have surreptitiously operated our pneumatic actuator and put in the terminal faraday cup (cuperture), blocking the beam. The younger author suppressed this fact at the time, keeping the event from the older author, who had fought for years to have the cuperture ripped out and dropped in the middle of nearby Lake Burley Griffin.

We put view ports in the straight through position of the analyzing magnet and looked through with the theodolite. No light appeared at the end of the tunnel; until we actuated the cuperture. Not content with clearing the blockage, we managed to barely operate the actuator several more times to confirm that the 12mm hole was selected; it jammed again in the 'shut' position. By undeserved luck we managed to reach the 12mm position. The younger author publicly offered thanks that the older one wasn't there that day. Looking through the stripper we were able to see that the terminal foil frames were also intercepting the beam, though not badly enough to prevent enough beam to go through and allow a GVM calibration, using 24 MeV protons. The GVM had been reading about 7% too high, so all our extremely impressive terminal voltage figures had to be reduced to merely very impressive ones.

The machine was then given over to experimenters while we caught our breaths and licked our wounds. Leo Parpart left on 22nd April after the machine achieved 15.56 MV.

Tests of the resistors in U14 continue to show that unit to be indistinguishable from corona graded units. The machine went to 15.7 MV after further standard subsection conditioning and was used by experimenters. It was opened again on 3rd May to fix the terminal triplet. We "fixed" the cuperture by a tubal ligation of the actuator.

Charging system

Chains:

Michael Stier, of NEC, wrote to us that differences in voltage between the charging and suppressing inductors can lead to tyres on the charging pulleys becoming punctured, on the principle that, if the field on the suppressor inductor is higher or lower than that on the pellet, current will flow when the pellet touches the pulley. Our charging and suppressing supplies, nominally identical, are driven by a common variac. Hitherto we have never bothered to compare voltages on the inductors; however, we measured volts on the cables where they enter the tank and found that they were within half a percent of each other at 6 kV.

The column
Posts.

Continuing with our plan to recondition all the column posts in the accelerator, (52/4), four reconditioned posts were put in each of Units 2 and 19. We have now put new or reconditioned posts in 36 of the 112 positions.

Initial performance

After the last button-up the machine was used for about 6 weeks for experiments with incidental conditioning. It has achieved 16.7 MV and performed experiments easily at 15 MV with pulsed beam.

Sir Ernest Titterton.

As a result of the car accident last September, which we reported (60/3), Sir Ernest was operated on in a Canberra hospital shortly afterwards. In October he was transferred to Sydney where he received daily therapy which led to signs of improvement in his condition. He could move his legs slightly and one arm a little.

In mid April this year Sir Ernest was brought back to Canberra. He receives hydro therapy and occupational therapy five days a week. His progress is best described by his own words in a circular letter which he dictated recently into a voice operated tape recorder. "My progress is still exceedingly slow, and I'm still improving very, very slowly. It doesn't give me great hope of any kind of miracle cure, but it does give me hope that I may be able to do a few useful things for myself, rather than be completely dependent, as I am at the moment." He enjoys receiving letters; the address is:

P.O. Box 331,
Jamison,
Canberra,
A.C.T., 2614
Australia.

Missing: The A.N.U. SF6 detector has become lost on its travelling loan to the laboratories where enthusiasts wanted to find out about their SF6 . Information leading to its recovery will be rewarded by a copy of the next report, signed by both authors.

Comment: Several people have told us that they never see these reports which we have been sending regularly to their laboratories for years. While the reports are addressed to individuals, we have assumed that others interested will see them. Costs prohibit us from posting more copies, therefore we ask recipients to circulate the copy they receive.

........PLEASE CIRCULATE THIS REPORT........

A.N.U.
7th June 1988

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.

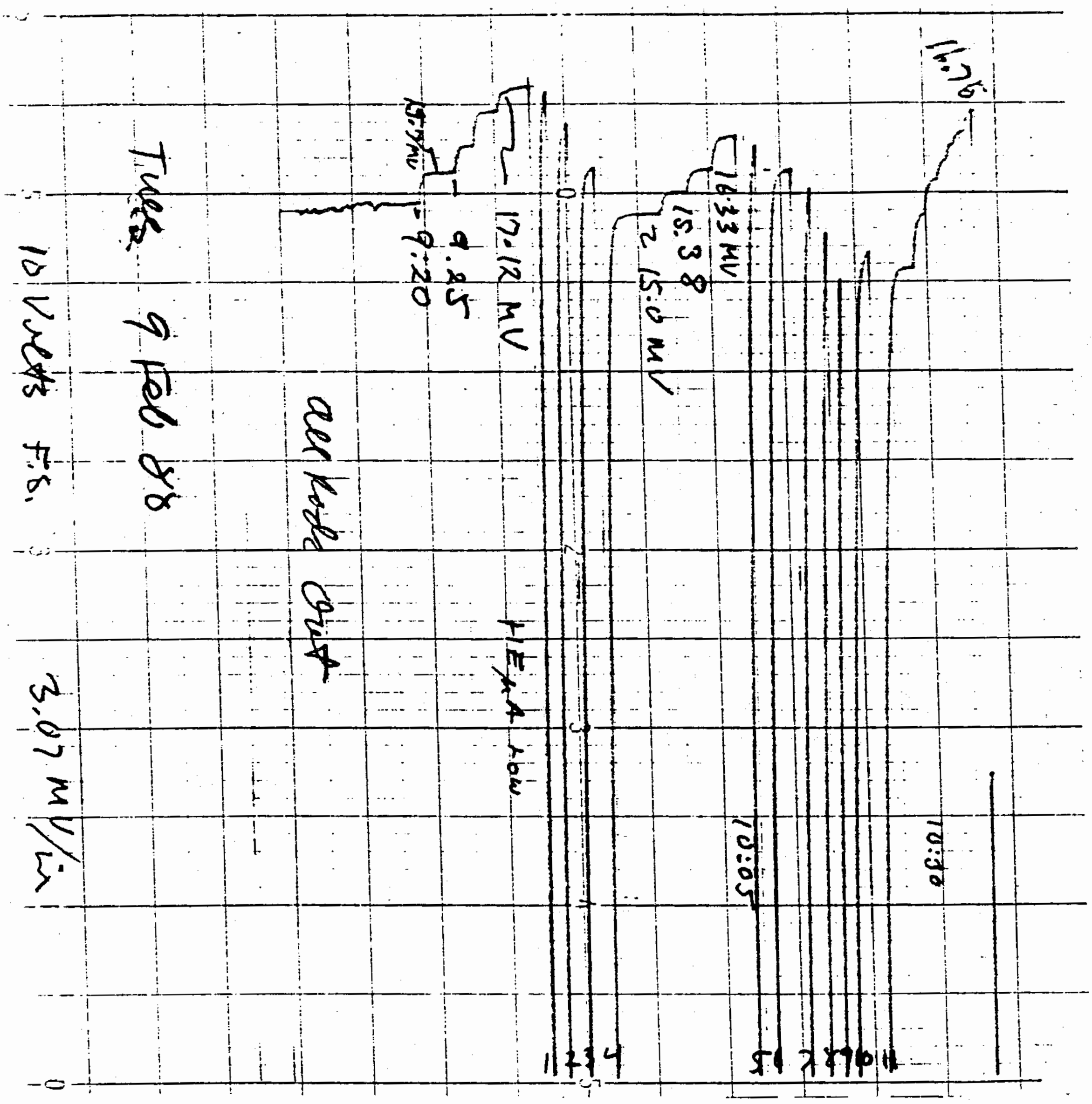
Glossary of terms and abbreviations:

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 and electrode 7.

- BDP or bdp - breakdown products.
- Conductivity cell - the breakdown product detector described 37/10.
- Vivalyme - assumed to be soda lime, CaO + NaOH

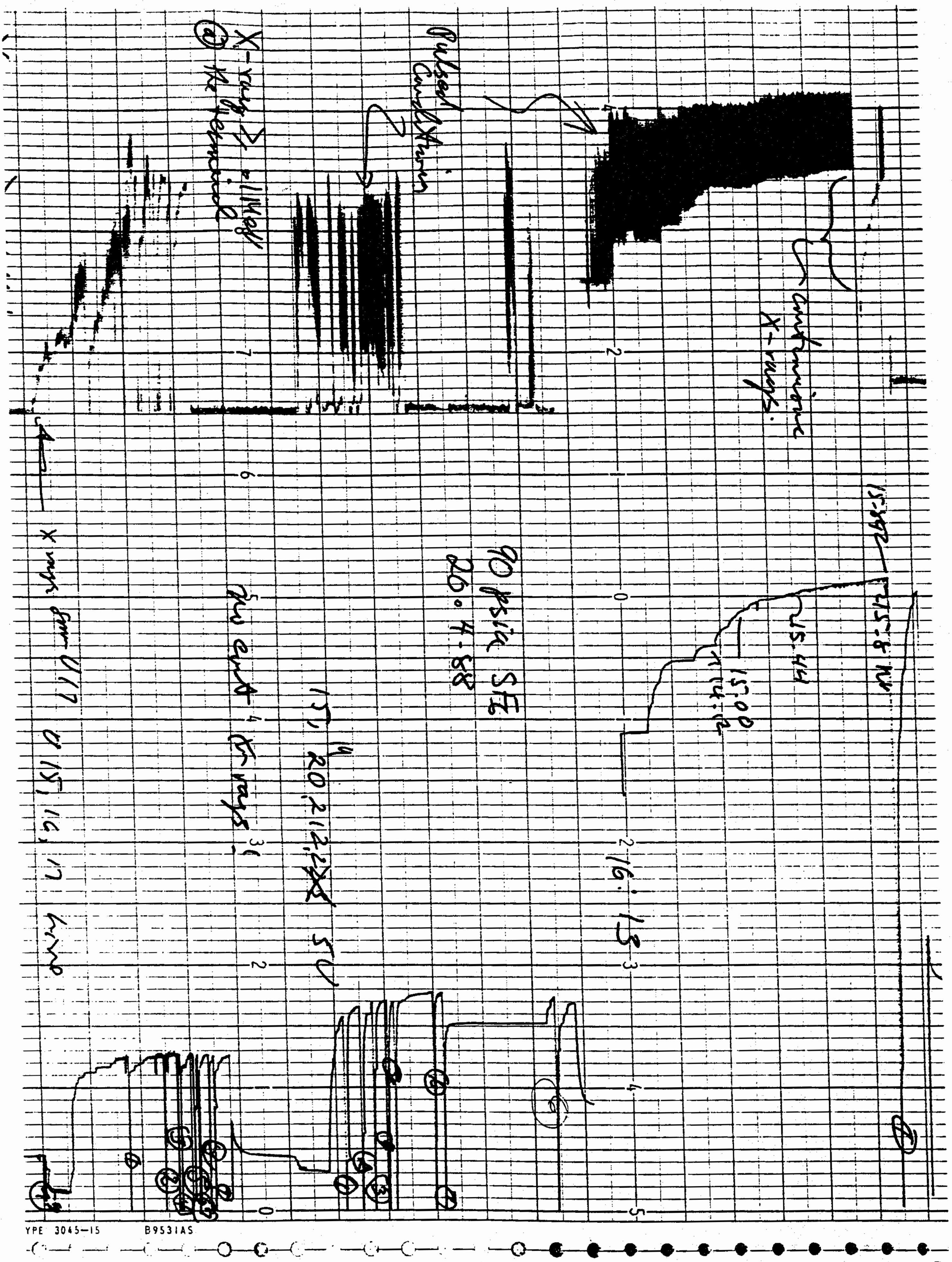
Operational time: We subtract tank opening time from elapsed time and quote the percentage of the remainder that the machine has volts on terminal. Sometimes, when the source is down, the column is voltage conditioned, leading to an overestimate. Comparison of the source and terminal plots shows that the difference is rarely noticeable.

Finally, to avoid confusion, David Weisser and the older author often eat lunch together.



Spark Induced Deconditioning

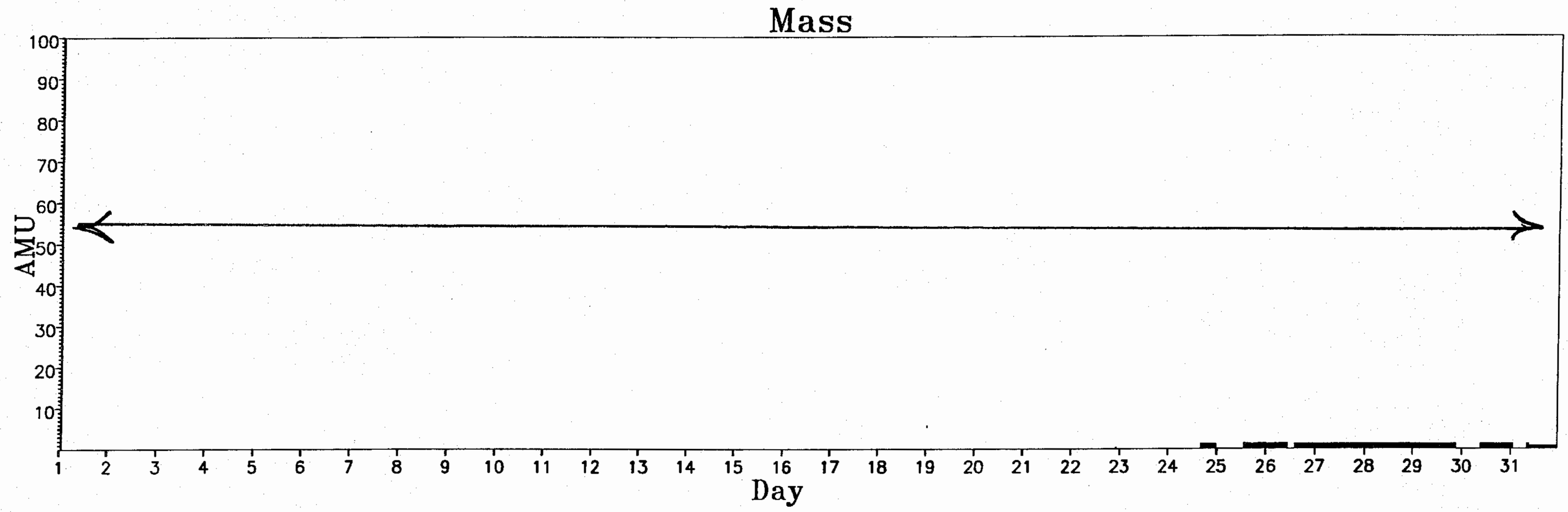
FIG. 1

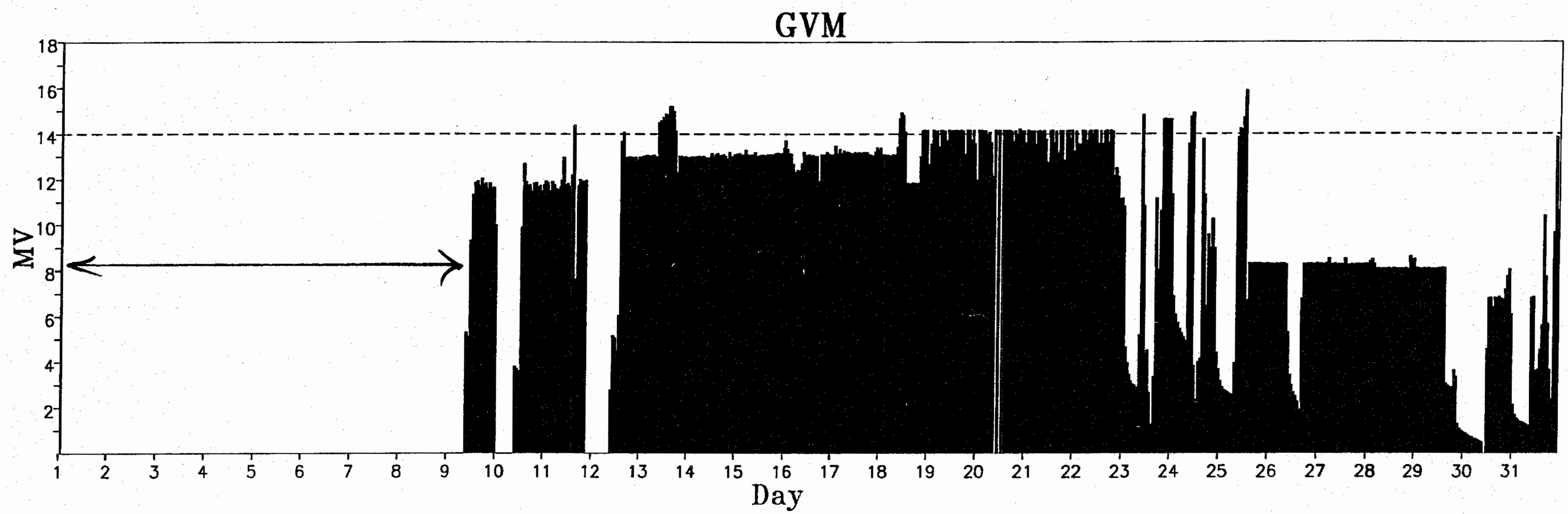


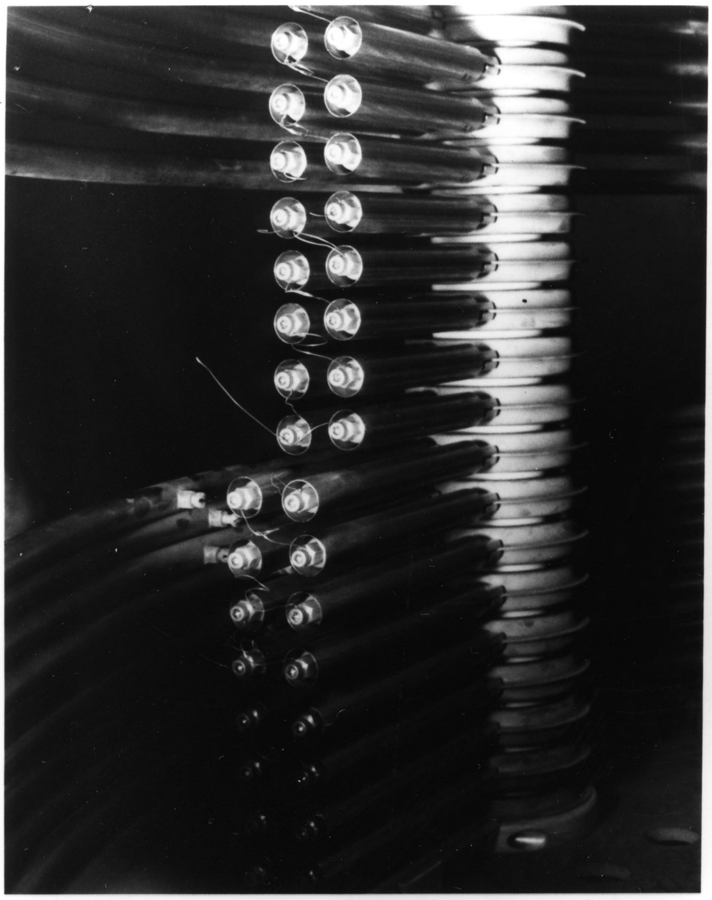
Pulse X-rays and Continuous X-rays.

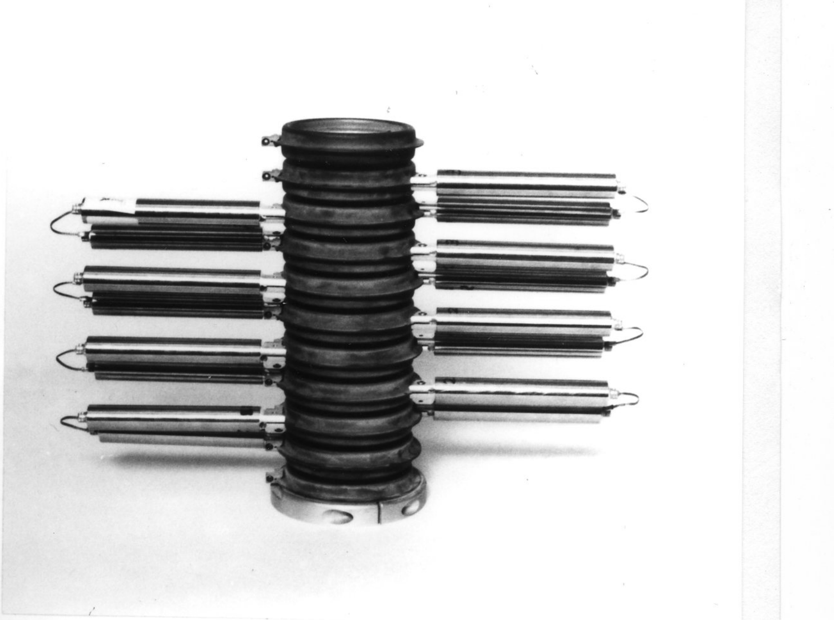
Figure 2.

14 UD log – MAY 1988









2. RESISTORS - MARK 2

1. RESISTORS - MARK 1

TO 61

3. ALIGNMENT SPOKES INSERTED IN OLD STABILIZER HOLES.

4. ALIGNMENT SPOKES CLAMPED TO TUBE FLANGE.