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14UD TANK OPENING REPORT No. 56
6th to 21st January 1987
(16 days open; 12 working days.)

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.

Acknowledgement:

In the last report we described a chain alignment device which we had made and found to be very successful. In a recent letter to us, N.E.C. pointed out that they had made a similar device and used it on the Sao Paolo machine as long ago as 1975. We didn't mean to steal our old friends' thunder, but perhaps it was a gentle peal because we simply didn't hear it. N.E.C. asked how we washed our chains and degreased our posts, a procedure which we had mentioned earlier (55/3) without giving details. In this report we have elaborated on the procedures in the sections for chains and posts.

REASON FOR TANK OPENING

In the past we have usually opened up a bit before Christmas to put a few sprigs of holly between the rings, a little tree on top of the column and renew foils in case any revellers wished to use the machine during the Christmas and New Year break, but this year the foils lasted well enough for us to delay the opening until the new year. As will be seen in the preamble, during Christmas, instabilities forced us to close down and wait until we could open the machine.

PREAMBLE

The 14UD was last closed on 26th September. For a while it was unwilling to hold voltages in excess of about 12 MV. Sparking troubled us to the extent that we carried out diagnostics with shorting rods, but we came to no firm conclusion. There were spells at 13.5 MV and the machine settled down somewhat. Low voltages were required at the end of October and there were no further problems until we returned to higher voltages wnen occasional sparks and sudden voltage dives became a nuisance. Towards the end of November we began to notice slight negative self-charge on chains 1 and 2. Two weeks later lost charge returned; by 16th December it was varying from 70 to 100 microamps for a terminal voltage of 13.6 MV. On 24th December there were voltage stabilization problems which were attributed to particulates; on 26th December the machine would not control and it was assumed that particulates, perhaps from b.d.ps, were both on the terminal and the triode assembly. It was decided to open the machine as soon as some of the workforce returned after the Christmas/New Year break.

OPERATIONAL TIME.

During the 100 days since the last closure, the 14UD operated for 1,210 hours. This was 59% of elapsed time, excluding the days for gas transfer (42/2), and the time between Christmas and 5th January when the machine remained closed, but inoperable.

THE TANK OPENING.

Exploratory tour.

The tour was begun in the bottom of the tank, before the platform was lowered. On the floor we found shattered and partly melted fragments of the nylon insulator which distributed the positive voltage to the suppression inductors. Most of the insulator was still in position, but its charred and carbonized condition, (photos 1 and 2), implied that it was conducting. When we examined the charging pulleys, there, indeed, we found troubles enough to predict that we would discover on the column particulate matter which would account for the instabilities experienced.

A thick deposit of black powder adhered to the "up" (negative) inductors, on all three chains. In some cases the buildup was so thick inside the inductor (photo 3) that the chain pellets must have been in contact with it. Large black specks, some large enough to be called flakes, were spattered over the whole of the inductor sides, including, in one case, the pickoff ring by which we observe chain performance; (photo 6).

There was spark damage on the new tyres in all three driving positions. In places, the tyre lip was penetrated. There were patches of damage on the outer face, (photo 4) and evidence of punctures fairly high up on the chain riding surface, (photo 5). When the pulleys were turned slowly, the outer faces of the tyres had long patches which were rough to the touch.

We had no doubt that the black deposit was an accumulation of fine powder, eroded by some process from the new conducting tyres installed at the last opening (55/2,4). From the way in which chain oil has always been transmitted up the column, we expected the powder to be likewise. All three chains had operated for close to 1,200 hours since the new tyres had been fitted.

Once on the platform, we promptly confirmed our apprehension about the black material being transported up the column by the chains. At stabilizing idler positions the spark shields were coated thickly in places, (photo 7), and flecks had been distributed onto both post and tube electrodes. In the lower terminal, the inductors, (photo 8), insulators, floor and the furniture in general, were coated significantly. Flecks were found on the rings and wall of the tank. In the region of the terminal, the flake density on the tank wall was about one per square metre; a somewhat higher density was found on the terminal, rings and triode mushroom. A particular, but not well recorded, area on the tank wall had a much higher concentration of black flakes than at other places.

The conducting tyres were supplied to us reluctantly by N.E.C. as an experimental measure, without any assurance of their success. The technological avarice which besets machine people drove us to gamble on an idea for tyre technology which was not fully developed, or even reasonably tested, and we record that N.E.C. indulged us without enthusiasm.

The terminal stain was a thinly coated, dry deposit, more grey in colour than the moist, rich brown which is frequently found. There were several large "splat" marks in the terminal stain: at their centres, a spot of clean metal could be seen with a few radial lines emerging, (photo 9). These are consistent with random sparking due to particulates.

As to other matters, we found that there were severe "snail tracks" (50/6; 53/4) in the perspex shafts at the top of the L.E. column, (photo 10), with tracks lessening in degree on the shaft sections in units closer to the terminal. There were no tracks in units 13 and 14. This bore out our earlier observation that snail tracks appear to be worst in shaft sections which are subjected to the greatest torsion; clearly the sections immediately after the shaft motor drive all the others. No snail tracks were found in the shaft sections in the H.E. column, which have been in the tank environment for 10 months, operating for 3,900 hours. The L.E. ones, which have been in the tank environment for 13 months, have operated for 4,900 hours.

And so to work!

CHARGING SYSTEM:

Chains:

Before work was begun on the chains, their operation was checked for twist and flop; they ran mechanically very well. We tested the tension with the chain disconnected by hooking a spring balance to the motor at the pulley shaft and lifting until the motor platform was level. With the complete motor system alone we measured 180 pounds and with the two lead blocks under the shaft, their 'normal' position,, we measured 215 pounds. These values are substantially in excess of the 80 to 120 pounds which N.E.C. suggested. No recent tests have been performed with less tension.

All six pulleys were removed; the conducting, self-lubricating tyres were taken off and the faithful old blue nylon ones were restored with their shimstock contact bands. The pneumatic oilers, which were gleefully thrown out when we put in the first new tyres (52/3), then put back when the new tyres didn't work (52/4), then thrown out again when the "good" new tyres came, (55/2), were fondly cleaned and re-instated. The old oil, Apiezon C, was removed and a low viscosity vacuum oil, Mobil Velocite D, was substituted in order to have a less gluggy mess. One oiler reservoir was found to be so scaly from previous silver soldering that it was beyond cleaning. It was disassembled, cleaned, and resoldered in a nitrogen atmosphere. Another oiler had a split in its stainless steel delivery tube which caused it to leak badly. After attention, oilers No. 1 and No. 3 delivered 4 drops in 2 seconds. No. 2 spat a reasonable quantity, and we left it at that.

The three chains were dealt with individually; they were washed outside the machine to remove the black flecks which were on the pellets and nylon links, then put back by the alignment jig method.

We found that all idlers were in excellent condition and, surprisingly, had collected none of the black flecks, though the sparkshields were thick with them; consequently these were all removed and washed outside the machine. This confirms that the flecks are electrically mobile.

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CHAIN WASHING PROCEDURE.

We reported (55/2) that we washed all three chains. This was to remove all traces of oil because we had converted to self-lubricating chains and taken out the oilers. Our washing process was as follows:

The chains were washed in a bath of RBS 25 at a strength of 20 gms/litre. In this bath they were scoured with a fluffless synthetic washer, such as dishes are washed with at home. Immediately on leaving the bath the chains were put in alcohol in which they were brushed with a paintbrush, trimmed short to make a stiff pad of bristles. When removed from the alcohol the chains were left to dry naturally.

RBS 25 is made by Chemical Products, Brussels, Belgium. The label on the container carries the following statement, verbatim: Surface cleaning agent for cleaning and decontamination of surfaces, material and equipment for medical laboratories and research in the scientific, nuclear, industrial, pharmaceutical and foodstuffs fields. It can be used very effectively instead of the dichromate sulphuric acid mixture. It eliminates grease, silicone oil, apiezon grease, Canada balsam. pH of 2% solution in water is 10.3. Leaves no film or trace after rinsing.

THE COLUMN.

Posts.

DEGREASING POSTS

They are degreased during the post reconditioning procedure described, in part, in the last report, (55/3). When the posts are removed from the machine they are put in a Chlorothene NU vapour degreaser first of all; this is simply to clean them up so that they can be worked on. The slots (55/3) are milled on the electrodes and deburred by hand. After this, the end caps are removed and, because of entrapped oil, the posts go in the vapour degreaser again. Spot welding is carried out as necessary and the posts are shotblasted. Finally, there is a third vapour degreasing in order to get rid of inescapable impurities from the shotblasting. The ends are then assembled with the epoxy and the remainder of the 55/3 reference is carried out.

Points.

The corona current of 5 kV in air was measured for all tube point assemblies. Variations in current of plus and minus a factor of three to four were found which imply voltage variations for fixed current of plus and minus 0.6 to 0.8 of the average voltage. Variations were worst at the tube ends, the sites of the major electron suppression fields. All extreme assemblies were regapped to homogenize the gradient. The consistency of the gradient over several months was also monitored and found to be within the intrinsic distribution.

Shafts.

In order to remove the snail tracks from some of the shafts, mentioned in the preamble, and get rid of the chemically contaminated surfaces, all shaft sections in the machine were removed and skimmed in a lathe using water soluble oil cooling. No further polishing was done. We found that removing about 0.08 mm did not remove all the tracks in all our shafts; the marks were as deep as 0.6 mm. The worst case, that in Unit 1, required the removal of 4.4 mm from the shaft diameter. (Photo 10).

The machinist noticed, while centring the shaft sections in his lathe, that some of them were bowed to the extent that they were 0.4mm out of true. In these cases we had the shafts machined down to eliminate the bow. At the suggestion of Alistair Muirhead, a polarizing analyzer was used to inspect the various shaft sections for evidence of stress. Examination with polarized light showed bowed shafts had severe stress radiating from the machined drive slot. This, presumably due to overheating during machining, introduced stress into the shaft which gradually relaxed, causing the shaft to bend.

The shaft sections in the machine at the time of this opening were made at A.N.U. (52/5). After machining they were polished with Brasso, (an old-established English brass cleaner) of which its label merely says: 'Contains 80% white spirit'. The contents appear to have a fine abrasive in suspension, and smell faintly of ammonia. "White Spirit" is one of those arcane appellations which have hung on since the alchemists, implying something between a ghostly visitor and what one finds in a schnapps bottle. Of three books which deigned to mention it; one calls it "a solvent with a narrow distillation range, 150 to 200 deg or less, prepared from kerosene", and the other two brush it aside as just mineral turpentine.

The polarizer led us to discover that old N.E.C. shafts, with bad snail tracks, showed almost no stress excepting at the centring hole, drive pin and end face.

Shaft sections manufactured at A.N.U. displayed a wealth of features which indicated that just about everything done during manufacture was wrong. Our shaft sections were polished at high speed, which we have now discovered is certainly the wrong thing to do because surface heating can produce crazing. Procedures for handling and machining scintillator plastics, given by Nuclear Enterprises, emphasise that all machining and polishing must avoid heating as this can cause the surface to craze at a later date. It was even pointed out that fingerprints can cause similar problems and clearly contamination from b.d.ps, tac rags, solvents and Brasso can cause trouble. Howard Wallace said that he had polished car bodies with Brasso and found later that a type of snail track formed. These tracks were removed with 1,200 grit carborundum paper, wet with water, and then polished with an electric buffer; after this treatment the snail tracks eventually returned. This suggests that deep chemical contamination of the substrate was the problem.

STRIPPERS

The terminal foils were renewed, including a selection of glow discharge foild manufactured at A.N.U., Arizona Carbon Foil Co. and Chalk River National Laboratory. The pneumatic actuator was modified by the installation of new springs with double the relaxed length. These increase the force available in the neutral position from 4 to 12 pounds. Although there is some coil squirming due to the necessarily incomplete anti-squirm guides, the actuator worked flawlessly in both forward and reverse directions at only 450 kpa actuating pressure.

INSULATING GAS.

We changed the Vivalyme in the gas purifier while the gas was being pumped out. It was time we changed the Vivalyme because we have promised ourselves to do so at least once a year, and some of the poltergeist phenomena could have been caused by b.d.ps due to exhausted Vivalyme. We last changed it on 20th January 1986 and that load functioned for 4,666 hours of volts on terminal, or approximately 330 mA.hr out of a projected life expectancy of 440 mA.hrs.

GRIDDED BUNCHER:

Far field extension using carbon coated teflon cylinders.

Gridded bunchers operating at low frequency, are limited in the acceptable particle velocity by the non-bunching effect of the R.F. fields between the external, grounded surface, and the grids. The three-frequency gridded buncher, based on 9.375 MHz at Canberra, was provided with 20 cm long teflon sleeves to extend the far field regions. This was an entirely successful strategy except that with low intensity beams, the surface of the teflon charged up, making focusing difficult. A few micrograms per square centimetre of carbon were evaporated on both inner and outer surfaces of the teflon, solving the charging problem and maintaining sufficiently high resistance to satisfy bunching requirements.

Cleaning.

The column was blown thoroughly with nitrogen, dislodging not only black flakes and flecks from tube and post electrodes, but also the first sand-mine (9/2; 13/5; 14/3; 21/8) we have "unearthed" for two or three years. It was just like old times. The younger author, who discovered sand-mines, and thus enjoys them most, devised a specially shaped shovel which he fitted to the end of the vacuum cleaner nozzle so that he could dig and extract at the same time.

The tank walls and the rings were tacragged by students with their usual cheerful willingness.

Button-up.

After charging tests we took an affectionate look in the tank at the faithful old blue tyres, the friendly oilers and the spotless column. With a happy smile, we gently closed the doors.

Initial performance.

There were about six sparks at ever increasing terminal voltage as the gas was put in. For the two experiments which followed at up to 11 MV, there were occasional sparks. We ascribed these sparks to the removal of particulates. We can only hope that having removed the source of the particulates, the residual ones can be coped with. Five days after button-up the logbook had an entry: "Machine running beautifully at 13.3 MV".

D. C. Weisser.

T. A. Brinkley

29th January 1987

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: (Photography by Gerald Clarkson.)

Numbers 1 to 10, as referred to in the text.

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; thus downtime, or failure to use the 14UD, count against us. 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.

The reports, including final copy, are produced on a computer which has no superscript capability or special symbols. Powers of 10 and mathematical expressions are given in Fortran; nuclei and units are written in full, e.g. 'boron eleven', 'millivolts' etc.

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

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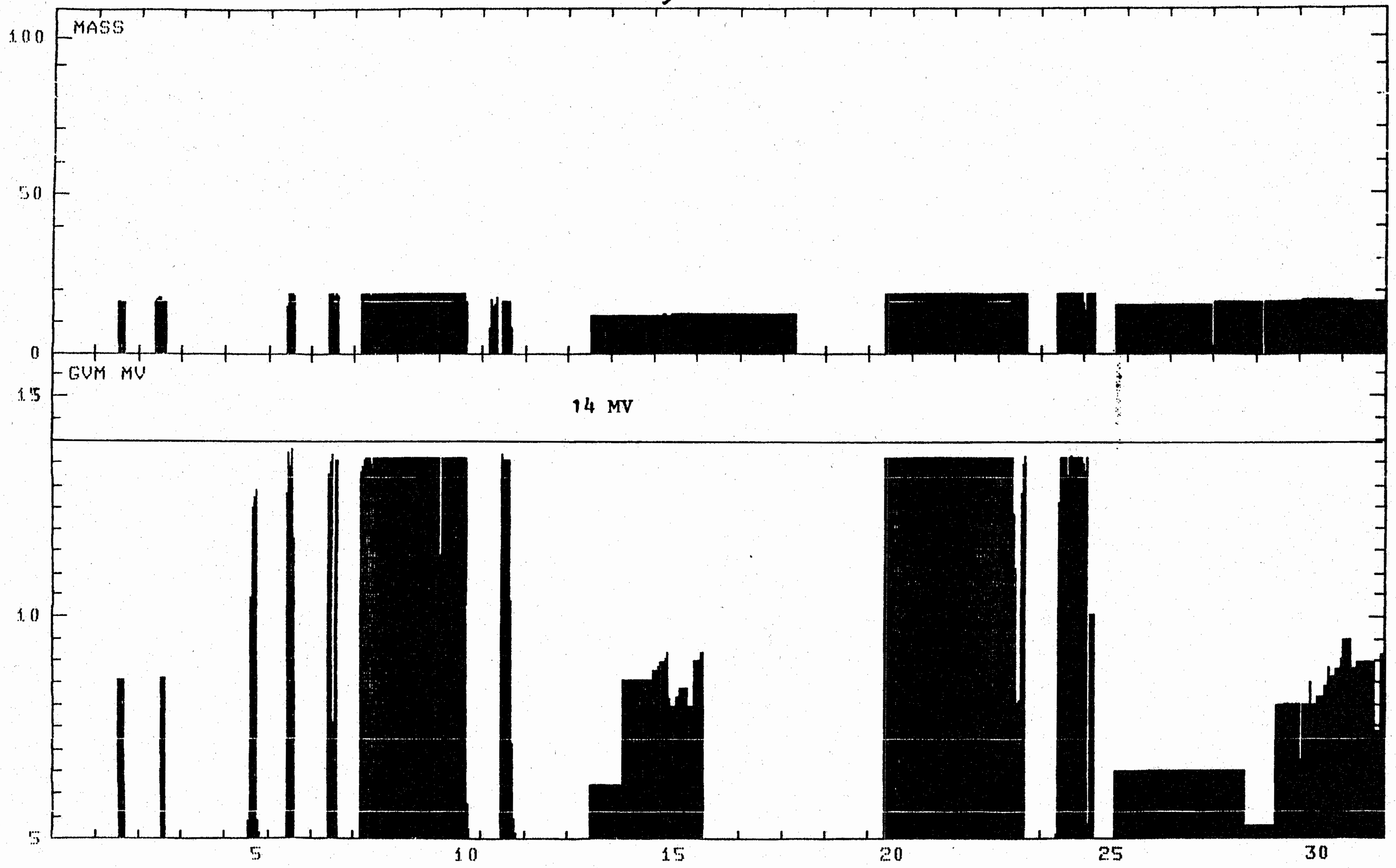
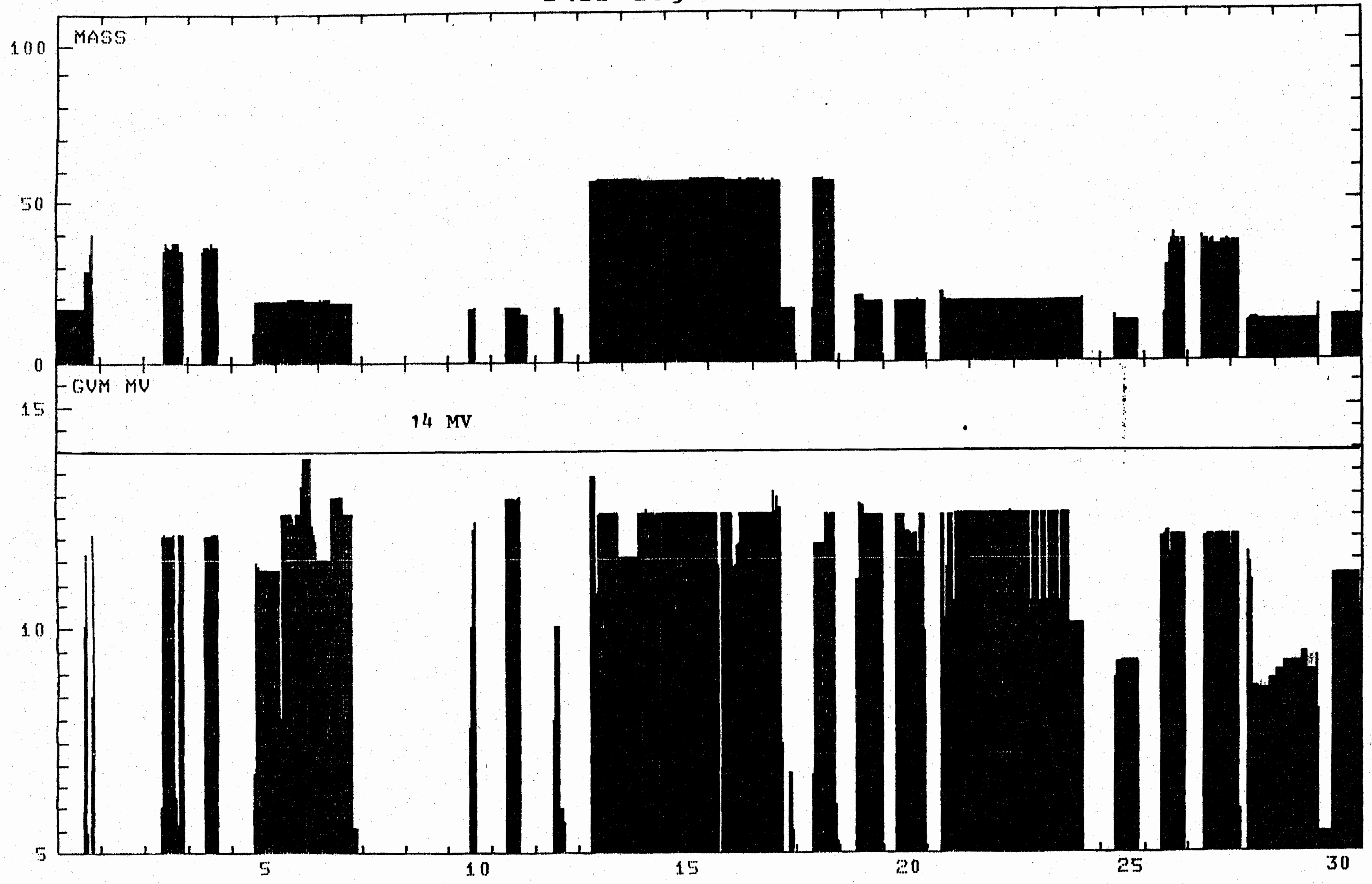
14UD log OCTOBER 1986



14UD log NOVEMBER 1986



14UD log DECEMBER 1986