AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT NO.26

(16th to 22nd June, 1981)
(7 days open; 5 working days)

REFERENCES: Earlier Tank Opening Reports are referred to by the notation (12/4) etc, meaning Report No. 12, page 4.

Correction:

We stated, (25/5), that the H.E. foil stripper assembly had not been removed since its installation in May 1978 (11/6); this was not true. We reported in Ausgust 1980 (21/5) that a number of H.E. foils were wrecked because of a vacuum mishap. Though not specifically stated the stripper assembly was, in fact, removed at that time and a full load of new standard foils was put in.

REASON FOR TANK OPENING

After three months peace in the machine the younger author gets restless and insists on scheduling a tank opening in case something is about to go wrong. He is in charge. Operation above 14.5 MV became difficult. The threshold voltage for difficulties progressed inexorably downward. The troubles were associated with operation of Chains 2 and 3, but not in a consistent way. Given the problems last reported with chain idler shafts, spares for these were made high priority and an outstanding order in the machine shop was expedited, with the usual results; they were a month behind schedule and 0.0005" under size. On the last operating weekend before pumpout there was a great deal of trouble with the terminal foil changer but after an hour or so of shots in the dark it operated. The scheduled experiment was completed. Both authors are proud of such high precision prognosis and scheduling.

PREAMBLE

The 14UD was last closed on February 26th. It was not used for the four days of Easter and of the remaining 2,448 hours of time elapsed since closure it operated for 1,714 hours, or 70% of scheduled time. Most of the remaining time the machine was available, but not used at the experimenters' discretion.

After gassing up, first tests revealed lost charge to be about 40 microamps at 11.5 MV, presumably due to deconditioning (gas) in the tube associated with the second stripper foil change. The instabilities seen on the lost charge prior

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to the tank opening had disappeared and this was attributed to absence of break-down products on the triode needles. New ones were fitted in order to make a new start with clean, sharp points which the new charge of alumina was expected to keep in good condition.

After the alumina was replaced it was reported during the first reactivation that the effluent did not have the pungent smell which has been characteristic for some time; moreover there continued to be no smell during the 15 subsequent weekly reactivations. Because the machine continues to operate with no "bad gas" symptoms, this implies that the alumina absorbs material which is not desorbed by our reactivation process. Presumably when the concentration of these products reaches a certain limit the excess is removed by reactivation. That limit has not yet been reached.

On the 4th day after closure conditioning began at 14.1 MV for 101 p.s.i.a. tank pressure, and quite soon the level improved with use, in fact an experimenter took data for about half an hour at 14.87 MV with no sparks. (See voltage plot for April 16th).

Stability was very good initially, and then went through a less satisfactory period when the image slits were used close in; eerie stability returned when they were opened to 0.05". Could the emittance of the source be greater than it was two years ago?

Late in May, sparking at 14.5 MV became persistent and an extensive series of diagnostics with shorting rod configurations indicated a problem at or near unit 22; unit 28 also was not above reproach. The tests were inconclusive since, when run alone, these units each went to an apparent 1.3 MV/unit. Although this apparent voltage might not be accurate, these units operated at 45 microamps, where 27 corresponds to 14.56 MV, (1.065 MV/unit, average).

At the end of March the upper rotating shaft became noisy. It was kept off until the end of May when it was tried again, seemed much quieter, and was allowed to stay on. Then the lower shaft became noisy and was banished for a day; it, likewise, was chastened and better behaved when it was put back on. It is probably the case that the shafts are not getting quieter, but that we are getting more tolerant, or the other author is also becoming a trifle deaf.

For some time we have had difficulty with the H.E. shorting rod clamping system. An A.N.U. version was installed two years ago, (15/2), and rods at the H.E. end have, at times, been very difficult to remove. When a film of oil has been put on the rods for lubrication the clamping system has been unable to retain 5 steel rods without them slowly slipping down.

Work had proceeded with renewing needles on a complete set of old tube and column corona point assemblies. The old points were removed and new sewing needles cut to length and secured with all-state solder.

THE TANK OPENING.

Before opening the upper door and starting ventilation two heads were poked into the tank immediately the lower door was opened. There was no strong smell as on occasions before, and, apart from a detectable scent, reminiscent of a half-forgotten favourite after-shave, the air was much the same as outside the tank. This spoke eloquently of the effectiveness of the new alumina. Since the doors were not opened until 5.45 p.m. the platform was not lowered until the next day.

Exploratory tour.

The reason for the chain-associated sparking was not apparent from anything on the column, though all chains were very dry and thickly tacky; the rims of the charging pulleys were bone dry. We had the feeling that all would be revealed when the covers were taken off castings where there were chain stabilizing idlers, and, indeed, it was.

An idler was off at one of the down positions for Chain 3 and was jammed between its support block and one of the three 'petals' of the A.N.U. spark shields (23/3; 25/6); the tyre was being rubbed by the chain. At another casting a down idler for Chain 3 had a very bad bearing and was loose and "sooted" up. This black "soot" is ground up steel from spark-eroded idler shafts.

On Chain 2, which had also given trouble, there were some loose idlers, but nothing dramatic.

There were, in all, three positions at which we believe the spark shields very probably saved two chains from the consequences of nomadic idlers. It is a nice irony that the spark shields which were installed to protect the idlers from chain sparks, protected the chain from detached idlers. Several displaced idler tyres had been ground up by the chains, producing bits of rubber which were deposited on nearby rings and on the terminal. Speckles of idler can be seen in the photo of the terminal as spots. There are no spark marks on the terminal in this location, though. It is likely that the instabilities at high voltage associated with the operation of chains 2 and 3 were caused by speckles travelling in the tank volume, and chain sparks. The large number of sparks which turned off the chain motor and caused the charging and suppressor supply meters to jump, testify to the latter. In addition, the series resistor protection assembly on the charging supply showed evidence of spark damage, but otherwise was serviceable.

The many chain sparks above 14MV did no damage to the RG8 cables from the supplies. This amply attests to the success of this protection device. The device consists of five 50 megohm Welwyn resistors mounted in a nylon "revolver chamber". The spark damage which did occur was between adjacent ends of the resistors. We shall try to overcome this with a generous barrier of silicone rubber.

One heartening aspect was the success of the experimental modification (25/6) of nickel plating a few idler shafts in order to get a tight push fit into the inner races to inhibit spark erosion; in all cases these were in excellent condition with no detectable play or looseness. A number of unplated shafts, fitted at the same time, were exhibiting wear, though they were not near danger point. One shaft completely snapped off. (see photo)

The terminal foil actuator was failing to work in the forward direction and exhibiting inconsistent stubbornness in reverse.

There was little oil on the H.E. castings, indicating success of the modification to oiler reservoir pneumatic vents (25/5).

We found no buildup of breakdown products on the corona triode needles mentioned in the last report (25/3). This relates to the absence of pungent smell in the tank. However, on the terminal, the usual brown patch opposite the stabilizing triode needles was distinctly heavier, though of significantly smaller area. There were 4 spark marks which had penetrated the brown layer leaving spots of bright metal clearly visible. (see photographs). Sparks to this location are

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unprecedented and suggest that once the deposit reaches a certain thickness, local voltage stresses are caused. This reinforces the need for tank oopenings more frequently than three month intervals. Our good intentions of mapping spark marks on the new terminal spinnings, and removing them with fine emery so that the next lot could be counted, had fallen by the wayside. The triode needles themselves were in good condition and the mushroom was smooth and unmarked.

And so to work!

Stabilizing idlers.

Every idler was removed from the column and examined. All shafts, excepting the plated ones from the previous occasion, were replaced with new ones, all nickle plated to give the desirable tight push fit into the inner ballraces. The new shafts, which had already been ordered as standbys, but not finished, were made urgent and came from the main workshop in batches, all either undersized or tapered. They were plated in the department and fitted on the bench as they came down. Had the shafts been machined to the correct size the plating would not have been necessary; it was only done to retrieve bad machining errors.

Corona points.

With only four working days available it was decided to stretch platform and personnel logisitics to the limit and change all the tube and column corona points; this was only feasible, in view of the work on the idlers, by enlisting student labour. Our grateful thanks are extended to the students, Aidan Byrne, Bob Charity, Fred Pribac and John Vermeer who took off rings and removed all the old points and put in the ones rebuilt in the department. This involved the students being shuffled sporadically on and off the platform, and working a number of hours in the evenings. All the new points were sorted according to length. The tube points which were between 1/4" and 9/32" were taken as nominal 1/4". Points 1/32" longer than these were put in units 1;2;3;11;12;15;16;19. The nominal 1/4" were put in all the other units. The tube entrance ones should help the beam optics and the ones near the terminal and second stripper should reduce quiescent voltage stress.

Foils.

The terminal foils were changed. The Weisser valve, which isolates the volume of the foil changer from the tube, was closed after carefully setting the foil changer to the blank position as indicated by zero on the foil counter. In the past there have been several occasions when zero has not corresponded to the blank and a foil frame has been knocked off by the closing valve. Nevertheless we have always religiously turned the mechanism to zero. On this occasion faith alone was not enough and for the first time a foil holder jammed in the seal without our knowing it at the time.

It is interesting to note that, when the stripper volume was let up to nitrogen, the seal with the foil holder in was good that the L.E. tube pressure barely moved from 4×10^{-8}. Only when the stripper was withdrawn could we tell

of the mishap. Zero position was found to be about 100 places from counter zero, indicating slip at the sextupole magnets which transmit torque to the internal mechanism through the wall of the stripper housing. We do not know when the gross discrepancy between the external counter and the internal mechanism occurred, nor how it occurred.

In order to remove the foil frame, and examine the seals, the tube had to be let up to argon; this was performed in the now time-honoured slowness of any other sacred ceremony.

The Weisser valve was taken out and fitted with new aluminium seats. The knife edges were not significantly damaged. The next foil change will tell if the valve still seals properly.

Shaft bearings

All the bearings were listened to with a stethoscope and two were pronounced noisy, but not vociferous enough to merit platform time; consequently shaft bearings were elected to be satisfactory. This apparent ostrich principle is known as selective preventive maintenance.

Terminal foil actuator.

The proximate cause of failure of the terminal foil actuator was that an under-size 1/16" thick O-ring popped out of its dove-tail groove. An O-ring of the correct circumference was substituted, and worked well.

The troublesome actuator had been stripped and lubricated. It was put in on Friday afternoon when there were still several hours of work to be done before button-up. After two hours of adjustment, trial and frustration it could not be made to work reliably and it was clear that workshop time had to be spent on the mechanism: while this was being done our efforts were transferred from Friday button-up to the Friday conference.

On Monday, while the repair of the actuator was being completed, one of the most thorough cleanings the column has ever had been subjected to was carried out. Every spark gap on the tube and posts was blown with nitrogen and every visible speck of anything movable was moved, even if to somewhere else. We believe pro-foundly in displacing from the column, and into the down-draught of filtered air, as much particulate matter as possible because it is blown out of the open lower door. Our maximum attainable voltage is now almost a million volts in excess of nominal and, as we have said, it is usable for reasonable spark-free periods.

During the cleanup there came to light an ingenious N.E.C. success. References 9/2; 13/3; 14/3 record the history of the discovery and gradual elimination of the sand mines which our friends at N.E.C. had humorously tucked away in the darker recesses of the castings for our continuing amusement. We referred (21/8) to the last trifling deposits being unearthed and, for us, the jest seemed sadly over. However, at this opening, the sheer subtlety of N.E.C. came to light. Each aluminium casting has on its inside a large capital letter "B"; each depression within the "B" contains a highly compacted and beautifully concealed miniature mine, right before our very eyes. We removed the mines from castings not yet closed up and at the next opening we shall keep our eyes peeled for lower case letters. What then, we wonder - microdots?

Chains

One pellet was taken out of each chain, and the chains were cleaned and oiled by hand.

MISCELLANEOUS

The H.E. shorting rod insertion mechanism was taken apart and modified in order to eliminate some of the difficulties mentioned earlier.

Button-up

Mechanically the chains ran beautifully and the charging currents were copy-book.

The doors were closed at 4.30 p.m. and there was an early start to the apres-buttonup conference while, in parallel with it, the tank was roughed for half an hour and then let up to atmospheric pressure again to check for leaks on the tube. All being well roughing continued overnight and the tank was gassed up next morning.

First tests

As the gas was going in volts were put on to observe the performance of the new tube and column corona points at different gas pressures. At 13MV, for about 100 psia SF_6, L.E. tube corona currents were about a factor of three higher than with the old points for about the same voltage and pressure. Column currents were 30 to 40% higher than with the old points. This higher L.E. tube current reflects the longer points used; it also resulted in the re-establishment of the 100% transmission for carbon beams, which was the case several years ago.

The machine conditioned up quite easily to 13 MV almost during gassing up and went into operation. Stability was excellent. It is noteworthy that, with the new tube and column points, the metered currents were almost eerily stable. Experimenters took over the machine and, at their option, operated it from 10 to 13 MV.

"THE END OF AN ERA"

(according to five separate comments; four from the same person)

On April 6th the E.N. Tandem tank was loaded onto a large truck and set out on the first stage of its journey to New Zealand after it had been autographed by many associated with it. The forlorn figure of the older author stood and watched it disappear into the sunset.

D.C. Weisser.

T.A. Brinkley.

30th June, 1981

Appendix follows.

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APPENDIX

We stated, (25/1) that we would give hourmeter readings to indicate machine operating time, and also lifetimes of charging chains, corona points, shaft bearings etc. The following summarizes the situation to date. A brief early history is included because the first Tank Opening Report to be circulated was in February 1976, two years after the 14UD was taken over from N.E.C. and went into operation; information for those two years has not been given before.

In February 1973, before the tube was installed, voltage tests were carried out by Jim Ferry, reaching 18.1 MV with 100 psia SF_6. The first beam went through the machine in August 1973.

CORONA POINTS. A history.

Considerable trouble was experienced in the early days with the tube and column corona assemblies. The original design was a dome with an old type gramophone needle held in by a grubscrew. This system failed persistently, causing instabilities which led to one tank opening after another. Several complete changes of points were made before October 1974 when the first set of Type 2 assemblies was put in. These versions were discs, each with three cut-off sewing needles soldered to the disc 120 degrees apart and a quarter of an inch from the centre. They were vastly superior to the original design; the points never fell off and rarely broke, as the gramophone needles so often did. At each tank opening a few points were changed but a complete change did not take place until February 1976 (after 16 months and estimated 4,000 running hours). These points were removed in September 1977, (about 6,000 hours) not because of their condition but because of a meticulous cleaning plan. The points were kept for possible further use and a complete new set was put in. This set was still in use after 16,500 hours, though the needles were undeniably dull and needed the change which has just been effected. We no longer find broken needles.

CHARGING CHAINS

The pellets of the original chains were hardened on the side in contact with the pulleys. One of these chains broke in October 1975 at 3,600 hours. The other two chains were taken out, unbroken, at the same time and new chains of a different design were put in all three positions. The pellets of the new chains were not hardened, but were chromium plated. The following table summarizes chain lifetimes:

CHAIN LIFETIMES

Chain 1 Position

(a) Original hardened verison removed unbroken at 3,215 hours.
(b) New chain fitted. It broke after 12,446 hours.
(c) New chain fitted and still running. Life to date: 10,112 hours.

Chain 2 Position

(a) Original hardened version removed unbroken at 3,556 hours.
(b) New chain fitted. It broke after 7,019 hours.
(c) New chain fitted and still running. Life to date: 14,926 hours.

Chain 3 Position

(a) Original hardened version broke at 3,610 hours.
(b) New chain fitted. It broke after 2,143 hours.
(c) Parts of previous chain plus 100 new pellets. Broke after 7,155 hours.
(d) Made up from previous breaks. Life 151 hours.
(e) New chain fitted. It broke after 5,012 hours.
(f) New chain fitted and still running. Life to date: 2,304 hours.

ROTATING SHAFT BEARINGS

It should be remembered that shaft time bears no relationship to machine operating time. Frequently the machine operates with no shafts, and shafts are run when volts are off.

In April 1976, when the original bearings were still in, and had operated for nearly 8,500 hours, investigations led to the discovery that many bearings were in bad condition. Because of the environment in which the bearings were operating we discussed the matter with Mobil who advised the use of a high temperature grease loaded with molybdenum disulphide. New bearings were bought and their grease was washed out and replaced with Mobil 78 as recommended. (This was reported in detail in T.O.R. 3/1). We soon found that the new grease was no better than the old and a number of bearings had to be replaced after 2,500 hours, by which time Mobil had changed their minds anyway and suggested we should return to standard grease. We did this for all individual replacements from then on.

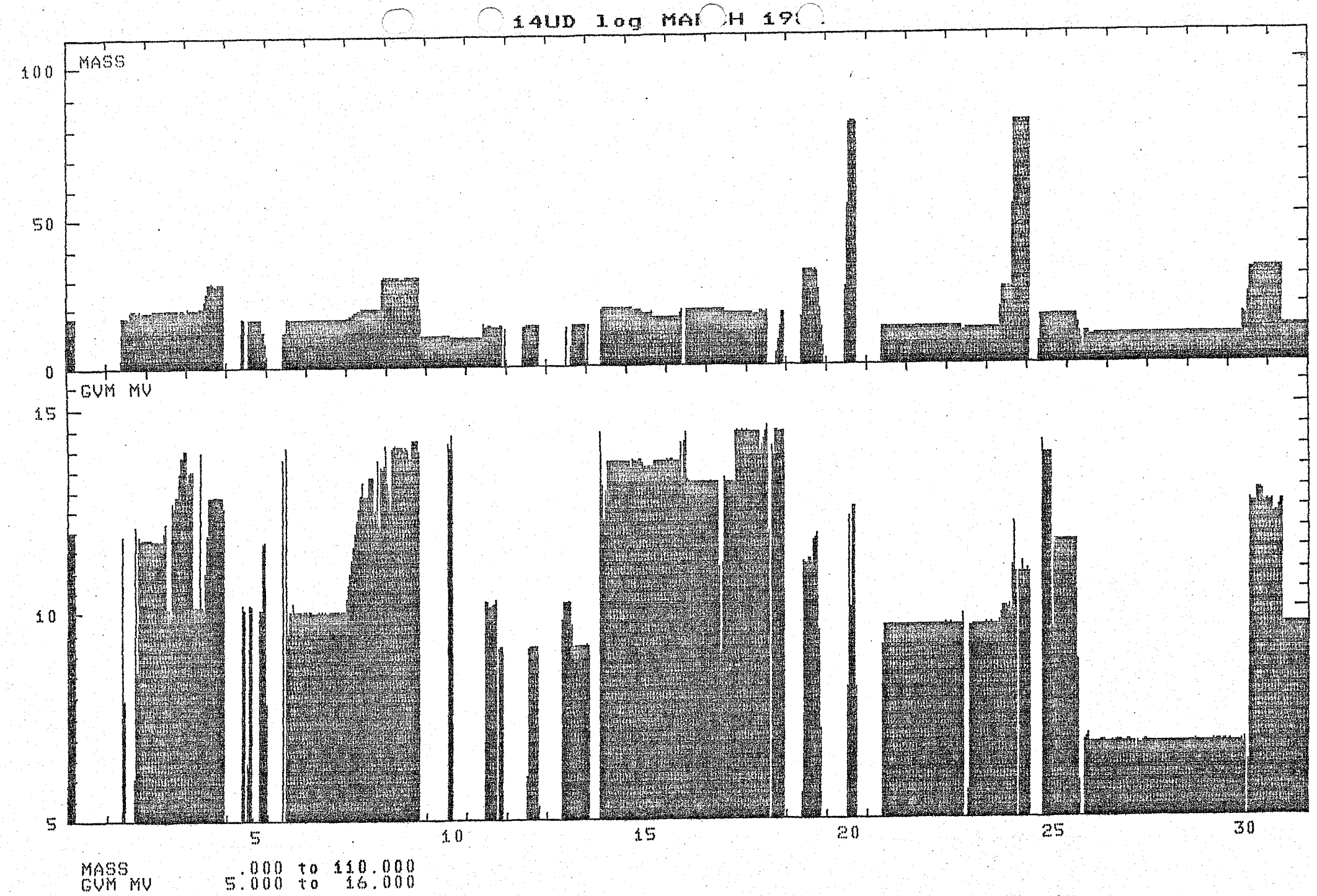
Between April 1976 and September 1977, when every bearing was again changed, the average life of 9 collections of bearings renewed at different tank openings, for both shafts, was 4,000 hours.

Following the complete change in September 1977 all the lower shaft bearings were changed after 6,360 hours and then were again replaced after a further 3,760 hours when it was decided to change every shaft bearing in the machine. (August 1979).

During the period September 1977 to August 1979 the upper shaft bearings, with two exceptions, served 9,650 hours.

When the old bearings were removed in August 1979 we discovered that bearings with red seals were in better condition than those with black seals. (This was reported in detail in T.O.R. 18/1). From then on only the red seal type has been used.

From August 1979 until March 31st. 1981 five bearings in the upper shaft were changed after 4,443 hours and seven in the lower shaft after 2,300 hours.


14UD log MAR H 19
MASS
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GVM MV
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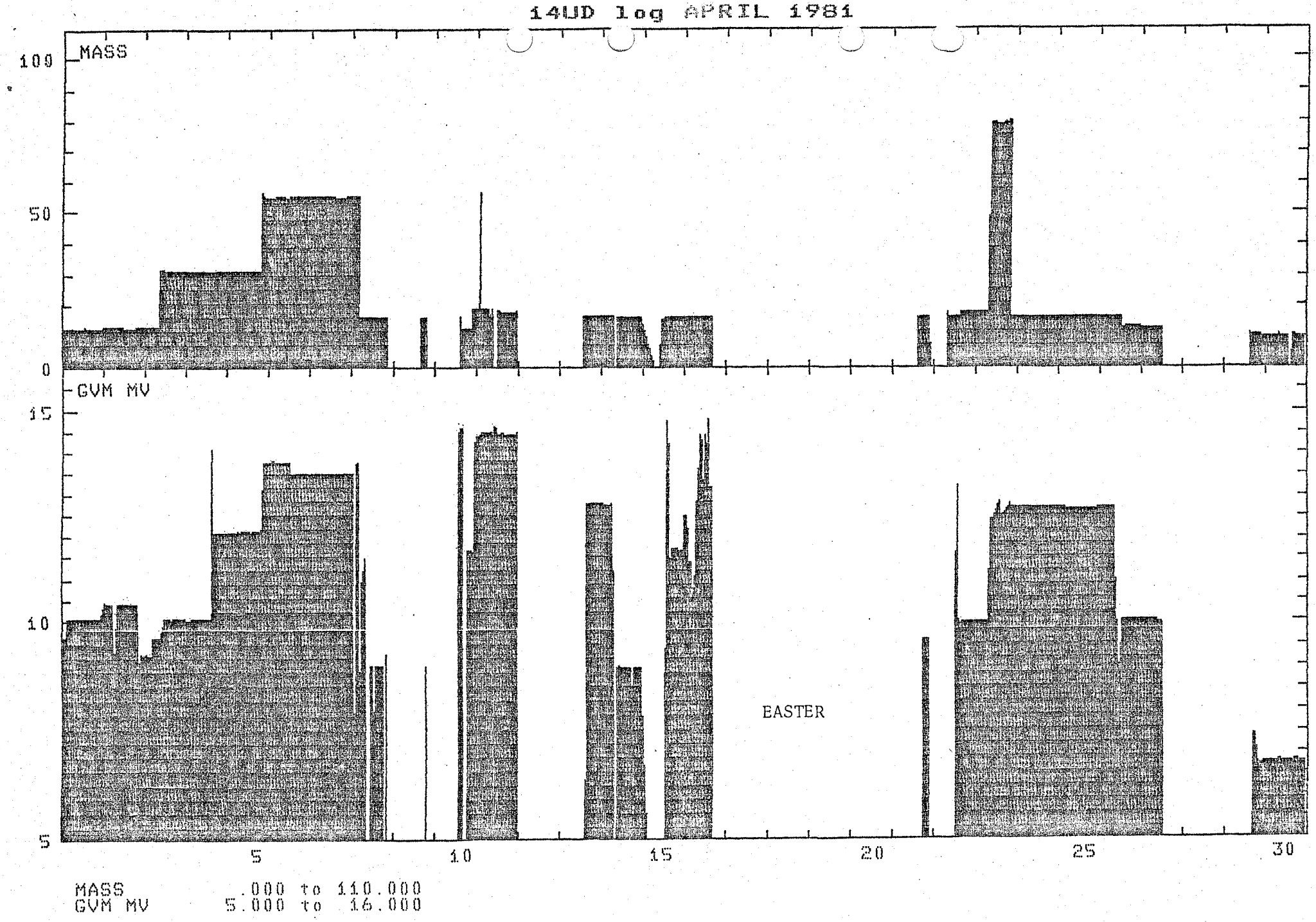
25
30
MASS .000 to 110.000
GVM MV 5.000 to 16.000


14UD log APRIL 1981
MASS
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GVM MV
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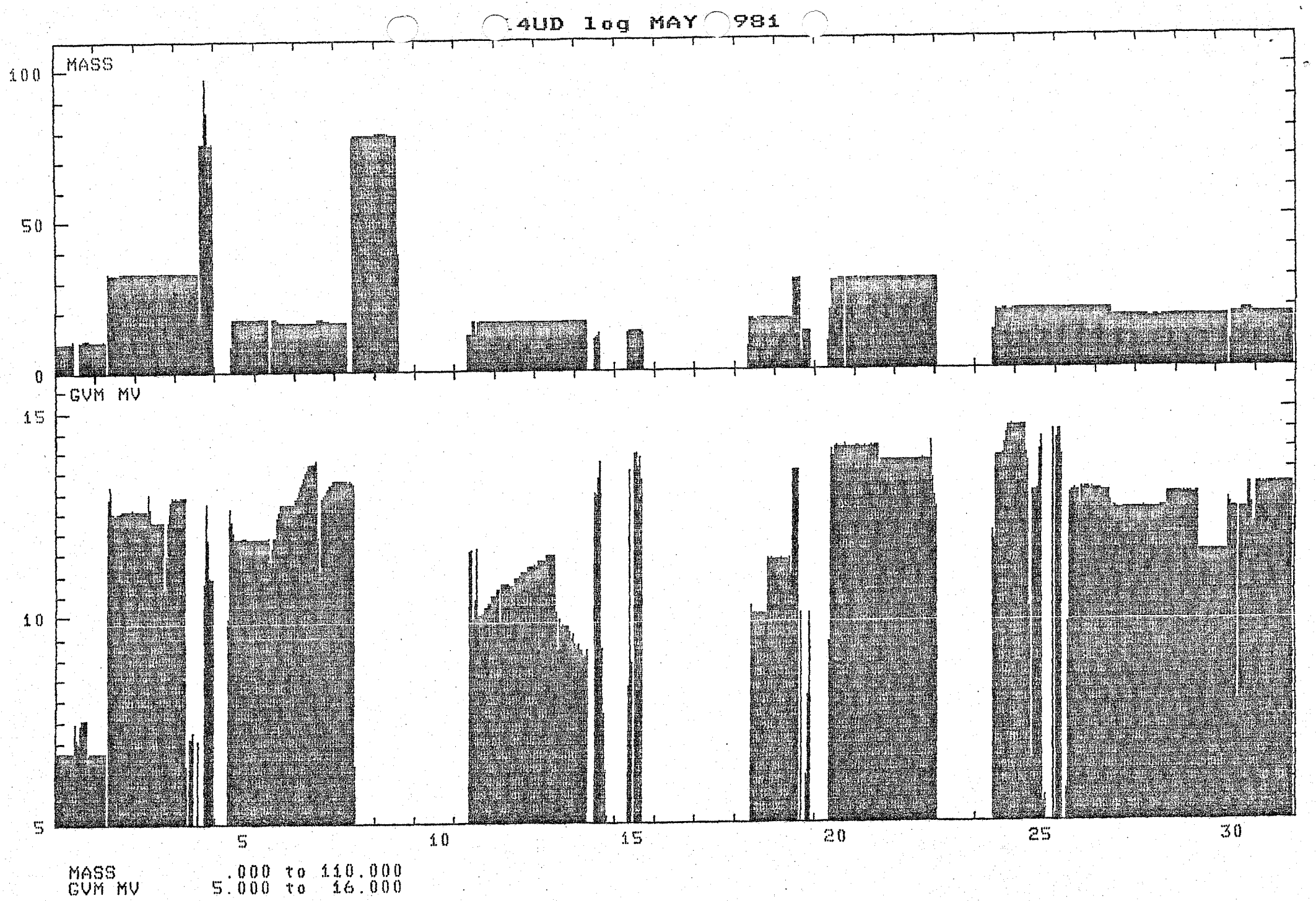
MASS .000 to 110.000
GVM MV 5.000 to 16.000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GVM MV
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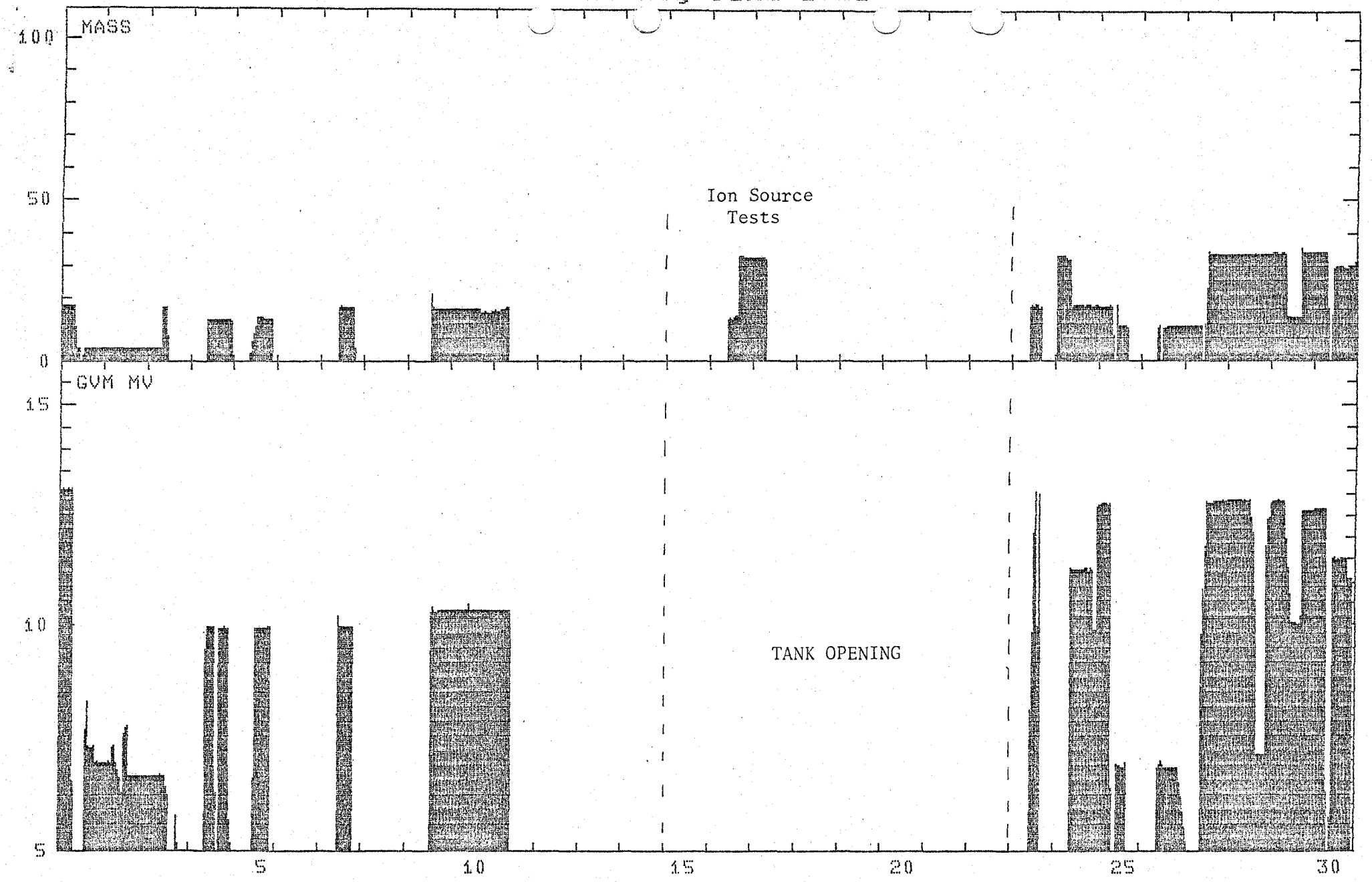
MASS .000 to 110.000
GVM MV 5.000 to 16.000

14UD log JUNE 1981



MASS .000 to 110.000
GVM MV 5.000 to 16.000